VIGILANCE PERFORMANCE OF MILDLY MENTALLY RETARDED CHILDREN AND ADULTS

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SUMMARY

The results of research suggest that mentally retarded people might have an attentional deficit or are abnormally distractible. The vigilance task provides a method for investigating these possibilities, as well as the suggestion that they are more suited to simple, monotonous tasks than nonretarded persons. However, only five studies had specifically investigated the vigilance performance of mildly mentally retarded people. Whilst there was some apparent disparity in the results of these studies, the overall findings suggested that mental age might be a primary factor of the performance of mentally retarded people. This thesis investigated the vigilance performance of mildly mentally retarded persons in terms of both attentional deficit and developmental lag hypotheses.

None of the previous five studies had included the subject groups necessary to test the developmental lag hypothesis. Thus, Experiment 1 in this thesis investigated the performances of both mentally retarded adults and children in comparison to those of nonretarded chronological age and mental age control subjects. In addition, the possibility of inattention to the stimulus source amongst younger subjects was tested by comparing performances on auditory and visual tasks. Results supported the developmental lag hypothesis and not the peripheral inattention hypothesis. Also, the results of a

signal detection theory analysis indicated that the mentally retarded children were slower to develop the capacity to maintain discriminability over time.

Given the evidence for a developmental lag, subsequent experiments investigated the nature of the change that occurs with age. Experiment 2 used continuous auditory and visual tasks to investigate the possibility that mentally retarded persons might be slower to develop a strategy involving the ability to predict when to attend to stimulus events. It was hypothesized that use of such a strategy would enable subjects to switch attention on and off appropriately. However, results did not support this particular strategy explanation.

Since previous evidence has suggested that mentally retarded people find the vigilance task particularly boring, it was hypothesized that mentally retarded children might be slower to develop a willingness to continue to attend to the vigilance task. An easy task, involving the detection of a signal with an intensity set well above threshold level which occurred frequently, was presented to subjects to test this hypothesis. Results failed to support willingness to continue to attend as a major factor, although signal characteristics such as intensity and frequency were shown to be important determinants of the decrement.

The last three experiments investigated the relative importance of signal intensity and frequency on the rate of decline of vigilance performance of mentally retarded children. These experiments were also used to test both a fatigue and a memory explanation for the more rapid decline in detection performance, and associated sensitivity decrement, shown by mentally retarded children in comparison to nonretarded children of similar chronological age. The results of these experiments supported the hypothesis that the developmental process is concerned with a fatigue effect, that is, an increasing ability to avoid becoming fatigued. Furthermore, the findings were consistent with an explanation that the fatigue process involves the nerve cells concerned with the task performance becoming unresponsive or insensitive through continued activity.

DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma at any university and, to the best of my knowledge and belief, it contains no material which has been previously published or written by any other person, except where due reference is made in the text.

PETER G. THOMAS

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To both my parents and wife...

CHAPTER 1

ATTENTIONAL DEFICITS IN MILDLY MENTALLY RETARDED PERSONS

1.1 MENTAL RETARDATION

The problems associated with mental retardation are complex and multifaceted. For example, there is still disagreement as to its definition with different definitions reflecting varying theories of aetiology and prognosis. In addition, there are many causes of mental retardation, which may be due to endogenous or exogenous factors or a combination of the two. While many of these factors are being identified, there are still a large number of cases which remain unexplained.

1.1.1 Definition

Initial concern with the classification of mental retardation in the nineteenth century was in terms of social competence which sought out those people who required care and protection in institutions. The development of tests of measured intelligence at the beginning of the twentieth century led to attempts to identify those who could not profit from formal education and hence required special schooling. Intelligence tests had the advantage of providing a quantifiable measure of mental retardation.

The American Association on Mental Deficiency (AAMD) adopted the definition of mental retardation as "sub-average general intellectual functioning existing concurrently with deficits in adaptive behaviour, and manifested during the developmental period" (Grossman, 1973). This definition combines both views, emphasizing deficits in both adaptive behaviour as well as general intellectual functioning.

This is the most widely accepted definition and stipulates that three criteria must be met before a person can be classified as mentally retarded. First, sub-average intellectual functioning indicates that an individual scores at least two standard deviations below the population mean on a standard intelligence test. Second, the individual must demonstrate deficits in adaptive behaviour, that is the individual's adjustment to the demands of the social environment must be impaired. Adaptive behaviours are manifested in different ways at different ages. During the preschool years adaptive behaviour may be reflected in the development of sensory-motor, communication and self-help skills. Throughout the school-age years, learning, or the ability to acquire academic skills, or the application of appropriate reasoning in the mastery of the environment is indicative of adaptive behaviour. At the adult level, vocational performance and social responsibility assume primary importance and so adaptive behaviour is indicated by the ability to maintain oneself independently in the community.

The third criterion is that deficits in intellectual functioning and adaptive behaviour must occur in the developmental period, the upper limit of which is approximately eighteen years. This implies that mental retardation is a developmental disorder and therefore, any individual who reaches adulthood after a normal development, cannot be considered to be mentally retarded. Hence, intellectual deterioration due to senility or brain damage is not considered as mental retardation.

An important feature of the AAMD definition is the emphasis on symptoms and not aetiology or prognosis. Definition is in behavioural terms and no mention is made of either cause or its permanence. Therefore, mental retardation is not defined as irreversible.

1.1.2 Categories of Mental Retardation

Mental retardation can be divided into two broad categories. One group consists of people for whom evidence exists which points to their diminished mental abilities being due to specific organic abnormalities. This group is referred to as the organically retarded. The other group involves those people for whom there is no apparent biological or medical cause for their lowered intellectual abilities with the functional reaction alone being manifest. These people are labelled as culturally retarded when their retardation is considered to be due to psychosocial conditions or familially retarded when their retardation is considered to be due to hereditary.

The second group is by far the larger with an estimated 80% of the mentally retarded population making up this group (Neisworth and Smith, 1978). Most individuals in this group manifest only mild mental retardation compared to the organically retarded who tend to be more severely retarded. Zigler (1967, 1969) postulates that cultural-familial retardation represents the lower end of the normal distribution of intelligence, that is, IQ scores between 50 and 70. However, there is a disproportionate number of individuals with IQ's below 50 which cannot be accounted for by a normal curve distribution, their subnormal intellectual functioning being due to organic or physical causes. Robinson and Robinson (1976) have shown that the estimated actual number of individuals with IQ's between 50 and 70 is close to the estimated number calculated from the normal curve distribution, whereas the estimated actual number of individuals with IQ's below 50 far exceeds the estimated number.

1.2 COGNITIVE PROCESSES IN MENTAL RETARDATION

Although the study of cognitive deficits in subnormality began in the nineteenth century, the attention paid to the concept of general intelligence diverted research from defects in more specific areas of cognitive processes. However, over the past few decades there has been a large amount of research into specific thinking and problem solving deficits.

Differences in performances found between retarded and nonretarded persons are generally interpreted in two opposing ways when considering cultural-familial retardation. One view is that retarded persons suffer from specific cognitive or physiological defects resulting in intellectual functioning different from that of nonretarded persons (Milgram, 1969). The contrasting view is that cultural-familial retarded persons suffer from a developmental lag with a slower rate of cognitive development and a more limited potential than nonretarded persons. An implication of this latter view is that retarded persons should perform similarly on cognitive tasks as nonretarded persons of equivalent mental age.

Cognitive research has suggested that attentional deficits are a major cause of adaptive behaviour disorders in mentally retarded people. Spitz (1963), Robinson and Robinson (1976) and Zeaman and House (1963) reported that retarded persons showed attentional difficulties in a variety of problem-solving and discrimination learning tasks. Crosby and Blatt (1968) reviewed reports from a number of studies which suggested that particular learning difficulties demonstrated by retarded people were due to attentional deficits. Retarded persons have also been reported to perform poorly on tasks that require sustained attention (Crosby, 1972; Krupski, 1979).

1.2.1 Attentional Deficit Theories

Zeaman and House (1963) proposed that the difficulties retarded persons show in discrimination learning tasks are due to limitations in attending to the appropriate stimulus dimension, rather than in the ability to select the appropriate cue within the particular dimension. Whilst two-choice visual discrimination tasks were used to test the hypothesis, it was suggested that the theory should hold for other sensory modalities, more complex learning tasks and for nonretarded people of equivalent mental age. Thus a developmental hypothesis underlies this theory. Support for this theory came from Folkard (1974) who suggested that retarded subjects are unable to attend to the correct dimension and O'Connor and Hermelin (1971) who stated that mentally retarded persons need to find out precisely what they should learn before they can learn.

Mentally retarded persons have also been considered to be abnormally distractible (Brown and Clarke, 1963; O'Connor and Hermelin, 1971; Sen and Clarke, 1968). However, Ellis (1963) found that distracting stimuli improved the learning performance of normal subjects but had little effect on retarded subjects. Similarly, the results of an investigation by Crosby (1972) indicated that mildly retarded children were not more easily distracted than nonretarded children of similar mental age by irrelevant facets of a stimulus display.

The rates of adaptation to distraction by retarded people were studied by Brown (1966). Results showed that the initial performance of a retarded group was affected by distraction but that most subjects adapted, so that eventually there was no performance decrement. In addition, mildly retarded subjects adapted more easily than severely retarded subjects. These findings support the Zeaman and House (1963) contention that severely retarded persons require more time to become familiar with the task situation and to discriminate relevant from irrelevant cues.

These attentional deficit models have been used as a basis for describing ways of teaching and training retarded people. Brown concluded, in his study outlined above, that the training situation should be free from distractions, particularly discontinuous extraneous stimulation which would prevent adaptation and prove more distracting. Gold and Scott (1971) stressed the need for breaking down a task into stimulus and response components so that they could be learned sequentially, with stimulus cues being highlighted. Thus, the essential cues in the task could be identified and selected. Gold (1973) demonstrated that moderate and severely retarded adults could perform complex assembly work when the situation was designed to overcome attentional deficiencies.

1.3 VIGILANCE EXPERIMENTS AND ATTENTIONAL BEHAVIOUR

Vigilance experiments involve tasks which are carried out in relatively controlled environments whereby extraneous stimulation can be extensively reduced. Therefore, it seems reasonable that this approach might aid the study of the attentional behaviour in retarded persons. Also, the dictum "dull minds for dull jobs" has been applied to the retarded person's work situation, that is, work which is monotonous to people of at least average intelligence might be pleasing to mentally retarded people

(Kohn, 1977). As vigilance tasks involve dull, monotonous environments then they are ideally designed to test this proposal. However, caution should be used when comparing workshop situations to vigilance tasks via this dictum as the former often require perseverance rather than vigilance.

The purpose of this thesis was to investigate attentional deficits, specifically attention span difficulties, in mildly mentally retarded persons via vigilance tasks. One aim was to further investigate the disparity in the results of experiments which have compared the vigilance performance of retarded with nonretarded subjects. Two studies found that mentally retarded children showed lower overall detection scores and an earlier and more rapid decline in vigilance performance over time compared with nonretarded children of equivalent chronological age (Kirby, Nettelbeck and Thomas, 1979; Semmel, 1965). However, the results of two other studies found no difference in either the rates of decline in detection over time or overall detection scores between mentally retarded adults and their nonretarded counterparts (Kirby, Nettelbeck and Bullock, 1978; Ware, Baker and Sipowicz, 1962). This thesis considered both subject and task characteristics which might not only account for the different results but also provide further knowledge about the vigilance performance of mildly mentally retarded persons.

In order to understand vigilance performance in retarded subjects, consideration will first be given to the performance of nonretarded persons. Therefore, the next chapter will be devoted to outlining the development of vigilance research and subsequent findings of investigations into the performance of nonretarded persons. A number of theories which have been advanced to account for the findings will then be reviewed.

CHAPTER 2

VIGILANCE PERFORMANCE OF NONRETARDED PERSONS

2.1 BACKGROUND

Performance on attentive watch tasks has repeatedly been observed to deteriorate as the watch progresses. These tasks have practical importance in areas such as radarscope operation through to assembly-line inspection of products.

One of the earliest studies of this problem was carried out by Wyatt and Langdon (1932) and involved cartridge case inspection. A sharp decline was found in the number of cartridge cases which were rejected by the operators after the first thirty to forty-five minutes of work with little correlation between the intelligence of the operators and their efficiency. Whilst similar studies were conducted, it was not until the Second World War that research directly concerned with sustained attention, or the monitoring element, commenced.

British radar operators failed to notice potential enemy submarine contacts while on patrol. In order to investigate this phenomenon, Mackworth (1948) devised the Clock Test which simulated the essentials of the radar operator's task. Subjects watched a black pointer six inches long rotate in discrete steps on a white background. These jumps took one second each, with one hundred jumps completing a revolution. The signal was a jump twice the usual distance to which subjects were required to respond by pressing a key. Twelve signals were presented in each half-hour of the two-hour task at intervals varying from three-quarters of a minute to ten minutes. There was a five-minute practice session with full knowledge of results prior to commencement of the task. Mackworth found that the mean percentage of signals detected fell after the first half-hour. This deterioration in detection efficiency has subsequently been found to occur in numerous other studies and is known as the "vigilance decrement".

2.2 DEFINITION AND PARADIGM

The term "vigilance" is difficult to define but has been used by Head (1923) and later Mackworth (1957) to refer to a prepared state of the nervous system to discriminate and respond to small changes in stimuli occurring at random time intervals. Hence, this definition implies that vigilance is physiologically based.

Vigilance tasks, otherwise referred to as monitoring or watchkeeping tasks, were designed to measure this hypothetical state of vigilance and, as indicated by Mackworth's experiment, involve the readiness to react to infrequent, low-intensity and unpredictable signals. These tasks also entail the presence or absence of a stimulus or the differences between various stimuli which are either signals or nonsignals. The stimuli used as signals characteristically occur at irregular and infrequent time intervals, as previously stated, with the intensity of signals being near the observer's threshold. The duration of the signal is normally brief, although in some tasks signals remain present until detected (for example, Broadbent, 1950, 1951). The task itself is usually, though not always, prolonged with experiments having ranged from five minutes (Davies, 1968; Thompson, Opton and Cohen, 1963) to over several hours (Webb and Wherry, 1960).

2.3 RESPONSE MEASURES

There are four main measures of vigilance performance.

2.3.1 Correct Detections and Omission Errors

The detection rate is the number of signals correctly detected and is the most extensively used measure in vigilance studies. Coupled with this are the omission errors which represent the number of signals the observer fails to detect. Buckner, Harabedian and McGrath (1960), using both an auditory and visual task, and Baker (1963a), using two visual tasks, have shown the test-retest reliability of detection rate to be high, the average correlation for both results being approximately 0.8.

2.3.2 Commission Errors

Commission errors, also referred to as Type I errors, false positives, or false alarms, indicate the reporting of a signal when none was presented. Few commission errors are usually found in experiments and so are disregarded or, alternatively, added to omission errors to give a total error score (for example, Roby and Roazen, 1963).

McGrath (1963) objected to the combining of error terms, stating that they are independent phenomena, and suggested that false alarms could be a useful index of the learning required to discriminate signals from nonsignals and not of vigilance performance. Hence, variables like the amount of pre-task training, signal frequency and knowledge of results should affect the commission error rate. For instance, if the signal has been properly learned in the pre-task training session, then the number of commission errors should be few throughout the course of the task.

2.3.3 Reaction Time

The time lapse between the signal presentation and the observer's response has often been used as a performance measure. This reaction time has been taken as an additional index of monitoring performance or, in some experiments in which the signal has persisted until detected, as the only measure (Broadbent, 1950, 1951). Reaction time has been found to lengthen with time on tasks conforming to the vigilance paradigm (Buck, 1966) as well as on tasks using signals presented above threshold level or at regular intervals (Boulter and Adams, 1963; Dardano, 1962; McCormack and Prysiazniuk, 1961).

The relationship between detection rate and reaction time is unclear due to varying results, although some studies have shown that variables which tend to increase detection rate also tend to shorten reaction time (for example, Adams, 1956; McCormack, 1958).

2.3.4 d' and beta (ß)

Whilst detection rate has been the most commonly used measure of vigilance performance, it does not take into account overall performance. Similar rates of detection can be accompanied by both different overall numbers of commission errors, as well as changes over time in the rates of these errors. Signal Detection Theory (Green and Swets, 1966) takes into account both the detection rate and the commission error rate to assess the detectability of the signal and the bias of the observer.

Signal Detection Theory assumes that to detect a signal, an observer must be able to distinguish between signal and nonsignal classes presented sequentially and decide from which of the two classes a particular observation has been drawn. Hence, signal detection involves the processes of "discrimination" and "decision". Decisions are thought to be influenced by the subjective probability that a signal will occur. d' is a measure of the discrimination process and ß is a measure of the decision process, both being derived from psychophysical data.

These measures are used to specify whether changes in the numbers of correct detections and commission errors reflect a change in the sensitivity (d') of the relevant sensory system or a change in the observer's criterion (ß) value. A change in either sensitivity or criterion is assumed to effect the likelihood that the observer will report a signal as present. So a decline in detection rate over time can be viewed in terms of either a reduction in sensitivity or an increase in criterion.

The theory assumes that, in the absence of a signal, there is a constant, randomly varying neural activity or noise occurring in the nervous system and that the magnitude of this activity follows a normal (Gaussian) distribution. This neural noise may be the result of either spontaneous internal neural activity or the effects of any external nonsignal stimulation presented to the subject. The superimposition of a signal on this background noise increases the magnitude of the neural process. The two distributions are assumed to be Gaussian with equal variances and in signal detection theory, the two distributions are always assumed to overlap to some extent.

The measure d' is defined as the distance, in standard score units, between the means of the noise (N) and the signal plus noise (S + N) distributions. The greater the value of d', the easier the signal is to discriminate from noise, at least for an ideal observer. ß is the ratio of the ordinate of the S + N distribution to the ordinate of the N distribution (see Figure 2.1). Both d' and ß are calculated from the ratio of correct detections to false positives expressed as probabilities and the value of d' can change without any variation in the value of ß and vice-versa.

The vigilance decrement has most often been found to

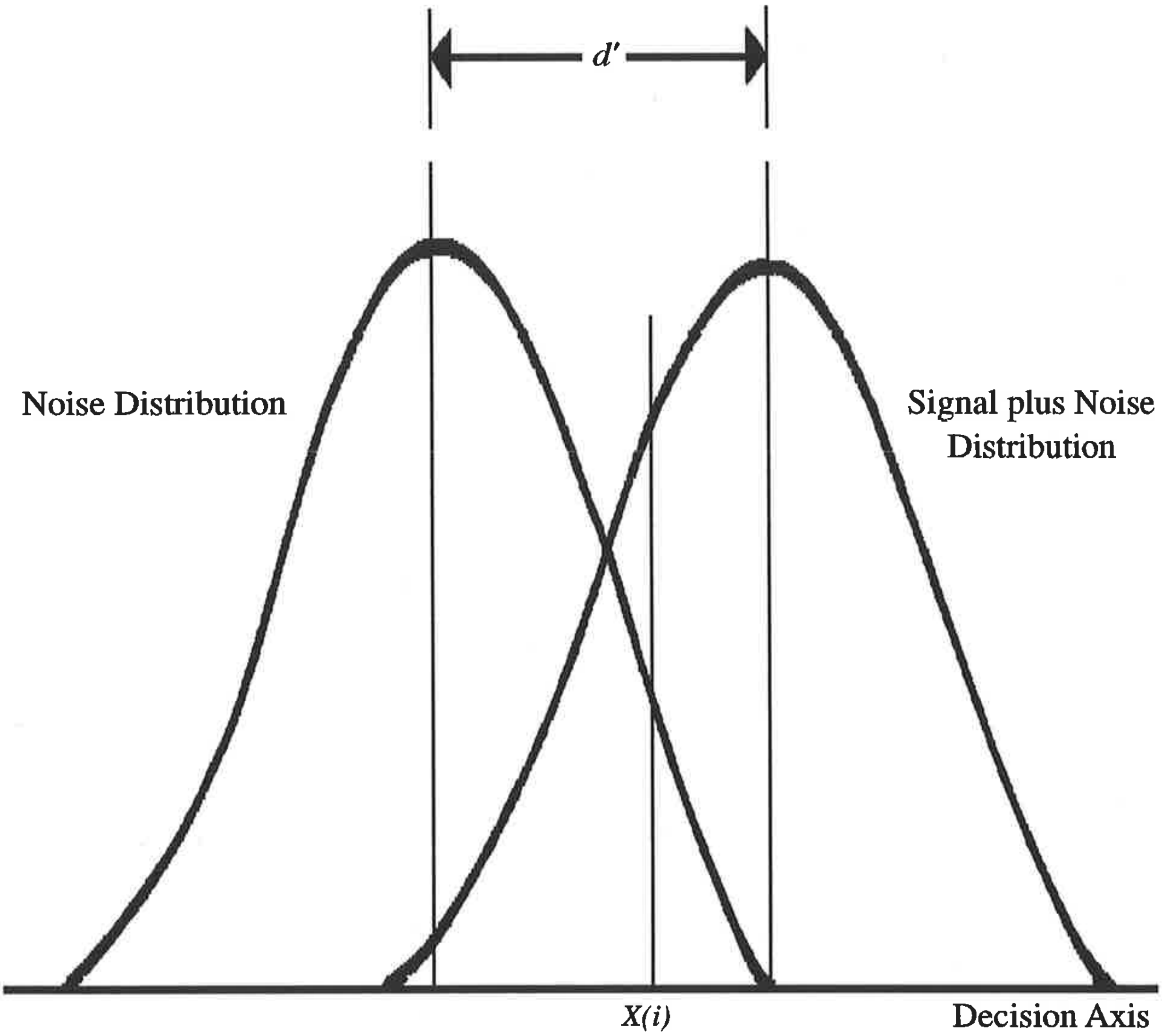

FIGURE 2.1 Noise (N) and signal plus noise (S + N) distributions for Signal Detection Theory. d' is the distance between the means of the distributions in standard score units. Criterion at $X(i)$ is the ratio of the ordinate of the S + N distribution to the ordinate of the N distribution.

be associated with a criterion increment; that is, observers become more cautious or less confident with time on task, although perceptual sensitivity has been found to decline in some tasks (Davies and Parasuraman, 1982).

2.4 PSYCHOPHYSICS

A number of signal characteristics and task variables have been shown to influence vigilance performance. The measures used have included overall performance and/or the degree of change of these parameters over time on task in terms of correct detections or with the addition of numbers of false alarms or response time.

2.4.1 Sense Modality

Vigilance experiments have used visual, auditory and tactile stimuli. Whilst higher overall levels of performance have been reported on auditory tasks, performance decrements have been found in each of these modes (Davenport, 1969; Gruber, 1964; Hatfield and Loeb, 1968; Mackworth, 1950). Studies comparing performance across the different sensory modes have failed to find a significant correlation and have been interpreted as indicating that performance is modality specific and not controlled by one central process (Buckner and McGrath, 1963; Dember and Warm, 1979; Pope and McKechnie, 1963). However, there is some evidence to support the possibility that the ability to maintain vigilance is a general characteristic. Some later studies found significant inter-modal correlations when tasks were equated across sensory modalities for difficulty and type of signal discrimination (Davies and Parasuraman, 1982).

2.4.2 Signal Intensity and Duration

Numerous investigations have been conducted into the effects of signal intensity and duration on vigilance performance. Results have shown that increasing the intensity of signals improves overall detection rate and decreases response time for both visual (Adams, 1956; Metzger, Warm and Senter, 1974; Smith and Boyes, 1957; Teichner, 1962; Wiener, 1964) and auditory tasks (Lisper et al., 1972; Loeb and Binford, 1963; Loeb and Schmidt, 1963; Webb and Wherry, 1960).

There is also some indication that the decrement can be reduced under these increased signal intensity conditions. For example, Corcoran, Mullin, Rainey and Frith (1977) demonstrated a vigilance increment over time when the amplitude of the signal in an auditory task was increased halfway through the task. Increases in signal duration have also resulted in a higher probability of detection (Adams, 1956; Baker, 1963c; Warm et al., 1970). In addition, Baker (1963c), using a visual task in which signal duration was varied, found that signals of shorter duration produced faster rates of decline in detection performance.

2.4.3 Signal Frequency and Inter-signal Interval

Data on the effects of signal frequency on vigilance performance have been comprehensively reviewed by Davies and Tune (1970). These investigations indicate that signal detection accuracy improves with increased signal frequency. Increasing signal frequency within a set time leads to greater a priori signal probability and decreased observer temporal uncertainty and so improved performance (Warm and Berch, 1985). Similarly, this uncertainty can be altered by varying inter-signal intervals, with regular intervals being more predictable. Generally, signal detection rate and detection speed have been found to be directly proportional to the regularity of inter-signal intervals (Adams and Boulter, 1964; Lisper and Tornros, 1974; Warm, Epps and Ferguson, 1974).

2.5 THEORIES OF VIGILANCE

A number of theoretical constructs have been forwarded to explain the vigilance decrement, the relation between signal frequency and detection probability, and other facets of vigilance performance such as those just described. A satisfactory theory of vigilance must, in other words, take into account the decline in performance during a session and determinants of the overall level of performance. The major theories will be briefly considered here.

2.5.1 Inhibition

An inhibitory state is postulated which is similar to that proposed by behaviourists to account for the extinction of conditioned responses. Mackworth (1950) emphasized these similarities in that there is no reward for responding to a signal, and thus the responses would be weakened and inhibited. That is, the vigilance decrement is caused through inhibition which could be corrected by interruptions and longer rests. However, this decrement is not simply an extinction of the conditioned response to the signal since the decline would then be faster when signals are more frequent whereas the reverse has, in fact, been shown (for example, Deese, 1955).

Welford (1968) considered that this extinction theory is more viable if the absence of reinforcement is thought of as bringing about a decrease in motivation. Evidence in support of this contention is that the performance decline has been reduced or prevented with better grade students, who are regarded as more highly motivated (Kappauf and Powe, 1959), by the presence of an officer for army trainees (Bergum and Lehr, 1963) and monetary rewards for good detection (Sipowicz, Ware and Baker, 1962).

However, as motivation appears to increase activation, this theory can be considered as a sub-class of an arousal theory.

2.5.2 Expectancy

The expectancy theory postulates that vigilance performance is a function of the signal rate expected by the observer based on previous experience of occurrence of signals (Baker, 1963b; Deese, 1955). Observers are assumed to continuously average times between previous signals so that future signal events can be predicted. This hypothesis predicts enhanced detection performance when signals occur at regular time intervals and more frequently since accurate expectations are more easily formed. Davis (1958, 1966) and Buck (1963) have suggested that expectancy may account for some industrial and driving errors, such as a train driver missing a signal when it is unusually against him.

Colquhoun and Baddeley (1964, 1967) have demonstrated that subjects detected more signals and scored more commission errors following a practice session in which there was a high probability of signal occurrence compared with a practice session in which signal probability was low. Further support for the expectancy hypothesis comes from studies which have shown that knowledge of results improves both detection rate and speed of response in vigilance tasks (see Davies and Tune, 1970; Davies and Parasuraman, 1982). Knowledge of results would aid observers to form more accurate expectations. On the other hand, false or random knowledge of results has been shown to be as effective as true knowledge of results in improving detection performance (Loeb and Schmidt 1963; Warm et al. 1974). Also, uncertainty has been expressed about temporal expectancy as a model of vigilance performance as human observers are not always accurate estimators of time intervals (Davies and Tune, 1970; Warm, 1977).

2.5.3 Observing Responses

Detection performance has been assumed to be related to the rate and quality of observing responses (Jerison, 1967, 1970). The theory proposes that reduction in detection efficiency occurs during increased periods of blurred or distracted observing. It is hypothesized that there is a cost associated with observing and that the decision to observe is dependent upon the benefit of detecting a signal. Factors including fatigue, inhibition and lack of motivation are presumed to increase the cost of observing and so produce a decrease in the quantity and quality of observing responses as the vigilance task progresses.

Warm and Berch (1985) point out that this theory can account for reduced vigilance performance with increased event rate as well as improved performance with greater signal intensity and frequency. The former situation leads to greater task demand and hence decreased readiness to attend whereas the latter tends to diminish the demands of observing.

Support for the observing response theory comes from studies in which the observer is more "closely coupled" to the visual display. Hatfield and Loeb (1968) used a procedure in which eye movements and eye blinks were minimized and Warm et al. (1976) used a head restraint in visual monitoring tasks. Both procedures led to improved monitoring of performance. However, it has been demonstrated that signals are still missed even when the visual display is being fixated (Mackworth et al., 1964).

Also, vigilance decrements are still found in auditory tasks even though the subject is "closely coupled" to the stimulus source via headphones (Davies and Parasuraman, 1982). Therefore, observing responses must be a combination of both internal as well as external elements of the observer.

2.5.4 Changes of Cutoff in Signal Detection

As noted earlier (Section 2.3.4), most studies employing the signal detection model to investigate the vigilance decrement have found an increase in criterion with no change in sensitivity, that is, a smaller number of signals passing criterion (Binford and Loeb, 1966; Broadbent and Gregory, 1963; Colquhoun, 1967; Loeb and Binford, 1964; Taylor, 1965). The rise in criterion was reflected by a decline in the frequency of both correct detections and commission errors. This finding is consistent with a fall of activation level with the distributions of both noise and signal plus noise being lowered so that the cutoff point is apparently raised (Welford, 1968, 1976).

However, there are conflicting results regarding this view. Chinn and Alluisi (1964), studying the effects of knowledge of results, obtained findings which indicate that d' might change in addition to the cutoff being shifted. The study found that providing feedback to subjects when they registered a commission error reduced both the number of these errors as well as correct detections, suggesting a change in cutoff. However, information about correct detections or omission errors reduced both omission errors as well as commission errors indicating an improvement in d'.

Mackworth and Taylor (1963) and Mackworth (1964, 1965) also found decreases in d' with time on watch. The tasks involved the detection of momentary interruptions of the movement of a pointer revolving around a dial. Welford (1968) proposed that these tasks required continuous monitoring of the stimulus source and were therefore probably fatiguing. Based on the results of other studies on fatigue in which d' was found to decline with time on task, Welford concluded that fatigue results in a decline in d', indicating a genuine impairment of function. A decline of vigilance performance might therefore result in either an increase in criterion or a decrease in discriminatory power.

2.5.5 Activation and Arousal

The arousal theory is based in the neurophysiological view that behaviour varies along a continuum from deep sleep to extreme excitement (Malmo, 1959) and that varied sensory stimulation is required to maintain alertness (Hebb, 1955). The theory assumes that a constant background of varied stimulation is necessary for general efficiency and alertness is diminished if variation declines below a crucial level. Deese (1955) has suggested that the waking centre of the hypothalamus could be involved, with the activity of this centre depending upon an influx of sensory stimulation. Therefore, when applied to the vigilance situation involving the detection of infrequent signals, the varied sensory input required to maintain alertness is reduced and so detection efficiency declines.

Evidence supporting this approach comes from better performance when stronger signals are used, the presence of others or knowledge of results, as previously mentioned, all of which increase stimulation in one way or another. Mackworth's (1950) results provide greater support in that they show that no significant decrement occurs when subjects are under the effect of benzedrine, a drug which stimulates the arousal mechanism. Coupled with this result, Colquhoun (1962) found that hyoscine impaired auditory vigilance performances and meclozine brought about a significant deterioration under both visual and auditory conditions. Both hyoscine and meclozine are depressant drugs.

Other studies have reported that a progressive decline in the detection rate is accompanied by changes in one or more physiological measures from which a progressive decrease in the level of arousal has been inferred. These measures involve EEG activity (Daniel, 1967; Davies and Krkovic, 1965), heart rate (Claridge, 1960; Davies, 1964; Stern, 1964), skin conductance (Dardano, 1962; Davies and Krkovic, 1965; Eason, Beardshall and Jaffee, 1965) and skin resistance (Stern, 1966).

The arousal theory has difficulties explaining those experiments in which a decrement has occurred even though subjects have been kept nearly continuously active (Adams and Boulter, 1962; Alluisi and Hall, 1963; Whittenburg, Ross and Andrews, 1956; Wiener, Poock and Steele, 1964). Here, signals were produced which should have maintained arousal if sensory input only was required. However, sensory input alone is not sufficient. As Welford (1968) points out, habituation to the feedback from repeated activity seems to occur, in the same way as habituation to repeated external stimuli occurs. The task activity is considered to be maintained in another way with relatively simple, repetitious actions being maintained at a lower level of arousal than more complex judgements requiring more information processing.

The relationship between performance and arousal is considered to be described by an inverted-U curve (for example, Malmo, 1959). Performance level increases monotonically from low activation to an optimal point for a particular function, but thereafter, any increase in activation produces a monotonic fall in performance level, which is related to the amount of increase in level of activation. Hence, performance is considered to be poor at low and high arousal levels and to be optimal at some intermediate point.

Welford (1962) has hypothesized that at low levels of arousal the nervous system is relatively inert, so allowing only the strongest signals to secure a response. A small increase in arousal level improves sensitivity and responsiveness to incoming signals, but with further increases, the cells become "fired", causing the nervous system to become "noisy". Thus, any further increase in arousal level will tend to impair performance.

It should be noted, however, that there is only limited evidence from physiological studies which support this inverted-U hypothesis. Stennett (1957), using a tracking task, provided some results which do support the hypothesis.

In summary, activation or arousal theory explains the vigilance decrement in terms of a fall in arousal due to a lack of varied sensory input.

2.5.6 Summary

A number of theories have been advanced to explain the decrement and other aspects of vigilance performance. However, no one theory can account for all these aspects of performance and so each is subject to criticism. Davies and Parasuraman (1982) point out that different experimenters seem to advocate particular theories according to the type of task used. Experimenters employing "unstimulating" tasks, for example, have tended to support theories related to the idea of arousal, while those who have employed "stimulating" tasks have tended to lean toward theories involving the division of attention.

CHAPTER 3

VIGILANCE PERFORMANCE OF MENTALLY RETARDED PERSONS

3.1 EXPERIMENTAL STUDIES

Only a few studies have been conducted which have considered the vigilance performance of mentally retarded persons.

Ware, Baker and Sipowicz (1962) compared the visual vigilance performance of mentally retarded adolescents (mean IQ of 58, mean chronological age of 17 years 8 months) with nonretarded subjects randomly selected from another study which used a comparable task. The task required subjects to detect irregular periodic interruptions of a continuous light source. No significant differences were found between the two subject groups in terms of mean overall percentage of signals detected. The rates of decline in detection rate over time of the two groups were not compared.

Semmel (1965) criticized these results on the basis that the data had been obtained from two separate investigations. Semmel also used a visual vigilance task which lasted for one hour to study the performance of retarded and nonretarded children. The average age and IQ score of the educable mentally retarded subjects were 12 years and 4 months, and 68 respectively. The chronological age control group consisted of students whose average age and IQ score were 12 years 2 months, and 106 respectively. Subjects were required to respond to a 0.5 second interruption of light from a signal source by pushing a button. Results showed that the retarded children had lower overall detection scores and displayed an earlier and more rapid decrement than the nonretarded children. These results were interpreted as being due to the retarded subjects experiencing a more rapid decay in alertness or arousal than the subjects of normal intelligence.

The disparity in the results of these experiments was investigated by Jones (1972) who noted that the subject groups differed in age between the two experiments. Jones compared the visual vigilance performance of four groups of subjects, mentally retarded and nonretarded preadolescents and adolescents. Mean ages for the preadolescent and adolescent groups were 11 years and 6 months, and 17 years and 3 months respectively. Mean IQ scores for the retarded and nonretarded groups were 68 and 110 respectively.

The vigilance task lasted for 45 minutes and used two red lights, one mounted 2.5 cm above the other, which flashed alternatively. Subjects had to detect a 2 second arrest of alternation, in which only one of the two lights continued to flash, by pressing a response button. Each subject performed the task twice under different conditions of extraneous auditory stimulation. One condition involved a continuous white noise background, the other a background of variety-audio stimulation such as music and television programmes. Jones assumed that if mentally retarded subjects are relatively less aroused than nonretarded subjects then they would benefit more from the arousing properties of variety-audio stimulation. Alternatively, if mentally retarded subjects are more distractible than nonretarded subjects, then any differences in performance would be enlarged under the variety-audio background condition.

Results of the study found that the mentally retarded preadolescent subjects had a significantly lower overall detection rate than the nonretarded preadolescents under both types of audio background conditions. However, the mentally retarded adolescents only showed lower overall detection scores under the variety-audio background condition compared with the nonretarded adolescents. In addition, there were no differences in the rates of decline in detection performance between the four subject groups under either of the two background stimulation conditions. It was concluded that age is an important factor in the monitoring performance of the mentally retarded subjects under specific conditions of background stimulation. In addition, the study supplied some evidence which supported the distraction explanation for the poorer performance of mentally retarded individuals. This contention holds that retarded persons are more susceptible than nonretarded persons to intrusions of environmental stimuli and so are more likely to miss signals. Subjects showed lower overall detection performance under the variety-audio condition compared with the white noise condition. Thus, this result did not support the arousal hypothesis offered by Semmel.

Kirby, Nettelbeck and Bullock (1978) compared mildly mentally retarded subjects with subjects of above average intelligence on both an auditory and visual task, each of fifty minutes duration. The study also investigated the possibility that mentally retarded persons suffer from greater distractibility than nonretarded persons. It was contended that any differences found in earlier studies which had used visual vigilance tasks could have been due to peripheral effects in that the mentally retarded subjects could have withdrawn their attention from the stimulus source sooner and more often. It was therefore hypothesized that delivering signals by earphones in an auditory task would minimize the possibility of peripheral effects as stimulation would always impinge upon the appropriate sense organs. Hence, if mentally retarded subjects are more distractible they would have been expected to show a more rapid decrement in performance on the visual task compared with the auditory task.

The average age and IQ score of the retarded subjects were 23 years and 70 respectively. The chronological age control group consisted of subjects with above average intelligence whose average age was also 23 years. In the auditory task, subjects wore a pair of earphones through which a 0.5-second pulse of white noise was presented every 3 seconds. The visual task used a circular red light which similarly appeared for a 0.5-second duration every 3 seconds. The signal in each task was an increment in the intensity of the stimulus to which subjects responded by pressing a button. No difference was found in the rates of decline of performance between the two subject groups in either of the two conditions, with the nonretarded subjects having a superior overall performance. Thus, the results did not support the contention that mentally retarded subjects are more distractible than nonretarded subjects.

Kirby, Nettelbeck and Thomas (1979) investigated the discrepancy in results between these earlier investigations. The possible differences between the earlier results were examined both in terms of developmental factors and procedural differences by using the same apparatus as that of Kirby et al. (1978) with subjects similar in age to those of Semmel (1965).

The average age and IQ score of the mentally retarded subjects in this study were 13 years and 1 month, and 68 respectively. The mean age of the nonretarded chronological age control group was 12 years and 9 months. A mental age control group was also included whose mean age was 7 years and 10 months. All nonretarded subjects were students whose academic performance was at least average.

The task involved monitoring a circular red light which appeared every 3 seconds for 0.5 second. Subjects had to detect an increment in the intensity of the light. The results were similar to those of Semmel (1965) but contrasted with those of both Ware et al. (1962) and Kirby et al. (1978). The mildly mentally retarded children demonstrated a lower overall detection rate and a more rapid vigilance decrement than the nonretarded children of above average intelligence and equivalent chronological age. In addition, the retarded children showed similar detection rates over time as the nonretarded children of equivalent mental age. Thus, the results were similar to Jones (1972) in that they suggested that the vigilance performance of mildly mentally retarded people is largely a function of mental development, that is, the mental age of the person is a significant factor in the maintenance of vigilance performance.

Each of the studies conducted into the vigilance performance of mentally retarded persons failed to support the "dull minds for dull jobs" dictum. In fact, two results actually opposed the dictum in so far as the performances of the mentally retarded persons appeared to suffer more from dull, monotonous environments than nonretarded persons. In these studies, mentally retarded children showed both lower overall, as well as a faster rate of decline in detection performance compared with nonretarded children of similar chronological age (Kirby, et al., 1979; Semmel, 1965). In addition, two other studies found that mentally retarded subjects showed lower overall detection performance compared with their nonretarded counterparts (Jones, 1972; Kirby et al., 1978). However, there are two important considerations which arise from the results of these investigations. Firstly, mentally retarded people seem to have a slower rate of development of their ability to maintain vigilance performance compared with nonretarded people. Secondly, there is no clear explanation for the differences in detection performance found between mentally retarded and nonretarded children. Therefore, investigations concerned with each of these two areas will be considered next.

3.2 A DEVELOPMENTAL LAG OR MENTAL AGE FACTOR IN VIGILANCE PERFORMANCE OF MENTALLY RETARDED PERSONS

Taken together, the results of the experimental studies indicate that mental age is a significant factor in the vigilance performance of mentally retarded persons. In contrast, there is no evidence that IQ is a determining factor in monitoring performance. This is consistent with the developmental lag interpretation of differences found between retarded and nonretarded persons considered earlier.

If a slower rate of development rather than intelligence per se is a factor in the vigilance performance of retarded persons, then the performance of nonretarded persons should also be subject to developmental factors. To this end the literature concerned with developmental changes and IQ factors in the vigilance performance of nonretarded persons will be reviewed next.

3.2.1 Developmental Changes in Nonretarded Persons

Few studies have been conducted into the vigilance performance of children. Locke (1970) investigated the vigilance performance of 80 children of 4 years of age.

The children had to detect the occurrence of a brief tone which occurred irregularly over a 5 minute and 40 second period of time. Detection performance was found to decline over time with the number of detections being inversely related to the length of the inter-signal interval.

Levy (1980) was interested in the development of sustained attention in young children and found that an increasingly greater percentage of children were able to complete a 4 minute and 40 second continuous performance test (CPT) as age increased from 3 years to 7 years. In addition, the number of omission errors declined as age increased. Simon (1982) used a 15 minute task in which kindergarten children had to detect a 0.5 second change in the colour of a stimulus. Whilst a decrement in correct detections was not found, children whose ages were greater than 5.5 years had higher detection rates than those whose ages were less than 5.5 years

A study by Gale and Lynn (1972) investigated developmental changes in the vigilance performance of children aged from 7 to 13 years. An auditory task was used in which the children had to detect the occurrence of a digit from a series of letters. A performance decrement was shown by all age groups but significantly more detections were made by each successively older age group. The largest improvement was demonstrated by children between the ages of 8 and 9 years.

Similar age trends in performance have been reported by investigators concerned with the sustained attention ability of children with various learning and behavioural disorders. Sykes, Douglas and Morgenstern (1973) reported a significant correlation between age and performance on visual and auditory modes of the CPT for hyperactive and normal children aged from 5 to 11 years. Anderson, Halcomb, Gordon and Oxolins (1974) used a task in which hyperactive children had to detect red-green combinations of lights amongst nonsignals consisting of red-red and green-green combinations. The 9 to 12 year old children detected significantly more signals and registered fewer false alarms than 6 to 8 year old children.

Thus, the results of these studies indicate that there are developmental changes in the vigilance performance of nonretarded children with overall detection rate improving as chronological age increases. The greatest improvement in detection performance seems to occur around the age of 9 years.

3.2.2 Relationship between IQ and Vigilance in Nonretarded Persons

Investigations with adults into possible associations between vigilance performance and general intelligence in the normal range have yielded conflicting results. Cahoon (1970) and Kappauf and Powe (1959) have both reported a positive relationship between intelligence and detection rate. However, a greater number of studies have not found a correlation between IQ and vigilance performance (Halcomb and Kirk, 1965; McGrath, 1960; Sipowicz and Baker, 1961; Ware, 1961). Davies and Parasuraman (1982) refer to other studies which, whilst intelligence was not a major independent variable, have provided similar results.

Warm and Berch (1985) cite a number of studies with children which have also found no relationship between performance and IQ in the normal range. However, Stankov (1983) contends that separate correlation coefficients should be made for each time block of a vigilance task. Vigilance performance is thought to be a factor of the level of arousal which, in turn, is considered to decline at a rate that is inversely related to IQ. Thus, the higher the observer's intellectual ability, the lower the level of arousal near the conclusion of the task. In this way, Stankov was able to show a negative relation between IQ and correct detections as a sixty-minute watch progressed.

Generally, the literature has shown no relationship between vigilance performance and IQ in the nonretarded range. However, there is some evidence that these variables may be found to be related if separate correlations are calculated for each time period within a watch rather than one overall correlation.

3.3 EXPLANATIONS FOR THE VIGILANCE PERFORMANCE OF MENTALLY RETARDED PERSONS

The five studies which specifically investigated the vigilance performance of mentally retarded people put forward two explanations to account for the differences found between mentally retarded and nonretarded subjects.

Semmel (1965) proposed that mentally retarded persons experience a more rapid decay in arousal or activation during the vigilance task compared with nonretarded persons. Arousal theory assumes that the lack of stimulus variation in vigilance tasks produces a progressive reduction in arousal level. Semmel hypothesized that environmental stimuli have less impact on mentally retarded children compared with nonretarded children. Thus, with continued exposure to the monotonous stimuli, the retarded children have a relatively more rapid sensory habituation process and a faster decline in arousal. Semmel predicted that, compared with nonretarded children, mentally retarded children would show lower overall detection performance and an earlier and more rapid rate of decline. Whilst experimental investigation supported these predictions, the additional prediction that the introduction of rest and/or novelty during the watch would improve performance by increasing sensory variation, and thus arousal, was not supported.

Jones (1972) found results which did not support the arousal hypothesis but rather a distraction explanation. This view assumes that mentally retarded people do not attend to the relevant task stimuli to the same extent as nonretarded people because they are more susceptible to intrusions of extraneous environmental stimuli. The distraction explanation predicts that mentally retarded people would miss the transient signals of the vigilance task more often, that is, show a lower overall detection rate, than nonretarded people. Kirby et al. (1978) also considered distraction in terms of withdrawal of attention from the stimulus source but their groups comprised adults and no support was found for this explanation.

As already noted in Chapter 1, distraction has been one of the theories put forward to account for adaptive behaviour disorders in mentally retarded persons. A few studies have been conducted which have considered distraction as a factor in sustained attention performance of mentally retarded persons in applied and experimental situations. Warm and Berch (1985) reported the unpublished results of a vigilance study (Fuller, 1975) which showed that mentally retarded children (mean chronological age 10.9 years) demonstrated behaviours including "rhythmic body movements, hand clapping, looking away from the display to be monitored, and restless twisting and turning" more often than nonretarded children of similar chronological age. Another study found that mentally retarded people demonstrated slower reaction times than nonretarded persons on a visual reaction time task due, at least in part, to more off-task glances by the retarded persons (Krupski, 1977).

Krupski (1979) studied behaviours demonstrated by educable mentally retarded and nonretarded students while they were engaged in academic and nonacademic tasks requiring sustained attention. Children aged between 9 and 12 years of age were observed during periods in which they worked individually. The mentally retarded children were found to spend significantly less time on tasks than nonretarded control children, more time out of their seats, and showed more "task-related desk glances", that is, time appearing busy but not working. Krupski concluded that the results indicated that mentally retarded children were more distractible than nonretarded children of similar age.

However, not all studies support a distractibility explanation for differences in performance between mentally retarded and nonretarded persons on vigilance or sustained attention tasks. Crosby (1972) used a version of the Continuous Performance Test (CPT) to investigate the contention that mentally retarded children are more distractible and less able to maintain attention than nonretarded children. The mentally retarded subjects were aged from 12 years 5 months to 17 years 7 months (mean 15 years 2 months) and IQ scores ranged from 50 to 80 (mean 65). These subjects were compared to control subjects of similar chronological and mental age whose IQ scores ranged from 94 to 109 (mean 100). The task involved the monitoring of two series of letters exposed sequentially. In the first series subjects had to detect each appearance of the letter X, and in the second series, each letter X which followed the letter A. The series were monitored under conditions of no distraction, visual, auditory and combined audiovisual distraction. Distractions consisted of letters different from task letters which appeared alongside the task letters in a different colour or presented acoustically through earphones.

Whilst distraction had a deleterious effect on performance, the retarded subjects did not show relatively more omitted responses than nonretarded persons. Hence the data did not support the contention that retarded persons are more distractible than nonretarded persons. Crosby noted that there were large differences in individual performance. Some subjects performed poorly under minimal (auditory) distraction while others performed at their best under maximal (audiovisual) distraction. Crosby related these results to the arousal model and suggested that persons with low levels of arousal could benefit from extra stimulation, whereas this could disrupt the performance of highly aroused persons. Finally, Crosby concluded that distractibility in mentally retarded persons could be "both idiosyncratic and situation specific".

Johnson (1977) used the AX version of the CPT to compare the sustained auditory attention performance of brain-damaged and non-brain-damaged mentally retarded children with brain-damaged and non-brain-damaged children of average intelligence. There were four groups of children aged approximately 11 years, and two mental age control groups aged approximately 7.5 years. IQ scores for the mentally retarded children ranged from 60 to 75, and for the average children from 90 to 110. The task was administered under conditions of no distraction and distraction which consisted of a background sound of classroom noise, conversation and story reading. Results showed that the mentally retarded children were less able to sustain attention compared with their chronological age controls, but showed similar sustained attention performance to their mental age controls. Also, the brain-damaged mentally retarded children, but not the non-brain-damaged, were more adversely effected by the distracting stimuli than the mental age control children. Hence, it was concluded that susceptibility to distraction in mentally retarded children could be related to brain damage.

Thus, investigators who have considered distractibility as an explanation for any differences in detection performance between mentally retarded and nonretarded persons have found opposing results. However, the studies differed in terms of subject ages and type of task. Therefore, no valid conclusions can be drawn about a distractibility hypothesis of vigilance performance in mentally retarded persons.

A different explanation was considered by Das and Bower (1971). These investigators examined the rates of conditioning and habituation to stimuli by mentally retarded and nonretarded subjects in a 30-minute auditory task. The subjects were aged from 13 to 16 years, with the estimated IQ scores of the mentally retarded children ranging from 40 to 60. The mean IQ of the nonretarded children was 119. A series of six familiar words was presented each minute. The critical signal was the word "man" which always followed a warning signal, the word "box". Subjects responded by pressing a button and galvonic skin response was used as the measure of habituation. The mentally retarded group made significantly more errors of omission and commission than the chronological age control group, but there was no difference in the rates of habituation between the two subject groups. Thus, an habituation explanation for the vigilance performance of mentally retarded and nonretarded people was not supported.

Thus, attempts to account for the differences in vigilance performance between mentally retarded and nonretarded persons have concentrated mainly on the theories of arousal and distraction. However, data have been obtained which dispute both approaches.

3.4 TRAINING APPROACHES FOR VIGILANCE PERFORMANCE

Recently there have been two studies which have considered training for vigilance performance of mentally retarded persons.

Perryman, Halcomb and Landers (1981) hypothesized that a training method consisting of a number of techniques would be more effective than a method using only one technique. Subjects were eight mentally retarded females whose mean age and IQ score were 18 years and 56 respectively. The task involved monitoring a three-section split screen. The simultaneous illumination of the two side sections was the nonsignal, while the illumination of the centre section was the signal. There was a column of 24 lights situated on either side of the screen through which knowledge of results was given to subjects. Each correct detection was indicated by the illumination of one of the lights and a light was turned off each time a false alarm was recorded. All subjects participated in four phases comprising 30 minutes training, a baseline period of 68 minutes, four 25-minute training sessions and a post-training period of 68 minutes.

During the training sessions the inter-signal interval was progressively increased, knowledge of results operated, subjects were praised and tokens given relative to their performance. Knowledge of results was not given during the post-training period but subjects were urged to do their best prior to commencement. So the training programme involved multiple practice sessions, decreasing signal density, use of prompts, knowledge of results and the provision of tangible incentives.

The results showed that the mean overall detection rate increased from 40% during pre-training to 82% in the post-training period. In addition, there was a significant performance decrement during pre-training but not over the post-training period. Hence, the detection performance of the mentally retarded subjects was enhanced by the training method. The study was not designed to identify particular aspects which were responsible for the improved performance.

Locke, Byrd, Berger and Childs (1982) used the same task and training method as Perryman et al. in an attempt to replicate their findings as well as to identify the components of the method affecting performance. In addition, two observers independently recorded task-irrelevant behaviour during the post-training session. These behaviours involved "active behaviour exceeding 5-seconds duration and incompatible with observation and/or response to the signal events".

A vigilance decrement was still shown following the training procedures. Detection accuracy was found to be related to the degree of tangible reinforcement and varied inversely to task-irrelevant behaviour. So the results of this investigation failed to support the earlier findings of Perryman et al. Also, a post-experimental interview indicated that most subjects found the task more uninteresting or boring than interesting.

3.5 SUMMARY

Only five investigations have been conducted into the vigilance performance of mentally retarded persons. None of the results supported the "dull jobs for dull minds" dictum in that the mentally retarded persons were not better monitors than nonretarded persons of equivalent chronological age. In contrast, the data demonstrated that mentally retarded children show an earlier and more rapid decline in performance compared with their nonretarded counterparts until they reach approximately 18 years of age. Also, another study concerned with training for vigilance performance conducted post-experimental interviews which indicated that mentally retarded young adults find these monitoring tasks uninteresting.

Explanations put forward to account for the vigilance performance of mentally retarded persons have met with conflicting evidence. There is some support for a distraction theory, although other data challenge this approach. However, as noted in Chapter 2, theories proposed to account for the vigilance performance, especially the performance decrement, of nonretarded persons have met with the same difficulties. Similarly, training programmes aimed at improving the detection performance of mentally retarded persons have proven unreliable as yet.

CHAPTER 4

MENTAL AGE AND PERIPHERAL ATTENTION EFFECTS ON VIGILANCE PERFORMANCE OF MENTALLY RETARDED PERSONS

4.1 EXPERIMENT 1

The overall results of the five studies which compared the vigilance performance of mentally retarded persons with nonretarded persons suggested that mental age may be a significant determinant of the performance of mentally retarded persons. This finding is consistent with a developmental lag interpretation and implies that mentally retarded persons suffer from a slower rate of development in terms of their ability to maintain vigilance performance. Inspection of the age ranges of the subjects in these studies indicates that the age by which mildly retarded persons are able to sustain their performance to a level comparable to that of nonretarded 12 year old children and adults is approximately 18 years.

As already noted in Chapter 1, to test the developmental lag hypothesis, it is essential that mental age control subjects are included in studies concerned with mentally retarded persons. However, only one of the five studies employed a mental age control group. Table 4.1 shows the subject groups used in each of the studies. It can be seen that chronological age control groups were used in all of the studies, yet only Kirby _et_ _al_. (1979)

specifically included a mental age control group. Jones (1972) used two chronological age control groups, the younger being of approximately the same mental age as the mildly mentally retarded adults. However, there were no mental age control subjects for the mildly mentally retarded children. Thus, as can be seen in Table 4.1, no one study has included the five subject groups required to fully test the developmental lag hypothesis. These groups would consist of mildly mentally retarded adults and children and their chronological and mental age nonretarded controls.

STUDY	ADULTS		CHILDREN		
	MR	CA	MR	CA	MA
Ware *et al*. (1962)	x	x			
Semmel (1965)			x	x	
Jones (1972)	x	x	x	x	
Kirby *et al*. (1978)	x	x			
Kirby *et al*. (1979)			x	x	x

TABLE 4.1 Mentally retarded (MR), nonretarded chronological age control (CA) and nonretarded mental age control (MA) subject groups used in the five studies concerned with the vigilance performance of mentally retarded persons.

Also, there is some support for a distractibility hypothesis for the vigilance performance of mentally retarded persons. Four experiments used a visual vigilance task but Kirby, Nettelbeck and Bullock (1978) also used an auditory task. It is possible then, that the vigilance decrement found by Semmel (1965) and Kirby, Nettelbeck and Thomas (1979) using a visual task could have been due to greater inattention to the signal source among their younger subjects compared to the older subjects in the other two studies. That is, the results could have been due to peripheral effects in that the younger subjects may have been looking elsewhere more often and so missed signals. In the auditory task used by Kirby, Nettelbeck and Bullock (1978) with the adult subjects this kind of inattention would not be possible.

The purpose of the present study was twofold. First, using the same visual and auditory tasks as Kirby et al. (1978), with subject groups similar in age to both those of Kirby et al. (1978) and Kirby et al. (1979) should replicate the results of both studies. That is, there should be no difference between the rates of decline of vigilance performance of the mentally retarded and nonretarded adults whereas the retarded children should show a more rapid vigilance decrement than the nonretarded children of equivalent chronological age. Also, the mentally retarded children should show a similar rate of decline to the nonretarded children of similar mental age. Second, the possibility of inattention amongst younger subjects would be tested by the addition of the auditory condition. Presentation of stimuli through headphones would eliminate the possibility of peripheral effects since signals would directly impinge upon the appropriate sense organ. If the performance of the younger subjects on the visual task were to decline more rapidly than that on the auditory task then this could be due to them being more easily distracted from the visual stimulus. If, on the other hand, similar decrements were to be obtained in both visual and auditory modes then the faster vigilance decrements amongst children could not be due to peripheral inattention.

4.2 METHOD

4.2.1 Subjects

There were five groups of subjects, two mildly mentally retarded and three nonretarded groups.

The older mentally retarded group consisted of two female and eight male employees from a vocational rehabilitation centre. Their IQ scores on the Wechsler Adult Intelligence Scale ranged from 61 to 76 (mean 70). Ages ranged from 17 years 2 months to 20 years (mean 18 years 9 months). The average mental age of the group was estimated to be 13 years 2 months by multiplying the IQ score by chronological age, and dividing by 100.

The corresponding chronological age control group consisted of seven female and three male students from The University of Adelaide aged from 17 years 8 months to 19 years 6 months (mean 18 years 8 months).

The younger retarded group consisted of five female and five male students from two special schools. Their IQ scores on the Wechsler Intelligence Scale for Children or the Stanford-Binet Intelligence Scale ranged from 45 to 74 (mean 57). Ages ranged from 13 years 1 month to 16 years 2 months (mean 14 years 2 months). The estimated average mental age for this group was 8 years.

The corresponding chronological age control group consisted of five female and five male students from a high school. They were aged from 12 years 7 months to 13 years 4 months (mean 13 years 1 month). The mean age of this group was therefore approximately equivalent to the mean mental age of the older mentally retarded group.

The mental age control group contained one female and nine male students from a primary school whose ages ranged from 8 years 6 months to 9 years 6 months (mean 8 years 11 months).

Nonretarded children were selected whose academic performance was at least average and thus were assumed to be at least of average intelligence. The schools and rehabilitation centre were within the metropolitan area of Adelaide, South Australia.

4.2.2 Apparatus and Stimulus Sequence

The apparatus and stimulus sequence were the same as that used for both the visual and auditory tasks by Kirby et al. (1978) and also the visual task by Kirby et al. (1979).

The visual task used a circular red light 3cm. in diameter which appeared every 3 seconds for 0.5 second approximately 2 metres in front of the subject. In the auditory task, a pair of earphones was used through which a pulse of white noise came on every 3 seconds for 0.5 second.

A preliminary study was conducted in which five mildly mentally retarded children were trained on the visual and auditory tasks to determine the threshold levels for vigilance tasks. The study found nonsignal and signal visual intensities of 10ftl. and 20ftl. respectively and nonsignal and signal auditory intensities of 30db. and 33db. respectively to be of appropriate and approximately similar difficulty for the subjects used. Subjects were instructed to respond to signals by pressing a button held in the preferred hand. Responses were recorded automatically as either a "hit" (correct detection) or a "false alarm" (commission error).

An experimental session lasted for 50 minutes and consisted of 5 continuous blocks of 10 minutes duration each. Blocks were composed of 200 stimulus pulses of which 10 were signals and 190 nonsignals. The time between signals varied randomly from 9 seconds to 141 seconds. Total hits and false alarms were recorded for each block.

4.2.3 Procedure

Subjects were seated at a table at one end of a room which was partitioned off from the control and recording equipment. Each subject was required to attend three sessions. At the first session, subjects were tested on the visual discrimination task followed by the auditory discrimination task. Subjects were informed that a light would appear every 3 seconds for 0.5 second and that sometimes it would be "bright", sometimes "dull". They initially learned to discriminate between a nonsignal of 10ftl. and a signal of 40ftl. Practice series consisted of 16 stimuli divided into an equal number of nonsignals and signals in random order. Evidence of discrimination ability was set at 13 correct out of the 16 stimuli presented. The difference between the intensities was progressively reduced by 5ftl. after the criterion was passed at each level until discrimination was achieved at a nonsignal intensity of 10ftl. and a signal intensity of 20ftl. The same procedure applied to the auditory task, except that subjects were informed that the noise would sometimes be "soft" and sometimes "loud". Nonsignal and signal intensities commenced at 30db. and 55db. respectively. Again the difference between the intensities was progressively reduced by 5db. from 55db. to 35db. with a final reduction of 2db. to 33db., until the criterion was passed at nonsignal and signal intensities of 30db. and 33db. respectively.

A total of 5 mentally retarded and 1 nine-year-old nonretarded subjects failed to pass criterion at the final test level and did not participate further.

There was a break of at least an hour between attendance at the first and second sessions to minimize the possibility of fatigue. Half the subjects were randomly selected to complete the visual vigilance task in the second session and the auditory vigilance task in the third session, while the other half completed the two tasks in the opposite order to offset any learning effects.

Before each task the final practice discrimination series was presented again. After subjects had passed criterion on the practice series they were informed that they would be presented with another sequence that would last for about 50 minutes. It was emphasized that the signal stimulus "would not occur very often and at varying times". Watches were removed for the duration of the task and earphones were worn throughout the visual task to reduce extraneous noise.

Subjects attended the third session at least one week following the second session to alleviate any problems with fatigue. The procedure was the same as that in the second session.

4.3 RESULTS

4.3.1 Hits

Figure 4.1 shows the mean percentage of correct detections (hits) for each successive ten-minute block for each group on the visual and auditory tasks. The figure shows that there were differences in both overall hit scores and rates of decline in performance between the five groups. The mentally retarded children and nonretarded children of equivalent mental age demonstrated similar hit rates over time blocks on each task. However, the rates of decline in performance of these groups were faster than those of the other three groups who showed similar performances to each other across time blocks on both tasks. All groups had higher hit rates on the auditory task than on the visual task.

A three-way analysis of variance of Groups by Tasks by Blocks with repeated measures on the last two variables found significant main effects between groups (F = 19.22, 4/45 df, $p < 0.01$), tasks (F = 9.11, 1/45 df, $p < 0.01$) and over blocks (F = 35.64, 4/180 df, $p < 0.01$). There

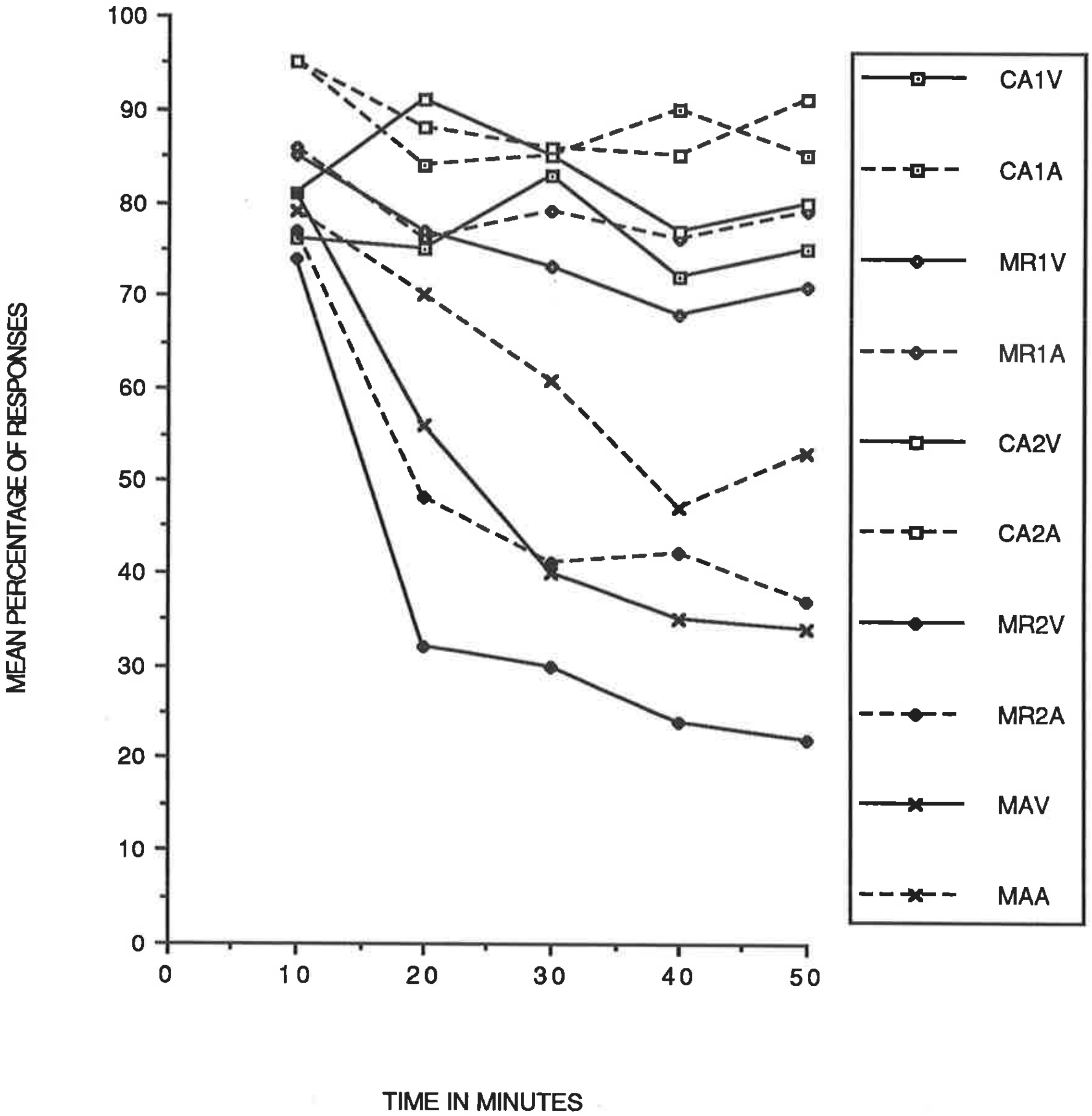

FIGURE 4.1 Mean percentages of hits on both visual (V) and auditory (A) tasks for nonretarded 19 year old adults (CA1), mentally retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), mentally retarded 14 year old children (MR2) and nonretarded 9 year old children (MA) as a function of time on task.

was also a significant interaction between groups and blocks ($F = 6.87$, 16/180 df, $p < 0.01$). Examination of these results in Figure 4.1 confirms the previous observations, that is, groups differed in their mean overall hit rates, subjects had a higher mean overall hit rate on the auditory task compared to the visual task, mean hit rates tended to decline over blocks and there were differences in the mean rates of decline of performance between groups. There was no blocks by task interaction indicating that there was no difference between the rates of decline on the visual and auditory tasks.

The mean percentages of hits for each successive ten-minute block for each group on both tasks combined are shown in Figure 4.2 in order to demonstrate the significant groups by blocks interaction more clearly. The figure shows the mean rates of decline in performance for the mentally retarded 14 year old children and the nonretarded 9 year old children appear to be greater than those of the other three groups of subjects.

Four planned comparisons were included in the analysis of variance to further investigate expected differences in performance between the experimental groups in terms of the developmental lag hypothesis. First, the nonretarded and retarded adults and nonretarded 13 year old children were compared with the retarded 14 year old and nonretarded 9 year old children. Second, the last two groups were compared with each other. Third, the retarded adults were compared with the nonretarded adults and 13

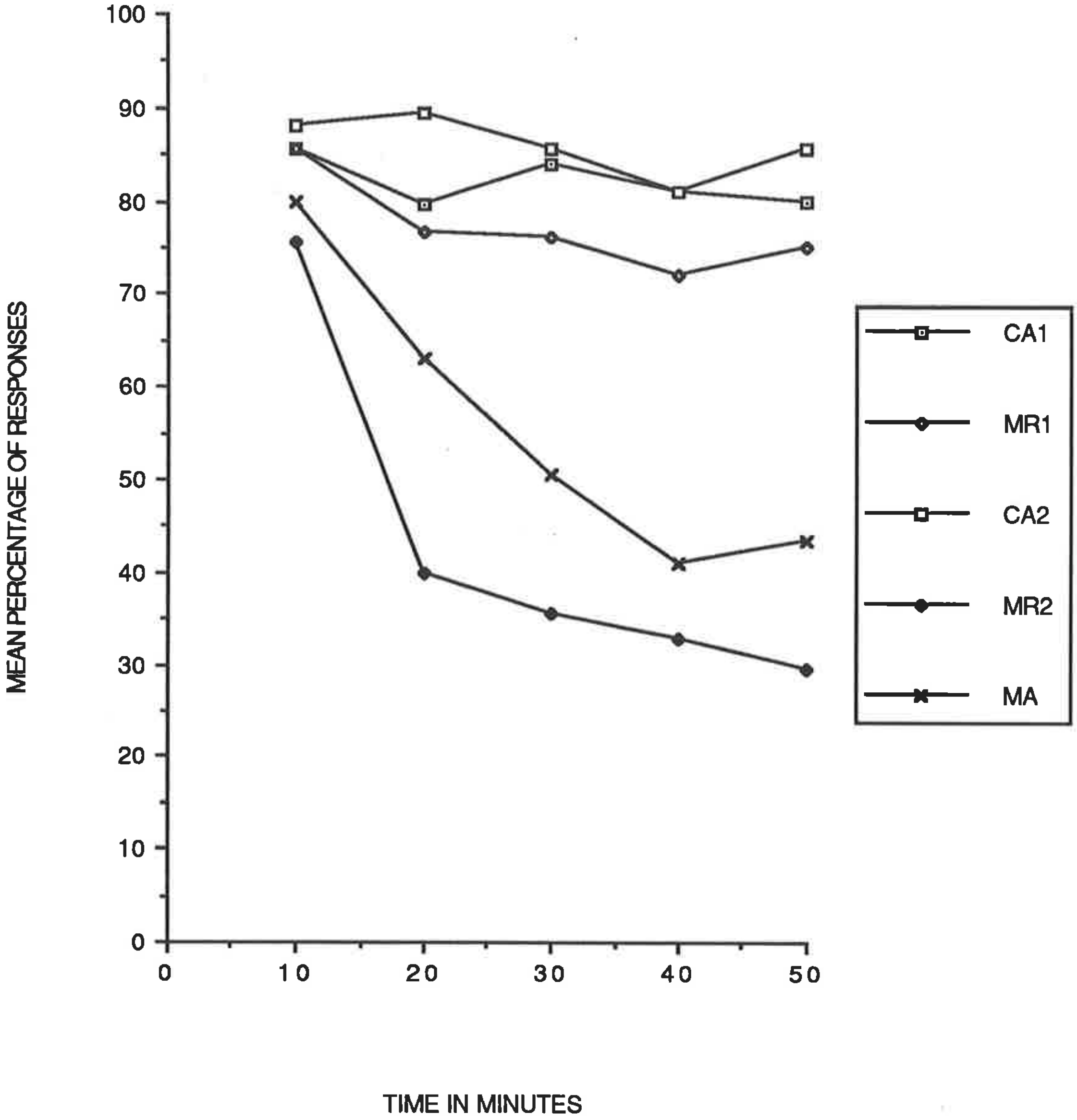

FIGURE 4.2 Mean percentages of hits on both visual and auditory tasks combined for nonretarded 19 year adults (CA1), mentally retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), mentally retarded 14 year old children (MR2) and nonretarded 9 year old children (MA) as a function of time on task.

year old children. Fourthly, the nonretarded adults and 13 year old children were compared with each other. Based on the results of the five previous studies, it was predicted that the mentally retarded 14 year old children and the nonretarded children of equivalent mental age would show a faster rate of decline in performance compared with the three other groups (comparison 1). Furthermore, no differences in the rates of decline were expected between the mentally retarded 14 year old children and the nonretarded mental age control subjects (comparison 2), or between the mentally retarded adults, the nonretarded adults and the nonretarded 13 year old children (comparisons 3 and 4).

Significant main effects were found between groups for both the first (F = 70.07, 1/45 df, $p < 0.01$) and second (F = 4.61, 1/45 df, $p < 0.05$) comparisons. There were also significant interactions between groups and blocks for the first comparison both linearly (F = 75.83, 1/180 df, $p < 0.01$) and quadratically (F = 16.42, 1/180 df, $p < 0.01$). Inspection of these results in Figure 4.2 indicates that the nonretarded and retarded adults, and nonretarded 13 year old children had a significantly higher mean overall hit rate than the retarded 14 year old and nonretarded 9 year old children. Also, the nonretarded 9 year old children had a higher mean overall hit rate than the retarded 14 year old children. However, there were no significant differences in mean overall hit rates between the nonretarded and retarded adults and nonretarded 13 year old children. In addition, the retarded 14 year old and nonretarded 9 year old children showed a greater decline in mean hit rates across blocks compared with the other three subject groups. The retarded 14 year old and nonretarded 9 year old children showed the greatest decline between the first and third time blocks with performance levelling out thereafter. However, the other three groups showed consistent decline over the five time blocks.

4.3.2 False Alarms

Figure 4.3 shows the mean percentage of commission errors (false alarms) for each group on both tasks for each successive ten-minute time block. The figure shows that the mean percentage of false alarms for each group of subjects was higher on the visual task compared to the auditory task. The nonretarded 19 year old and 13 year old groups registered the lowest false alarm rate with the largest rate registered by the retarded 19 year old group. The decline in mean false alarm rates over ten-minute blocks appeared similar for all groups except the retarded 19 year old subjects who showed an increase over time. The same analysis of variance model as that used for hits (Groups by Tasks by Blocks) showed a significant difference between groups (F = 6.70, 4/45 df, $p < 0.01$), tasks (F = 13.22, 1/45 df, $p < 0.01$) and over blocks (F = 9.26, 4/180 df, $p < 0.01$). There was a significant interaction between groups and blocks (F = 2.93, 16/180 df, $p < 0.01$). There were no other significant interaction effects, with no differences in

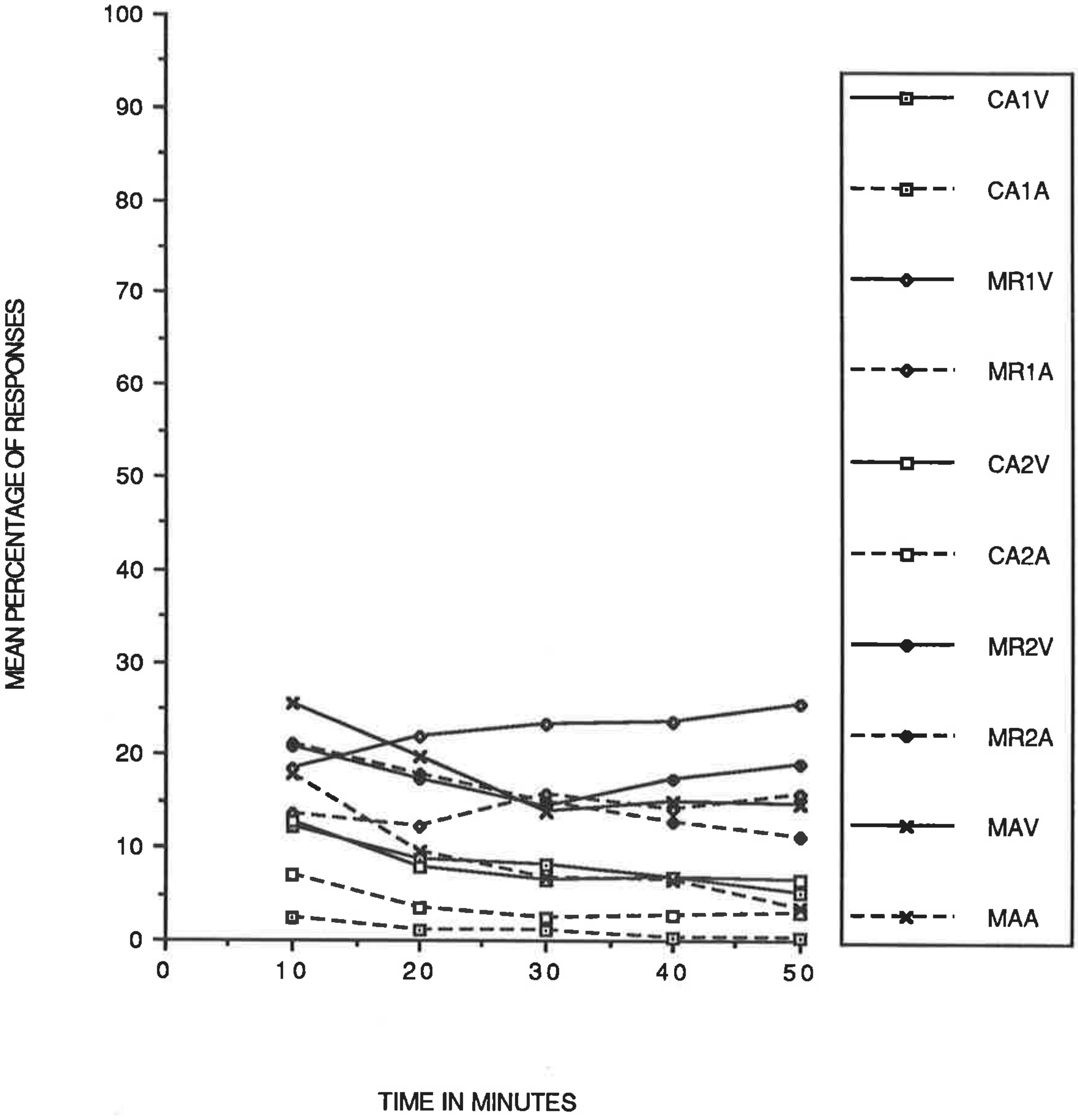

FIGURE 4.3 Mean percentages of false alarms on both visual (V) and auditory (A) tasks for nonretarded 19 year old adults (CA1), mentally retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), mentally retarded 14 year old children (MR2) and nonretarded 9 year old children (MA) as a function of time on task.

the false alarm rates over time between the visual and auditory modes.

The interaction between groups and blocks is shown in Figure 4.4 in terms of mean percentages of false alarms for visual and auditory tasks combined for each successive ten-minute block. It can be seen that the retarded 19 year old group showed an increase in mean false alarms over time whereas all other groups showed decreases in mean false alarm rates over time. The same planned comparisons as those used for hits found significant main effects between groups for the first ($F = 5.91$, 1/45 df, $p < 0.05$) and third ($F = 19.76$, 1/45 df, $p < 0.01$) comparisons. There were also significant linear interactions between groups and blocks for the first ($F = 18.24$, 1/180 df, $p < 0.01$), second ($F = 5.23$, 1/180 df, $p < 0.05$) and third ($F = 14.85$, 1/180 df, $p < 0.01$) comparisons. Examination of these results in Figure 4.4 indicates that the mentally retarded 19 year old subjects registered the greatest number of false alarms. The mentally retarded 14 year old and nonretarded 9 year old subjects registered fewer false alarms and the nonretarded 19 year and 13 year old subjects registered the least number of false alarms. Also, the retarded 19 year old subjects showed an increment in the number of false alarms registered across time blocks whereas each of the other subject groups showed a decrement over blocks.

4.3.3 Signal Detection Theory Analysis

The different changes in both hit and false alarm

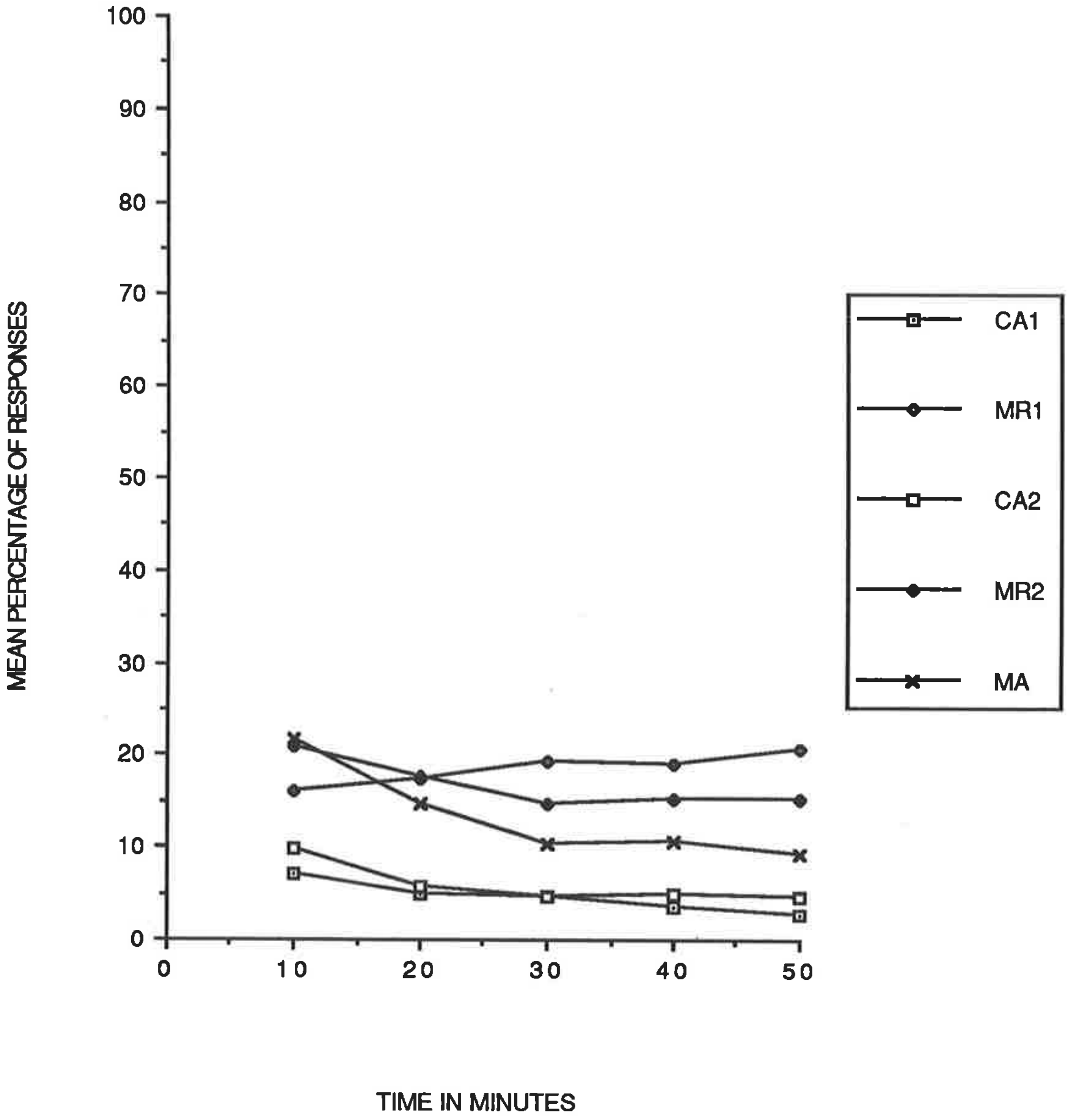

FIGURE 4.4 Mean percentages of false alarms on both visual and auditory tasks combined for nonretarded 19 year old adults (CA1), mentally retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), mentally retarded 14 year old children (MR2) and nonretarded 9 year old children (MA) as a function of time on task.

rates between the subject groups might be expected to reflect a difference in change in either sensitivity or criterion. Hence, sensitivity and criterion values were calculated for each subject at each time block on both tasks. In a few instances when the percentage of hits or false alarms was 0 or 100 a small arbitrary constant (0.001) was added or subtracted as suggested by McNicol (1972).

The mean values of d' and ß at each successive time block for each group for both tasks are shown in Tables 4.2 and 4.3 respectively. The first table shows that all subject groups had higher overall mean sensitivity values on the auditory task compared with the visual task. Both mentally retarded groups and the nonretarded 9 year old children showed a decline in sensitivity across time blocks, with the greatest decline being shown by the mentally retarded 14 year old children. The retarded adults showed only a relatively small decline in sensitivity. The nonretarded 19 year old adults and 13 year old children showed an increase in sensitivity values on the visual task, with little change on the auditory task.

The same analysis of variance model as used for both hits and false alarms (Groups by Tasks by Blocks) found significant main effects between groups ($\underline{F}$ = 32.35, 4/45 $\underline{df}$, $\underline{p} < 0.01$), tasks ($\underline{F}$ = 56.36, 1/45 $\underline{df}$, $\underline{p} < 0.01$) and over blocks ($\underline{F}$ = 4.19, 4/180 $\underline{df}$, $\underline{p} < 0.01$). There was also a significant interaction between groups and blocks ($\underline{F}$ = 3.36, 16/180 $\underline{df}$, $\underline{p} < 0.01$). These results confirm the previous observations, that is, groups differed in their mean overall sensitivity values, subjects had higher sensitivity values on the auditory task compared to the visual task, mean sensitivity values decreased over blocks and there were differences in the rates of decline in values between groups. There was no blocks by task interaction indicating that there was no difference between the mean rates of decline in sensitivity values on the visual and auditory tasks.

VISUAL TASK

GROUP	BLOCK 1	2	3	4	5	MEAN
CA1	2.06	2.70	3.32	2.85	3.12	2.81
MR1	2.54	2.17	1.90	1.47	1.64	1.94
CA2	2.30	3.55	3.09	2.97	3.10	3.00
MR2	1.51	0.33	0.41	-0.03	-0.24	0.40
MA	1.90	1.25	0.82	0.49	0.50	0.99
MEAN	2.06	2.00	1.91	1.55	1.62	1.83

AUDITORY TASK

GROUP	BLOCK 1	2	3	4	5	MEAN
CA1	4.73	4.38	4.30	4.88	4.60	4.57
MR1	3.07	2.64	2.68	2.93	2.62	2.75
CA2	3.99	3.94	3.78	3.86	4.18	3.95
MR2	2.11	0.92	0.92	1.04	0.73	1.15
MA	2.43	2.28	2.11	1.75	1.98	2.11
MEAN	3.27	2.81	2.74	2.88	2.82	2.90

TABLE 4.2 Mean d' values at each successive time block on the visual and auditory tasks for the nonretarded 19 year old adults (CA1), retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), retarded 14 year old children (MR2) and nonretarded 9 year old children (MA).

The same four planned comparisons as those used for both hits and false alarms to investigate the developmental lag hypothesis were included in the analysis. Significant main effects were found between groups for the first (F = 101.26, 1/45 df, $p < 0.01$), second (F = 6.36, 1/45 df, $p < 0.05$) and third (F = 21.29, 1/45 df, $p < 0.01$) comparisons. Inspection of these results in Table 4.2 indicates that the nonretarded adults and nonretarded 13 year old children had a significantly higher mean overall sensitivity value than the retarded adults who in turn had a higher mean overall value than the nonretarded 9 year old children. The retarded 14 year old children had the lowest mean overall sensitivity value. There were also significant interactions between groups and blocks for the first comparison both linearly (F = 26.73, 1/180 df, $p < 0.01$) and quadratically (F = 3.92, 1/180 df, $p < 0.05$), as well as linearly for the third comparison (F = 9.92, 1/180 df, $p < 0.01$). These results support the previous observations about the different changes in sensitivity values across time blocks shown by the subject groups.

The same analysis of variance model (Groups by Tasks by Blocks) for the ß values found significant main effects between groups (F = 2.81, 4/45 df, $p < 0.05$), tasks (F = 11.28, 1/45 df, $p < 0.01$) and over blocks (F = 3.73, 4/180 df, $p < 0.01$). Inspection of these results in Table 4.3 indicates that groups differed in their mean overall ß values, there were higher mean overall ß values on the auditory task compared with the visual task and mean overall ß values increased over time blocks.

VISUAL TASK

GROUP	BLOCK 1	2	3	4	5	MEAN
CA1	2.69	13.84	8.44	19.58	16.93	12.30
MR1	1.33	1.54	2.24	2.61	2.63	2.07
CA2	1.59	2.18	2.45	4.73	13.88	4.97
MR2	1.16	1.41	1.48	1.16	0.75	1.19
MA	0.80	1.29	1.45	0.92	1.20	1.13
MEAN	1.52	4.05	3.21	5.80	7.08	4.33

AUDITORY TASK

GROUP	BLOCK 1	2	3	4	5	MEAN
CA1	6.92	22.03	27.58	27.11	45.26	25.78
MR1	12.60	12.45	23.64	33.94	25.53	21.63
CA2	1.14	14.62	8.82	21.58	10.76	11.38
MR2	1.01	1.68	2.46	2.13	1.98	1.85
MA	1.63	3.21	23.25	4.26	5.30	7.53
MEAN	4.66	10.80	17.15	17.80	17.76	13.63

TABLE 4.3 Mean ß values at each successive time block on the visual and auditory tasks for the nonretarded 19 year old adults (CA1), retarded 19 year old adults (MR1), nonretarded 13 year old children (CA2), retarded 14 year old children (MR2) and nonretarded 9 year old children (MA).

The same planned comparisons as those used for sensitivity values found both a significant main effect between groups (*F* = 7.33, 1/45 *df*, *p* < 0.01) and a significant interaction between groups and blocks (*F* = 7.17, 1/180 *df*, *p* < 0.01) for the first comparison. Examination of these results in Table 4.3 indicates that the retarded and nonretarded 19 year old adults and nonretarded 13 year old children had a higher mean overall ß value and greater increment in ß values across time blocks compared with the other two groups.

It should be noted that the raised mean criterion value in the third block on the auditory task for the nonretarded 9 year old children was due to two subjects registering no false alarms. Thus, the criterion value was disproportionately elevated for that block.

4.4 DISCUSSION

The results of this experiment were similar to both those of Kirby et al. (1978) and Kirby et al. (1979). There was no difference in either mean overall hit rates or the decline in average hit rates over time blocks between mildly mentally retarded adults and nonretarded adults of the same chronological age. Nor was there any difference in either mean overall hit rates or the decline in hit rates between the nonretarded 13 year old subjects and those of both adult groups. However, the mildly mentally retarded 14 year old children showed an earlier and more rapid decline in performance and a lower mean overall hit rate than the nonretarded 13 year old children, whilst there was no difference in the decline in hit rates over time between the retarded 14 year old children and the nonretarded 9 year old children of equivalent mental age. However, the retarded children scored a lower mean overall hit rate than the nonretarded 9 year old children. These results indicate that the mental age of the subjects is a decisive factor in the ability to maintain vigilance over time. Inspection of the age ranges of the subject groups suggests that the age at which mildly retarded persons have developed the capacity to maintain performance to a level comparable to that of nonretarded adults and 13 year old children is around the age of 17 years.

This experiment also found similar decrements in both visual and auditory modes for all subject groups which indicates that the faster decline in performance amongst retarded children was not due to peripheral attention effects. However, the opportunity to become distracted by extraneous environmental stimulation was minimized as the room in which the subjects were tested was relatively bare and darkened. Also, higher mean scores were found in the auditory mode for all subject groups implying that the auditory task was relatively easier than the visual task. Whilst the preliminary discrimination study attempted to equate the intensities approximately for each task, it was obviously not successful in establishing vigilance tasks of equal difficulty in different sensory modes.

Notable features of both the mentally retarded 14 year old children and nonretarded children of similar mental age were periods of multiple responding, that is, responding to a number of successive stimuli, as well as audibly restless behaviour including intermittent calling out and loud sighing. The multiple responding might have been due to a strategy which tried to maintain arousal and hence attention. That is, as concentration waned during the task, the subjects might have pushed the button for successive stimuli in order to raise their arousal and so maintain performance.

There were differences between the mean number of false alarms registered across time blocks for the different subject groups. In particular, the retarded adult group showed a small increase in false alarms across time blocks whereas the other groups showed a decline across blocks. Also, there were different total mean false alarm rates for different levels of both chronological age and intelligence, thus indicating the relative difficulty of discrimination for the different groups. The retarded adults and children registered most false alarms, followed by the two groups of nonretarded children, while the nonretarded adults registered fewest false alarms.

Given the differences in hit and false alarm rates between the groups a signal detection theory analysis was conducted. The results found that all groups had a higher mean overall d' value on the auditory task compared with the visual task supporting the above conclusion that subjects found the auditory task relatively easier than the visual task. Also, the mentally retarded 14 year old children and nonretarded 9 year old children showed a significant decline in sensitivity across time blocks with virtually no change in criterion. However, the other three groups showed the opposite result, that is, an increase in criterion over time with little change in sensitivity. Thus, this indicates that mentally retarded persons are slower to develop the capacity to maintain discriminability over time.

Overall, the results of this experiment support the conclusions drawn by Kirby, Nettelbeck and Thomas (1979), that is, the poorer maintenance of vigilance performance by mildly mentally retarded persons is due primarily to developmental factors. They may develop this skill to the same level as nonretarded persons by about 17 years of age. However, the poorer discriminative ability demonstrated by retarded persons seems to be related to intellectual impairment rather than age.

CHAPTER 5

SENSITIVITY DECREMENTS IN VIGILANCE TASKS

The results of the signal detection theory analysis of performance in Experiment 1 indicated that the nonretarded adults, the mentally retarded adults and the nonretarded 13 year old children became more cautious in responding with time on the task but with little change in perceptual sensitivity. Similar results have been reported in a large number of studies with nonretarded persons which show an association between a criterion increment and the vigilance decrement (Davies and Parasuraman, 1982). However, the greater decline in detection performance shown by the mentally retarded 14 year old children and nonretarded 9 year old children was associated with a deterioration in perceptual sensitivity, not with a change in decision criterion. A review of vigilance experiments by Swets (1977) indicates that perceptual sensitivity does decline in some vigilance tasks. Hence, the characteristics of tasks for which sensitivity decrements or criterion increments have been found and theories forwarded to explain these changes will be examined next.

5.1 TAXONOMIC ANALYSIS

Early vigilance studies found that sensitivity decrements occurred in visual tasks requiring a high rate of observation (Broadbent, 1971; Mackworth, 1970). However, Swets (1977) noted that some studies had used high event rate tasks and had not shown a sensitivity decrement whilst others had found a sensitivity decrement with auditory tasks. Subsequently, consideration has been given to the influence of both event rate and task type on sensitivity changes.

Davies and Parasuraman (1982) summarized the results of studies which were concerned with a taxonomic analysis of vigilance tasks and sensitivity shifts. Vigilance tasks used in studies up to 1975 were divided into two general categories. The first group consisted of "successive-discrimination" tasks in which subjects needed to identify from successively presented stimuli a change from a standard value stored in memory. The other group consisted of "simultaneous-discrimination" tasks in which signal and nonsignal events were presented simultaneously. In addition, the tasks were further divided according to the event rate. Those with an event rate of less than 24 per minute were classified as "low event rate" tasks. Alternatively, tasks which involved an event rate of 24 per minute or greater were classified as "high event rate" tasks. The analysis found that sensitivity decrements were associated with successive-discrimination tasks using a high event rate. The vigilance decrement is associated with increased criterion for all other combinations of task type and event rate.

The task employed in Experiment 1 involved discrete stimulus events which occurred every 3 seconds with the signal being an increase in stimulus intensity. That is, it was a successive-discrimination task with a low event rate. Therefore, the criterion increments for the nonretarded adults, the retarded adults and the 13 year old children were consistent with previous results for this kind of task. However, the sensitivity decrements found with the mentally retarded 14 year old children and nonretarded 9 year old children were not consistent with the results of other studies which used the same task types.

5.2 THEORIES OF THE SENSITIVITY DECREMENT

5.2.1 Coupling

The coupling theory postulates that the sensitivity decrement only occurs in tasks which are "loosely coupled" to the observer's perceptual system, such as in visual tasks. Hence, perceptual efficiency declines when the peripheral receptor system is oriented away from the visual display.

Whilst initial studies found that sensitivity decrements occurred in visual tasks (Loeb and Binford, 1968; Mackworth, 1970), later studies failed to support this hypothesis as sensitivity decrements were also found in auditory tasks (Corcoran et al., 1977) and "closely coupled" visual tasks (Loeb and Binford, 1971).

5.2.2 Observing Response

As outlined in Chapter 2, the observing response theory postulated by Jerison (1970) suggests that vigilance performance deterioration is the result of increased periods of either failure to observe the display or blurred (distracted) observations. In this theory, "observing" is assumed to be a more central process so that while the stimulus might be impinging on the appropriate receptor organ, it is not "observed" as a signal by the central decision making system.

The theory also proposes that there is a cost associated with observing and that the decision to observe is dependent upon the benefit of detecting a signal. Factors like poor motivation and fatigue increase the cost of observing and so increase the number of periods of blurred observations or failures to observe. Increases in event rate are also viewed as increasing task demand as there is a greater rate of observation required. Hence, the increased cost results in a decreased willingness to attend and so to a decline in performance. Alternatively, factors which reduce task demand, such as more conspicuous signals, should improve performance efficiency.

5.2.3 Habituation

The habituation model postulated by Mackworth (1968, 1969) suggests that the sensitivity decrement is the result of habituation of the neural responses to the repetitive stimulus events of the task. This theory provides an explanation for the sensitivity decrement found in tasks using high event rates in that habituation is faster in these tasks as a result of the greater frequency of background events.

The theory also suggests that performance is improved by the process of dishabituation which should follow any change in task conditions. However, Krulewitz et al. (1975) found that detection rate changed inversely to a shift in event rate, that is, an increase in event rate decreased detection rate whereas a decrease in event rate increased detection rate. Hence, their results failed to support the hypothesis since an increase in detection rate would have been predicted under both conditions.

5.2.4 Memory

Davies and Parasuraman (1982) suggest that memory could be an important factor in vigilance performance given the results of the taxonomic analysis of tasks outlined earlier. Successive-discrimination tasks are considered to depend more on memory compared with simultaneous-discrimination tasks as information has to be integrated over successive events as well as a particular nonsignal stimulus characteristic remembered. The sensitivity decrement found in successive-discrimination tasks with a high event rate is viewed as the combined effect of dependence on memory and the demands of a high stimulation rate.

The results of a study by Johnston et al. (1969) were cited to support this theory. Subjects in the study monitored two tasks involving an 8 x 8 matrix of alphanumeric stimuli. One task, which was hypothesized to be more memory dependent, involved the detection of deletions of some stimuli compared with the previous display. The other task involved detection of additions to the display. Results found that sensitivity values were reliably lower for the former task compared to the latter.

It was also noted that an implication of the theory is that if the sensitivity decrement is assumed to be the result of the decay of a memory trace then an increase in signal rate should stop the process and so the decrement. However, signal probability has been shown to effect criterion but not detectability (Loeb and Binford, 1968; Parasuraman and Davies, 1976).

5.2.5 Fatigue

Welford (1976), in attempting to explain the sensitivity decrement associated with tasks such as that in which subjects had to detect momentary interruptions of a continuously rotating pointer (Mackworth 1964, 1965; Mackworth and Taylor, 1963), hypothesized that monitoring in such tasks has to be continuous as signals could occur at any time rather than at discrete intervals, and that this was likely to be fatiguing.

Studies concerned with the effects of fatigue on vigilance performance provide some support for this hypothesis. Mast and Heimstra (1964), for example, studied the effects of working for four hours on tasks including mental arithmetic and simulated driving.

Results found that the mental arithmetic task led to a significant reduction in detection efficiency in a subsequent visual vigilance task compared to a control condition. The mental arithmetic task was postulated to involve "mental fatigue". Reductions in sensitivity also occurred for two simulated driving tasks but these were not statistically significant. However, Bonnet (1980) found that sensitivity in an auditory vigilance task was reduced by prior exercise.

There have been two theories put forward to explain mental fatigue. Welford (1976) referred to the traditional hypothesis that the nerve cells involved either directly or indirectly in the fatiguing performance become insensitive or unresponsive due to the continued activity. Short-term retention has been shown to be effected by fatigue (Welford, Brown and Gabb, 1950) and this theory suggests that short-term retention depends on self-maintaining neuronal circuits which become insensitive, resulting in memory traces decaying.

The second explanation is an overarousal effect in which either general or local neural activity rises beyond an optimum level (Bartley and Chute, 1947; Crawford, 1961; Woodworth and Schlosberg, 1954). Loss of short-term retention is viewed as resulting from disturbance of the memory traces.

Welford suggests that there is evidence to support each hypothesis and that the two processes could operate in different circumstances. Observations of irritability and difficulty in sleeping or relaxing after extended periods of taxing mental work support the arousal theory.

Alternatively, the results of a study by Berger and Mahneke (1954) support the impairment theory when considered in terms of the signal detection theory. Their study found that visual acuity and critical flicker frequency decreased when repeated measurements were taken continuously over a period of about 30 minutes. Welford suggests that sensitivity would decrease as a result of local neural failure, whereas criterion would decrease with overarousal. Furthermore, there would be little change in sensitivity with moderate overarousal. However, intense overarousal resulting in the firing of cells in the cortex would increase noise and lower sensitivity as well as criterion. Mackworth and Taylor (1963) interpreted the results of Berger and Mahneke as indicating a decline in sensitivity without alteration to criterion.

5.3 THE SENSITIVITY DECREMENT AND MENTAL RETARDATION

The results of Experiment 1 suggest that mentally retarded people have a slower rate of development in terms of their sustained attention ability compared with nonretarded people. The signal detection theory analysis indicates that the difference in both overall hits and rates of decline found between young mentally retarded and nonretarded people is related to the ability to maintain discriminability of signal from the nonsignal events. This finding is particularly notable given that the type of task used has not previously been shown to be associated with a decrement in perceptual sensitivity in nonretarded subject groups. The other three groups in Experiment 1 showed the expected increase in ß rather than a change in d'.

A number of theories forwarded to explain the sensitivity decrement found in vigilance tasks have been unable to account for all the findings of experiments. The results of Experiment 1 also failed to support the coupling hypothesis for both retarded and nonretarded subjects as there were no differences in sensitivity decrements on the visual and auditory tasks for all subject groups.

Three of the remaining theories can be viewed as being interrelated and could explain the results obtained in Experiment 1. If the task is fatiguing for the mentally retarded 14 year old children and nonretarded 9 year old children then, in terms of the observing response theory, the cost of observing is increased and so also would be the number of periods of blurred observations or failures to observe the display. Also, a direct relationship has been assumed by Welford (1976) to exist between fatigue and memory, with a loss of short-term retention being a result of fatigue. Hence, there is no clear explanation for the greater decline in detection rate over time and the sensitivity decrement shown by the mentally retarded 14 year old children and their nonretarded mental age counterparts. Further experimental consideration will therefore be given to finding a possible explanation for the results obtained in Experiment 1.

CHAPTER 6

STRATEGY EFFECTS

6.1 EXPERIMENT 2

The previous experiment investigated the results of five earlier studies which compared the vigilance performance of mentally retarded and nonretarded persons. Results showed that mildly mentally retarded children had a lower mean overall hit rate, and an earlier and more rapid decline in performance compared with nonretarded children of the same chronological age, but performed similarly to nonretarded children of equivalent mental age. However, there were no significant differences in either the mean overall hit rate or decline in hit rates over time between mentally retarded and nonretarded adults. In addition, there was no difference in the rates of decline of performance in visual and auditory modes of the task for all subject groups and hence no support for a distraction explanation for the poorer sustained performance of the mentally retarded children. Thus, the results gave further evidence of a developmental lag in the ability of mentally retarded persons to sustain vigilance performance.

The evidence for a developmental lag raises the further question of the nature of the change that occurs over time. The results of the signal detection theory analysis in the previous experiment indicated that the lag is concerned with the ability to continuously discriminate between the signal and nonsignal events over time. One possible explanation is that when stimulus events occur regularly, subjects try to maintain vigilance by adopting a strategy of only attending when a stimulus event is about to occur and resting between stimulus events. Welford (1976) has postulated that the ability to predict the occurrence of events enables the efficient deployment of attention and so reduces susceptibility to, or avoids the adverse effects of fatigue. Thus, the adoption of such a strategy of only attending when a stimulus is about to occur could prevent fatigue and so the sensitivity decrement. Mentally retarded subjects might be slower to develop this strategy.

Both the visual and auditory tasks used in the previous experiment utilized discrete stimuli which occurred at regular intervals of 3 seconds for a duration of 0.5 second each. In both cases, nonretarded adults and 13 year old children and mentally retarded adults may have learned to "switch off" their attention between stimuli, that is, they may have developed the ability to predict when inspection of the signal source was required which may also minimize fatigue. Given this explanation, arranging stimulus events so that their arrival could not be predicted would prevent the use of this strategy. While this might not effect performance on an auditory task where any signal impinges directly on the ear, it would require continuous attention in a visual task. Thus, in a visual task, having a continuous stimulus source might be expected to lead to greater decline in vigilance performance if subjects have developed and are dependent on a monitoring strategy of "switching attention off" between stimuli. Since signals in an auditory task having a continuous stimulus source would simply consist of increases in the intensity of the nonsignal source, these should be more easily detected and hence performance might be expected to improve compared with a task having discrete signals and nonsignals. This should occur regardless of whether subjects have an appropriate monitoring system or not.

The purpose of this experiment was to investigate the possibility of an attention strategy effect by utilizing a continuous stimulus source which would not allow subjects the chance to predict when inspection of the source was important. If the ability to predict stimulus events and switch attention on and off appropriately is an important factor in maintaining vigilance performance then both nonretarded and retarded adults should show an earlier and more rapid decline in performance when compared with their performance using discrete stimuli. To the extent that retarded adults are more dependent on such a strategy, and may be more susceptible to fatigue, they might be expected to show a faster decline than nonretarded subjects. This latter result would suggest either that mentally retarded subjects have still not fully reached the vigilance capacity of nonretarded subjects by the time they are 17 years old or that they have some genuine deficit. No difference in the rates of decline in performance between retarded and nonretarded groups would further support a general developmental delay in mentally retarded persons which is overcome by approximately age 17 years.

6.2 METHOD

6.2.1 Subjects

The retarded subjects were 7 male and 3 female employees from a vocational rehabilitation centre. Their IQ scores on the Wechsler Adult Intelligence Scale ranged from 61 to 81 (mean 70). Ages ranged from 17 years 0 months to 23 years 1 month (mean 19 years 0 months).

The nonretarded control subjects were 4 male and 6 female students from the University of Adelaide aged from 17 years 7 months to 18 years 11 months (mean 18 years 3 months).

Therefore, both these subject groups were comparable in age to the adult subjects in Experiment 1.

6.2.2 Apparatus and Stimulus Sequence

The apparatus was the same as that used for the visual and auditory tasks in the previous experiment.

The visual task consisted of a circular red light 3 cm. in diameter which remained illuminated. The signal was a 0.5 second increase in the intensity of the light. The subjects wore a pair of earphones in the auditory task through which a continuous white noise was played. The signal was a 0.5 second increase in the intensity of the noise. The background visual and auditory intensities were the same as the nonsignal intensities in the previous experiment, that is, 10ftl. and 30db. respectively.

The lowest intensities at which each subject could discriminate signals from the background stimulus was determined using a method which is described in the procedure section. In addition, this attempted to equate approximately the degree of difficulty on the visual and auditory tasks as the training procedure used in the first experiment was unable to achieve equivalent degrees of difficulty for the two tasks. Visual and auditory signal intensities for the mentally retarded subjects ranged from 18ftl. to 28ftl. (mean 22ftl.) and 32db. to 39db. (mean 34db.) respectively. Visual and auditory signal intensities for the nonretarded subjects varied from 15ftl. to 24ftl. (mean 19ftl.) and 32db. to 39db. (mean 34db.) respectively.

The duration of an experimental session and the inter-signal intervals were the same as in the previous experiment with each 10-minute time block containing 10 signals.

6.2.3 Procedure

The procedure was similar to that used in the first experiment with each subject required to attend three sessions. At the first session, subjects were tested on a visual discrimination training task. Subjects were informed that a light would appear and that sometimes it would be "brighter" for 0.5 second. The subjects initially learned to discriminate between the background stimulus and a signal intensity of 40ftl. Subsequent training was extensive and linked to specific success criterion, with training involving up to 300 trials, with signal intensities ranging from 11 ftl. to 60ftl. Signal intensity was initially 40ftl. but was thereafter varied using a computer controlled parameter estimation by sequential testing ("PEST") procedure (Taylor and Creelman, 1967). This raised or lowered the signal intensity as response accuracy fell below or increased beyond a predetermined level of accuracy of 80%, the equivalent criterion level to that used in Experiment 1, for as many trials as were necessary to achieve this level for a minimum of 10 consecutive trials.

The same procedure applied to the auditory task, commencing at a signal intensity of 55db. Signal intensity ranged from 31db. to 60db. during the training procedure. The total training session lasted up to 30 minutes.

All subjects were able to complete the training on both tasks and thus participated in the final two testing sessions.

Subjects attended the following two sessions to complete the visual and auditory tasks in the same way as in the first experiment. Before each task, practice series of 16 stimuli each were presented at the subject's final training discrimination intensity until a criterion of 13 correct (that is, approximately 80%) was passed.

6.3 RESULTS

6.3.1 Hits

The mean percentage of correct detections (hits) for each successive ten-minute block for the two groups on each task are shown in Figure 6.1. The figure indicates that the nonretarded adults had a higher mean hit rate on each task for each successive time block than the mentally retarded adults. There appeared to be little change in these differences over blocks, indicating that the vigilance decline of both groups was similar. Both groups of subjects had higher hit rates on the auditory task compared with the visual task.

A three-way analysis of variance of Groups by Tasks by Blocks with repeated measures on the last two variables found significant main effects between groups ($F = 7.59$, 1/18 df, $p < 0.05$), tasks ($F = 4.90$, 1/18 df, $p < 0.05$) and over blocks ($F = 10.54$, 4/72 df, $p < 0.01$). Examination of these results in Figure 6.1 indicates that the nonretarded adults scored a higher mean overall hit rate compared with the retarded adults, subjects obtained a higher mean overall hit score on the auditory task and mean hit rates tended to decline across time blocks. However, there were no significant interaction effects which indicated that there was no difference between the mean rates of decline of the two groups on each task.

6.3.2 False Alarms

The mean percentage of commission errors (false alarms) for each successive ten-minute time block for the

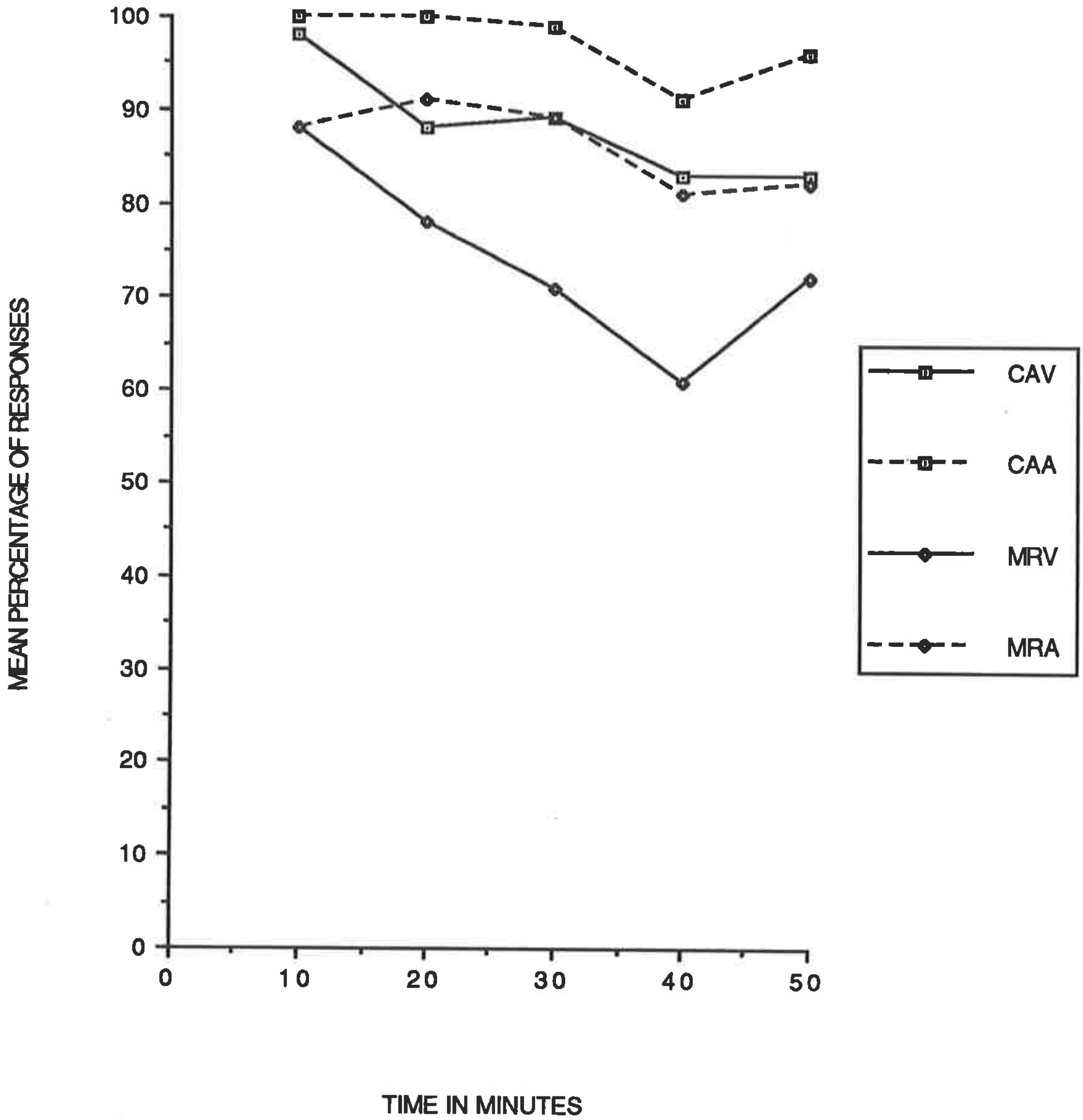

FIGURE 6.1 Mean percentages of hits on both visual (V) and auditory (A) tasks for nonretarded adults (CA) and mentally retarded adults (MR) as a function of time on task.

two groups on each task are shown in Table 6.1. The table indicates that both groups registered relatively few false alarms at each time block. The mentally retarded adults registered the most false alarms on the visual task followed by the auditory. The nonretarded adults registered very few false alarms on either task. A statistical analysis was not conducted due to the low frequency of false alarms registered by both of the subject groups on both tasks.

GROUP	TASK	TIME BLOCK				
		1	2	3	4	5
MR	Visual	3.6	2.0	1.6	1.5	2.2
	Auditory	0.5	0.5	0.8	0.6	0.4
NR	Visual	0.7	0.0	0.1	0.0	0.1
	Auditory	0.1	0.0	0.0	0.1	0.0

TABLE 6.1 Mean percentage of commission errors for each successive time block for the mentally retarded adults (MR) and nonretarded adults (NR) on the visual and auditory tasks.

6.3.3 Signal Detection Theory Analysis

Craig and Colquhoun (1975) have advised against the uncritical use of d' when there are frequent occurrences of no false alarms. Also, the failure to emit false alarms has been the most common reason for not being able to perform a Signal Detection Theory analysis (Jerison et al., 1965). Thus, given the low numbers of false alarms registered by the subjects, a signal detection theory analysis was not performed.

6.4 COMPARISON TO EXPERIMENT 1

Figure 6.2 shows the mean percentage of correct detections (hits) for each successive ten-minute block on the visual and auditory modes of the tasks used in the first two experiments for the mentally retarded and nonretarded adults. A four-way analysis of variance of Experiments (discrete vs continuous stimulus) by Groups (mentally retarded vs nonretarded) by Tasks (visual vs auditory) by Blocks, with repeated measures on the last two variables, found significant main effects between experiments (F = 5.99, 1/36 df, $p < 0.05$), groups (F = 8.28, 1/36 df, $p < 0.01$), tasks (F = 5.15, 1/36 df, $p < 0.05$) and over blocks (F = 13.13, 4/144 df, $p < 0.01$). Examination of these results in Figure 6.2 indicates that subjects had a higher mean overall hit rate on the continuous stimulus task compared to the discrete stimulus task and on the auditory task compared to the visual task. Also, the nonretarded subjects had higher overall hit rates than the mentally retarded subjects and mean hit rates tended to decline over blocks. There were no significant interaction effects. In particular, there was no interaction between conditions and blocks indicating that there was no difference between the mean rates of decline on the discrete and continuous stimulus conditions.

6.5 DISCUSSION

This experiment investigated one possible aspect of the developmental lag in the vigilance performance of mildly mentally retarded subjects. An attention strategy

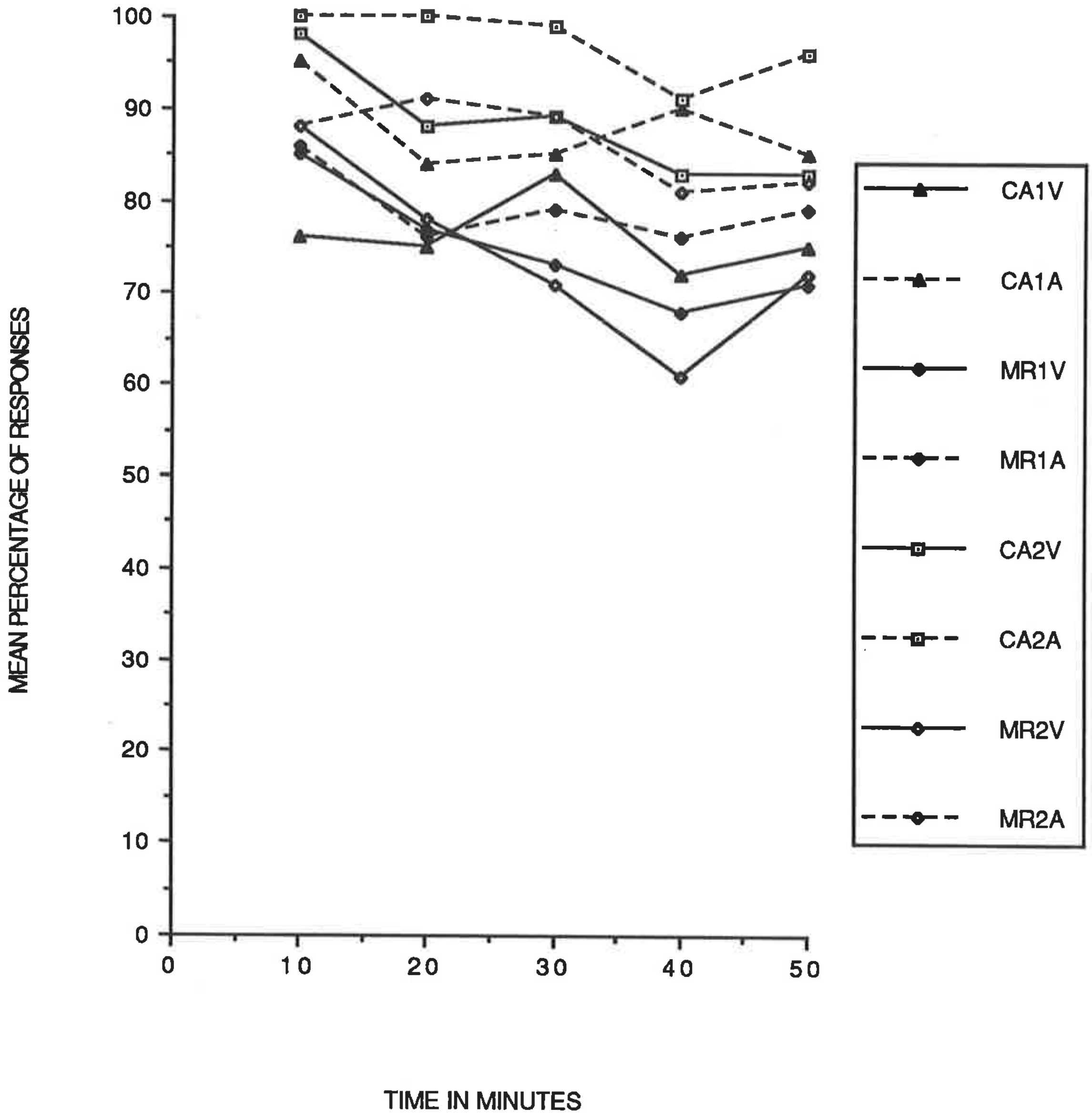

FIGURE 6.2 Mean percentages of hits on both visual (V) and auditory (A) tasks for nonretarded adults (CA1) and mentally retarded adults (MR1) in Experiment 1, and nonretarded adults (CA2) and mentally retarded adults (MR2) in Experiment 2 as a function of time on task.

effect was considered by using a task involving a continuous stimulus source which did not allow subjects the opportunity to predict when inspection of the stimulus source was required. Results were similar to those found in the first experiment in that there was no difference in the rates of decline of average correct detections across time blocks between mildly mentally retarded and nonretarded adults. However, the nonretarded adults showed a significantly higher absolute hit rate compared to the retarded adults. These results indicate that retarded adults are no more dependent on such a strategy than nonretarded adults, although their performance on the task was still inferior overall.

The results again showed similar decrements in hit rates over time blocks on both auditory and visual tasks. Also, higher mean overall scores were found in the auditory mode for all subject groups which implies that the auditory task was again relatively easier than the visual task. The preliminary study attempted to both equate the intensities approximately for the two modes of the task as well as comparative levels of difficulty for all subjects. However, it was not successful in establishing tasks of equal difficulty for both subject groups and in different sensory modes.

There was no difference in the decline of average hit rates across time blocks between the adult subject groups on the discrete stimulus task used in the first experiment and the continuous stimulus task used in this experiment. This result implies that arranging stimulus events so that their occurrence cannot be predicted does not lead to greater decline in vigilance performance for either retarded or nonretarded adults. That is, the ability to predict when inspection of the stimulus source is required is not an important factor in maintaining vigilance performance for these subjects. In fact, subjects scored a higher mean overall hit rate on the continuous stimulus task, which implies that it was relatively easier than the discrete stimulus task. Alternatively, it is possible that the different training procedure used in this experiment resulted in a relatively easier discrimination for both subject groups.

Overall, these results support the conclusions reached in the previous experiment, that the maintenance of vigilance performance of mentally retarded persons is due largely to a general developmental factor and that mildly mentally retarded persons reach the level of nonretarded persons by the age of approximately 17 years.

CHAPTER 7

TASK DIFFICULTY AND WILLINGNESS TO ATTEND

7.1 EXPERIMENT 3

The results of the first experiment indicated that the relatively poorer vigilance performance of mildly mentally retarded persons is to a large extent a factor of mental age up to approximately 17 years. Experiment 2 indicated that mentally retarded adults are able to maintain their vigilance performance over time even when stimulus events cannot be predicted. However, the mentally retarded adults in Experiment 2 scored a lower mean overall detection score than their nonretarded counterparts. Also, the results of Experiment 1 indicated that the greater decline in hit rate across time shown by the mentally retarded children and their nonretarded mental age control counterparts was associated with a sensitivity decrement. The observing response theory, which was discussed in Chapters 2 and 5, has been put forward to explain the sensitivity decrement. One aspect of this theory is that the decision to observe is associated with the cost of observing and increased cost results in a decreased willingness to attend. Poor motivation is one factor which is viewed as increasing the cost of observing. Vigilance tasks are monotonous and may hold little interest for subjects. It is possible that one aspect of the developmental lag could be a decreased willingness to attend to the vigilance task.

Smith (1966) has proposed a motivational theory of vigilance which postulates that nonretarded persons are capable of attending to a vigilance task for up to two hours but differ in their "willingness to do so". Hence, nonretarded persons are assumed not to perform to their ability although there are individual differences in the degree to which they attend. Furthermore, there is some evidence from a study conducted by Locke et al. (1982) which was outlined in Chapter 3, to support consideration of motivational factors in the vigilance performance of mentally retarded persons. A post-experimental interview indicated that the mentally retarded adults found the vigilance task "more boring or otherwise unenjoyable than interesting". It is possible that mentally retarded children find the vigilance situation particularly boring so that their performance and that of the nonretarded children of equivalent mental age in the first experiment may have been due in part to a lack of willingness to continue to attend to the task. That is, mentally retarded persons may be slower to develop a willingness to continue to attend to the vigilance task.

The observing response hypothesis suggests that factors which reduce task demands, such as decreases in event rate, should result in an improvement in detection efficiency. Similarly, the motivation theory proposes that the manipulation of task characteristics such as signal frequency should reduce task monotony and so improve performance. Therefore, if subjects were to be presented with a task in which signal frequency and intensity were altered so as to make the task easier and less demanding, then the possibility of a decreased willingness to attend would be tested.

The purpose of this experiment was to investigate the possibility that mentally retarded children are less prepared than nonretarded children to continue to attend over time to vigilance tasks. Subjects were presented with a relatively easy, but prolonged task which did not conform to the vigilance paradigm. Hence, the task would not test vigilance per se but willingness to continue to attend to the task. The vigilance task used in the previous experiments involved the detection of signals which occurred at irregular and infrequent time intervals with their intensity being near the observer's threshold. Each task was of fifty minutes duration. In this experiment, both signal frequency and intensity were altered so that the task was relatively easier. Signal frequency was altered from irregularly and infrequently occurring to occurring with the same frequency as the nonsignal, that is, the signal-to-nonsignal ratio was set at one-to-one. The intensity of the signal was set at well above the observer's threshold. Task duration remained at 50 minutes.

All groups might be expected to show improved performance under the easier task conditions, at least in terms of mean overall hit rate. However, if mentally retarded children are less prepared to maintain attention over time then they should continue to show a faster decline in performance compared with nonretarded children of the same chronological age. Alternatively, if the retarded children show a similar hit rate over time to that of the nonretarded children then the willingness to continue to attend hypothesis would not be supported.

A visual task only was utilized as the results of the previous two experiments demonstrated that there were no differences between the rates of decline in performance in visual and auditory modes for both nonretarded and retarded groups.

7.2 METHOD

7.2.1 Subjects

There were 7 male and 3 female mentally retarded students from a special school whose IQ scores on the Wechsler Intelligence Scale for Children ranged from 52 to 72 (mean 64). Ages ranged from 11 years 5 months to 15 years 9 months (mean 13 years 9 months). The average mental age for the group was estimated to be 8 years 9 months.

Chronological age control subjects were 5 male and 5 female students from a secondary school. Ages ranged from 12 years 6 months to 14 years 0 months (mean 13 years 0 months).

Mental age control subjects were 5 male and 5 female subjects from a primary school whose ages ranged from 8 years 6 months to 10 years 3 months (mean 9 years 7 months).

Nonretarded subjects were selected whose academic performance was at least average and were thus assumed to be of at least average intelligence.

7.2.2 Apparatus

The apparatus was the same as that used in the visual task of the previous two experiments. There was a circular red light 3cm. in diameter which appeared every 3 seconds for 0.5 second. The nonsignal intensity was the same as that used in the previous experiments, that is, 10ftl. The signal intensity was set at 40ftl., the initial intensity at which subjects learned to discriminate between the nonsignal and signal, and well above their threshold level which was determined using the PEST procedure for each subject.

An experimental session lasted for 50 minutes with each 10 minute time block consisting of 100 signals and 100 nonsignals. The time between signals varied randomly from 3 seconds to 27 seconds.

7.2.3 Procedure

The procedure was similar to that used in the second experiment but with subjects required to attend only two sessions. At the first session subjects learned to discriminate between the nonsignal and a signal of 40ftl. Then the computer controlled sequential testing (PEST) procedure employed in Experiment 2 was again used to determine the lowest intensity at which subjects could discriminate signals from the nonsignal at a level of at least 80% accuracy. In this way, it was possible to ensure that the intensity of the task signal was set well above each subject's threshold level.

All subjects were able to complete the training and thus participated in the second (test) session.

At the second session, subjects were presented with a practice discrimination series of 16 stimuli with the signal intensity set at 40ftl. The series contained an equal number of signals and nonsignals presented in random order. The same criterion as that in the previous experiments was used, that is, 13 correct (approximately 80%). After subjects had passed criterion on the practice series they were informed that they would be presented with a similar sequence but that it would last for about 50 minutes. It was emphasized that there would be an equal number of signal and nonsignal stimuli but that they would occur in random order. Watches were removed and earphones were worn throughout the task to reduce extraneous noise.

7.3 RESULTS

Figure 7.1 shows the mean number of correct detections (hits) and commission errors (false alarms) for each group of subjects on each successive ten-minute block.

7.3.1 Hits

Figure 7.1 indicates similar hit rates across time blocks for the chronological and mental age control groups with the mentally retarded group showing an earlier and more rapid decline. A two-way analysis of variance of Groups by Blocks with repeated measures on the latter variable found significant main effects between groups ($F = 5.20$, 2/27 *df*, $p < 0.05$) and over time blocks ($F = 11.15$, 4/108 *df*, $p < 0.01$). There was also a significant interaction between groups and blocks ($F = 3.65$, 8/108 *df*, $p < 0.01$). Examination of these results in Figure 7.1 indicates that groups differed in their mean overall hit rates, mean hit rates tended to decline over time blocks and there were differences in the mean rates of decline in performance between the three groups.

Two planned comparisons were included in the analysis to further investigate possible differences in performance of the three groups in terms of the developmental lag hypothesis. The first compared the nonretarded 13 year old children with the mentally retarded 14 year old children and nonretarded children of similar mental age. The second compared the last two groups with each other. Results found significant main effects between groups on both the first ($F = 5.74$, 1/27 *df*, $p < 0.05$) and second ($F = 4.67$, 1/27 *df*, $p < 0.05$) comparisons. There were also significant linear interactions between groups and blocks for both the first ($F = 19.58$, 1/108 *df*, $p < 0.01$) and second ($F = 9.00$, 1/108 *df*, $p < 0.01$) comparisons. Further examination of Figure 7.1 indicates that the mentally retarded children scored a lower mean overall hit rate than the other two subject groups. Also, groups differed from each other in their rates of decline in performance across time blocks. The mentally retarded

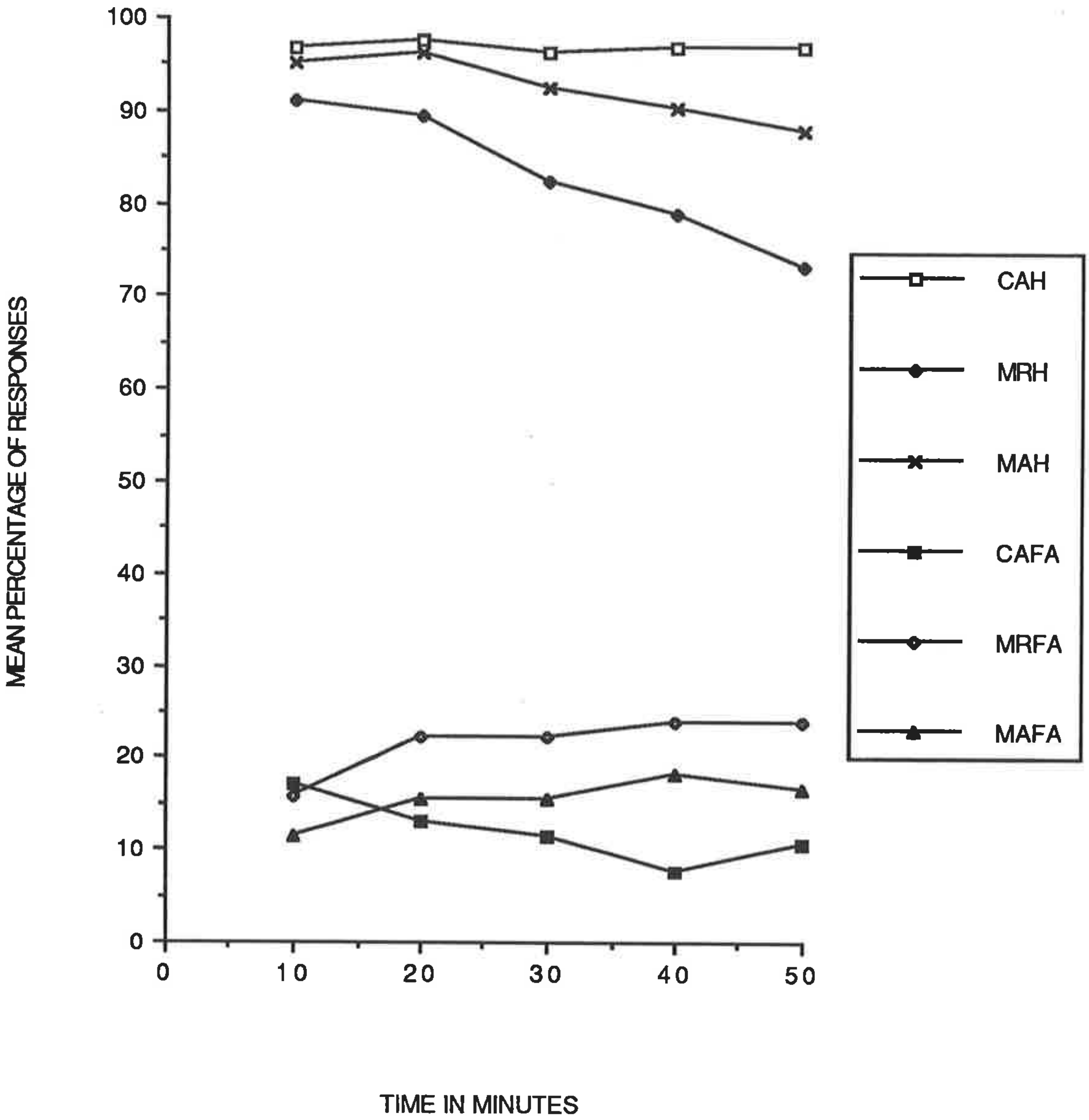

FIGURE 7.1 Mean percentages of hits (H) and false alarms (FA) for nonretarded 13 year old children (CA), mentally retarded 14 year old children (MR) and nonretarded 10 year old children (MA) as a function of time on task.

children and the nonretarded 10 year old children showed a greater mean decline than the nonretarded 13 year old children. In addition, the mentally retarded children showed a greater decline than both of the two nonretarded groups.

7.3.2 False Alarms

Figure 7.1 shows that the mentally retarded group registered the most false alarms followed by the mental age control group which in turn registered more false alarms than the chronological age control group. The retarded and mental age control groups registered progressively more false alarms over time blocks whereas the chronological age control group registered progressively fewer false alarms over blocks. The same analysis of variance model (Groups by Blocks) found only a significant interaction between groups and blocks (F = 2.15, 8/108 df, $p < 0.05$).

The same two planned comparisons as those used for hits were included in the analysis. Results found only a significant interaction between groups and blocks on the first comparison (F = 12.00, 1/108 df, $p < 0.01$). These results confirm the previous observations that the mentally retarded and nonretarded 10 year old children showed similar increments in false alarms registered across time blocks whereas the nonretarded 13 year old children showed a decrement across time blocks.

7.3.3 Signal Detection Theory Analysis

As there were differences in hit and false alarm rates across time blocks between the subject groups sensitivity and criterion values were calculated for each subject at each time block. The same procedure was used to that in Experiment 1 when the percentage of hits or false alarms was 0 or 100. The mean values of d' and ß at each successive time block for each group are shown in Tables 7.1 and 7.2 respectively. Table 7.1 indicates that sensitivity values declined for the mentally retarded 14 year old children and nonretarded 10 year old children. However, there was a small increment in sensitivity values for the nonretarded 13 year old children.

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	3.41	3.81	3.72	3.90	3.72	3.71
MR	2.75	2.31	2.15	1.88	1.67	2.15
MA	3.28	3.37	2.88	2.61	2.51	2.93
MEAN	3.14	3.16	2.91	2.79	2.63	2.93

TABLE 7.1 Mean sensitivity values at each successive time block for the nonretarded 13 year old children (CA), mentally retarded 14 year old children (MR) and nonretarded 10 year old children (MA).

The same analysis of variance model as that used for both hits and false alarms (Groups by Blocks) found significant main effects between groups ($\underline{F}$ = 8.07, 2/27 $\underline{df}$, $\underline{p} < 0.01$) and linearly over blocks ($\underline{F}$ = 5.36, 4/108 $\underline{df}$, $\underline{p} < 0.01$). There was also a significant interaction between groups and blocks ($\underline{F}$ = 3.47, 8/108 $\underline{df}$, $\underline{p} < 0.01$).

Inspection of these results in Table 7.1 indicates that there were differences in the overall mean sensitivity values between the groups, that mean sensitivity values declined across time blocks and that there were differences in the change in sensitivity values across blocks between the three groups. The same two planned comparisons as those used for both hits and false alarms were again included in the analysis to further investigate the developmental lag hypothesis. That is, first the nonretarded 13 year old children were compared with both the mentally retarded 14 year old children and the nonretarded 10 year old children. Second, the last two groups were compared with each other.

A significant main effect was found between groups for the first comparison only (F = 12.14, 1/27 df, $p < 0.01$). There was also a significant interaction between groups and blocks for the first comparison only (F = 23.05, 1/108 df, $p < 0.01$). Inspection of these results in Table 7.1 indicates that the nonretarded 13 year old children had a higher overall mean sensitivity value compared with the other two subject groups. Also, the mentally retarded children and their nonretarded mental age counterparts showed similar sensitivity decrements over time to each other. However, the nonretarded 13 year old children showed little change in sensitivity over time.

The same analysis of variance model as those used for all the previous analyses in this experiment (Groups by Blocks) for the criterion values found a significant main effect across blocks only (F = 2.47, 4/108 df, $p < 0.05$).

Inspection of this result in Table 7.2 indicates that overall mean criterion values increased over time blocks. There was no interaction between groups and blocks which indicates that there were no differences in the change in criterion values over time between the three groups.

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	0.34	0.21	0.60	0.52	0.51	0.43
MR	1.64	0.64	1.04	1.25	2.51	1.42
MA	0.57	0.49	0.65	1.16	0.92	0.76
MEAN	0.85	0.45	0.76	0.98	1.31	0.87

TABLE 7.2 Mean criterion values across time blocks for the nonretarded 13 year old children (CA), mentally retarded 14 year old children (MR) and nonretarded 10 year old children (MA).

7.4 COMPARISON TO EXPERIMENT 1

The performances of the three subject groups in this experiment were compared with the performances of the corresponding groups on the visual task in Experiment 1 to establish any differences under the two task conditions. In particular, it was important to determine if the performances of the mentally retarded children in this experiment and the nonretarded 13 year old children in the first experiment were comparable.

7.4.1 Hits

Figure 7.2 shows the mean percentage of correct detections (hits) on each successive time block for the nonretarded 9/10 and 13 year old children, and mentally retarded 14 year old children in both the first and third experiments. The figure shows that each of the three subject groups in the third experiment scored a higher mean hit rate at each time block than their counterparts in the first experiment. In addition, the mean rates of decline in performance of the mentally retarded and nonretarded 10 year old children in the third experiment do not appear as fast compared with the corresponding groups in the first experiment. The retarded children in this experiment showed similar hit rates at each time block to the nonretarded 13 year old children in the first experiment.

A three-way analysis of variance of Groups by Experiments by Blocks with repeated measures on the last variable found, in particular, a significant main effect between experiments ($F = 79.24$, 1/54 df, $p < 0.01$), and significant interactions between experiments and blocks ($F = 14.7$, 4/216 df, $p < 0.01$), as well as between groups, experiments and blocks ($F = 4.82$, 8/216 df, $p < 0.01$). A separate analysis of variance of Groups by Blocks with repeated measures on the latter variable compared the mentally retarded children in the third experiment with the nonretarded 13 year old children in the first experiment. Results did not show either a main effect between groups or an interaction effect between groups and blocks.

Examination of these results in Figure 7.2 supports the previous observations. Groups in the third experiment scored a higher mean overall hit rate, and showed a slower

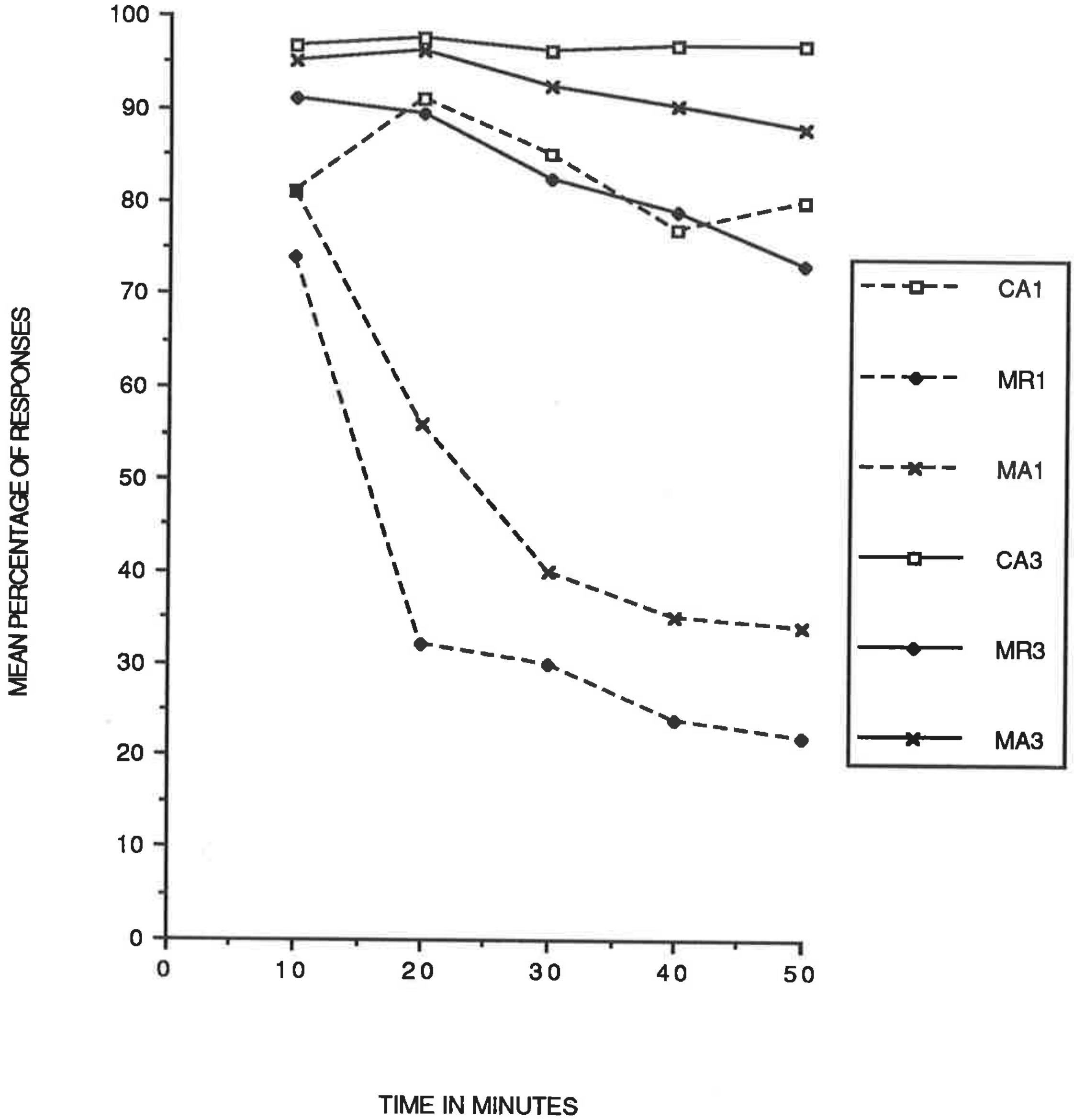

FIGURE 7.2 Mean percentages of hits for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1), and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA3), mentally retarded 14 year old children (MR3) and nonretarded 10 year old children (MA3) in Experiment 3 as a function of time on task.

decline in mean hit rates across time blocks compared with groups in the first experiment. In addition, there was no difference in either mean overall hit rates or mean rates of decline in performance between the mentally retarded children in Experiment 3 and nonretarded 13 year old children in Experiment 1. Thus, given easier task conditions the mentally retarded 14 year old children were able to show similar hit rate performance as nonretarded children of similar chronological age on a more difficult task with characteristics which conformed with the vigilance paradigm.

7.4.2 False Alarms

Figure 7.3 shows the mean number of commission errors (false alarms) registered at each time block by the three groups in Experiment 3 and the corresponding groups in Experiment 1. The figure indicates that more false alarms were registered by the mentally retarded and nonretarded 13 year old children in the third experiment compared with their counterparts in the first experiment.

The same analysis of variance model as that used for hits (Groups by Experiments by Blocks) found only a significant interaction between experiments and blocks ($F = 4.18$, 4/216 df, $p < 0.01$) This result indicates that, whilst groups registered similar mean overall false alarms in both experiments, there was a difference in the mean false alarms registered across time blocks between the experiments. Table 7.3 shows the mean number of false alarms registered at each time block by the relevant

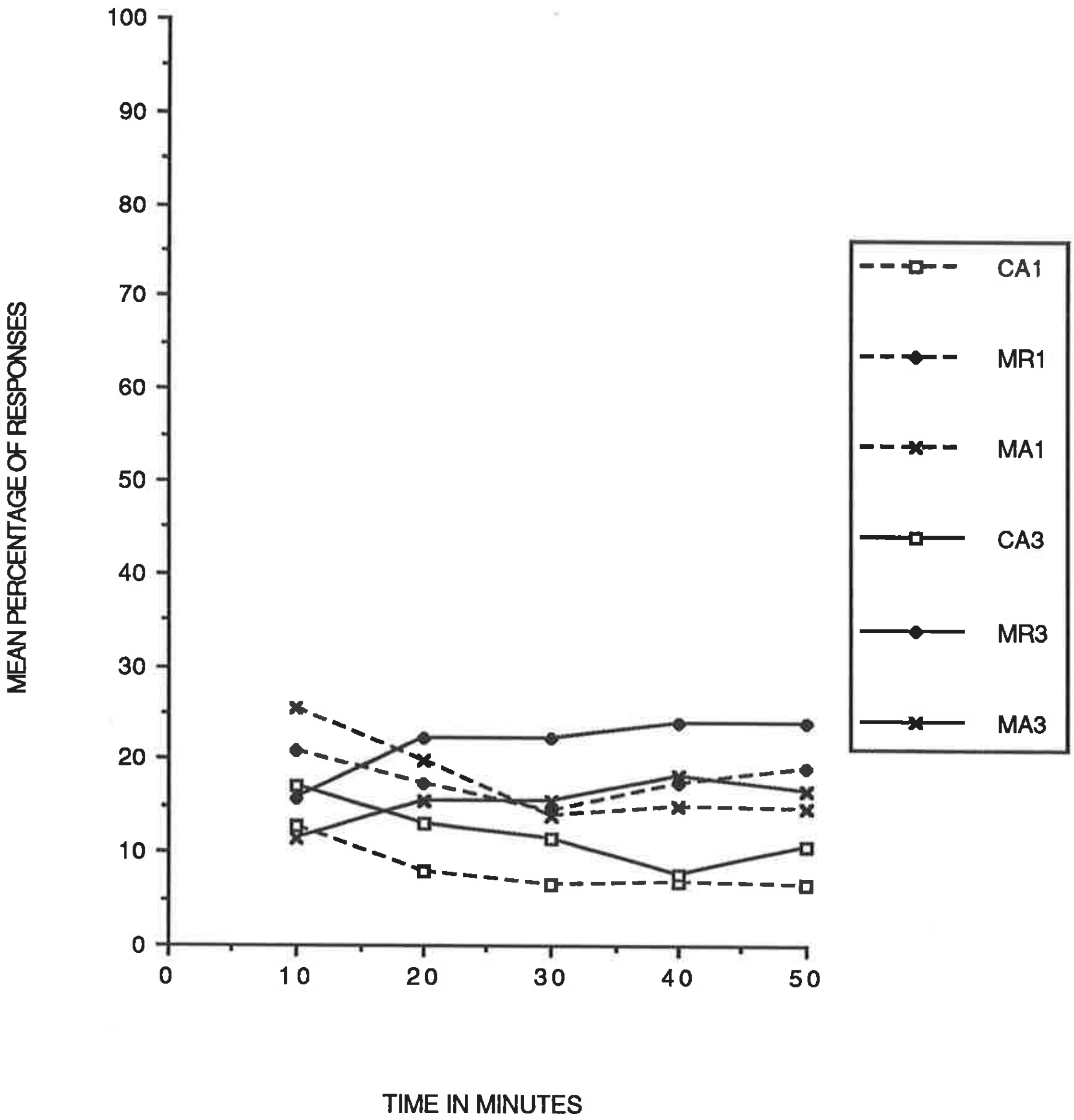

FIGURE 7.3 Mean percentages of false alarms for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA3), mentally retarded 14 year old children (MR3) and nonretarded 10 year old children (MA3) in Experiment 3 as a function of time on task.

groups in Experiments 1 and 3, and reflects the significant interaction between groups and experiments. The table indicates that the groups in Experiment 1 registered more mean false alarms at the first block but showed a decline thereafter. However, the groups in Experiment 3 showed a small increment in false alarms across time blocks.

EXPERIMENT	BLOCK 1	2	3	4	5
1	19.7	15.1	11.7	13.1	13.6
3	14.8	16.9	16.3	16.6	17.1

TABLE 7.3 Total mean overall number of false alarms registered at each time block by the mentally retarded, nonretarded 13 year old and 9/10 year old children combined in Experiments 1 and 3.

The same separate analysis of variance model as that used for hits (Groups by Blocks) comparing the mentally retarded children in Experiment 3 with the nonretarded 13 year old children in Experiment 1 found both a significant main effect between groups (F = 10.01, 1/54 df, $p < 0.01$) and a significant interaction between groups and blocks (F = 8.98, 1/216 df, $p < 0.01$). Examination of these results in Figure 7.2 shows that the mentally retarded children in Experiment 3 registered a greater number of false alarms than the nonretarded 13 year old children in Experiment 1. Also, the former group showed an increment over time blocks whereas the latter showed a decrement. Thus, even with easier task conditions the mentally retarded 14 year old children registered more false alarms than the nonretarded children of equivalent chronological age on the more difficult vigilance task.

7.4.3 Signal Detection Theory Analysis

The mentally retarded 14 year old children in this experiment were compared with the nonretarded 13 year old children in Experiment 1 to determine whether the easier task conditions had resulted in an alleviation of the sensitivity decrement or a change in criterion values. Table 7.3 shows the mean sensitivity and criterion values at each time block for both groups.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	2.30	3.55	3.09	2.97	3.10	3.00
MR:Exp 3	2.75	2.31	2.15	1.88	1.67	2.15

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	1.59	2.18	2.45	4.73	13.88	4.97
MR:Exp 3	1.64	0.64	1.04	1.25	2.51	1.42

TABLE 7.3 Mean sensitivity and criterion values for the nonretarded 13 year old children in Experiment 1 (CA:Exp 1) and mentally retarded 14 year old children in Experiment 3 (MR:Exp 3).

An analysis of variance of Groups by Blocks with repeated measures on the latter variable found a significant main effect between groups (F = 6.06, 1/54 df, $p < 0.05$) and a significant interaction between groups and blocks (F = 13.56, 1/216 df, $p < 0.01$) for the sensitivity values. Similarly, there was a significant interaction between groups and blocks ($\underline{F}$ = 7.47, 1/216 $\underline{df}$, $\underline{p}$ < 0.01) for the criterion values. Inspection of these results in Table 7.3 indicates that the mentally retarded 14 year old children in this experiment had lower overall mean sensitivity values compared with the nonretarded 13 year old children in Experiment 1. Also, the former group still showed a decline in sensitivity across time and little change in criterion compared with the latter group which showed an increase in both sensitivity and criterion across time.

7.5 DISCUSSION

The purpose of this experiment was to investigate the possibility that mentally retarded children find the vigilance task relatively less interesting than nonretarded children of corresponding chronological age and so are not prepared to continue to attend for the duration of the task. A relatively easier task was used to test this hypothesis.

Results found that the mentally retarded children scored a lower mean overall hit rate and showed a significantly faster rate of decline in performance across time blocks compared with nonretarded children of both equivalent chronological and mental age. The nonretarded 10 year old children in turn showed a faster decline in performance compared with the nonretarded 13 year old children. The three groups in this experiment showed a higher mean overall hit rate and a slower mean rate of decline compared with the corresponding three groups in the first experiment which used more difficult task characteristics. In addition, there were no significant differences in either mean overall hit rates or rates of decline in performance between the mentally retarded children in this experiment and the nonretarded 13 year old children in the first experiment.

There were no differences in the mean absolute number of false alarms registered by the three groups in this experiment. However, there were significant differences in the number of false alarms registered across time blocks by the three subject groups. Both the retarded and mental age control groups registered progressively more false alarms whereas the chronological age control group showed a decline in false alarms. The three groups in this experiment and the corresponding groups in the first experiment registered similar absolute numbers of false alarms. However, the combined results for subjects in the third experiment showed progressively more false alarms over time blocks whereas the results for subjects in the first experiment showed progressively fewer false alarms. In addition, the mentally retarded children in the third experiment registered more absolute false alarms compared with the nonretarded 13 year old children in the first experiment.

Overall, these results show that the performance of both mentally retarded and nonretarded children improved under task conditions which were relatively easier than those used in a previous experiment. The improvement was shown in terms of a higher mean overall hit rate and a slower rate of decline in hits over time, whilst similar absolute numbers of false alarms were registered. A relatively greater improvement in performance was shown by the mentally retarded children and nonretarded 10 year children compared with the nonretarded 13 year old children. However, the improvement which the latter group of children could show was limited because of the ceiling effect.

The faster decline in detection rate shown by the mentally retarded children relative to the two nonretarded groups of children in this experiment suggests that willingness to continue to attend may be a factor in the greater vigilance decrement of retarded children. However, this factor is not sufficient to fully explain the performance of mentally retarded children since their performance did improve markedly in comparison to their counterparts in Experiment 1. In fact, the performance of the mentally retarded children in this experiment was equal to that of the nonretarded children of similar chronological age in Experiment 1.

This finding raises the question of the nature of the "unwillingness" of mentally retarded children to continue to attend to the vigilance task. Given that the retarded children registered an increasing number of false alarms over time, their performance decrement might be due to a memory loss of the task requirements, that is, confusion about which stimulus to respond to due to the equal signal-to-nonsignal ratio. Alternatively, it might involve a fatigue effect due to the continual need to decide whether the stimulus presented was a signal or a nonsignal. Both these explanations would be consistent with the finding of a sensitivity decrement for the mentally retarded children and nonretarded children of similar mental age.

CHAPTER 8

THE EFFECTS OF SIGNAL INTENSITY AND FREQUENCY ON THE VIGILANCE DECREMENT

The last experiment demonstrated that variation of visual vigilance task characteristics in such a way as to make the task easier improved the performance of both nonretarded and mildly mentally retarded children. However, the retarded children still showed a decrement in performance over time which was significantly faster than nonretarded children of both equivalent chronological and mental age. This difference in rates of decline was not as marked as it had been between the mentally retarded children and nonretarded children of similar chronological age on the vigilance task used in the first experiment. In fact, performance improved to the extent that there was no difference in either overall hit scores or rates of decline in hits over time between the mentally retarded children on the relatively easier task and nonretarded children of similar chronological age on the vigilance task used in the first experiment.

These results indicated that while willingness to continue to attend to the task might be a significant factor in the greater vigilance decrement shown by mentally retarded children, it is not sufficient to explain the total decrement. However, the results did indicate that signal characteristics are significant determinants of the decrement and that the decrement might be explained by either a fatigue or memory loss hypothesis.

In studies involving nonretarded persons, detection rates have been enhanced by increasing signal intensity or frequency (see Section 2.4.2 and 2.4.3). Both signal intensity and frequency were altered in the last experiment. It is possible that alteration of only one of these variables is important in improving absolute vigilance performance and decreasing the rate of decline of performance of mentally retarded children. The following two experiments considered the relative importance of signal intensity and frequency in determining the decline in vigilance performance of retarded children by varying each of these task characteristics separately.

8.1 EXPERIMENT 4

This experiment investigated the effect of altering signal intensity on the vigilance performance of mildly mentally retarded children. A task was used in which the signal intensity was set well above the observer's threshold. Signal frequency remained irregular and low, as it had been in the first two experiments. If difficulty of discrimination is an important determinant of vigilance performance this alteration in task characteristic should result in an improvement in the performance of all subject groups. If discriminability is a significant factor of the vigilance decrement for the mentally retarded children, then they would be expected to show a relatively greater improvement in detection performance. Thus, the sensitivity decrement found in Experiment 1 would be expected to be reduced or eliminated.

A signal intensity set well above threshold level might be expected to offset the effects of fatigue. If, as suggested in Chapter 5, the nerve cells become insensitive through fatigue, then a stronger stimulus would be required to continue to operate them. Alternatively, if fatigue is an overarousal effect then an increase in noise level would result. Hence, stronger signals would be required to maintain the signal-to-noise ratio and so the effective strength of the signal. If the retarded children maintain their performance over time to a similar level as nonretarded children of equivalent chronological age, then this would indicate that signal intensity is an important determinant of the greater decline in vigilance for mentally retarded persons. In addition, failure to find a sensitivity decrement for the mentally retarded children would provide some support for the fatigue hypothesis.

8.2 METHOD

8.2.1 Subjects

There were 5 male and 5 female mentally retarded students from a special school whose IQ scores on the Wechsler Intelligence Scale for Children ranged from 48 to 75 (mean 59). Ages ranged from 12 years 1 month to 16 years 9 months (mean 14 years 9 months). The average mental age of the group was estimated to be 8 years 8 months.

Chronological age control subjects were 5 male and 5 female students from a secondary school. Ages ranged from 13 years 0 months to 13 years 9 months (mean 13 years 5 months).

Mental age control students were 5 male and 5 female students from a primary school. Ages ranged from 7 years 8 months to 9 years 6 months (mean 8 years 6 months).

Nonretarded children were selected whose academic performance was at least average and thus were assumed to be at least of average intelligence.

8.2.2 Apparatus and Stimulus Sequence

The apparatus was the same as that used in the visual task of all previous experiments. The stimulus sequence was exactly the same as that used in the first experiment. That is, time blocks consisted of 10 signals and 190 nonsignals and the time between signals varied randomly from 9 seconds to 141 seconds. Nonsignal and signal intensities were set at 10ftl. and 40ftl. respectively, the same as that used in Experiment 3.

8.2.3 Procedure

The procedure used was the same as that in Experiment 3, with subjects required to attend two sessions. At the first session, subjects learned to discriminate between the nonsignal and a signal of 40ftl. Then the lowest intensity at which subjects could discriminate signals from the nonsignals was found using the PEST procedure to ensure that 40ftl. was well above the threshold value for each subject.

All subjects were able to complete the training and thus participated in the second session.

At the second session, subjects were presented with the same practice discrimination series as in previous experiments but with the signal intensity set at 40ftl. After subjects had passed criterion on the practice series they were informed that they would be presented with a sequence containing similar intensities of signal and nonsignal but that it would last for about 50 minutes. It was emphasized that the signal stimulus would not occur very often and at varying times.

8.3 RESULTS

Figure 8.1 shows the number of correct detections (hits) and commission errors (false alarms) for each subject group in terms of the mean percentage for each successive ten-minute block.

8.3.1 Hits

Figure 8.1 indicates that the three subject groups showed similar mean rates of decline in performance over time blocks with the mentally retarded group scoring the lowest mean overall hit rate. However, a two-way analysis of variance of Groups by Blocks with repeated measures on the latter variable found only a significant main effect over blocks ($\underline{F}$ = 6.38, 4/108 $\underline{df}$, $\underline{p} < 0.01$). There was no

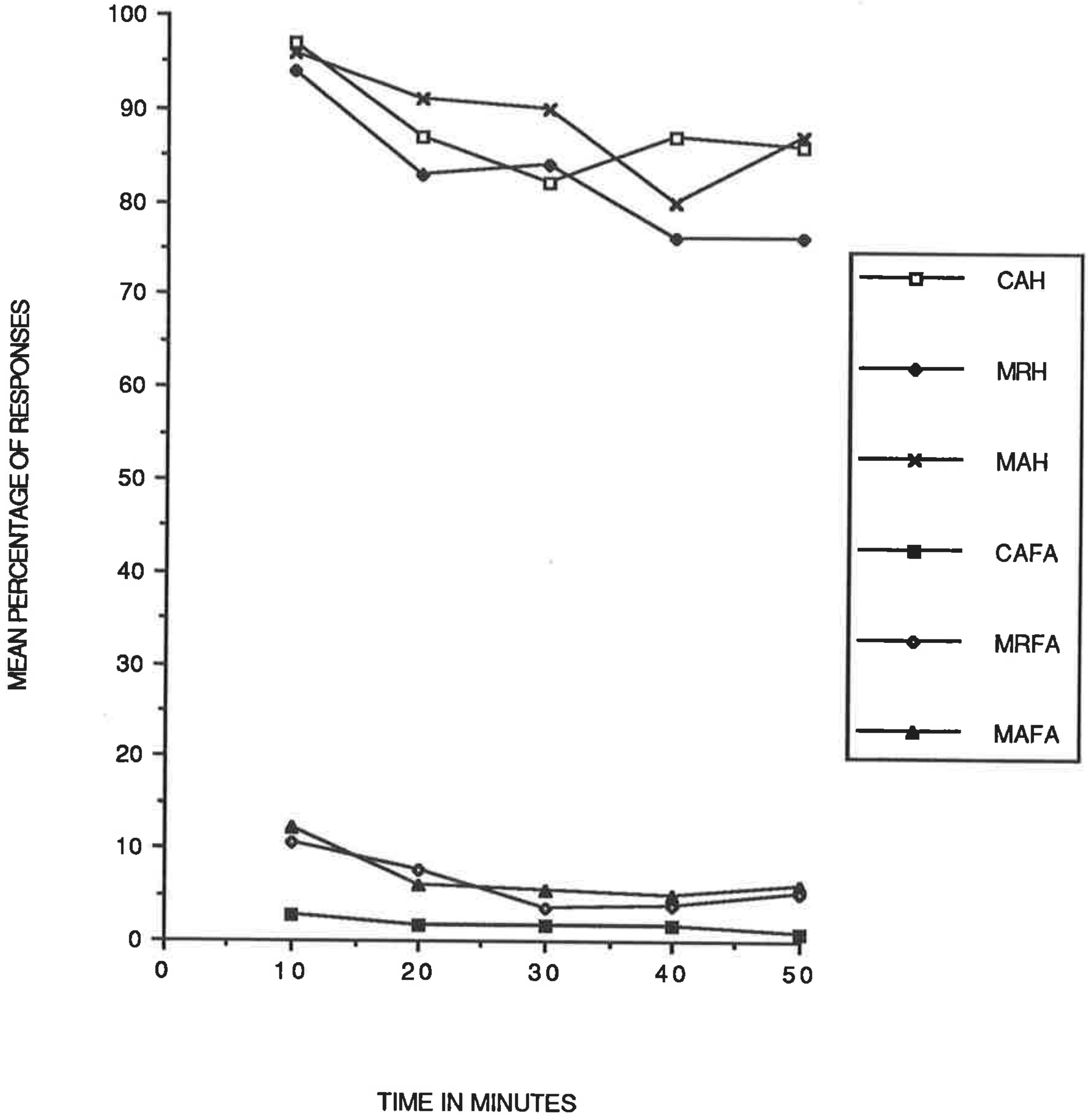

FIGURE 8.1 Mean percentages of hits (H) and false alarms (FA) for nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA) as a function of time on task.

significant main effect between groups and no significant interaction effect. This result indicates that mean hit rates tended to decline over time blocks but that there were no differences between the overall means and rates of decline of correct detections for the three subject groups.

8.3.2 False Alarms

Figure 8.1 also shows that all groups demonstrated similar rates of decline of mean false alarms over time blocks. The retarded and nonretarded children of equivalent mental age registered similar mean overall number of false alarms and the chronological age control group registered the fewest mean overall number. The same two-way analysis of variance model as that used for hits (Groups by Blocks) found only a significant main effect over blocks (F = 10.04, 4/108 df, $p < 0.01$). This result indicates that mean number of false alarms registered tended to decline over time blocks. Again there was no significant interaction effect which shows that there were no differences in the decline of false alarm rates over time between the groups.

8.3.3 Signal Detection Theory Analysis

The similar decrements in hit and false alarm rates shown by the three subject groups might be expected to reflect similar trends in sensitivity and criterion values. The decline in both hits and false alarms should reflect an increase in criterion with little or no change in sensitivity. Hence, sensitivity and criterion values were calculated for each subject at each time block using the same method as that used in the previous experiments.

Table 8.1 shows the mean sensitivity and criterion values at each time block for each subject group. The same analysis of variance model as that used for hits and false alarms (Groups by Blocks) found only a significant main effect across blocks both linearly ($\underline{F}$ = 13.59, 1/108 $\underline{df}$, $\underline{p}$ < 0.01) and quadratically ($\underline{F}$ = 5.78, 1/108 $\underline{df}$, $\underline{p}$ < 0.05) for the criterion values. There were no other significant results for either sensitivity or criterion values, including no interaction between groups and blocks.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	4.80	4.22	4.03	4.38	4.50	4.38
MR	3.90	3.12	3.70	3.15	3.47	3.47
MA	3.82	3.85	4.30	3.34	3.40	3.74
MEAN	4.17	3.73	4.01	3.62	3.79	3.86

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	6.0	29.8	36.9	44.1	48.0	33.0
MR	0.7	9.8	30.7	41.9	16.2	19.9
MA	0.4	1.4	12.1	16.0	6.8	7.3
MEAN	2.4	13.6	26.6	34.0	23.7	20.0

TABLE 8.1 Mean sensitivity and criterion values for the nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA).

Inspection of these results in Table 8.1 indicates that there were no differences in mean overall sensitivity and criterion values between the groups. In addition, mean sensitivity values did not change significantly over blocks whereas mean criterion values increased over blocks. Finally, there were no differences between the groups in mean sensitivity and criterion values across blocks. Thus, there was an increase in criterion over time, but no change in sensitivity, for all groups under the task conditions utilized in this experiment.

8.4 COMPARISON TO EXPERIMENT 1

The performances of the three subject groups in this experiment were compared with the performances of the equivalent groups in Experiment 1 to determine relative changes in performance when a signal with an intensity set well above threshold level was used.

8.4.1 Hits

Figure 8.2 shows the mean percentage of correct detections (hits) at each time block for the three subject groups in this experiment and the corresponding groups in Experiment 1. The figure shows that the mentally retarded children and nonretarded 9 year old children in the fourth experiment scored a higher mean hit rate at each time block and showed a slower rate of decline than their counterparts in the first experiment. The nonretarded 13 year old children in the fourth experiment scored a higher overall hit rate but showed a similar rate of decline as their nonretarded counterparts in the first experiment.

A three-way analysis of variance of Groups by

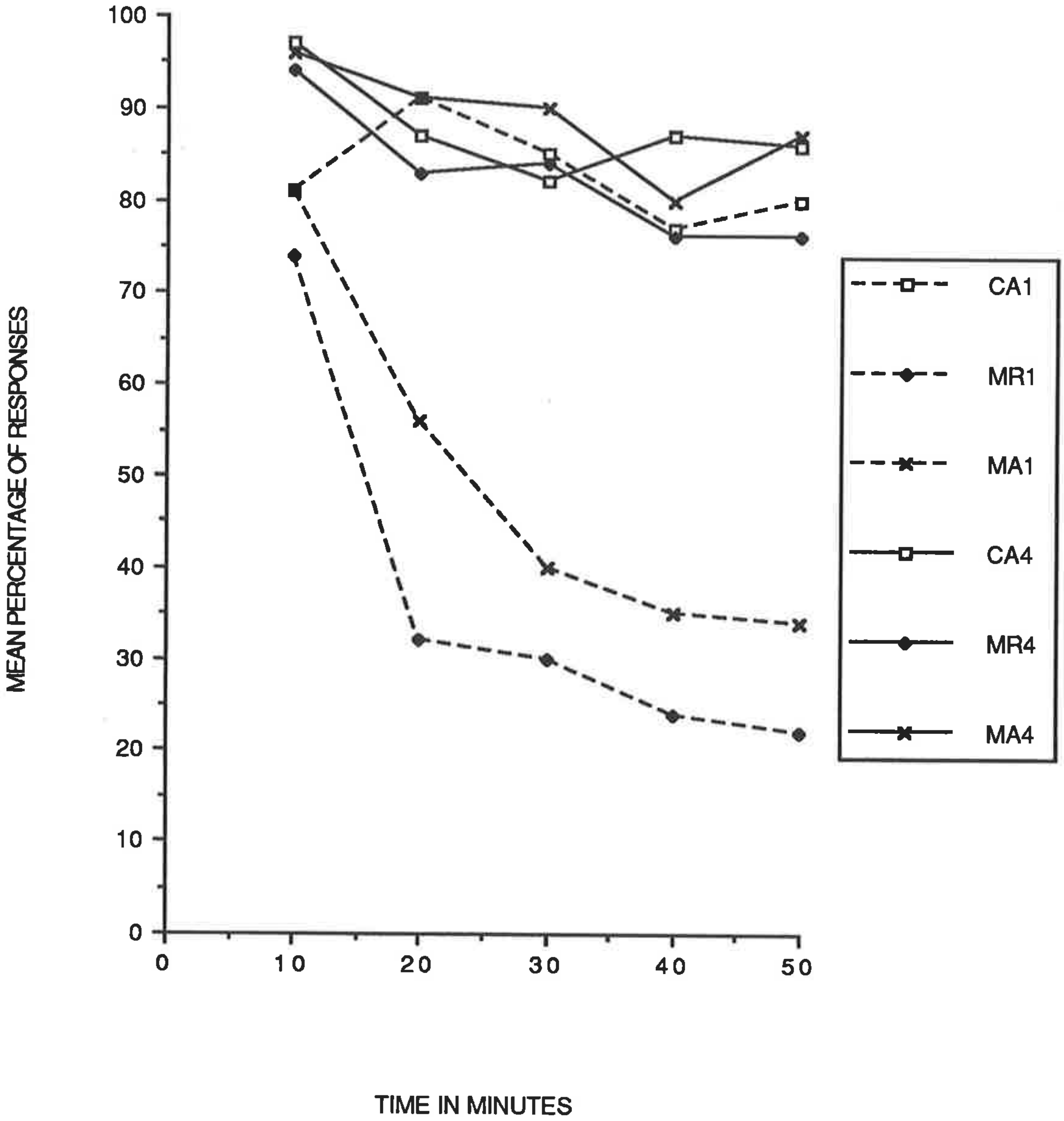

FIGURE 8.2 Mean percentages of hits for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA4), mentally retarded 15 year old children (MR4) and nonretarded 9 year old children (MA4) in Experiment 4 as a function of time on task.

Experiments by Blocks with repeated measures on the last variable found, in particular, a significant main effect between experiments ($F = 50.60$, 1/54 df, $p < 0.01$), significant interactions between experiments and blocks ($F = 5.81$, 4/216 df, $p < 0.01$), and between groups, experiments and blocks ($F = 4.35$, 8/216 df, $p < 0.01$). Examination of these results in Figure 8.2 indicates that groups in the fourth experiment showed a higher mean overall hit score and a slower rate of decline across time blocks compared to groups in the first experiment.

A separate analysis of variance of Groups by Blocks with repeated measures on the latter variable compared the mentally retarded children in the fourth experiment with the nonretarded 13 year old children in the first experiment. Results did not find either a main effect between groups or an interaction effect between groups and blocks. This indicates that there was no difference in either mean overall hit scores or rates of decline between the two groups of subjects. Thus, given a signal intensity set well above threshold level mentally retarded 15 year old children show similar detection efficiency for signals with a low probability as nonretarded children of similar chronological age with signal intensity set near to threshold.

8.4.2 False Alarms

Figure 8.3 shows the mean percentage of commission errors (false alarms) registered at each time block by the three groups in the fourth experiment and the

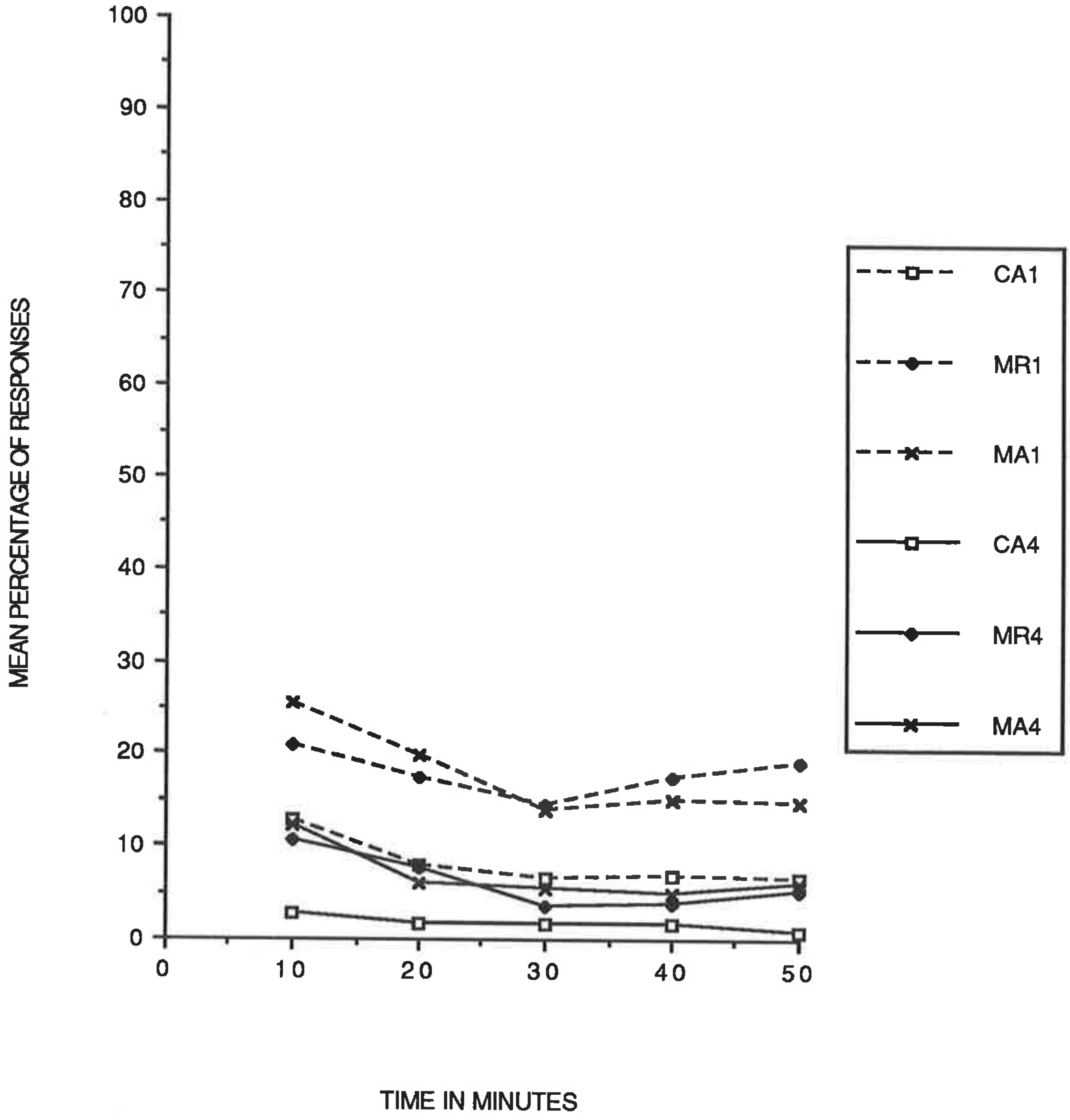

FIGURE 8.3 Mean percentages of false alarms for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA4), mentally retarded 15 year old children (MR4) and nonretarded 9 year old children (MA4) in Experiment 4 as a function of time on task.

corresponding groups in the first experiment. The figure shows that each group in the fourth experiment registered fewer false alarms at each time block than their corresponding groups in the first experiment. In fact, each of the groups in the fourth experiment registered fewer false alarms than each of the groups in the first experiment.

The same analysis of variance model as that used for hits (Groups by Experiments by Blocks) found only a significant main effects between experiments ($F = 29.89$, 1/54 df, $p < 0.01$). This result indicates that fewer overall false alarms were registered on the fourth experiment compared with the first experiment. There was no interaction between experiments and blocks indicating that there was no difference in the trends in mean false alarms registered over time between the two experiments.

8.4.3 Signal Detection Theory Analysis

The similarity in detection performance and lower overall commission error rate shown by the mentally retarded children in this experiment compared with their nonretarded counterparts in Experiment 1 might be expected to reflect similar sensitivity and criterion trends across time blocks. Table 8.2 shows the mean sensitivity and criterion values for the mentally retarded children in this experiment and the nonretarded 13 year old children in Experiment 1.

A two-way analysis of variance of Groups by Blocks with repeated measures on the latter variable found only a significant main effect between groups for mean criterion values ($F = 4.14$, 1/54 df, $p < 0.05$). These results indicate, as can be seen in Table 8.2, that the mentally retarded children in Experiment 4 had a higher overall mean criterion value compared with their nonretarded counterparts in Experiment 1. Furthermore, there were no differences between the two groups in their sensitivity and criterion trends over time.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	2.30	3.55	3.09	2.97	3.10	3.00
MR:Exp 4	3.90	3.12	3.70	3.15	3.47	3.47

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	1.59	2.18	2.45	4.73	13.88	4.97
MR:Exp 4	0.73	9.76	30.68	41.91	16.21	19.86

TABLE 8.2 Mean sensitivity and criterion values for the nonretarded 13 year old children in Experiment 1 (CA:Exp 1) and mentally retarded 15 year old children in Experiment 4 (MR:Exp 4).

8.5 DISCUSSION

Mentally retarded and nonretarded children were presented with a task identical to that used in the first experiment except that the signal intensity had been increased. The intensity was set well above, rather than near, their threshold level.

Results found no differences in the absolute hit scores or rates of decline in hits across time blocks between the retarded children and nonretarded children of both equivalent chronological and mental age. All groups showed a significant decline in performance over time. Similarly, there were no differences in the rates of decline in false alarms for the three subject groups or in absolute number of false alarms registered. The results of the signal detection theory analysis indicated that the subjects from the three groups became more cautious in responding with time on task but without loss in perceptual sensitivity.

Subject groups showed superior performance to their corresponding groups in the first experiment in which the signal intensity was near threshold level. Subjects in this experiment scored a higher overall hit rate, showed a slower hit rate decline and registered fewer false alarms when compared with their counterparts in the first experiment. The mentally retarded children in this experiment showed similar performance to the nonretarded 13 year old children in the first experiment. There were no differences in overall hit scores, rates of decline and numbers of false alarms registered. In addition, there were no differences in the trends across time in both sensitivity and criterion between the two groups.

Taken together, these results indicate that mentally retarded children can maintain their performance over time to the same level as nonretarded children of equivalent chronological age on a visual task which uses a signal stimulus set well above their threshold level. Thus the mentally retarded children in this experiment were no less willing to continue to attend to the task than the nonretarded children. The results support the possibility that signal intensity is a significant factor in the vigilance performance of mildly mentally retarded children. Furthermore, it was hypothesized that a signal set well above threshold level would continue to operate nerve cells as they become insensitive through fatigue or would maintain the signal-to-noise ratio as neural noise level rose. In this way, perceptual sensitivity was expected to be maintained over the duration of the task. Therefore, the result of no significant change in sensitivity over time, provides some support for the fatigue theory forwarded to account for the loss of perceptual sensitivity associated with the greater vigilance decline shown by the mentally retarded children in Experiment 1.

A signal intensity set well above threshold level was also used in Experiment 3 but a sensitivity decrement was still found for the mentally retarded children even though the task would appear to be easier since, in addition, signals occurred frequently rather than infrequently. However, this sensitivity decrement was associated with an increment in false alarms across time blocks. The high signal frequency might have led to confusion about which stimulus to respond to, or fatigue at having to make more responses.

8.6 EXPERIMENT 5

This experiment investigated the effect that changing the signal frequency had on the vigilance performance of mentally retarded children. The task involved the detection of a signal stimulus which occurred as often as the nonsignal stimulus. The intensity of the signal was set slightly above the observer's threshold level as in the first two experiments. If signal frequency is a significant determinant of ability to maintain vigilance performance, then all subject groups might be expected to show improvement on this task when compared with performance on the first experiment. If the retarded children were to show similar average hit rates at each successive block as nonretarded children of equivalent chronological age then the possibility that signal frequency is a decisive factor in their performance would be supported. However, if the retarded children show a more rapid decline in performance over time than nonretarded children, then this possibility would not be supported.

An increase in the probability of a signal occurring would also test the memory theory proposed to account for the sensitivity decrement as outlined in Chapter 5. Davies and Parasuraman (1982) suggested that if the sensitivity decrement is related to loss of output of a memory trace, then an increase in signal rate should arrest the process. Similarly, Dornic (1967) proposed that nonsignals disrupt the memory trace and that the degree of disruption or consolidation is proportional to the number of intervening nonsignals and signals respectively. Hence, an increase in the signal rate should reduce or remove the sensitivity decrement. Therefore, a reduction or removal of the sensitivity decrement for the mentally retarded children in addition to a finding of similar declines in detection performance between the subject groups would support the memory theory.

8.7 METHOD

8.7.1 Subjects

The mentally retarded group consisted of 6 male and 4 female students from a special school whose IQ scores on the Wechsler Intelligence Scale for Children ranged from 49 to 75 (mean 62). Ages ranged from 13 years 8 months to 16 years 9 months (mean 15 years 0 months). The average mental age of this group was estimated to be 9 years 4 months.

The chronological age control group consisted of 5 male and 5 female students from a secondary school whose ages ranged from 12 years 8 months to 13 years 9 months (mean 13 years 3 months).

Mental age control subjects were 4 male and 6 female students from a primary school. Ages ranged from 8 years 5 months to 9 years 6 months (mean 8 years 11 months).

Nonretarded subjects were selected whose academic performance was at least average and thus were assumed to be at least of average intelligence.

8.7.2 Apparatus and Stimulus Sequence

The apparatus was the same as that used in all the previous experiments. The stimulus sequence was similar to that used in the third experiment except that each ten-minute block consisted of approximately an equal number of signals and nonsignals. Owing to changes in computer programmes at this time, exactly equal numbers of signals and nonsignals could not be obtained.

The nonsignal stimulus intensity was set at 10ftl. and the signal intensity 20ftl., the same as that used in the first experiment. The number of signals per block ranged from 79 to 115 (mean 100) and nonsignals from 85 to 121 (mean 100). The time between signals varied randomly from 3 seconds to 27 seconds.

8.7.3 Procedure

The procedure was the same as that used in the first experiment, except that subjects were only required to attend two sessions. At the first session, subjects initially learned to discriminate between a nonsignal of 10ftl. and a signal of 40ftl. The difference between the intensities was progressively reduced by 5ftl., as it had been in the first experiment, until discrimination was achieved at a nonsignal intensity of 10ftl. and a signal intensity of 20ftl. This procedure was used to make it the same as that in Experiment 1.

Two mentally retarded subjects failed to pass criterion at the final test level and did not participate further.

At the second session, a final practice series was presented again prior to presentation of the 50-minute task. It was emphasized that there would be an equal number of signal and nonsignal stimuli but that they would occur in random order.

8.8 RESULTS

Figure 8.4 shows the mean percentage of correct detections (hits) and commission errors (false alarms) for each successive ten-minute block for each of the three subject groups. Raw data for subjects in terms of the ratios of hits-to-signals and false alarms-to-nonsignals are shown in Appendix B-5.

8.8.1 Hits

Figure 8.4 shows that the chronological age control subjects maintained their hit rate performance at a consistent level over time. The mental age control subjects had a lower mean hit score at each time block but also showed relatively consistent performance over time. The mentally retarded subjects had the lowest mean hit rate at each time block and appeared to show a greater rate of decline compared with the other two groups. A two-way analysis of variance of Groups by Blocks with repeated measures on the latter variable found significant main effects between groups (F = 7.85, 2/27 df, $p < 0.01$) and over time blocks (F = 9.99, 4/108 df, $p < 0.01$). There was a significant interaction between groups and blocks (F = 4.84, 8/108 df, $p < 0.01$).

The same two planned comparisons as those used in Experiments 3 and 4 were included in the analysis to investigate possible differences in performance based on

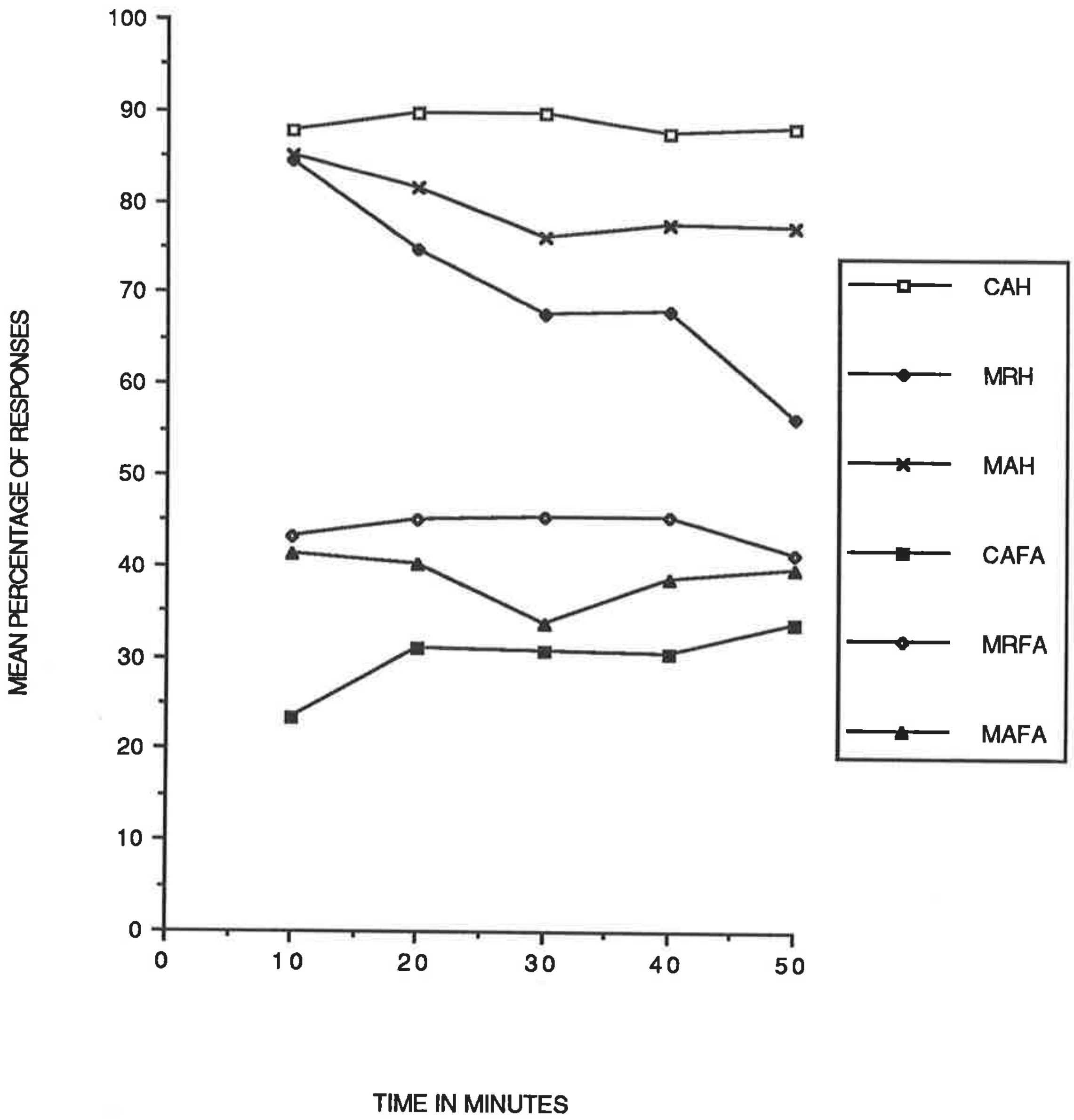

FIGURE 8.4 Mean percentages of hits (H) and false alarms (FA) for nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA) as a function of time on task.

the developmental lag hypothesis. That is, the first compared the nonretarded 13 year old children with the mentally retarded 15 year old children and the nonretarded 9 year old children. The second compared the last two groups with each other. Results found a significant main effect between groups for the first comparison only (F = 11.72, 1/27 df, p < 0.01). There was also a significant linear interaction between groups and blocks for both the first (F = 17.39, 1/108 df, p < 0.01) and second (F = 15.10, 1/108 df, p < 0.01) comparisons. Examination of these results in Figure 8.5 indicates that the mentally retarded children and nonretarded children of similar mental age obtained a lower mean overall score compared with the nonretarded 13 year old children. In addition, the mentally retarded children showed a faster rate of decline compared with the two nonretarded groups of children.

8.8.2 False Alarms

Figure 8.4 shows that the mentally retarded children registered the most false alarms at each time block and showed little change in false alarms across time blocks. The nonretarded 9 year old children registered fewer false alarms and the nonretarded 13 year old children the least. The last group showed a slight increment in the number of false alarms across time blocks. The same analysis of variance model as that used for hits (Groups by Blocks) found no significant main effects between groups or across blocks, and no interaction between groups and blocks. This indicates that groups registered similar numbers of false alarms at each time block and that there was little change in the numbers of false alarms registered across time blocks.

8.8.3 Signal Detection Theory Analysis

The faster rate of decline in hit rate across blocks and similar false alarm rate shown by the mentally retarded children compared to the two groups of nonretarded children might be expected to reflect a faster sensitivity decrement. Hence, sensitivity and criterion values were calculated for each subject at each time block using the same method as that employed in the previous experiments.

Table 8.3 shows the mean sensitivity and criterion values at each time block for each of the three subject groups. The table shows that there was a decline in sensitivity across time blocks for all three subject groups. Also, there was little change in criterion values across time blocks for all three subject groups.

The same analysis of variance model as those used for hits and false alarms (Groups by Blocks) found significant main effects between groups ($\underline{F}$ = 11.32, 2/27 $\underline{df}$, $\underline{p}$ < 0.01) and across blocks ($\underline{F}$ = 7.98, 4/108 $\underline{df}$, $\underline{p}$ < 0.01) for sensitivity values. Inspection of these results in Table 8.3 indicates that groups differed in their mean overall sensitivity values, with the mentally retarded children having the lowest overall mean value, and that there was a loss of sensitivity over time. There was no significant interaction between groups and blocks which indicates that groups showed similar rates of decline in sensitivity. Also, there were no significant main effects or interaction between groups and blocks for criterion values. Hence, there were no differences between the groups in overall mean criterion values and mean criterion values did not change significantly over time. Taken together these results indicate that there was a loss of perceptual sensitivity over time and little change in degree of caution.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	2.23	2.07	2.07	1.95	1.81	2.03
MR	1.25	0.86	0.64	0.68	0.42	0.77
MA	1.30	1.26	1.37	1.20	1.10	1.25
MEAN	1.59	1.40	1.36	1.28	1.11	1.35

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	0.83	0.59	0.60	1.04	0.77	0.77
MR	0.65	0.87	0.99	1.12	1.18	0.96
MA	0.61	0.74	0.88	0.77	0.80	0.76
MEAN	0.69	0.73	0.82	0.98	0.92	0.83

TABLE 8.3 Mean sensitivity and criterion values for the nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA).

8.9 COMPARISON TO EXPERIMENT 1

8.9.1 Hits

Figure 8.5 shows the mean percentage of correct detections (hits) for each successive time block for the three groups in this experiment and the corresponding groups in the first experiment. The figure shows that the groups in the fifth experiment had a higher hit rate compared with the groups in the first experiment. The mentally retarded children and nonretarded 9 year old children in Experiment 5 showed a slower rate of decline compared with their counterparts in Experiment 1.

A three-way analysis of variance of Groups by Experiments by Blocks with repeated measures on the last variable found, in particular, a significant main effect between experiments (F = 35.12, 1/54 df, p <0.01), and significant interactions between experiments and blocks (F = 10.37, 4/216 df, p < 0.01) as well as between groups, experiments and blocks (F = 3.38, 8/216 df, p <0.01). These results indicate that subjects in the fifth experiment obtained a higher mean overall hit score and had a slower rate of decline compared with subjects in the first experiment.

A separate analysis of variance of Groups by Blocks with repeated measures on the latter variable compared the performances of the mentally retarded children in the fifth experiment with the nonretarded 13 year old children in the first experiment. Results found a significant interaction between groups and blocks (F = 8.22, 1/216 df, p < 0.01). Examination of this result in Figure 8.5 indicates that the mentally retarded children showed a faster rate of decline compared with the nonretarded 13 year old children.

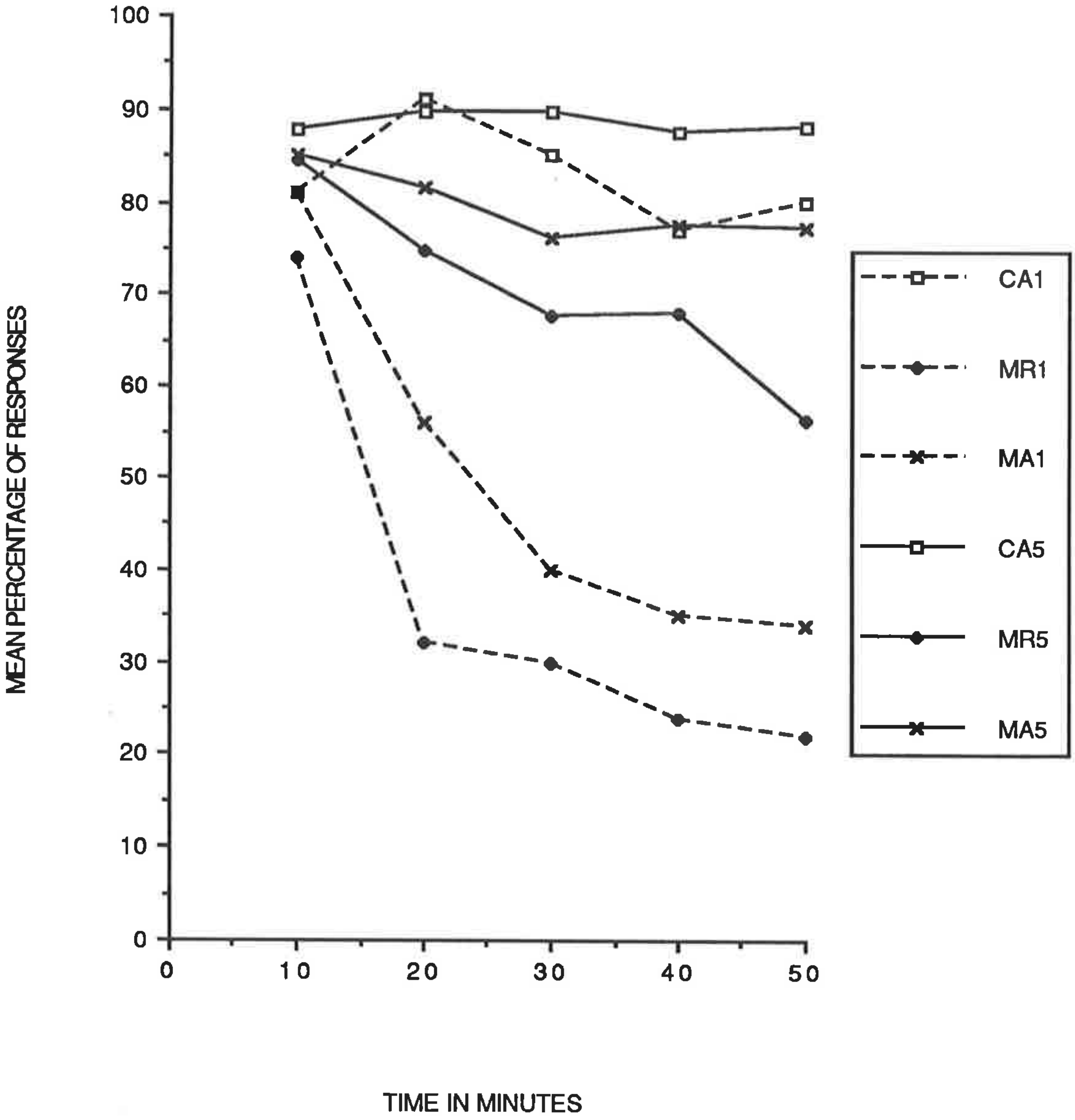

FIGURE 8.5 Mean percentages of hits for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA5), mentally retarded 15 year old children (MR5) and nonretarded 9 year old children (MA5) in Experiment 5 as a function of time on task.

8.9.2 False Alarms

Figure 8.6 shows the mean percentage of commission errors (false alarms) registered for each successive block for each of the three groups in the fifth experiment and corresponding groups in the first experiment. The figure indicates that each of the groups in Experiment 5 registered more false alarms at each time block compared with their counterparts in Experiment 1.

The same analysis of variance model as that used for hits (Groups by Experiments by Blocks) found a significant main effect between experiments (F = 43.54, 1/54 df, $p < 0.01$), and a significant interaction between experiments and blocks (F = 3.03, 4/216 df, $p < 0.05$). Examination of these results in Figure 8.6 shows that subjects in the fifth experiment registered a greater number of false alarms. Also, false alarms tended to decline over successive time blocks in the first experiment, whereas this trend was not evident in the fifth experiment.

The same separate analysis of variance model as that used for hits (Groups by Blocks) compared the performances of the mentally retarded children in the fifth experiment and the nonretarded 13 year old children in the first experiment. Results found only a significant main effect between groups (F = 35.42, 1/54 df, $p < 0.01$). This indicates that the mentally retarded children registered a greater number of false alarms compared with the nonretarded children.

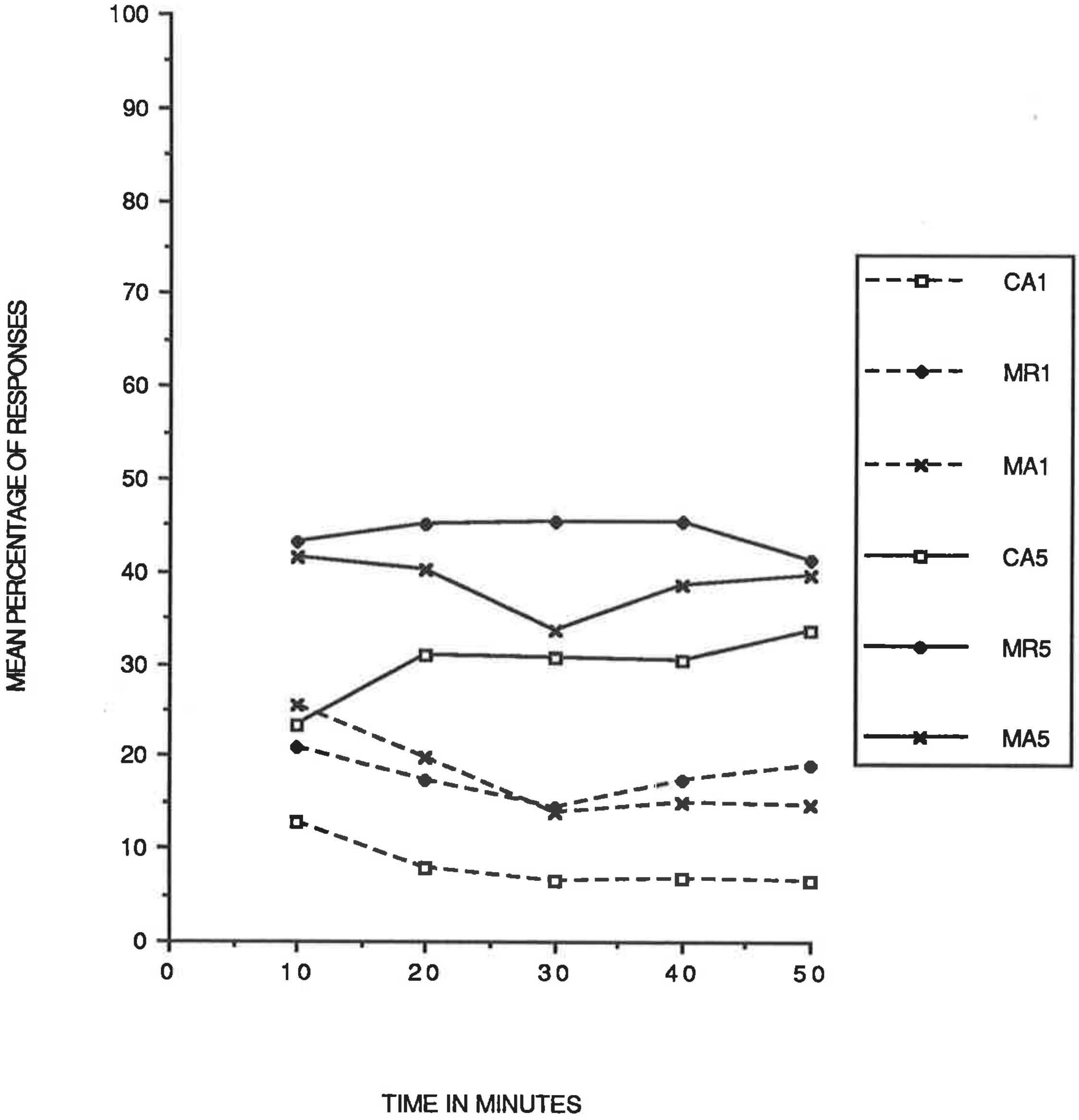

FIGURE 8.6 Mean percentages of false alarms for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA5), mentally retarded 15 year old children (MR5), and nonretarded 9 year old children (MA5) in Experiment 5 as a function of time on task.

8.9.3 Signal Detection Theory Analysis

The different overall detection and false alarm rates, and faster decline in hits shown by the mentally retarded children in Experiment 5 compared with the nonretarded 13 year old children in Experiment 1 should reflect a difference in perceptual sensitivity. Table 8.4 shows the mean sensitivity and criterion values at each block for the two subject groups.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	2.30	3.55	3.09	2.97	3.10	3.00
MR:Exp 5	1.25	0.86	0.64	0.68	0.42	0.77

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	1.59	2.18	2.45	4.73	13.88	4.97
MR:Exp 5	0.65	0.87	0.99	1.12	1.18	0.96

TABLE 8.4 Mean sensitivity and criterion values for the nonretarded 13 year old children in Experiment 1 (CA:Exp 1) and mentally retarded 15 year old children in Experiment 5 (MR:Exp 5).

The same separate analysis of variance model as that used for both hits and false alarms (Groups by Blocks) found a significant main effect between groups (F = 62.29, 1/54 df, $p < 0.01$) and a significant interaction between groups and blocks (F = 10.35, 1/216 df, $p < 0.01$) for sensitivity values. Similar results were found for the criterion values, with a significant main effect between groups (F = 5.30, 1/54 df, $p < 0.05$) and a significant interaction between groups and blocks ($F = 8.22$, 1/216 df, $p < 0.01$). Inspection of these results in Table 8.4 indicates that the mentally retarded children in Experiment 5 had a lower mean overall sensitivity value and showed a sensitivity decrement compared with their nonretarded counterparts in Experiment 1. Also, the latter group was more cautious overall and became more cautious in responding with time on the task compared with the former group of subjects.

8.10 DISCUSSION

Mentally retarded and nonretarded children were presented with a task similar to that used in the first experiment except that the signal stimulus occurred with the same probability as the nonsignal stimulus rather than with a low probability. Subjects exhibited a higher overall hit score and slower rate of decline on this task compared with the corresponding subjects on the vigilance task in the first experiment. However, the mentally retarded children in this experiment had a lower overall hit score and a greater decrement compared with the nonretarded 13 year old children in the first experiment, and a faster decline in performance compared with the two nonretarded groups in the fifth experiment. Although these results for hits are not consistent with the developmental hypothesis, signal detection analysis comparing both hits and false alarms found no differences in rates of decline in sensitivity between the groups.

Similar numbers of false alarms were registered at each time block by the three subject groups in this experiment. However, more false alarms were registered by these groups compared with the corresponding subjects in the first experiment. In particular, the mentally retarded subjects in this experiment registered a higher number of false alarms but showed a similar trend across time blocks compared with nonretarded 13 year old children in the first experiment.

Hence, overall detection efficiency improved but false alarm rate was higher for all three subject groups under task conditions involving an increased signal rate. The results do not support the possibility that the greater decline in detection efficiency shown by the mentally retarded 14 year old children and nonretarded 9 year old children in Experiment 1 was due to a progressive loss of memory output for the signal stimulus. Given the higher signal probability, the mentally retarded children still demonstrated a faster rate of decline compared with their nonretarded counterparts in both this experiment as well as compared with those in Experiment 1. In addition, the retarded children still showed a sensitivity decrement in this experiment. The memory theory predicted that the mentally retarded children would show similar detection efficiency to the nonretarded children of equivalent chronological age and that there would not be a sensitivity decrement.

8.11 COMPARISON OF RESULTS FOR THE MENTALLY RETARDED CHILDREN FROM EXPERIMENTS 3, 4 AND 5

The results of the previous three experiments indicate that mildly mentally retarded children show improved performance when either signal intensity or frequency or both are altered so that the task is relatively easier. However, performance varied according to which signal characteristic was altered.

The mentally retarded children in both the third and fourth experiments (high intensity, high frequency signal and high intensity, low frequency signal respectively) showed similar rates of decline in hits and overall hit scores to that of the nonretarded 13 year old children in the first experiment (low intensity, low frequency signal). However, the retarded children in the fifth experiment (low intensity, high frequency signal) had a greater decline in hits, although similar overall hit scores, compared with the nonretarded 13 year old children in the first experiment.

The retarded children in both the third and fifth experiments registered more false alarms than the nonretarded 13 year old children in the first experiment. However, the retarded children in the fifth experiment showed a decrement across time blocks similar to that shown by the nonretarded 13 year old children, whereas the retarded children in the third experiment showed an increment over time. In contrast, the retarded children in the fourth experiment registered both similar false alarms overall and at each time block as the nonretarded children.

The relative differences in performance between Experiments 3, 4 and 5 are shown in Figure 8.7. The

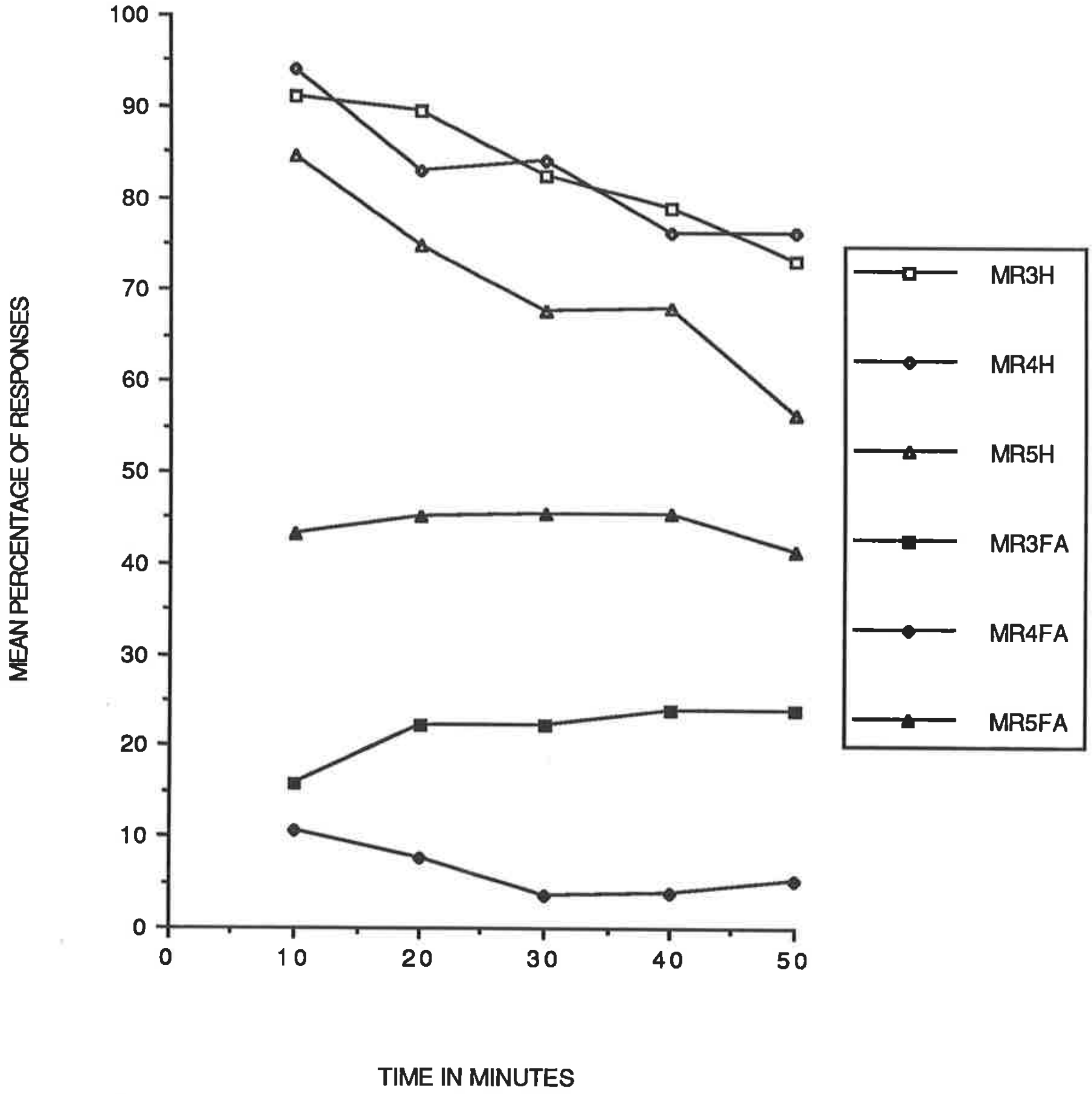

FIGURE 8.7 Mean percentages of hits (H) and false alarms (FA) for mentally retarded children in Experiment 3 (MR3), Experiment 4 (MR4) and Experiment 5 (MR5) as a function of time on task.

figure shows the mean percentage of hits and false alarms for each successive time block for the mentally retarded children in each of these experiments. The figure, together with the above results, indicates that the retarded children in the fourth experiment showed best overall performance as significantly fewer false alarms were registered. Also, the retarded children in the fifth experiment showed the worst overall performance.

8.12 THE IMPORTANCE OF SIGNAL INTENSITY AND FREQUENCY ON VIGILANCE PERFORMANCE

The last two experiments considered the relative importance of signal intensity and frequency to the vigilance performance of mildly mentally retarded children. Subjects were presented with tasks in which signal intensity and frequency had been varied separately. The results of these experiments were also compared to both those of Experiment 3, in which both signal characteristics were altered, and Experiment 1 in which signal characteristics conformed with the vigilance paradigm.

The results demonstrated that the performance of mildly mentally retarded children improves when either or both of these signal characteristics are increased. Hence, both signal intensity and frequency are important determinants of the vigilance decrement shown by mildly mentally retarded children. However, the results support signal intensity as the more important of the two signal characteristics in that retarded subjects showed best overall performance on the task with a high intensity signal. In addition, the mentally retarded children were able to maintain perceptual sensitivity over the duration of the task in which signal intensity was set well above threshold level, but occurred infrequently. However, sensitivity declined on the task involving a signal set near threshold level but which occurred with equal probability as the nonsignal events. Overall, these results provide some support for a fatigue explanation for the vigilance performance of mildly mentally retarded children given that memory should be more influenced by frequency of the signal whereas fatigue should be more influenced by intensity.

CHAPTER 9

MAINTENANCE OF VIGILANCE PERFORMANCE BY VARIATION OF SIGNAL INTENSITY

9.1 EXPERIMENT 6

The results of the last three experiments indicate that the vigilance performance of mildly mentally retarded children can be improved by increasing signal intensity and/or frequency. These changes result in a higher overall hit score as well as a slower rate of decline in hit performance. In addition, signal intensity was found to be the more important of the two task characteristics in determining both overall hit rate and rate of decline.

The results found that the sensitivity decrement associated with the decline in detection efficiency in Experiment 1 was completely arrested in the task with a signal set well above threshold level but not in the task with a low intensity signal which occurred frequently. Overall the results provided some support for the fatigue theory. However, the more intense signals used in Experiment 4 might have also placed less demand on memory since the signal intensity was set well above the threshold level of subjects. Moreover, it might be possible that more "powerful" signals consolidate the memory trace for signals. Further consideration therefore needs to be given to the two theories.

The fatigue theory suggests that either the nerve cells concerned with performance become insensitive through continued activity or that neural activity rises beyond an optimum level. These suggestions imply that more powerful signals are required either to operate the nerve cells or to maintain the effective strength of the signals. Hence, as fatigue is a progressive process, it might be expected that progressively more powerful signals would be required to prevent the sensitivity decrement and maintain performance.

The memory theory suggests that the memory trace or store of signals decays or is disrupted over the duration of the task. Therefore, the sensitivity decrement would be expected to be prevented by processes which consolidate the memory trace for signals.

One method of testing these theories would be to present subjects with a task in which signal intensity could vary according to performance efficiency. If task performance is related to a fatigue process due to the monitoring demands of the task and the nerve cells become insensitive or neural noise level rises then signal intensity would be expected to progressively increase. However, signal intensity might be expected to vary differently if the performance decrement is due to loss of memory traces. As the task progresses and the memory trace decays the signal intensity should increase. As the memory trace for signals is then consolidated by the more intense signals, perceptual sensitivity should be enhanced and signal intensity should decrease until the memory trace again decays.

Thus, signal intensity would be expected to increase monotonically across time blocks for the fatigue explanation. Alternatively, for the memory hypothesis, signal intensity would be expected to oscillate up and down around a constant value as the memory trace decays and is then consolidated. However, the averaging of subject data into time blocks would be expected to obscure the oscillation. In this way, a higher signal intensity value overall would be expected in comparison to the low intensity value used in previous experiments but intensity would not be expected to increase steadily across time blocks.

The purpose of this experiment was to further investigate the possibilities that fatigue or memory are factors in the vigilance performance of mildly mentally retarded children. Subjects were presented with a task which was an extension of the computer controlled sequential testing (PEST) procedure used in the discrimination training task in earlier experiments. The intensity of the signal automatically increased as performance fell below a set criterion level, or decreased if performance remained consistently above criterion.

If fatigue is a significant factor in the vigilance performance of mildly mentally retarded children then signal intensity should increase monotonically over the duration of the task as the nerve cells become insensitive or as neural noise increases. Alternatively, if memory load is a significant factor then signal intensity should increase and then oscillate around a relatively constant value across time blocks as the memory trace for the signal decays and then is consolidated. The signal should not vary across time for the nonretarded children of equivalent chronological age since they did not show any loss of perceptual sensitivity to the vigilance task in Experiment 1. If there is a developmental factor involved, then the nonretarded children of equivalent mental age should show similar performance and change in signal intensities over time as the mentally retarded children.

9.2 METHOD

9.2.1 Subjects

Mentally retarded subjects were 3 male and 7 female students from special schools whose IQ scores on the Wechsler Intelligence Scale for Children ranged from 47 to 67 (mean 59). Ages ranged from 12 years 4 months to 17 years 0 months (mean 15 years 3 months). The average mental age of this group was estimated to be 9 years.

Chronological age control subjects were 5 male and 5 female students from a secondary school. Ages ranged from 12 years 11 months to 13 years 11 months (mean 13 years 5 months).

Mental age control subjects were 4 male and 6 female students from a primary school. Ages ranged from 8 years 4 months to 9 years 0 months (mean 8 years 7 months).

Nonretarded students were selected whose academic performance was at least average and thus were assumed to be at least of average intelligence.

9.2.2 Apparatus and Stimulus Characteristics

The apparatus was the same as that used in the visual task in each of the five previous experiments. The circular red light 3cm. in diameter appeared every 3 seconds for 0.5 second.

The PEST procedure automatically increased signal intensity when performance fell below a set criterion of 80% correct or decreased the intensity if performance remained consistently above that criterion. Signals and nonsignals occurred with equal probability in the PEST procedure in order to determine overall performance so that signal intensity could be adjusted accordingly. Thus, there was more opportunity for a higher percentage of false alarms.

The nonsignal intensity was again set at 10ftl. Signal intensity could vary between 11ftl. and 60ftl. Each ten-minute block consisted of approximately an equal number of signals and nonsignals. The number of signals per block ranged from 84 to 117 (mean 100) and nonsignals from 83 to 116 (mean 100). The time between signals varied randomly from 3 seconds to 27 seconds.

9.2.3 Procedure

The procedure was the same as that used in the last experiment except that prior to commencement of the task it was emphasized that there would be approximately the same number of signal and nonsignal stimuli but that they would occur randomly. Also, it was explained that the intensity of the signal stimuli might change as the task progressed but that they should respond to the "brighter" of the lights presented by pressing the button held in the hand.

Three mentally retarded subjects failed to pass criterion at the final test level and did not participate further.

9.3 RESULTS

Figure 9.1 shows the mean percentage of correct detections (hits) and commission errors (false alarms) for each of the three subject groups for each successive ten-minute block. Raw data for subjects in terms of the ratios of hits-to-signals and false alarms-to-nonsignals are shown in Appendix B-6.

9.3.1 Hits

Figure 9.1 indicates that the nonretarded 13 year old children scored at a higher mean rate from the first to the second block and at a consistent level thereafter. The mentally retarded children scored at a relatively consistent level across time blocks, with only a small decrement in performance. The nonretarded 9 year old children showed a small decrement over blocks similar to that of the mentally retarded group. The nonretarded 13 year old children scored the highest overall hit score followed by the nonretarded 9 year old children who in turn scored higher than the mentally retarded group. A two-way analysis of variance of Groups by Blocks with repeated measures on the latter variable found only a

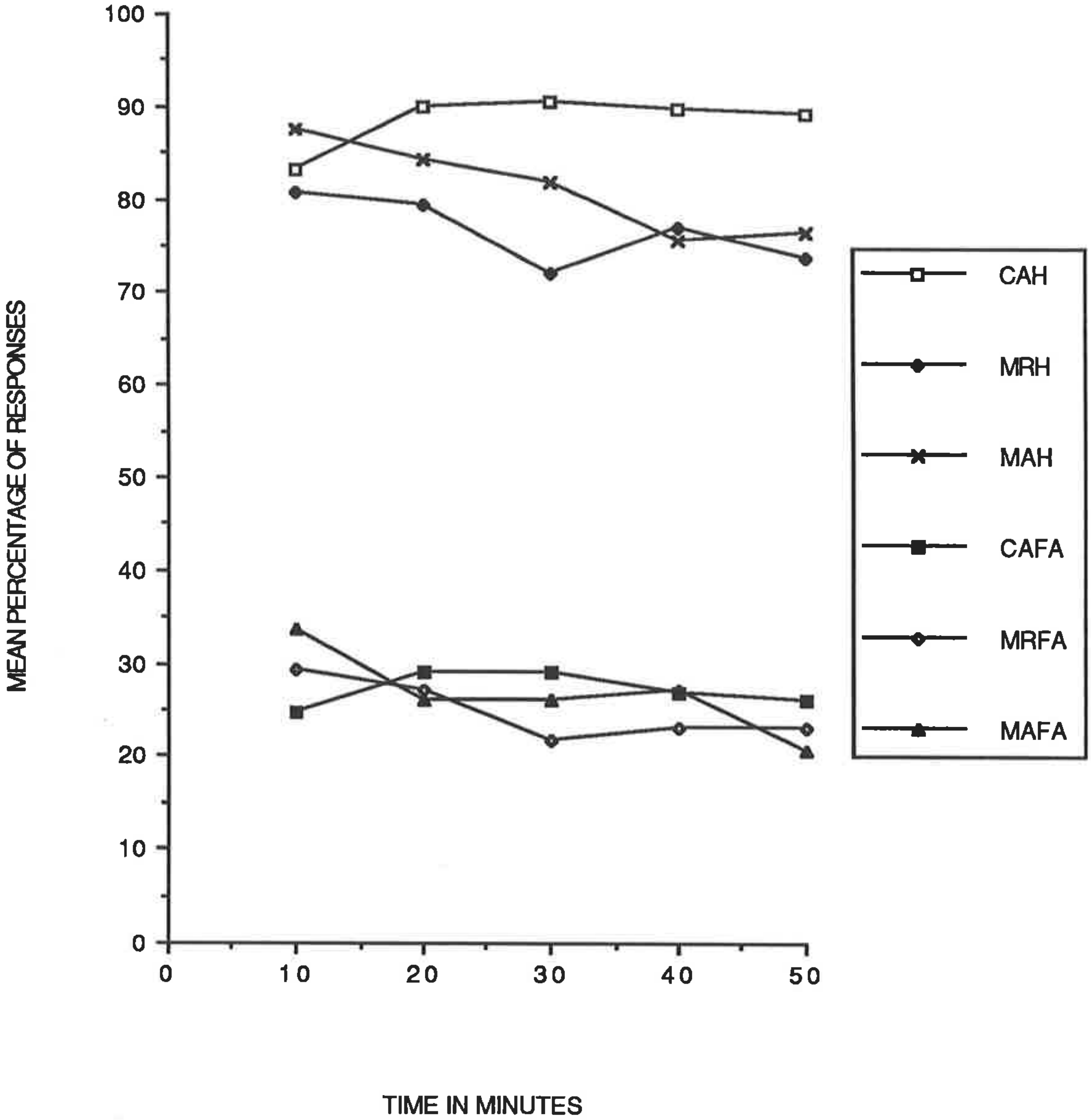

FIGURE 9.1 Mean percentages of hits (H) and false alarms (FA) for nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA) as a function of time on task.

significant interaction between groups and blocks (F = 3.30, 8/108 df, $p < 0.01$). This result indicates that groups differed in their rates of change in hits over time.

The same two planned comparisons as those used in previous experiments were included in the analysis to examine the developmental lag hypothesis. Hence, the performance of the nonretarded 13 year old children was compared with those of the mentally retarded children and nonretarded 9 year old children. Also, the performances of the last two groups were compared. Results found significant interactions between groups and blocks both linearly (F = 15.38, 1/108 df, $p < 0.01$) and quadratically (F = 4.19, 1/108 df, $p < 0.05$) for the first comparison only. Examination of these results in Figure 9.1 indicates that the mentally retarded children and nonretarded 9 year old children showed similar decrements across time blocks. However, these groups showed a greater decline than the nonretarded 13 year old children who showed an overall increment in hits.

9.3.2 False Alarms

Figure 9.1 shows that all groups registered similar false alarm rates across time blocks. The mentally retarded children and nonretarded 9 year old children showed a decline in false alarms over time blocks whereas the nonretarded 13 year old children showed no decline. The mentally retarded subjects registered the lowest false alarm rate. The same analysis of variance model as that used for hits (Groups by Blocks) did not find any significant main effects or an interaction between groups and blocks. Thus, all groups of subjects registered similar mean overall percentages of false alarms as well as similar mean numbers of false alarms across time blocks.

9.3.3 Signal Detection Theory Analysis

The variable-intensity signal used in this experiment should change in such a way as to maintain subjects' discriminability over time. Hence, sensitivity and criterion values were calculated for each subject at each time block using the same method as that employed in the previous experiments.

Table 9.1 shows the mean sensitivity and criterion values for each subject group at each time block. The table shows that there was little change in either sensitivity or caution across time blocks for the three subject groups, except for a raised mean criterion value in the second block for the mentally retarded children. This was due to one subject who registered no false alarms and so disproportionately elevated the criterion value for that block.

The same analysis of variance model as that used for hits and false alarms (Groups by Blocks) did not find any significant main effects or any interaction between groups and blocks for either sensitivity or criterion values. Inspection of these results in Table 9.1 indicates that groups showed similar overall mean sensitivity and criterion values, and that there was no significant change in either value across time blocks for the three groups.

Hence, subjects maintained a constant degree of perceptual sensitivity and caution over time.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	1.70	2.08	2.08	2.18	2.07	2.02
MR	1.60	1.85	1.65	1.71	1.45	1.65
MA	1.77	1.86	1.84	1.49	1.71	1.74
MEAN	1.69	1.93	1.85	1.80	1.74	1.80

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA	0.88	0.60	0.49	0.83	1.72	0.90
MR	1.31	13.11	2.69	2.43	2.56	4.42
MA	0.61	0.72	0.85	0.95	1.09	0.85
MEAN	0.93	4.81	1.34	1.40	1.79	2.06

TABLE 9.1 Mean sensitivity and criterion values for the nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA).

9.3.4 Signal Intensity

Figure 9.2 shows the mean signal intensity for each successive ten-minute block for each of the three subject groups. The figure indicates that signal intensity for the nonretarded 13 year old children showed little change across time blocks. However, the intensity increased markedly for the mentally retarded and nonretarded 9 year old children. The intensity for the mentally retarded children increased the most within the first two blocks and more steadily over the last three. On the other hand, the intensity for the mental age control group increased

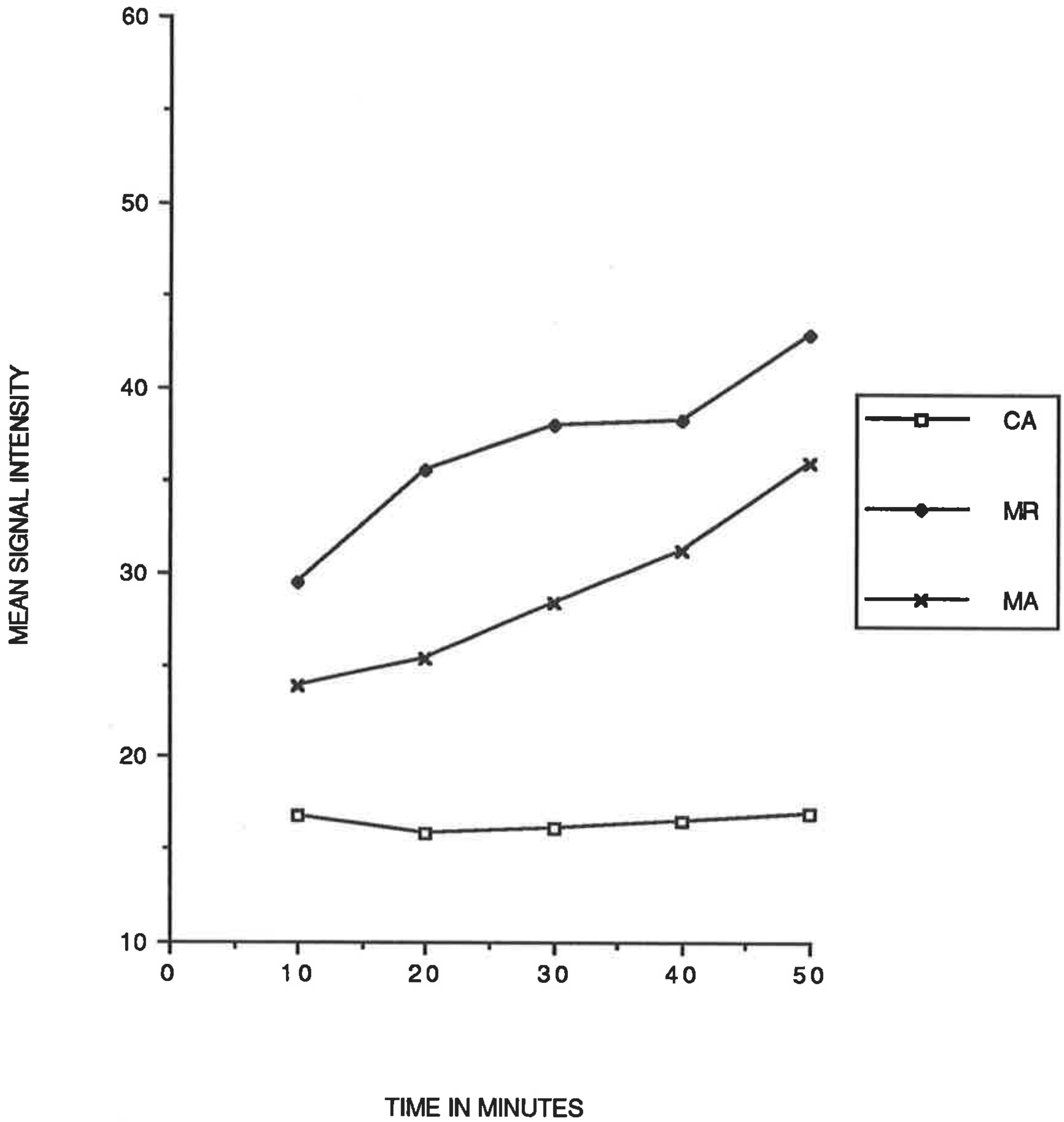

FIGURE 9.2 Mean signal intensities for nonretarded 13 year old children (CA), mentally retarded 15 year old children (MR) and nonretarded 9 year old children (MA) as a function of time on task.

steadily over each of the time blocks.

The same analysis of variance model as that used in previous comparisons (Groups by Blocks) found a significant main effect between groups (F = 10.92, 2/27 df, $p < 0.01$) and across blocks (F = 13.38, 4/108 df, $p < 0.01$). There was also a significant interaction between groups and blocks (F = 3.55, 8/108 df, $p < 0.01$). These results indicate that groups differed in mean overall signal intensities and in changes in signal intensity over time.

The same planned comparisons found a significant main effect between groups (F = 18.62, 1/27 df, $p < 0.01$) and a significant interaction between groups and blocks (F = 24.20, 1/108 df, $p < 0.01$) for the first comparison. Examination of these results in Figure 9.2 indicates that the mentally retarded children and nonretarded 9 year old children had a higher mean overall signal intensity compared with the nonretarded 13 year old children. The first two groups also showed a similar increase in signal intensity across time blocks to each other. However, the nonretarded 13 year old children showed no change in signal intensity across blocks.

9.4 COMPARISON TO EXPERIMENT 1

9.4.1 Hits

Figure 9.3 shows the mean percentages of correct detections (hits) for each successive ten-minute block for the three subject groups in Experiment 6 and the corresponding groups in Experiment 1. The figure shows

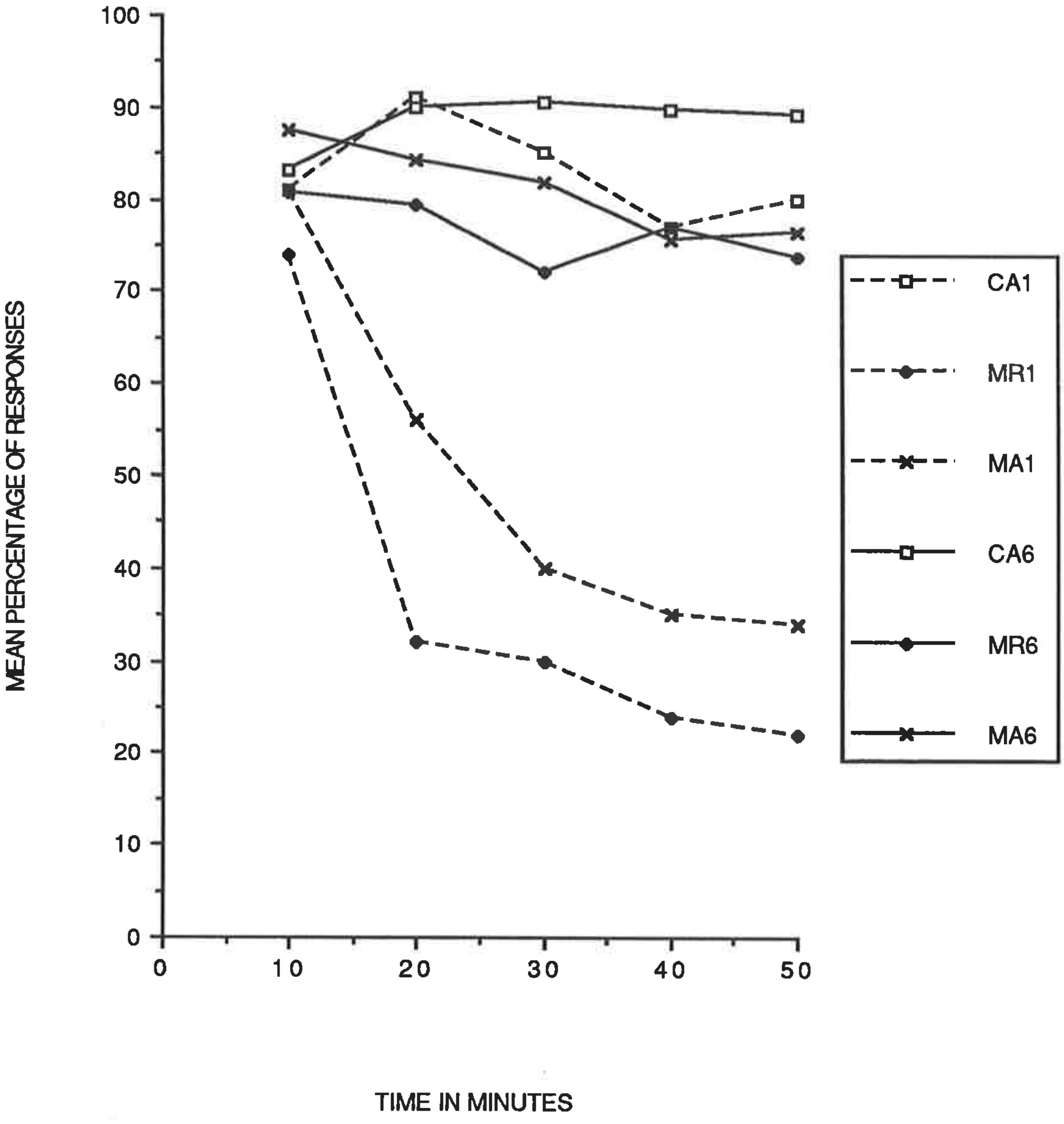

FIGURE 9.3 Mean percentages of hits for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA6), mentally retarded 15 year old children (MR6) and nonretarded 9 year old children (MA6) in Experiment 6 as a function of time on task.

that subject groups in the sixth experiment scored higher mean hit scores at each time block and a slower rate of decline compared with their corresponding groups in the first experiment.

A three-way analysis of variance of Groups by Experiments by Blocks with repeated measures on the last variable found, in particular, a significant main effect between experiments ($F = 42.72$, 1/54 df, $p < 0.01$), and a significant interaction between experiments and blocks ($F = 17.24$, 4/216 df, $p < 0.01$). These results confirm the previous observations from Figure 9.3 that groups in the sixth experiment obtained a higher overall hit score and showed a slower rate of decline compared with groups in the first experiment.

A separate analysis of variance of Groups by Blocks with repeated measures on the latter variable compared the performances of the mentally retarded children in the sixth experiment and the nonretarded 13 year old children in the first experiment. Results did not find either a significant main effect or interaction between groups and blocks. This result indicates that there was no difference in either overall hit scores or rates of decline between the two subject groups.

9.4.2 False Alarms

Figure 9.4 shows the mean percentage of commission errors (false alarms) for each time block for the three subject groups in the sixth experiment and the corresponding groups in the first experiment. The figure

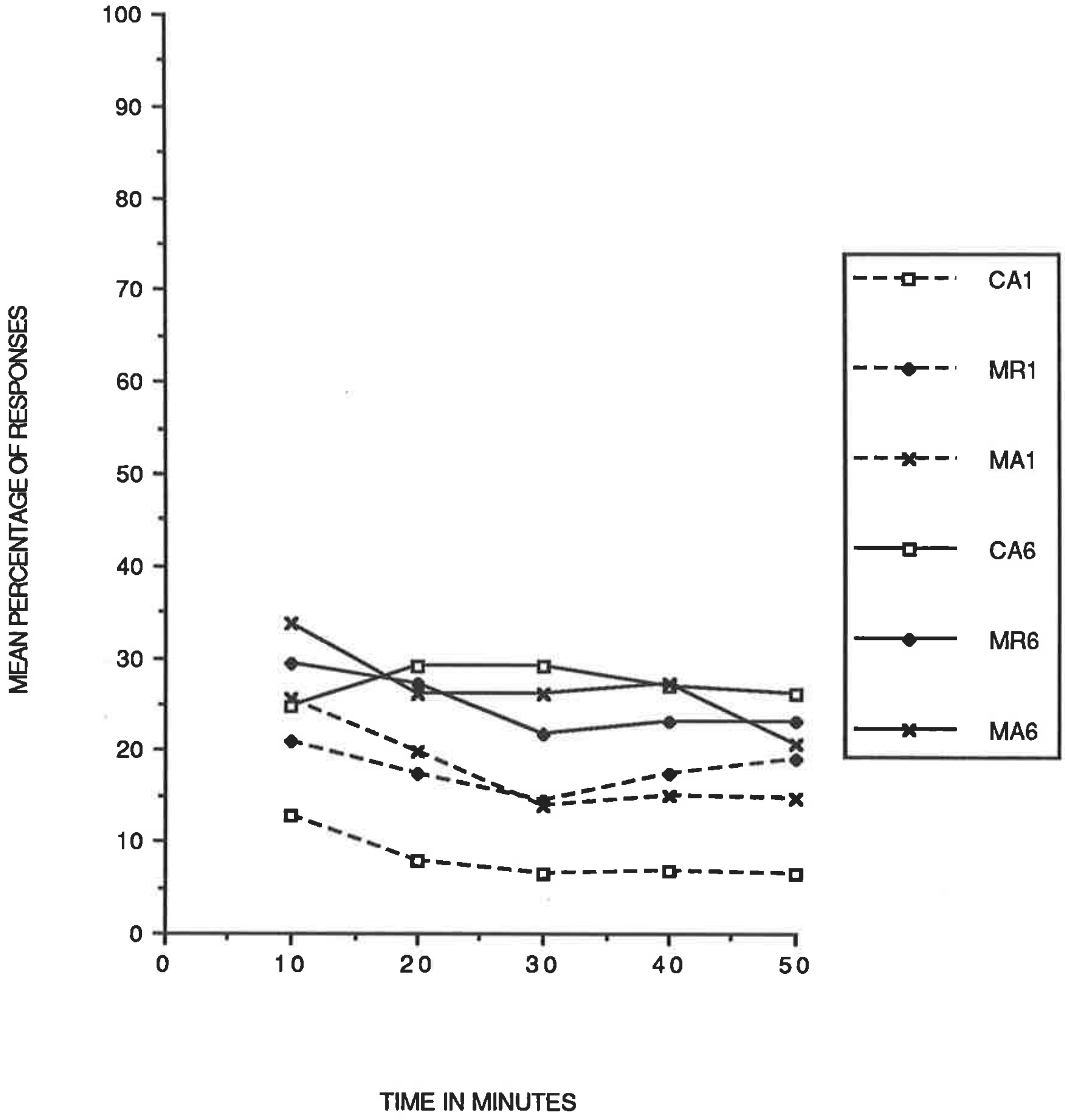

FIGURE 9.4 Mean percentages of false alarms for nonretarded 13 year old children (CA1), mentally retarded 14 year old children (MR1) and nonretarded 9 year old children (MA1) in Experiment 1, and nonretarded 13 year old children (CA6), mentally retarded 15 year old children (MR6) and nonretarded 9 year old children (MA6) in Experiment 6 as a function of time on task.

shows that each of the subject groups in the sixth experiment registered more false alarms than each of the groups in the first experiment.

The same analysis of variance model as that used for hits (Groups by Experiments by Blocks) found, in particular, a significant main effect between experiments (F = 22.60, 1/54 df, $p < 0.01$). This result confirms the observation from Figure 9.4 that more false alarms were registered on the sixth experiment.

The same separate analysis of variance model as that used for hits (Groups by Blocks) compared the performances of the mentally retarded children in the sixth experiment and the nonretarded 13 year old children in the first experiment and found only a significant main effect between groups (F = 15.44, 1/54 df, $p < 0.01$). That is, the mentally retarded subjects in the sixth experiment registered more false alarms than nonretarded 13 year old children in the first experiment. There was no difference in trends across time blocks.

9.5.2 Signal Detection Theory Analysis

The performance of the mentally retarded children in Experiment 6 was compared to the nonretarded children of equivalent chronological age in Experiment 1 to determine if there were similar trends in sensitivity and caution across time blocks. Table 9.2 shows the mean sensitivity and criterion values at each time block for the two subject groups.

SENSITIVITY

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	2.30	3.55	3.09	2.97	3.10	3.00
MR:Exp 6	1.60	1.85	1.65	1.71	1.45	1.65

CRITERION

GROUP	BLOCK 1	2	3	4	5	MEAN
CA:Exp 1	1.59	2.18	2.45	4.73	13.88	4.97
MR:Exp 6	1.31	13.11	2.69	2.43	2.56	4.42

TABLE 9.2 Mean sensitivity and criterion values for the nonretarded 13 year old children in Experiment 1 (CA:Exp 1) and mentally retarded 15 year old children in Experiment 6 (MR:Exp 6).

The same analysis of variance model as used earlier for hits and false alarms (Groups by Blocks) found only a significant main effect between groups for sensitivity ($F = 27.58$, 1/54 df, $p < 0.01$) and only a significant interaction between groups and blocks for criterion ($F = 8.40$, 1/216 df, $p < 0.01$). Inspection of these results in Table 9.2 indicates that the mentally retarded children in Experiment 6 showed a lower mean overall sensitivity value and a slower increment in caution over time compared with the nonretarded children in Experiment 1. In addition, both groups showed similar overall mean criterion values and similar trends in sensitivity over time to each other. Hence, the mentally retarded children in Experiment 6 were less able to discriminate overall and remained less cautious over the duration of the task compared to the nonretarded children in Experiment 1.

9.5 COMPARISON TO EXPERIMENTS 3, 4 AND 5

Figure 9.5 shows the mean percentage of correct detections (hits) and commission errors (false alarms) for each successive ten-minute block for the mentally retarded children from Experiments 3, 4, 5 and 6.

9.5.1 Hits

Figure 9.5 shows that the retarded children in Experiment 6 had a mean hit rate on the first block similar to the retarded children in Experiment 5 (low intensity, high frequency signal). Their performance over successive time blocks remained relatively consistent compared with the performance of the children in the three other experiments. There appears to be no difference between their mean hit rate on the last two time blocks and those of the children in Experiments 3 and 4, both involving high intensity signals. The more consistent performance shown by the mentally retarded children in Experiment 6 reflects the effects of the PEST procedure which maintained performance around the 80% accuracy level.

9.5.2 False Alarms

Figure 9.5 shows that the retarded children in Experiment 6 registered similar mean percentages of false alarms across time blocks as the children in Experiment 3. Signals and nonsignals occurred with approximately equal probability in Experiment 6 so that the PEST procedure could determine overall performance and adjust the signal intensity accordingly. Thus there was more

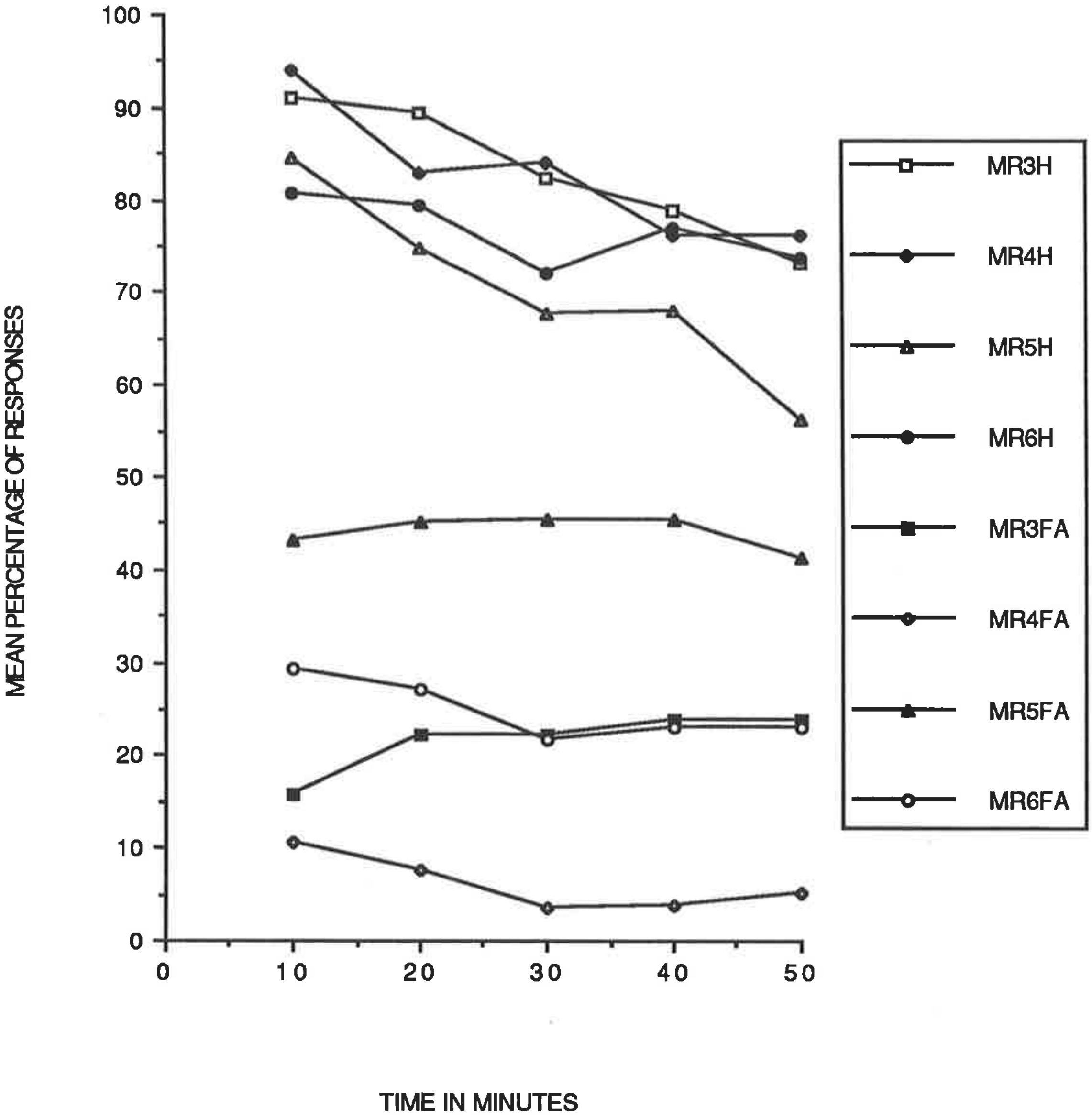

FIGURE 9.5 Mean percentages of hits (H) and false alarms (FA) for mentally retarded children in Experiment 3 (MR3), Experiment 4 (MR4), Experiment 5 (MR5) and Experiment 6 (MR6) as a function of time on task.

opportunity for a higher percentage of false alarms in Experiment 6. Similarly, signals and nonsignals occurred with equal probability in Experiment 3 and signal intensity was also well above threshold level.

9.6 DISCUSSION

The purpose of this experiment was to further investigate the possible influences of fatigue and memory load on the vigilance performance of mildly mentally retarded children. Subjects were presented with a task in which the intensity of the signal stimulus altered according to level of performance. The signal intensity automatically increased if performance fell below the set criterion of 80% and decreased if performance was consistently higher than that criterion.

The mentally retarded children and nonretarded 9 year old children showed similar hit rates across time blocks. However, both groups showed a greater rate of decline compared with the nonretarded 13 year old children who showed no decline in performance. All groups registered similar numbers of false alarms.

Whilst there were differences between the three groups in this experiment in terms of their detection performances, all three groups showed significantly higher overall and sustained detection efficiency compared with the equivalent groups in Experiment 1 who monitored the low frequency and low intensity signal. However, each subject group in this experiment registered greater numbers of false alarms compared with their counterparts in Experiment 1. The mentally retarded children in Experiment 6 showed similar overall detection performance and rate of decline as the nonretarded children of equivalent chronological age in Experiment 1. Also, there was no difference in the rates of decline in the mean percentages of false alarms across time blocks although the retarded children showed a higher mean overall score. The difference in overall false alarm percentages could be attributed to the higher frequency of the signal stimulus in this experiment. The higher frequency was required to determine overall performance level in order to adjust the signal as part of the computer controlled task. If the signal intensity could be adjusted using a low frequency signal then the false alarm rates might be expected to be similar to the rates shown by the nonretarded 13 year old children in Experiment 1.

When compared to the results of the retarded children in the three previous experiments, the retarded children in this experiment showed more consistent hit rate performance over time blocks due to the PEST procedure maintaining performance around a set level of 80% accuracy. Similar percentages of false alarms were registered at each time block by the retarded subjects in this experiment and the retarded subjects who monitored the high frequency and high intensity signal stimulus (Experiment 3). There were more opportunities in both these experiments for higher percentages of false alarms since signals and nonsignals occurred with at least approximately equal probability in each of the experiments. Similarly, signal intensity rose further above threshold level as performance declined for the retarded children in Experiment 6 and so was similar to the signal intensity used in Experiment 3 which was set at well above threshold level.

Overall, these results indicate that mildly mentally retarded children can maintain their vigilance performance at a higher level when the intensity of the signal stimulus increases or decreases according to their performance as the task progresses. Given this condition, mildly mentally retarded children show no difference in either their absolute detection performance or rate of decline compared with nonretarded children of similar chronological age monitoring a signal stimulus which remains at a low intensity and low probability for the duration of the task.

The average signal intensity increased significantly and monotonically over successive time blocks for both the mentally retarded children and nonretarded children of equivalent mental age. On the other hand, the average signal intensity did not vary over time for the nonretarded children of similar chronological age. The results of the signal detection analysis indicated that each of the groups maintained their relative degree of perceptual sensitivity across time blocks. However, the nonretarded 13 year old children became more cautious over the duration of the task whereas the other two groups did not change their degree of caution over the watch.

Given the memory hypothesis, it was predicted that signal intensity would increase from its initial level as the memory trace decayed and then decrease again as the trace was consolidated. Thus, the intensity would oscillate around a relatively constant value and, with the averaging of subject data into time blocks, the overall result would be an elevated but relatively constant signal intensity across time blocks. Alternatively, the fatigue hypothesis predicted that progressively more powerful signals would be required either to continue to operate the nerve cells as they became unresponsive or to maintain the effective strength of signals as neural activity rose. Thus, this hypothesis predicted that signal intensity would increase monotonically across time blocks. Therefore, taken together, the results of this experiment support the fatigue, rather than the memory explanation for the greater decline in detection performance demonstrated by the mildly mentally retarded children and the nonretarded children of equivalent mental age in Experiment 1.

CHAPTER 10

CONCLUSIONS AND IMPLICATIONS

The vigilance task provides a method for studying the possibilities that mentally retarded people suffer from attentional deficits, are abnormally distractible or are more suited to simple, monotonous tasks than nonretarded persons. However, only a few studies have specifically investigated the vigilance performance of mentally retarded people. Whilst initial studies had obtained apparently conflicting results, the overall findings suggested that mental age might be a primary determinant of the performance of mentally retarded people. In addition, each of the studies found that the mentally retarded persons were not better monitors than nonretarded persons of equivalent chronological age and so failed to support the "dull minds for dull jobs" dictum. The purpose of this thesis was to investigate the vigilance performance of mildly mentally retarded people in terms of both the attentional deficit and developmental lag hypotheses.

10.1 DULL MINDS FOR DULL JOBS

The results of previous studies comparing the vigilance performance of mentally retarded people with nonretarded people failed to support the "dull minds for dull jobs" dictum. The results of each of the experiments in this thesis also failed to support the dictum. Both mentally retarded adults and children did not outperform their nonretarded counterparts of equivalent chronological age under any of the experimental conditions. In fact, the results suggest that mentally retarded children perform less well in dull, monotonous conditions than nonretarded children of similar chronological age.

10.2 DEVELOPMENTAL PROCESSES AND ATTENTIONAL DEFICITS

The two interpretations for differences in cognitive performances between mentally retarded and nonretarded persons were outlined in Chapter 1. One view considers that mentally retarded persons have physiological defects whilst the other views mentally retarded persons as having a slower rate of cognitive development. The former interpretation implies a permanent defect (Krupski, 1980; Stanovich, 1978) whilst the latter implies that retarded persons perform similarly to nonretarded persons of equivalent mental age.

The results of Experiment 1 supported the developmental lag hypothesis in that both the mentally retarded adults and children showed similar rates of decline in vigilance performance to nonretarded subjects of relatively equivalent mental age. The results also found that mentally retarded people develop the ability to maintain performance over time to the same relative degree, that is, both similar overall hit rates and rates of decline in performance, as nonretarded people by about the age of 17 years. The only difference obtained was in terms of sensitivity due to the mentally retarded adults making more false alarms. Overall these results indicate that both mentally retarded and nonretarded people improve their ability to maintain vigilance performance with increasing chronological age. However, there is a slower rate of development with the mentally retarded persons. Thus, these results also failed to support an attentional deficit hypothesis.

10.3 FATIGUE AND THE DEVELOPMENTAL LAG

The finding of a slower rate of development in the vigilance performance of mildly mentally retarded people raised the further question of the nature of the lag. A signal detection theory analysis, which had not been used in any of the previous experiments, found that the faster rate of decline in detection efficiency shown by the mentally retarded children and nonretarded children of equivalent mental age in Experiment 1 corresponded with a sensitivity decrement with little change in criterion. Subsequent experiments in the thesis considered possible explanations for the faster decline in hit rates and corresponding sensitivity decrements. Results supported the hypothesis that the developmental process is concerned with a fatigue effect, that is, an increasing ability to avoid becoming fatigued.

10.3.1 Explanation of Fatigue

Welford (1976) referred to two explanations for fatigue. The first considers that the nerve cells concerned with the task performance become unresponsive or insensitive through continued activity. The other considers fatigue as the effect of overarousal due to neural activity, either local or general, rising beyond an optimum level.

Welford suggested that in terms of signal detection theory d' and ß would be expected to vary in different ways in relation to each of the two explanations.

> "Local neural failure would be expected to reduce d', whereas overarousal would be expected to lower ß. Moderate overarousal would leave d' little changed, but if overarousal was so intense that cells in the cortex were not merely sensitized but actually fired, the increased noise that would result might lower d' as well as ß." (p.145)

Furthermore, Welford referred to an interpretation by Mackworth and Taylor (1963) that impairment is associated with a reduction in d' with no alteration in ß.

The results for the mentally retarded 14 year old children and nonretarded children of similar mental age in Experiment 1 of this thesis are consistent with the impairment rather than the overarousal hypothesis because there was a fall in d' and no change in ß. This corresponds to a slowly decreasing noise (N) distribution and a more rapidly decreasing signal plus noise (S + N) distribution since there was a relatively rapid decline in hit rate over time combined with a small decrement in false alarms for these subjects. However, for the nonretarded adults, mentally retarded adults and nonretarded 13 year old children, ß increased and d' remained relatively unchanged, and there was a small decrement in both hits and false alarms over time except for the retarded adults who showed a small increment in false alarms. These findings are generally consistent with slowly decreasing N and S + N distributions.

Thus, these results suggest that the monotonous conditions of the vigilance task might lead to a fall in arousal for each of the subject groups. However, with increasing age, neural networks are developed and strengthened so that fatigue can be resisted. These networks must be developed sufficiently to avoid fatigue by about age 13 years for nonretarded persons but take longer to develop in mentally retarded persons and are only sufficiently developed by about the age of 17 years.

The two fatiguing processes referred to by Welford (1976) would presumably apply not only to neurons which activate task activity but also to those which inhibit other activity. Given that the results of this thesis support a developmental process, there must be progressive changes in cognitive and perceptual mechanisms which enable people to avoid becoming fatigued due to neural impairment on these tasks. Mentally retarded persons seem to be slower in developing these mechanisms.

It is interesting to consider three attentional theories that have been put forward to account for possible processes involved in perceptual and cognitive development. Bindra (1976), Hebb (1949, 1976) and Neisser (1976) propose similar theories, each of which proposes that neural representations of perceptual experiences develop over time. The developing neural representations are assumed to influence the quality of perception and the efficiency of perceptual and logical strategies which guide attentional processes. Each of the theories similarly suggests that interactions with the environment progressively refine and elaborate the neural representations which in turn make perceptions more meaningful and effective.

Given these theories, any obstacles to the establishment of the neural representations might be expected to effect perceptual and cognitive development. Hebb (1976) has suggested that minimal brain damage could result in a loss of inhibitory neurons due to toxins or lack of nutrition such as anoxia, and as a result the "cell assemblies" (neural representations) remain active after their function in a particular activity has been completed. Hence, perception and other cognitive processes would not be able to maintain selectivity or "concentration on one topic". Bindra (1976) also considered that the development of "contingency organizations" (neural representations) are dependent on inhibitory processes. Furthermore, it was suggested that these inhibitory processes mature slowly and only become effective "late in the maturational period".

Hebb (1976) further suggested that the ability to maintain attention on a particular task not only depends on the development of these cell assemblies but also on the subsequent recruitment of associative connections. In this way, a set of mental activities is able to be maintained despite noise from irrelevant stimulation and spontaneous noise from other neurons in the brain, "not by inhibiting other activity, but by co-opting and imposing its own order widely throughout the brain" (p. 313). However, once an activity has been initiated, the efficient completion of the required sequence of events depends on the inhibition of the activity in each part of the sequence after its completion. Otherwise, continued activity of preceding parts of the sequence would disrupt efficient functioning of subsequent parts and hence of the total task. Hebb further suggested that children with minimal brain damage have fewer inhibitory neurons and are therefore less able to switch off an activity at the appropriate time. Thus, they are less able to maintain selectivity or concentration on a topic.

The development of the ability to maintain attention on an activity is therefore hypothesized to involve two stages, first the development of neural representations and second the recruitment of other neurons into the activity. In these sorts of terms, it might be possible that mentally retarded children have fewer inhibitory neurons and are therefore slower to develop both these higher-order cell assemblies and, in particular, the ability to recruit other activities. The lack of inhibitory neurons would also mean an inherently noisy system with noise from irrelevant sensory systems as well as from other neural activities. Thus, sensitivity might be expected to develop even more slowly than the ability to sustain control and concentration. The results of the signal detection theory analysis in Experiment 1 found that the mentally retarded adults showed a lower mean overall sensitivity value compared with nonretarded subjects of both similar chronological and mental ages. This result indicates that the mentally retarded adults had greater overall difficulty with discrimination and this might suggest a slower development in sensitivity compared with ability to maintain attention over time.

Finally, in terms of these theories, the development of these neural mechanisms could however equally account for the two explanations for mental fatigue suggested by Welford (1976). As suggested to explain the results in Experiment 1, the nerve cells concerned with the task performance could become insensitive through continued activity as other cells cannot be recruited to relieve the fatiguing cells. Alternatively, the lack of neural connections would mean that order could not be spread and maintained throughout the brain and so neural noise would increase through irrelevant sensory stimulation and spontaneous activity in other neurons.

10.4 ALTERNATIVE EXPLANATIONS

Whilst the results of this thesis support a fatigue explanation, other theories were also considered.

10.4.1 Distraction

It was noted in Chapter 1 that some investigators have considered mentally retarded persons to be abnormally distractible (Brown and Clarke, 1963; O'Connor and Hermelin, 1971; Sen and Clarke, 1968). Also, the results of an investigation by Jones (1972) provided some support for a distraction explanation for the vigilance performance of mentally retarded persons. In addition, Fuller (1975) reported that mentally retarded 11 year old children demonstrated greater task-irrelevant behaviour during a vigilance task compared with nonretarded children of equivalent chronological age. These behaviours involved hand clapping, wriggling and other body movements.

Experiment 1 in this thesis also investigated the possibility of peripheral inattention to the stimulus source amongst the mentally retarded subjects. The results did not support the distraction hypothesis. However, extraneous stimulation was extensively reduced in Experiment 1 with the room being relatively bare and darkened. Thus the opportunity to become distracted by extraneous environmental stimulation was minimized. Nevertheless, a feature of both the mentally retarded 14 year old children and nonretarded children of equivalent mental age was the occurrence of periods of multiple responding, that is, responding to several successive stimuli, as well as audibly restless behaviour involving intermittent loud sighing or calling out. The former behaviour might have been due to a strategy which attempted to maintain arousal and hence attention. That is, as the task progressed and concentration waned, the subjects might have pushed the button for successive stimuli in order to increase their arousal and so perform more satisfactorily. This is similar to the suggestion by Welford (1976) that overactivity might be explained by the possibility that, as performance declines, subjects make compensatory increases of effort to offset losses due to fatigue. However, this explanation would imply increases in ß and no change in d', whereas only decreases in d' were found for the mentally retarded children and nonretarded children of equivalent mental age in Experiment 1.

Alternatively, both the multiple responding and restless behaviour might be indicative of an overarousal effect. Welford (1976) suggested that increased neural noise with short periods of intense neural activity would result in brief periods during which unwanted responses might be promoted. Thus, the multiple responding might occur during these periods of intense neural activity. Welford also suggested that observations of irritability and difficulty in relaxing following demanding mental activity support an overarousal theory. The restless behaviour noted might also be the result of an overarousal effect. However, such an explanation would imply decreases in ß and d', whereas only decreases in d' were found for the mentally retarded children and nonretarded children of equivalent mental age in Experiment 1.

10.4.2 Attention Strategy

The possibility that the developmental lag in the vigilance performance of mildly mentally retarded people is concerned with the ability to predict when inspection of the signal source is required was considered in Experiment 2. Welford (1976) postulated that one skill which reduces susceptibility to, or avoids the adverse effects of fatigue is the ability to predict the occurrence of events which enables the efficient deployment of attention. Subsequently, vigilance performance would be expected to improve since attention would be concentrated at appropriate times and positions.

Visual and auditory tasks with continuous stimulus sources were used with mentally retarded adults and nonretarded adults to test the attention strategy hypothesis. As subjects were more "closely coupled" to the stimulus source in the auditory task (through earphones) compared with the visual task, it was predicted that the auditory task would be relatively easier and the visual task relatively harder compared with tasks using discrete stimuli. Results indicated that the mentally retarded adults were no more dependent on being able to predict when inspection of the stimulus source is required than nonretarded adults. In fact, the subjects monitoring the continuous task in Experiment 2 scored at a higher overall hit rate on both visual and auditory modes compared with their counterparts in Experiment 1 who monitored the discrete stimulus source. Coupled with the finding that subjects in Experiment 2 registered few false alarms on both modes, this latter result implies that the continuous task was relatively easier than the discrete task for both visual and auditory modes.

Given that the auditory task was found to be relatively easier than the visual task in Experiment 1, a different training method was used in Experiment 2 (a computer controlled sequential testing procedure), in an attempt to more effectively equate the degree of difficulty of the two tasks. In this method, signal intensity was automatically raised or lowered as response accuracy varied until the lowest level at which each subject could discriminate signals from the background stimulus to at least 80% accuracy was established. It is possible that this method was more effective than the training procedure used in Experiment 1 in which the signal intensity was progressively lowered until discrimination was achieved at the same predetermined level for each subject. Thus, the different training method might have been a determinant of the improved performance in Experiment 2.

10.4.3 Poor Motivation and Willingness to Attend

There was some evidence to support the possibility that motivation could be an important factor in the vigilance performance of mildly mentally retarded people (Locke et al., 1982). Hence, Experiment 3 tested the possibility that mentally retarded children are slower than nonretarded children to develop a willingness to attend to the task. Subjects were presented with a relatively easy task in which there were as many signals as nonsignals and signal intensity was set at well above threshold level.

Results indicated that willingness to continue to attend might be a factor, although not a major factor, in the performance of mentally retarded children. The mentally retarded children showed a faster rate of decline in hit rate compared to the nonretarded children of both equivalent chronological and mental age, although their hit rate performance was similar to that of the nonretarded children of equivalent chronological age in Experiment 1. Also, both the mentally retarded children and the nonretarded children of equivalent mental age showed similar increments in false alarms over the duration of the task. One possible explanation is that both of these groups of subjects became confused about which stimulus to respond to as the task progressed, with the mentally retarded children becoming relatively more confused. Alternatively, the high rate of responding might have been fatiguing in a similar manner as physical activity which has been shown to be associated with a sensitivity decrement. This possibility is supported by the finding of a sensitivity decrement for the mentally retarded 14 year old children and nonretarded children of equivalent mental age.

10.4.4 Memory

Memory has been suggested as an important factor in vigilance performance and has been proposed to account for the sensitivity decrement found in successive-discrimination tasks with a high event rate. However, the results of both Experiment 5 and 6 failed to support a memory explanation of the greater decline in performance of mentally retarded people. In Experiment 5, it was predicted that a high signal probability would help to offset any loss of the memory trace for the signal and so reduce or avoid any loss of sensitivity. However, while performance improved compared with the corresponding results in Experiment 1, mentally retarded children showed a faster decline in hits than nonretarded children of both similar chronological and similar mental age. Experiment 6 used a signal which automatically varied in intensity according to the performance of the subject, that is, increased if performance fell and decreased if performance remained at a high level. It was predicted that the intensity would change in a wave-like fashion as the memory trace decayed and was then consolidated and would thus oscillate around a relatively constant value. The overall result, due to the averaging of subject data, was expected to be an elevated but approximately constant signal intensity across time blocks. However, mean signal intensity was found to increase monotonically across time blocks which was consistent with the fatigue explanation.

Welford, (1976) has proposed that a breakdown of short-term retention can occur as a result of fatigue. A study by Welford, Brown and Gabb (1950) was cited to support this proposal. Radio officers were tested on an electrical problem-solving task before and after international flights. Results indicated that the officers forgot information and took longer to solve the problem after a flight compared with before a flight.

Also, Kahneman (1973) has proposed a theory of attention and effort, in which effort is activated according to task demands. Time pressure is assumed to be a significant determinant of effort. Tasks which impose extreme time pressure are assumed to impose a high load on short-term memory. Davies and Parasuraman (1982) have suggested that increasing event rate also increases time pressure and thus, according to Kahneman's theory, a greater load is placed on memory. It is possible that tasks which are fatiguing require greater effort in order to sustain performance and thus the effort theory could be directly related to the fatigue hypothesis.

10.5 IMPLICATIONS FOR FURTHER RESEARCH AND TRAINING

The overall results of this thesis suggest that the early differences in vigilance performance between mildly mentally retarded children and nonretarded children are due to a slower rate of development of ability to avoid fatigue. A number of investigations could further investigate this hypothesis.

A sensitivity decrement is usually associated with successive-discrimination tasks with high event rates (greater than 24 events per minute) with adult subjects. However, in this thesis a sensitivity decrement was found for mentally retarded children with a successive-discrimination task with a low event rate. A study designed to test the vigilance performance of mildly mentally retarded children using tasks with even lower event rates could investigate the generality of the fatigue phenomenon. Welford (1976) has suggested that one skill which avoids fatigue is the pacing of performance. A lower event rate might allow the progressive local neural failure to recover. If so, sensitivity should not decline or decline less over the duration of the task and the vigilance decrement would not be expected to be as pronounced compared with performance on tasks using higher event rates.

Each of the mentally retarded subject groups in Experiment 1 demonstrated more overall false alarms compared with nonretarded subjects of similar chronological age. Studies concerned with the vigilance performance of learning disabled children who are hyperactive have found that sustained attention capacity is lower and impulsivity higher for these children (Davies and Parasuraman, 1982). These results have been interpreted as supporting the hypothesis that false alarm rate is positively related to impulsivity (Anderson et al., 1973, 1974; Doyle et al., 1976). Thus, another possibility is that mentally retarded children might be more impulsive and less able to control or inhibit irrelevant sensory stimulation and spontaneous neural activity. Given that the vigilance task is "a situation where nothing much is happening" (Moray, 1969), mentally retarded children might find it difficult not to respond to the nonsignal stimulus events. A study in which subjects could respond to each stimulus event, such as pushing a button on their right for occurrences of signals and a button on the left for nonsignals, might test this possibility. A series of low event rate tasks could be used to determine whether consistent responding is also fatiguing.

Welford (1976) has suggested that prolonged practice could reduce susceptibility to fatigue. Whilst all subjects who participated in the experiments reported in this thesis were trained to equivalent criterion levels, the mentally retarded children required more trials to reach criterion than the nonretarded subjects of equivalent chronological age. This suggests that the retarded children have more difficulty both learning and understanding the task and therefore might benefit from even more prolonged training.

The mentally retarded subjects in all but two (Experiments 4 and 6) of the experiments in this thesis tended to register more false alarms compared with their nonretarded counterparts, although a significant mean overall difference was only found in Experiment 1. This tendency might be explained in a number of ways apart from the impulsivity possibility mentioned above. First, the retarded subjects might have been responding more to keep up their arousal and so their performance. However, as already discussed earlier in this chapter (Section 10.4.1), the results of the Signal Detection Theory analysis did not support this possibility. Second, there might have been some confusion about which stimulus required the response. Third, lower perceptual sensitivity on the part of the retarded subjects would result in more false alarms. Fourth, the mentally retarded subjects might have had the expectation that there were going to be many more signals than in fact was the case. This possibility could be tested by providing more extensive training with signal/nonsignal ratios which were more similar or the same as that used in the task, and/or by providing feedback on both correct and incorrect responses during the task.

The overall results of the experiments in this thesis indicate that mentally retarded persons develop the ability to sustain vigilance performance over time to a level similar to that of nonretarded persons by about the age of 17 years. However, the finding in Experiment 1 that each of the mentally retarded groups of subjects showed lower overall discriminability compared with nonretarded subjects of both similar chronological and mental age suggests that they might develop sensitivity at an even slower rate. A further study using older mentally retarded adults, for example of 30 years of age, could determine if discriminability continues to improve with age and ultimately reaches a level similar to that of nonretarded persons.

Two different pre-task training methods were used in different experiments in this thesis. One method involved training subjects to discriminate signals from nonsignals at one predetermined intensity level. The other, a computer controlled sequential testing (PEST) procedure, determined the lowest level at which each subject could discriminate signals from nonsignals. A number of subjects failed to reach criterion at the final test level using the former training method and therefore did not participate in the particular test sessions. However, all subjects completed training using the PEST procedure. Therefore, the PEST procedure might be useful in future experiments for equating the level of difficulty for each subject. In this way, there might be less dropout of subjects which could otherwise leave only "better performers" in the study.

The PEST procedure might also provide the opportunity to further test the previous suggestion that discriminability, as measured by d', is slower to develop in mentally retarded persons. The lowest level at which subjects could discriminate signals from nonsignals could be determined using the PEST procedure with the same task and subject groups employed in Experiment 1. In this way, the lowest intensity levels at which signals could be discriminated from nonsignals for the mentally retarded children and adults could be compared with those for nonretarded persons of equivalent chronological and mental ages. The hypothesis would predict that the intensity levels for the mentally retarded persons would be the same as those for nonretarded persons of similar mental age, but lower than those of nonretarded persons of similar chronological age.

There seems to be some confusion in the literature about how differences in performance between mentally retarded and nonretarded persons should be measured. Some studies have only measured hits and not false alarms although both measures may be necessary to accurately compare differences in discriminability. In addition, some studies have only measured overall performance and not rate of decline over time. Differences in overall performance may only reflect differences in discriminability whereas differences in rates of decline are indicative of differences in rates of loss of vigilance or sustained attention. Thus, in any further investigations, both hits and false alarms should be measured and a distinction should be made between overall performances and rates of decline.

Since the experiments in this thesis suggest that the capacity of mentally retarded persons to sustain attention does not reach that of nonretarded persons until about 17 years of age, this might imply that learning requiring sustained attention might only be reaching its maximum level in mentally retarded persons when they are about to leave high school. If this was so, there might be benefits in providing tertiary education for mentally retarded persons, particularly in adaptive behaviour skills, so that education is available when their sustained attention has reached its maximum level.

Also, the question arises as to whether the development of the ability of mentally retarded persons to avoid fatigue and maintain vigilance performance can be accelerated and so the extent of the delay in comparison to nonretarded persons reduced. If the extensive neural networks which are required to resist fatigue are built up through repeated organized activities, this would suggest that mentally retarded children might benefit from repeated exposure to organized activities, as opposed to less structured activities, in primary and secondary education. In this way, the neural networks which underlie performance on tasks requiring sustained attention might be built up more quickly. An investigation designed to measure the vigilance performance of children of similar IQ levels who have received education involving more structured activities versus those who have received less structured activities could provide some indication of the validity of this hypothesis.

None of the five previous investigations into the vigilance performance of mentally retarded persons used signal detection theory methods to analyse their data. A number of criticisms have been put forward when considering the application of signal detection theory to vigilance. These criticisms centre around the possibility that certain assumptions are not met, such as the requirement of equal variances for both signal and signal plus noise distributions and the use of an invariable decision rule by subjects, as well as the appropriateness of parameters like d' and ß for describing performance (Davies and Parasuraman, 1982). In addition, signal detection theory analysis depends on the majority of the number of hits being less than maximum and false alarms being more than zero, otherwise unrealistic values of d' and ß are obtained. However, Davies and Parasuraman (1982) proposed that the approach does "provide a basis for a more complete understanding of the processes underlying vigilance behaviour, and a better technique for analysis of performance than the "traditional" vigilance performance" (p.59). Similarly, whilst some aspects of signal detection theory might not have been entirely met in the studies in this thesis, the analysis did provide information on sensitivity and criterion which was useful. Thus, it would be seem beneficial to employ the signal detection theory approach, where possible, in future investigations into the vigilance performance of mentally retarded persons.

APPENDIX A - 1

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 1

	GROUP							
	NONRETARDED (CA1)		MENTALLY RETARDED (MR1)			NONRETARDED (CA2)	
S	SEX	AGE	SEX	IQ	AGE	SEX	AGE
1	F	18-09	M	67	20-00	M	13-00
2	M	19-03	F	76	17-07	M	13-00
3	F	19-03	M	75	19-02	M	12-07
4	F	17-11	M	68	17-02	F	13-00
5	M	19-06	M	61	18-08	F	13-04
6	F	18-09	M	74	19-04	M	13-02
7	F	19-04	M	66	20-00	F	13-04
8	F	18-03	F	67	19-00	M	12-11
9	F	18-02	M	74	18-03	F	13-07
10	M	17-08	M	74	18-02	F	12-10
MEAN		18-08		70	18-09		13-01
S.D.		0-08		5	0-11		0-04

	GROUP				
	MENTALLY RETARDED (MR2)			NONRETARDED (MA)	
S	SEX	IQ	AGE	SEX	AGE
1	M	74	14-00	M	8-08
2	M	58	14-10	M	8-06
3	M	63	13-10	M	8-08
4	F	45	13-08	M	8-11
5	M	60	13-01	M	9-06
6	M	46	14-08	M	9-06
7	F	70	14-10	M	9-04
8	F	53	13-08	M	8-08
9	F	45	16-02	M	8-10
10	F	53	13-02	F	8-08
MEAN		57	14-02		8-11
S.D.		10	0-11		0-05

APPENDIX A - 2

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 2

	GROUP				
	MENTALLY RETARDED (MR1)			NONRETARDED (CA1)	
S	SEX	IQ	AGE	SEX	AGE
1	M	64	17-07	M	18-03
2	F	66	20-08	M	18-11
3	M	64	17-07	F	17-08
4	M	61	18-02	F	18-10
5	M	81	17-09	M	17-07
6	F	80	22-02	F	18-01
7	M	64	23-01	F	18-00
8	M	78	19-02	M	18-10
9	F	62	17-01	F	18-07
10	M	76	17-00	F	17-07
MEAN		70	19-00		18-03
S.D.		8	2-02		0-06

APPENDIX A - 3

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 3

	GROUP						
	NONRETARDED (CA)		MENTALLY RETARDED (MR)			NONRETARDED (MA)	
S	SEX	AGE	SEX	IQ	AGE	SEX	AGE
1	M	12-09	M	72	12-00	M	9-10
2	F	12-09	M	63	14-07	F	9-09
3	F	13-02	F	65	14-03	M	9-10
4	M	13-05	M	67	13-03	F	9-10
5	M	13-07	M	52	15-09	M	10-03
6	M	12-09	M	58	12-10	M	9-05
7	M	14-00	F	70	11-05	M	9-02
8	F	12-08	M	59	14-04	F	8-06
9	F	12-06	M	68	15-00	F	9-11
10	F	12-10	F	68	13-11	F	9-04
MEAN		13-00		64	13-09		9-07
S.D.		0-06		6	1-04		0-06

APPENDIX A - 4

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 4

	GROUP							
	NONRETARDED (CA)		MENTALLY RETARDED (MR)			NONRETARDED (MA)	
S	SEX	AGE	SEX	IQ	AGE	SEX	AGE
1	F	13-06	F	48	14-05	F	8-02
2	M	13-06	F	62	13-11	M	8-04
3	M	13-03	F	64	14-01	M	9-05
4	M	13-06	M	75	12-01	F	9-06
5	F	13-06	F	54	15-10	M	7-11
6	F	13-05	M	58	16-00	F	7-08
7	F	13-06	F	52	16-09	M	8-06
8	M	13-09	M	59	14-10	M	8-01
9	F	13-00	M	55	13-08	F	8-07
10	M	13-04	M	59	16-03	F	8-06
MEAN		13-05		59	14-09		8-06
S.D.		0-02		8	1-05		0-07

APPENDIX A - 5

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 5

	GROUP						
	NONRETARDED (CA)		MENTALLY RETARDED (MR)			NONRETARDED (MA)	
S	SEX	AGE	SEX	IQ	AGE	SEX	AGE
1	F	13-02	F	57	16-09	M	8-05
2	F	13-09	M	75	14-09	F	8-06
3	F	13-03	M	49	15-08	F	8-09
4	M	12-08	F	74	15-02	F	8-07
5	F	13-05	M	55	14-04	M	8-07
6	F	12-09	M	62	14-04	F	8-09
7	M	13-01	F	63	15-02	M	9-05
8	M	13-04	F	67	15-07	F	9-06
9	M	13-04	M	62	15-03	M	9-03
10	M	13-00	M	55	13-08	F	9-04
MEAN		13-03		62	15-00		8-11
S.D.		0-04		8	0-10		0-05

APPENDIX A - 6

DEMOGRAPHIC INFORMATION FOR SUBJECTS IN EXPERIMENT 6

	GROUP						
	NONRETARDED (CA)		MENTALLY RETARDED (MR)			NONRETARDED (MA)	
S	SEX	AGE	SEX	IQ	AGE	SEX	AGE
1	F	13-05	M	65	15-05	F	8-08
2	F	13-07	F	60	15-10	M	8-09
3	M	12-11	F	67	14-11	M	8-04
4	F	12-11	F	55	15-10	M	8-07
5	M	13-03	M	47	16-07	F	8-05
6	M	13-11	F	58	15-05	F	8-09
7	M	13-06	F	60	16-00	F	8-05
8	F	13-00	M	56	17-00	F	8-05
9	M	13-08	F	52	13-02	M	9-00
10	F	13-09	F	66	12-04	F	8-08
MEAN		13-05		59	15-03		8-07
S.D.		0-04		6	1-05		0-02

APPENDIX B – 1

RAW DATA FOR EXPERIMENT 1

NONRETARDED 19 YEAR OLD SUBJECTS

HITS

	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	9	9	9	9	9	10	10	10	9	9
2	7	5	8	7	6	10	10	9	9	7
3	9	10	10	10	10	10	10	10	10	10
4	6	8	10	8	9	10	10	10	9	8
5	8	8	9	7	9	10	10	9	10	10
6	9	10	10	10	10	10	10	10	10	10
7	7	9	9	7	8	10	8	6	10	7
8	6	3	5	2	2	9	6	8	8	6
9	8	5	5	4	6	7	2	4	5	8
10	7	8	8	8	6	9	8	9	10	10

FALSE ALARMS

	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	26	1	0	0	0	0	0	0	0	0
2	41	25	33	34	25	11	3	5	1	1
3	18	6	6	3	2	6	4	1	0	0
4	16	16	16	11	5	2	5	0	1	0
5	9	5	1	7	1	0	1	0	0	0
6	63	66	61	58	44	12	5	10	1	2
7	20	11	3	1	0	3	1	1	0	0
8	26	13	7	4	3	0	0	0	0	0
9	2	0	1	0	1	1	0	0	0	0
10	8	24	27	11	15	10	1	2	0	0

APPENDIX B – 1

RAW DATA FOR EXPERIMENT 1

RETARDED 19 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	8	8	7	7	7	10	7	8	8	9
2	9	8	8	7	7	7	7	7	6	6
3	10	9	8	5	7	10	9	5	7	7
4	6	5	4	2	4	10	5	7	10	9
5	8	10	8	6	8	6	5	8	7	7
6	9	6	7	9	6	10	10	10	10	10
7	6	4	2	6	4	7	7	10	8	9
8	10	10	10	8	10	10	10	9	10	9
9	9	9	9	9	9	9	8	7	3	6
10	10	8	10	9	9	7	8	8	7	7

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	22	13	21	16	23	27	20	22	8	22
2	6	7	1	1	1	4	1	0	0	0
3	69	75	66	69	62	19	1	1	0	0
4	6	10	5	8	6	29	15	27	8	1
5	40	27	42	14	20	0	1	1	2	1
6	32	25	30	27	34	19	24	20	26	42
7	48	60	64	89	84	45	91	103	116	111
8	45	45	31	49	52	69	80	70	53	67
9	28	73	83	77	108	11	0	0	0	1
10	54	85	99	101	97	33	11	45	53	53

APPENDIX B - 1

RAW DATA FOR EXPERIMENT 1

NONRETARDED 13 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	6	9	10	10	9	10	10	10	9	10
2	8	10	6	6	4	10	10	9	10	10
3	8	10	10	6	9	8	6	7	9	8
4	9	10	8	10	10	10	9	9	9	10
5	10	8	10	8	9	9	9	8	7	7
6	9	10	9	9	10	10	8	10	7	10
7	8	9	9	10	10	10	8	9	6	9
8	8	6	6	4	5	9	10	10	10	10
9	6	9	9	5	7	9	10	7	8	8
10	9	10	8	9	7	10	8	7	10	9

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	35	24	20	12	9	21	10	7	6	10
2	22	19	7	11	6	4	0	0	0	1
3	19	29	26	33	32	21	20	20	23	21
4	4	10	13	19	19	11	14	5	6	11
5	36	23	15	3	3	2	0	1	2	1
6	35	6	2	1	3	0	0	0	0	0
7	32	13	6	13	18	21	10	7	4	1
8	13	2	3	1	0	24	2	0	0	1
9	11	2	1	2	3	19	1	1	0	0
10	35	24	33	36	32	10	8	7	10	9

APPENDIX B - 1

RAW DATA FOR EXPERIMENT 1

RETARDED 14 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	8	7	6	3	7	10	7	2	8	10
2	8	2	1	0	2	6	4	3	2	2
3	7	2	2	2	0	5	5	1	1	0
4	9	3	1	1	0	9	7	3	3	2
5	7	3	4	5	0	7	6	7	5	7
6	7	3	0	1	0	10	3	2	2	0
7	8	0	3	1	2	7	3	5	1	3
8	8	4	4	4	4	6	4	6	9	6
9	6	7	6	7	5	10	8	7	8	6
10	6	1	3	0	2	7	1	5	3	1

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	54	44	42	64	116	25	29	23	47	9
2	51	60	14	12	33	45	15	4	7	2
3	33	12	10	13	16	42	12	9	8	6
4	36	25	5	9	1	51	16	6	11	9
5	31	18	26	30	0	72	68	57	16	33
6	35	22	7	5	3	49	18	9	3	1
7	47	53	42	67	57	15	36	38	33	61
8	30	44	56	55	36	28	40	24	13	20
9	58	44	49	62	51	57	65	70	61	43
10	20	7	25	14	50	18	41	45	44	28

APPENDIX B - 1

RAW DATA FOR EXPERIMENT 1

NONRETARDED 9 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	9	8	8	7	4	9	9	7	7	10
2	10	9	8	9	8	9	7	6	4	7
3	10	8	6	5	6	6	2	3	0	1
4	7	6	1	1	1	10	10	6	7	5
5	6	2	2	0	1	10	7	8	6	8
6	8	6	7	6	8	6	5	6	1	1
7	8	2	0	0	1	6	7	2	4	0
8	6	1	1	0	0	9	6	9	5	7
9	9	6	1	2	1	9	9	8	10	7
10	8	8	6	5	4	5	8	6	3	7

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	39	27	16	14	13	15	4	0	1	1
2	60	56	65	46	48	23	10	15	6	2
3	40	33	18	57	26	3	2	0	4	2
4	45	38	8	29	24	27	11	17	6	5
5	27	33	17	15	17	40	6	15	25	20
6	70	58	77	69	76	29	23	16	5	3
7	40	5	0	2	12	81	86	40	65	18
8	37	25	12	1	1	43	19	17	4	5
9	91	60	22	15	34	65	7	1	0	2
10	38	43	29	35	31	12	12	9	8	8

APPENDIX B - 2

RAW DATA FOR EXPERIMENT 2

NONRETARDED 18 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	10	8	10	9	10	10	10	10	10	10
2	10	10	10	10	9	10	10	10	10	10
3	10	10	10	10	10	10	10	10	10	10
4	10	8	8	9	9	10	10	10	9	10
5	10	9	9	9	5	10	10	9	3	7
6	9	10	9	8	9	10	10	10	10	10
7	10	9	8	5	4	10	10	10	10	9
8	9	4	6	3	7	10	10	10	10	10
9	10	10	9	10	10	10	10	10	10	10
10	10	10	10	10	10	10	10	10	9	10

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0
3	1	0	0	0	0	0	0	0	0	0
4	0	0	0	0	1	1	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0
6	8	0	0	0	1	0	0	0	0	0
7	1	0	0	0	0	0	0	0	0	0
8	2	0	1	0	0	0	0	0	1	0
9	1	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0

APPENDIX B - 2

RAW DATA FOR EXPERIMENT 2

RETARDED 19 YEAR OLD SUBJECTS

	HITS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	8	7	8	6	9	5	6	5	4	4
2	10	9	9	10	9	10	10	10	10	10
3	10	9	9	9	7	9	10	10	9	10
4	8	6	7	5	5	10	10	10	10	10
5	10	10	7	6	9	10	10	10	8	10
6	10	7	5	6	8	9	9	9	7	9
7	8	5	6	1	3	10	10	10	10	10
8	10	10	10	10	10	9	9	9	7	5
9	6	7	3	2	3	7	10	9	8	8
10	8	8	7	6	9	9	7	7	8	6

	FALSE ALARMS									
	VISUAL TASK					AUDITORY TASK				
	TIME BLOCKS					TIME BLOCKS				
S	1	2	3	4	5	1	2	3	4	5
1	0	0	0	0	0	3	3	6	2	1
2	24	7	1	0	1	2	0	0	0	0
3	2	1	1	1	1	0	4	0	2	0
4	25	21	22	24	19	0	0	1	0	0
5	3	3	1	1	1	0	0	3	3	1
6	0	0	0	0	0	1	0	0	0	0
7	7	2	0	1	5	4	2	5	4	2
8	1	0	0	0	0	0	0	0	0	3
9	0	0	0	0	0	0	0	0	0	0
10	6	3	5	1	15	0	0	0	0	0

APPENDIX B - 3

RAW DATA FOR EXPERIMENT 3

NONRETARDED 13 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
	1	2	3	4	5
1	99	100	100	100	99
2	100	100	100	99	100
3	87	87	80	84	83
4	100	100	100	100	100
5	99	99	100	99	100
6	96	91	88	97	98
7	100	100	98	100	100
8	99	100	100	100	100
9	99	100	98	91	96
10	88	98	97	97	91

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	29	12	9	11	14
2	1	1	6	3	11
3	11	20	19	11	19
4	27	18	16	15	20
5	11	23	25	8	13
6	28	17	5	10	2
7	5	4	1	6	4
8	3	3	3	0	12
9	46	24	25	8	9
10	10	8	4	4	3

APPENDIX B – 3

RAW DATA FOR EXPERIMENT 3

RETARDED 14 YEAR OLD SUBJECTS

S	HITS — VISUAL TASK — TIME BLOCKS				
	1	2	3	4	5
1	93	93	81	94	75
2	100	89	83	84	84
3	91	87	77	67	61
4	95	95	98	89	85
5	90	100	99	97	89
6	88	75	82	74	74
7	83	71	42	26	34
8	91	96	100	98	99
9	80	90	65	60	54
10	99	98	96	98	77

S	FALSE ALARMS — VISUAL TASK — TIME BLOCKS				
	1	2	3	4	5
1	43	38	33	46	52
2	6	24	37	34	43
3	8	26	35	33	28
4	20	18	22	13	9
5	8	23	10	10	4
6	25	41	35	48	43
7	30	20	21	7	9
8	1	14	8	15	17
9	2	5	3	3	1
10	15	13	19	31	33

APPENDIX B - 3

RAW DATA FOR EXPERIMENT 3

NONRETARDED 10 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	92	100	100	96	98
2	96	99	96	92	92
3	98	99	95	91	85
4	80	76	73	67	70
5	100	99	98	98	99
6	100	99	98	96	86
7	94	100	99	98	99
8	96	94	93	86	86
9	99	100	90	94	95
10	97	96	83	83	69

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	6	19	37	62	50
2	12	20	19	23	20
3	22	18	9	11	16
4	19	5	9	11	12
5	3	7	6	1	5
6	6	6	4	1	5
7	4	9	3	5	2
8	6	6	10	9	9
9	24	40	34	37	24
10	12	26	23	21	24

APPENDIX B - 4

RAW DATA FOR EXPERIMENT 4

NONRETARDED 13 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	9	10	9	9	10
2	10	10	7	10	9
3	10	10	10	10	10
4	10	7	7	6	8
5	9	9	9	10	10
6	10	10	10	9	10
7	10	6	10	9	7
8	9	9	5	6	7
9	10	9	8	9	8
10	10	7	7	9	7

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	5	1	0	0	0
2	4	10	9	15	13
3	0	0	0	0	0
4	1	0	0	0	0
5	0	0	1	0	0
6	30	16	21	14	5
7	1	0	0	0	0
8	8	2	1	0	0
9	5	1	0	0	0
10	0	1	0	0	0

APPENDIX B – 4

RAW DATA FOR EXPERIMENT 4

RETARDED 15 YEAR OLD SUBJECTS

S	HITS — VISUAL TASK — TIME BLOCKS				
	1	2	3	4	5
1	10	8	7	5	6
2	10	9	9	5	2
3	9	9	9	9	10
4	9	8	10	9	10
5	6	2	3	5	3
6	10	10	10	9	9
7	10	10	9	9	10
8	10	9	9	6	7
9	10	8	8	9	9
10	10	10	10	10	10

S	FALSE ALARMS — VISUAL TASK — TIME BLOCKS				
	1	2	3	4	5
1	41	30	0	0	2
2	8	2	5	0	0
3	5	9	2	13	18
4	19	17	6	5	2
5	15	14	0	0	4
6	20	8	16	9	12
7	28	12	13	11	2
8	16	16	1	7	9
9	0	0	0	0	0
10	50	38	25	26	47

APPENDIX B - 4

RAW DATA FOR EXPERIMENT 4

NONRETARDED 9 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	10	10	9	10	10
2	8	6	4	4	9
3	9	10	10	6	9
4	10	10	10	8	7
5	10	10	10	9	10
6	10	9	7	8	8
7	10	9	10	10	9
8	10	10	10	10	10
9	10	9	10	6	7
10	9	8	10	9	8

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	13	18	27	23	23
2	13	5	0	2	0
3	40	0	0	0	17
4	6	4	2	1	5
5	1	1	2	0	0
6	22	3	8	2	7
7	13	10	15	20	17
8	29	3	2	1	0
9	64	39	30	27	39
10	29	33	15	16	7

APPENDIX B - 5

RAW DATA FOR EXPERIMENT 5

NONRETARDED 13 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	94/98	90/92	95/95	92/95	109/115
2	102/108	97/98	98/104	102/106	91/96
3	100/100	88/89	105/106	101/103	100/102
4	61/107	66/100	65/93	69/94	65/94
5	95/98	99/105	83/101	68/99	86/96
6	88/104	85/104	86/104	96/114	87/103
7	80/101	97/103	108/114	90/93	97/103
8	92/101	94/101	93/101	89/101	87/101
9	94/112	88/93	94/101	93/100	87/99
10	92/98	74/96	80/90	70/88	86/104

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	33/102	51/108	63/105	62/105	63/85
2	42/92	61/102	55/96	62/94	71/104
3	30/100	49/111	24/94	23/97	28/98
4	12/93	12/100	12/107	28/106	24/106
5	15/102	11/95	18/99	3/101	16/104
6	29/96	31/96	27/96	15/86	6/97
7	7/99	11/97	14/86	12/107	17/97
8	5/99	9/99	13/99	9/99	9/99
9	19/98	47/107	40/99	50/100	53/101
10	34/102	40/104	40/110	44/112	41/96

APPENDIX B - 5

RAW DATA FOR EXPERIMENT 5

RETARDED 15 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	102/108	75/98	74/106	64/95	37/95
2	85/91	67/96	66/101	62/96	55/98
3	90/102	85/95	76/107	70/97	52/95
4	98/110	86/101	83/101	77/111	73/100
5	97/105	82/102	61/87	63/96	55/97
6	73/100	38/95	46/100	66/92	70/112
7	79/100	73/97	65/99	71/94	62/98
8	72/98	66/102	48/95	35/103	31/95
9	78/94	94/108	86/97	92/98	48/79
10	83/105	77/97	66/97	72/111	64/101

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	18/92	17/102	16/94	8/105	8/105
2	66/109	53/104	63/99	40/104	42/102
3	32/98	27/105	23/93	33/103	41/105
4	58/90	56/99	61/99	66/89	69/100
5	62/95	58/98	45/113	54/104	50/103
6	23/100	16/105	19/100	36/108	19/88
7	60/100	67/103	54/101	59/106	55/102
8	25/102	42/98	48/105	14/97	30/105
9	41/106	54/92	64/103	78/102	55/121
10	41/95	61/103	68/103	62/89	57/99

APPENDIX B - 5

RAW DATA FOR EXPERIMENT 5

NONRETARDED 9 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	85/88	90/100	91/103	93/97	95/103
2	91/98	99/102	101/106	83/102	82/101
3	85/107	78/93	97/102	97/113	99/106
4	80/103	69/106	45/98	50/108	55/112
5	77/90	85/100	71/90	71/99	90/112
6	73/103	67/108	66/105	52/93	48/96
7	86/100	88/96	78/106	98/103	95/105
8	91/100	88/103	85/93	83/91	67/91
9	85/99	82/101	56/94	92/109	74/98
10	81/95	68/93	63/89	70/107	81/94

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	37/112	14/100	6/97	18/103	21/97
2	44/102	41/98	20/94	23/98	19/99
3	17/93	17/107	25/98	18/87	37/94
4	35/97	29/94	26/102	17/92	21/88
5	50/110	67/100	47/110	65/101	71/88
6	50/97	60/92	33/95	47/107	45/104
7	45/100	22/104	26/94	38/97	31/95
8	53/100	61/97	71/107	77/109	35/109
9	29/101	38/99	30/106	35/91	38/102
10	64/105	49/107	66/111	45/93	72/106

APPENDIX B - 6

RAW DATA FOR EXPERIMENT 6

NONRETARDED 13 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	78/91	80/100	76/93	69/95	72/91
2	88/103	86/96	101/103	88/98	100/108
3	70/91	86/92	95/108	92/102	86/99
4	75/100	91/98	102/103	97/103	93/100
5	78/92	103/110	97/99	88/93	87/89
6	77/96	78/101	71/97	79/101	71/100
7	88/101	93/101	80/91	98/100	100/109
8	75/96	84/91	93/105	92/106	96/102
9	95/103	87/100	84/93	91/99	91/100
10	89/102	96/96	96/97	90/90	91/98

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	28/109	19/100	26/107	14/105	20/109
2	29/97	29/104	25/97	17/102	30/92
3	10/109	23/108	20/92	13/98	34/101
4	20/100	38/102	29/97	40/97	32/100
5	28/108	23/90	28/101	37/107	33/111
6	17/104	9/99	15/103	4/99	1/100
7	22/99	38/99	40/109	56/100	19/91
8	35/104	39/109	37/95	29/94	41/98
9	30/97	32/100	35/107	32/101	29/100
10	32/98	47/104	40/103	31/110	21/102

APPENDIX B - 6

RAW DATA FOR EXPERIMENT 6

RETARDED 15 YEAR OLD SUBJECTS

	HITS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	91/97	100/106	91/96	91/96	100/106
2	80/107	85/108	63/101	90/108	66/84
3	88/102	99/105	78/93	76/95	71/100
4	79/87	88/99	85/98	95/100	86/94
5	91/96	101/104	99/107	68/89	75/97
6	81/100	81/98	88/102	89/99	84/103
7	70/92	68/107	50/103	55/102	44/95
8	68/105	60/90	61/105	66/94	64/94
9	82/102	73/98	76/104	67/109	57/94
10	61/96	60/112	34/97	63/100	71/107

	FALSE ALARMS				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	44/103	28/94	19/104	39/104	17/94
2	21/93	36/92	27/99	6/92	8/116
3	57/98	41/95	58/107	40/105	33/100
4	38/113	52/101	24/102	19/100	24/106
5	45/104	28/96	30/93	28/111	30/103
6	29/100	15/102	16/98	47/101	48/97
7	13/108	0/93	1/97	1/98	1/105
8	6/95	29/110	20/95	21/106	23/106
9	41/98	37/102	21/96	26/91	41/106
10	4/104	1/88	3/103	9/100	9/93

APPENDIX B – 6

RAW DATA FOR EXPERIMENT 6

NONRETARDED 9 YEAR OLD SUBJECTS

S	HITS – VISUAL TASK – TIME BLOCKS				
	1	2	3	4	5
1	83/94	95/110	87/99	60/106	78/97
2	99/117	75/99	83/98	81/98	89/102
3	97/104	105/109	92/97	104/106	97/99
4	72/89	74/99	52/105	68/92	63/95
5	92/101	79/102	84/106	50/104	55/96
6	81/96	89/99	91/105	79/94	89/115
7	87/92	78/94	85/99	73/100	55/98
8	101/101	100/100	93/93	96/98	89/94
9	64/91	73/102	65/98	65/107	60/102
10	88/102	90/103	89/107	87/110	98/112

S	FALSE ALARMS – VISUAL TASK – TIME BLOCKS				
	1	2	3	4	5
1	25/106	18/90	8/101	17/94	14/103
2	25/83	19/101	28/102	24/102	17/98
3	46/96	37/91	50/103	58/94	43/101
4	46/111	38/101	17/95	28/108	32/105
5	31/99	24/98	35/94	19/96	20/104
6	16/104	17/101	24/95	44/106	17/85
7	56/108	26/106	39/101	27/100	16/102
8	43/99	30/100	24/107	20/102	19/106
9	18/109	21/98	15/102	11/93	8/98
10	36/98	26/97	20/93	20/90	17/88

APPENDIX B - 6

RAW DATA FOR EXPERIMENT 6

NONRETARDED 13 YEAR OLD SUBJECTS

	MEAN SIGNAL INTENSITY				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	14.9	14.0	15.0	16.0	16.0
2	16.6	16.0	16.0	15.0	15.0
3	16.9	17.0	18.0	16.0	14.0
4	18.3	18.0	18.0	17.0	18.0
5	15.3	15.0	15.0	15.0	16.0
6	17.6	15.0	13.8	15.0	14.0
7	17.7	15.0	15.0	16.0	19.0
8	16.3	19.0	19.0	20.0	22.0
9	16.7	15.0	15.0	16.8	17.0
10	18.4	15.0	17.0	19.0	18.0

APPENDIX B - 6

RAW DATA FOR EXPERIMENT 6

RETARDED 15 YEAR OLD SUBJECTS

	MEAN SIGNAL INTENSITY				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	25.2	30.0	29.1	26.8	25.9
2	28.6	41.9	53.6	58.0	58.0
3	37.1	56.8	50.8	42.4	54.0
4	40.5	49.2	56.9	56.0	54.0
5	23.5	23.0	22.5	23.0	28.5
6	22.8	24.0	20.9	20.0	26.0
7	38.6	38.4	43.0	47.0	51.8
8	24.8	28.7	36.4	42.0	46.0
9	29.9	41.1	41.2	40.7	52.4
10	23.2	22.0	25.2	27.1	32.0

APPENDIX B – 6

RAW DATA FOR EXPERIMENT 6

NONRETARDED 9 YEAR OLD SUBJECTS

	MEAN SIGNAL INTENSITY				
	VISUAL TASK				
	TIME BLOCKS				
S	1	2	3	4	5
1	24.3	23.0	20.8	19.6	26.9
2	16.8	14.0	16.0	17.9	17.0
3	21.7	30.0	30.0	34.0	56.7
4	33.7	29.2	53.3	57.1	59.5
5	25.3	28.0	30.0	41.2	49.3
6	20.7	16.0	14.9	15.0	18.8
7	36.0	52.0	53.9	58.0	60.0
8	30.9	30.0	28.9	28.0	26.9
9	13.9	15.9	20.0	24.0	27.0
10	14.9	15.0	16.0	17.0	18.0

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 19 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	2.36	3.61	4.37	4.37	4.37
2	1.30	1.13	1.80	1.44	1.38
3	2.56	4.97	4.97	5.14	5.42
4	1.66	2.25	4.50	2.40	3.16
5	2.49	2.72	3.61	2.28	3.61
6	1.72	3.48	3.56	3.59	3.83
7	1.75	2.84	3.34	2.85	3.93
8	1.33	0.95	1.75	1.21	1.21
9	3.17	3.09	2.33	2.84	2.58
10	2.28	1.97	1.92	2.40	1.66
MEAN	2.06	2.70	3.22	2.85	3.12

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	0.79	6.59	52.12	52.12	52.12
2	1.17	1.89	1.11	1.33	1.83
3	1.00	0.05	0.05	0.07	0.13
4	2.60	1.88	0.02	2.35	2.58
5	2.72	4.12	6.59	4.04	6.59
6	0.49	0.01	0.01	0.01	0.01
7	1.85	1.47	3.63	13.05	83.15
8	1.74	2.59	4.63	5.78	5.78
9	10.50	118.48	14.97	114.74	14.50
10	4.04	1.32	1.26	2.35	2.60
MEAN	2.69	13.84	8.44	19.58	16.93

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE AUDITORY TASK FOR THE NONRETARDED 19 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	6.18	6.18	6.18	4.37	4.37
2	4.65	5.14	3.16	3.61	2.85
3	4.97	5.14	5.42	6.18	6.18
4	5.41	4.97	6.18	3.61	3.93
5	6.18	5.42	4.37	6.18	6.18
6	4.65	4.97	4.74	5.42	5.42
7	5.14	3.17	2.58	6.18	3.62
8	4.37	3.34	3.93	3.93	3.34
9	2.85	2.25	2.84	3.09	3.93
10	2.93	3.17	3.61	6.18	6.18
MEAN	4.73	4.38	4.30	4.88	4.60

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	1.00	1.00	1.00	52.12	52.12
2	0.03	0.07	2.58	6.59	13.05
3	0.05	0.07	0.13	1.00	1.00
4	0.13	0.05	1.00	6.59	83.15
5	1.00	0.13	52.12	1.00	1.00
6	0.03	0.05	0.03	0.13	0.13
7	0.07	10.50	14.50	1.00	103.26
8	52.12	114.74	83.15	83.15	114.74
9	13.05	83.15	114.74	118.48	83.15
10	1.70	10.50	6.59	1.00	1.00
MEAN	6.92	22.03	27.58	27.11	45.26

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 19 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	2.02	2.32	1.75	1.93	1.70
2	3.16	2.59	3.17	2.85	2.85
3	3.45	3.03	1.23	0.36	0.97
4	2.13	1.65	1.63	0.91	1.63
5	1.65	4.17	1.61	1.73	2.07
6	2.24	1.38	1.52	2.36	1.17
7	0.93	0.22	-0.43	0.33	-0.10
8	3.80	3.80	4.09	1.49	3.70
9	2.32	1.59	1.43	1.51	1.11
10	3.67	0.97	3.04	1.21	1.26
MEAN	2.54	2.17	1.90	1.47	1.64

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	1.40	2.09	1.85	2.34	1.74
2	2.58	3.25	10.50	13.05	13.05
3	0.01	2.04	0.76	1.07	0.96
4	5.68	3.87	5.68	3.25	5.68
5	0.97	0.02	0.95	2.88	1.49
6	0.69	1.83	1.43	0.79	1.47
7	1.22	1.08	0.76	0.97	0.98
8	0.01	0.01	0.01	0.86	0.01
9	0.75	0.46	0.45	0.45	0.45
10	0.01	0.71	0.01	0.44	0.44
MEAN	1.33	1.54	2.24	2.61	2.63

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE AUDITORY TASK FOR THE MENTALLY RETARDED 19 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	4.17	1.75	2.02	2.59	2.46
2	2.58	2.85	3.62	3.34	3.34
3	4.37	3.61	2.33	3.62	3.62
4	4.13	1.41	1.59	4.84	3.61
5	3.34	2.33	3.17	2.85	2.85
6	3.14	4.22	4.32	4.17	3.86
7	1.23	0.58	2.99	0.56	1.08
8	3.45	3.29	1.61	3.67	1.67
9	2.84	3.93	3.62	2.57	2.58
10	1.48	2.40	1.55	1.11	1.11
MEAN	3.07	2.64	2.68	2.93	2.62

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.02	1.85	1.40	3.25	0.88
2	7.18	13.05	103.26	114.74	114.74
3	0.02	6.59	14.97	103.26	103.26
4	0.01	2.68	1.57	0.04	6.59
5	114.74	14.97	10.50	13.05	13.05
6	0.01	0.02	0.02	0.02	0.01
7	1.12	0.87	0.01	0.73	0.45
8	0.01	0.01	0.47	0.01	0.48
9	1.47	82.15	103.26	103.26	14.50
10	1.37	2.35	0.90	1.03	1.30
MEAN	12.60	12.45	23.64	33.94	25.53

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	1.17	2.41	4.32	4.65	2.93
2	2.02	4.37	2.00	1.81	1.63
3	2.12	4.13	4.17	1.21	2.24
4	3.34	4.74	2.32	4.37	4.37
5	3.97	2.02	4.50	2.90	3.34
6	2.20	4.97	3.34	3.61	4.97
7	1.80	2.76	2.84	4.57	4.37
8	2.32	2.58	2.31	2.07	3.09
9	1.81	3.34	3.34	2.33	2.58
10	2.20	4.22	1.80	2.16	1.48
MEAN	2.30	3.55	3.09	2.97	3.10

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	1.47	0.83	0.02	0.03	1.70
2	1.40	0.02	4.48	3.24	5.68
3	1.60	0.01	0.02	1.53	0.69
4	3.63	0.03	2.09	0.02	0.02
5	0.01	1.40	0.02	5.78	3.63
6	0.67	0.05	3.63	6.59	0.05
7	1.11	1.31	1.47	0.03	0.02
8	2.09	14.50	7.98	14.50	118.48
9	3.24	3.63	3.63	14.97	7.18
10	0.67	0.02	1.11	0.65	1.37
MEAN	1.59	2.18	2.45	4.73	13.88

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE AUDITORY TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	4.27	4.74	4.84	3.16	4.74
2	5.14	6.18	4.37	6.18	5.42
3	2.07	1.48	1.75	2.46	2.07
4	4.65	2.76	3.16	3.16	4.65
5	3.61	4.37	3.17	2.85	2.85
6	6.18	3.93	6.18	3.62	6.18
7	4.27	2.49	3.03	2.31	3.61
8	2.41	5.42	6.18	6.18	5.42
9	2.56	5.42	2.85	3.93	3.93
10	4.74	2.59	2.28	4.74	2.93
MEAN	3.99	3.94	3.78	3.86	4.18

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.02	0.33	0.04	2.58	0.33
2	0.07	1.00	52.12	1.00	0.13
3	1.49	2.06	1.85	0.88	1.49
4	0.03	1.31	2.58	2.58	0.03
5	6.59	52.12	10.50	13.05	13.05
6	1.00	83.15	1.00	103.26	1.00
7	0.02	2.72	2.04	7.98	6.59
8	0.83	0.13	1.00	1.00	0.13
9	1.00	0.13	13.05	83.15	83.15
10	0.33	3.25	4.04	0.33	1.70
MEAN	1.14	14.62	8.82	21.58	10.76

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')

S	TIME BLOCK 1	2	3	4	5
1	1.42	1.26	1.03	-0.11	0.25
2	1.45	-0.37	0.19	-1.54	0.11
3	1.48	0.71	0.80	0.63	-1.69
4	2.16	0.60	0.60	0.36	-0.76
5	1.52	0.76	0.83	0.99	0.00
6	1.44	0.65	-1.34	0.60	-1.04
7	1.52	-2.51	0.25	-0.90	-0.32
8	1.84	0.49	0.27	0.30	0.63
9	0.75	1.26	0.90	0.97	0.61
10	1.48	0.47	0.60	-1.61	-0.20
MEAN	1.51	0.33	0.41	-0.03	-0.24

CRITERION (ß)

S	TIME BLOCK 1	2	3	4	5
1	0.83	1.15	1.31	0.95	0.91
2	0.85	0.78	1.31	0.03	1.11
3	1.37	2.35	2.72	2.09	0.02
4	0.65	1.64	2.58	1.70	0.11
5	1.43	1.98	1.74	1.64	1.00
6	1.33	1.74	0.03	2.58	0.06
7	0.88	0.01	1.17	0.47	0.81
8	1.15	1.27	1.11	1.13	1.42
9	1.09	1.15	1.19	0.96	1.21
10	2.06	2.04	1.64	0.02	0.86
MEAN	1.16	1.41	1.48	1.16	0.75

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE AUDITORY TASK FOR THE MENTALLY RETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	4.22	1.56	0.33	1.52	4.74
2	0.96	1.15	1.53	0.91	1.49
3	0.77	1.56	0.36	0.47	-2.57
4	1.89	1.93	1.36	1.03	0.80
5	0.83	0.61	1.05	1.34	1.48
6	3.73	0.76	0.80	1.21	-0.76
7	1.93	0.35	0.84	-0.33	-0.06
8	1.29	0.55	1.38	2.76	1.48
9	3.62	1.26	0.86	1.31	0.99
10	1.81	-0.51	0.71	0.21	-0.25
MEAN	2.11	0.92	0.92	1.04	0.73

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.02	1.49	1.40	0.88	0.03
2	1.24	2.60	7.18	3.25	10.50
3	1.35	3.35	1.70	2.04	0.01
4	0.53	2.34	5.11	2.92	2.72
5	0.91	1.03	1.00	2.46	1.37
6	0.01	1.98	2.72	5.78	0.11
7	2.34	1.28	1.43	0.69	0.97
8	1.66	1.34	1.83	1.31	2.06
9	0.01	0.76	0.92	0.78	1.27
10	1.98	0.59	1.28	1.15	0.75
MEAN	1.01	1.68	2.46	2.13	1.98

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 9 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	2.09	1.92	2.25	2.00	1.22
2	3.56	3.62	1.26	3.78	1.52
3	3.90	1.80	1.54	0.52	1.33
4	1.23	1.10	0.47	-0.25	-0.16
5	1.33	0.11	0.50	-1.69	0.06
6	1.17	0.75	0.75	0.61	1.10
7	1.65	1.04	0.00	-0.76	0.27
8	1.10	-0.16	0.27	-0.76	-0.76
9	1.33	0.72	-0.11	0.56	-0.37
10	1.68	1.58	1.29	0.92	0.74
MEAN	1.90	1.25	0.82	0.49	0.50

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	0.61	1.26	1.88	2.59	2.88
2	0.01	0.01	0.76	0.01	0.88
3	0.01	1.11	2.20	1.15	1.74
4	1.12	1.38	2.04	0.75	0.83
5	1.74	1.11	1.72	0.02	1.08
6	0.74	1.09	0.89	1.03	0.73
7	0.97	4.12	1.00	0.11	1.47
8	1.38	0.83	1.47	0.11	0.11
9	0.44	1.08	0.88	1.88	0.67
10	1.00	0.92	1.66	1.52	1.59
MEAN	0.80	1.29	1.45	0.92	1.20

APPENDIX C - 1

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE AUDITORY TASK FOR THE NONRETARDED 9 YEAR OLD SUBJECTS IN EXPERIMENT 1

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	2.69	3.34	3.62	2.85	5.42
2	4.27	2.17	1.66	1.63	2.85
3	2.31	1.49	2.57	-1.04	1.05
4	4.17	4.65	1.66	2.41	1.88
5	3.90	2.41	2.25	1.38	2.07
6	1.29	1.18	1.66	0.60	0.77
7	0.43	0.63	-0.04	0.16	-1.81
8	2.02	1.54	2.62	2.05	2.41
9	1.70	3.03	3.17	6.18	2.85
10	1.56	2.40	1.90	1.23	2.28
MEAN	2.43	2.28	2.11	1.75	1.98

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	1.18	3.63	103.26	13.05	0.13
2	0.02	3.37	2.60	5.68	13.05
3	7.98	10.50	103.26	0.06	6.59
4	0.02	0.03	2.60	5.11	5.86
5	0.01	5.11	1.88	1.83	1.49
6	1.66	1.99	2.60	2.58	3.63
7	0.98	0.88	0.97	1.05	0.02
8	0.58	2.20	1.08	8.24	5.11
9	0.48	2.04	10.50	1.00	13.05
10	3.35	2.35	3.75	4.04	4.04
MEAN	1.63	3.21	23.25	4.26	5.30

APPENDIX C - 2

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 3

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	2.88	4.27	4.43	4.32	3.41
2	5.42	5.42	4.65	4.21	4.32
3	2.35	1.97	1.72	2.22	1.83
4	3.70	4.01	4.09	4.13	3.93
5	3.55	3.07	3.77	3.73	4.22
6	2.33	2.30	2.82	3.16	4.11
7	4.74	4.84	4.38	4.65	4.84
8	4.21	4.97	4.97	6.18	4.27
9	2.43	3.80	2.73	2.75	3.09
10	2.46	3.46	3.63	3.63	3.22
MEAN	3.41	3.81	3.72	3.90	3.72

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	0.08	0.02	0.02	0.02	0.12
2	0.13	0.13	0.03	0.39	0.02
3	1.13	0.76	1.03	1.29	0.93
4	0.01	0.01	0.01	0.01	0.01
5	0.14	0.09	0.11	0.18	0.02
6	0.26	0.64	1.94	0.39	1.00
7	0.03	0.04	1.82	0.03	0.04
8	0.39	0.05	0.05	1.00	0.02
9	0.07	0.01	0.15	1.09	0.53
10	1.14	0.33	0.79	0.79	2.39
MEAN	0.34	0.21	0.60	0.52	0.51

APPENDIX C - 2

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 14 YEAR OLD SUBJECTS IN EXPERIMENT 3

SENSITIVITY (d')

S	TIME BLOCK 1	2	3	4	5
1	1.65	1.78	1.32	1.66	0.63
2	4.65	1.93	1.29	1.41	1.17
3	2.75	1.77	1.12	0.88	0.86
4	2.49	2.56	2.82	2.35	2.38
5	2.69	3.83	3.61	3.16	2.98
6	1.85	0.90	1.30	0.69	0.82
7	1.48	1.40	0.61	0.83	0.93
8	3.67	2.83	4.50	3.09	3.28
9	2.90	2.93	2.27	2.13	2.43
10	3.36	3.18	2.63	2.55	1.18
MEAN	2.75	2.31	2.15	1.88	1.67

CRITERION (ß)

S	TIME BLOCK 1	2	3	4	5
1	0.34	0.35	0.75	0.30	0.80
2	0.03	0.60	0.67	0.66	0.62
3	1.09	0.65	0.82	1.00	1.14
4	0.37	0.39	0.17	0.89	1.44
5	1.18	0.01	0.15	0.39	2.18
6	0.63	0.82	0.71	0.81	0.82
7	0.73	1.22	1.36	2.42	2.26
8	6.09	0.39	0.02	0.21	0.11
9	5.78	1.71	5.44	5.68	14.89
10	0.11	0.23	0.32	0.14	0.84
MEAN	1.64	0.64	1.04	1.25	2.51

APPENDIX C - 2

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 10 YEAR OLD SUBJECTS IN EXPERIMENT 3

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	2.96	3.97	3.42	1.45	2.05
2	2.93	3.17	2.63	2.14	2.25
3	2.83	3.24	2.99	2.57	2.03
4	1.72	2.35	1.95	1.67	1.70
5	4.97	3.80	3.61	4.38	3.97
6	4.65	3.88	3.81	4.08	2.73
7	3.31	4.43	4.21	3.70	4.38
8	3.31	3.11	2.76	2.42	2.42
9	3.03	3.34	1.70	1.89	2.35
10	3.06	2.39	1.69	1.76	1.20
MEAN	3.28	3.37	2.88	2.61	2.51

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	1.25	0.01	0.01	0.23	0.12
2	0.43	0.10	0.32	0.49	0.53
3	0.16	0.10	0.64	0.86	0.96
4	1.03	3.01	2.04	1.93	1.74
5	0.05	0.20	0.41	1.82	0.26
6	0.28	0.22	0.56	3.23	2.16
7	1.38	0.02	0.39	0.47	0.55
8	0.72	1.00	0.77	1.37	1.37
9	0.09	0.01	0.48	0.31	0.33
10	0.34	0.27	0.83	0.88	1.14
MEAN	0.57	0.49	0.65	1.16	0.92

APPENDIX C - 3

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 4

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	3.16	5.42	4.37	4.37	6.18
2	5.14	4.74	2.17	4.50	2.76
3	6.18	6.18	6.18	6.18	6.18
4	5.42	3.62	3.62	3.34	3.93
5	4.37	4.37	3.61	6.18	6.18
6	4.09	4.50	4.32	2.76	4.97
7	5.42	3.34	6.18	4.37	3.62
8	3.03	3.61	2.33	3.34	3.62
9	4.97	3.61	3.93	4.37	3.93
10	6.18	2.85	3.62	4.37	3.62
MEAN	4.80	4.22	4.03	4.38	4.50

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	2.58	0.13	52.12	52.12	1.00
2	0.70	0.03	3.37	0.02	1.31
3	1.00	1.00	1.00	1.00	1.00
4	0.13	103.26	103.26	114.74	83.15
5	52.12	52.12	6.59	1.00	1.00
6	0.01	0.02	0.02	1.31	0.05
7	0.13	114.74	1.00	52.12	103.26
8	2.04	6.59	14.97	114.74	103.26
9	0.05	6.59	83.15	52.12	83.15
10	1.00	13.05	103.26	52.12	103.26
MEAN	5.98	29.75	36.87	44.13	48.04

APPENDIX C - 3

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 15 YEAR OLD SUBJECTS IN EXPERIMENT 4

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	3.86	1.84	3.62	3.09	2.58
2	4.84	3.61	3.16	3.09	2.25
3	3.16	2.91	3.61	2.76	4.37
4	2.56	2.18	4.97	3.16	5.42
5	1.66	0.63	2.57	3.09	1.53
6	4.32	4.84	4.50	2.93	2.84
7	4.17	4.65	2.76	2.84	5.42
8	4.50	2.69	3.61	2.00	2.17
9	6.18	3.93	3.93	4.37	4.37
10	3.73	3.93	4.22	4.17	3.77
MEAN	3.90	3.12	3.70	3.15	3.47

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.01	1.15	103.26	118.48	14.50
2	0.04	6.59	2.58	118.48	83.15
3	2.58	1.65	6.59	1.31	0.02
4	1.00	1.72	0.05	2.58	0.13
5	2.60	2.09	103.26	118.48	7.18
6	0.02	0.04	0.02	1.70	1.47
7	0.02	0.03	1.31	1.47	0.13
8	0.02	1.18	6.59	4.48	3.37
9	1.00	83.15	83.15	52.12	52.12
10	0.01	0.01	0.02	0.02	0.01
MEAN	0.73	9.76	30.68	41.91	16.21

APPENDIX C - 3

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 9 YEAR OLD SUBJECTS IN EXPERIMENT 4

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	4.57	4.37	2.36	4.27	4.27
2	2.32	2.13	2.84	2.07	4.37
3	2.09	6.18	6.18	3.34	2.62
4	4.97	5.14	5.42	3.17	2.41
5	5.42	5.42	5.42	3.61	4.97
6	4.27	3.34	2.28	3.17	2.59
7	4.57	2.93	4.50	4.32	2.62
8	4.13	5.14	5.42	5.42	6.18
9	3.50	2.09	4.09	1.33	1.33
10	2.32	1.80	4.50	2.69	2.59
MEAN	3.82	3.85	4.30	3.34	3.40

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.03	0.02	0.79	0.02	0.02
2	2.09	5.68	114.74	14.50	52.12
3	0.61	1.00	1.00	114.74	1.08
4	0.05	0.07	0.13	10.50	5.11
5	0.13	0.13	0.13	6.59	0.05
6	0.02	3.63	4.04	10.50	3.25
7	0.03	1.70	0.02	0.02	1.08
8	0.01	0.07	0.13	0.13	1.00
9	0.01	0.61	0.01	1.74	1.21
10	0.75	1.11	0.02	1.18	3.25
MEAN	0.37	1.40	12.10	15.99	6.82

APPENDIX C - 4

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 5

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	2.22	2.13	2.84	1.65	1.00
2	1.66	2.07	1.38	1.31	1.18
3	3.62	2.39	2.97	2.76	2.61
4	1.30	1.59	1.75	1.26	1.24
5	2.92	2.73	1.83	2.38	2.32
6	1.56	1.38	1.54	1.95	2.55
7	2.28	2.78	2.64	3.11	2.47
8	2.99	2.82	2.53	2.52	2.42
9	1.77	1.80	1.73	1.48	1.13
10	2.00	1.05	1.53	1.10	1.13
MEAN	2.23	2.07	2.07	1.95	1.81

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.24	0.12	0.01	0.17	0.32
2	0.30	0.07	0.30	0.23	0.29
3	0.01	0.07	0.08	0.16	0.14
4	1.86	1.83	1.85	1.02	1.16
5	0.29	0.60	1.00	5.19	0.75
6	0.67	0.73	0.75	0.96	2.04
7	2.15	0.63	0.42	0.36	0.45
8	1.58	0.83	0.70	1.23	1.37
9	0.82	0.26	0.35	0.34	0.50
10	0.33	0.80	0.53	0.73	0.64
MEAN	0.83	0.59	0.60	1.04	0.77

APPENDIX C - 4

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 15 YEAR OLD SUBJECTS IN EXPERIMENT 5

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	2.40	1.69	1.48	1.85	1.13
2	1.20	0.50	0.03	0.69	0.38
3	1.62	1.87	1.23	1.05	0.41
4	0.87	0.86	0.61	-0.15	0.12
5	1.02	0.61	0.78	0.36	0.20
6	1.35	0.78	0.78	1.02	1.10
7	0.55	0.29	0.34	0.56	0.23
8	1.29	0.56	0.13	0.67	0.11
9	1.23	0.90	0.92	0.85	0.41
10	0.98	0.58	0.06	-0.14	0.13
MEAN	1.25	0.86	0.64	0.68	0.42

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	0.43	1.20	1.37	2.44	2.58
2	0.35	0.87	0.99	0.97	1.02
3	0.55	0.58	1.08	0.94	1.03
4	0.50	0.59	0.69	1.09	0.94
5	0.40	0.72	0.90	0.92	0.98
6	1.09	1.66	1.46	0.93	1.28
7	0.75	0.86	0.92	0.79	0.95
8	1.04	0.94	1.01	1.65	1.06
9	0.66	0.54	0.49	0.38	0.97
10	0.73	0.74	0.98	1.06	0.97
MEAN	0.65	0.87	0.99	1.12	1.18

APPENDIX C - 4

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 9 YEAR OLD SUBJECTS IN EXPERIMENT 5

SENSITIVITY (d')					
	TIME BLOCK				
S	1	2	3	4	5
1	2.32	2.36	2.73	2.71	2.18
2	1.65	2.08	2.45	1.62	1.76
3	1.72	1.99	2.89	1.89	1.76
4	1.13	0.88	0.57	0.82	0.68
5	1.21	0.60	0.98	0.22	-0.04
6	0.05	-0.08	0.72	0.30	0.18
7	1.21	2.21	1.23	1.92	1.72
8	1.27	0.71	0.93	0.79	1.11
9	1.63	1.18	0.84	1.30	1.04
10	0.76	0.71	0.33	0.44	0.61
MEAN	1.30	1.26	1.37	1.20	1.10

CRITERION (ß)					
	TIME BLOCK				
S	1	2	3	4	5
1	0.19	0.79	1.68	0.34	0.50
2	0.34	0.17	0.36	0.89	1.00
3	1.10	1.00	0.32	0.77	0.35
4	0.79	1.05	1.25	1.51	1.28
5	0.56	0.64	0.73	0.90	1.03
6	0.86	1.03	1.02	1.00	1.02
7	0.56	0.52	0.96	0.27	0.49
8	0.41	0.62	0.44	0.47	0.91
9	0.65	0.71	1.15	0.64	0.82
10	0.61	0.83	0.88	0.93	0.62
MEAN	0.61	0.74	0.88	0.77	0.80

APPENDIX C - 5

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 13 YEAR OLD SUBJECTS IN EXPERIMENT 6

SENSITIVITY (d')

S	TIME BLOCK 1	2	3	4	5
1	1.72	1.72	1.62	1.74	1.72
2	1.56	1.86	2.70	2.24	1.92
3	2.08	2.82	1.95	2.41	1.54
4	1.52	1.81	2.85	1.78	1.94
5	1.68	2.20	2.63	2.03	2.58
6	1.84	2.08	1.65	2.52	2.88
7	1.90	1.71	1.51	1.90	2.21
8	1.19	1.76	1.51	1.62	1.76
9	1.90	1.59	1.72	1.87	1.89
10	1.57	3.22	2.61	3.67	2.28
MEAN	1.70	2.08	2.08	2.18	2.07

CRITERION (ß)

S	TIME BLOCK 1	2	3	4	5
1	0.69	1.03	0.84	1.56	1.10
2	0.67	0.52	0.15	0.69	0.37
3	1.87	0.47	0.68	0.83	0.58
4	1.14	0.35	0.08	0.31	0.37
5	0.72	0.37	0.14	0.28	0.14
6	1.15	1.87	1.42	3.44	12.84
7	0.71	0.39	0.53	0.12	0.52
8	0.81	0.40	0.49	0.60	0.30
9	0.42	0.59	0.49	0.42	0.47
10	0.59	0.01	0.07	0.01	0.47
MEAN	0.88	0.60	0.49	0.83	1.72

APPENDIX C - 5

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE MENTALLY RETARDED 15 YEAR OLD SUBJECTS IN EXPERIMENT 6

SENSITIVITY (d')

S	TIME BLOCK 1	2	3	4	5
1	1.73	2.08	2.56	1.95	2.47
2	1.41	1.09	0.95	2.43	2.23
3	0.88	1.73	0.89	1.15	0.99
4	1.75	1.18	1.83	2.52	0.84
5	1.82	2.43	1.94	1.38	1.29
6	1.43	1.99	2.08	1.36	0.94
7	1.88	3.45	2.30	2.43	2.23
8	1.94	1.08	1.01	1.37	1.24
9	1.04	1.00	1.39	0.86	0.56
10	2.11	2.44	1.50	1.67	1.69
MEAN	1.60	1.85	1.65	1.71	1.45

CRITERION (ß)

S	TIME BLOCK 1	2	3	4	5
1	0.30	0.34	0.39	0.27	0.45
2	1.05	0.75	1.14	1.89	2.15
3	0.57	0.30	0.61	0.73	0.94
4	0.44	0.47	0.68	0.38	1.31
5	0.26	0.20	0.29	0.98	0.89
6	0.79	1.09	0.92	0.44	0.66
7	1.55	111.11	14.96	14.89	14.89
8	3.10	1.12	1.36	1.24	1.21
9	0.72	0.87	1.12	1.11	1.00
10	4.34	14.87	5.44	2.33	2.09
MEAN	1.31	13.11	2.69	2.43	2.56

APPENDIX C - 5

SENSITIVITY AND CRITERION VALUES FOR EACH SUCCESSIVE TEN-MINUTE TIME BLOCK FOR THE VISUAL TASK FOR THE NONRETARDED 9 YEAR OLD SUBJECTS IN EXPERIMENT 6

SENSITIVITY (d')

	TIME BLOCK				
S	1	2	3	4	5
1	1.88	1.97	2.58	1.09	1.92
2	1.56	1.58	1.62	1.66	2.08
3	1.53	1.98	1.67	1.75	2.23
4	1.11	0.98	0.92	1.29	0.91
5	1.84	1.45	1.14	0.79	1.05
6	2.03	2.24	1.80	1.20	1.58
7	1.60	1.63	1.63	1.23	1.15
8	3.27	3.62	3.86	2.90	2.56
9	1.48	1.39	1.45	1.45	1.57
10	1.41	1.74	1.73	1.58	2.05
MEAN	1.77	1.86	1.84	1.49	1.71

CRITERION (ß)

	TIME BLOCK				
S	1	2	3	4	5
1	0.64	0.76	1.35	1.50	1.26
2	0.67	1.15	0.69	0.81	0.84
3	0.34	0.22	0.26	0.13	0.12
4	0.70	0.83	1.52	1.00	1.04
5	0.46	0.93	0.76	1.42	1.45
6	1.04	0.69	0.67	0.62	1.09
7	0.26	0.80	0.80	1.00	1.62
8	0.01	0.01	0.01	0.17	0.39
9	1.37	1.17	1.57	1.92	2.39
10	0.59	0.64	0.86	0.97	0.74
MEAN	0.61	0.72	0.85	0.95	1.09

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