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NAME OF AUTHOR..... Douglas Tate
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..... Upon Activity, Arousal and Attention in Retarded
..... Youngsters
UNIVERSITY..... Carleton University
DEGREE FOR WHICH THESIS WAS PRESENTED..... Doctor of Philosophy - Psychology
YEAR THIS DEGREE GRANTED..... 1975

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THE EFFECTS OF METHYLPHENIDATE AND THIORIDAZINE
UPON ATTENTION, AROUSAL, AND ACTIVITY IN
MENTALLY RETARDED YOUNGSTERS

by

Douglas Lloyd Tate

Thesis presented to the Faculty of Graduate
Studies of Carleton University in partial
fulfillment of the requirements for the
degree of Doctor of Philosophy

DEPARTMENT OF PSYCHOLOGY

CARLETON UNIVERSITY

Ottawa, March, 1975

The undersigned recommend to the Faculty
of Graduate Studies acceptance of the thesis
"The Effects of Methylphenidate and Thioridazine Upon
Activity, Arousal and Attention in Retarded Youngsters"

submitted by

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ABSTRACT

Theory and research on the nature of problems of hyperactivity, distractibility, and short attention span in children of normal and subnormal intelligence were reviewed. It was argued that these problems represent a single dysfunction which is characterized as weak arousal in response to stimulation. Research was reviewed to show that the stimulant methylphenidate is often effective in improving attentiveness in children of normal intelligence but has seldom been used with the retarded. Little research has been done with the tranquilizer thioridazine, however, despite its wide usage with the retarded.

Three studies compared the effects of methylphenidate and thioridazine on measures of arousal, attention, and activity in mentally retarded youngsters. The first study attempted to compare these effects in a group of hyperactive and a group of normoactive retardates. Insufficient data were collected for the hyperactive group to attain statistical reliability. The results for the two groups were compared, however, and discussed with regard to methodological problems and arousal theory of hyperactivity. When drug effects were examined, methylphenidate did not significantly alter heart rate or skin

conductance measures of tonic arousal, or orienting to periodic tones. Methylphenidate did, however, reduce two measures of motor activity in a playroom. Thioridazine significantly reduced tonic and spontaneous electrodermal activity, as well as the frequency and magnitude of skin conductance responses to tones.

These results were interpreted as suggesting the possible beneficial and debilitative effects upon attention in the retarded of methylphenidate and thioridazine, respectively.

In the second and third studies, measures of reaction time, vigilance, and classroom behaviour were employed to examine the effects of these two drugs in retarded youngsters. Neither methylphenidate nor thioridazine significantly altered any of the dependent measures. Reaction time performance improved significantly over five weeks of testing, however. The results were discussed with reference to experimental design, drug dosages, subject characteristics, the interaction between environmental and drug effects, and reaction time deficits in the mentally retarded. Some areas for future research were proposed and discussed in relation to the use of psychotropic drugs in the treatment of learning and behaviour problems in children.

ACKNOWLEDGEMENTS

I am indebted to many people for their help throughout this research. The critical comments and suggestions of Drs. Marilyn Marshall, Bruce Pappas, Alan Moffitt, and Bruce Ferguson are appreciated. I am also grateful for the support of Mr. Don Richardson, Dr. John McHugh, Mr. Jim McGregor, and the staff of the Education Unit at the Rideau Regional Centre. The interest and cooperation of Drs. John Stewart and Angel Gomez was invaluable. Dr. Tom Tombaugh, Mr. Ed Achorn, and Ms. Jocelyn Eastland aided in the assemblage of experimental equipment and Ms. Heather Lloyd in the collection of data, for which I am thankful. Mr. David Roach and Dr. Richard Dillon offered help and advice on several occasions regarding computer programming and data analysis. I was very fortunate to have the expert secretarial skills of Mrs. Yvonne Horner on several drafts of the prospectus and thesis. In particular, I express my appreciation and gratitude to my advisor Dr. Robert Knights for his guidance and encouragement over the past five years and to Dr. Archie Bower who helped me on many occasions during each phase of the research. Finally, I thank my wife Adele who worked hard and had faith when the task was most difficult.

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INTRODUCTION

The following is a description of three studies of the effects of methylphenidate and thioridazine upon measures of motor activity, arousal, and attention in mentally retarded youngsters. The syndrome of behaviours associated with hyperactivity are discussed in relation to arousal theory, mental retardation, and the effects of stimulant drugs upon attention and motor activity. The first study was an attempt to compare hyperactive and normoactive retarded children on measures of motor activity and attention. In addition, the effects of the drugs methylphenidate and thioridazine were examined. Insufficient data were collected for the hyperactive subjects to allow for statistical tests but informal comparisons were made and discussed with regard to arousal theory and future research. Significant effects on some dependent measures for both methylphenidate and thioridazine led to the second and third studies. In these, the effects of the drugs upon performance measures of attention were examined.

Hyperactivity

During the past twenty years within the field of education and related professions, there has been an increasing focus of concern upon the problems of children manifesting a cluster of symptoms such as restlessness,

short attention span, poor impulse control, learning difficulties, emotional lability, etc. This syndrome is usually referred to as Minimal Brain Dysfunction (MBD), Learning Disability, Hyperkinetic, or Hyperactivity Syndrome.

These symptoms are the most common complaint of parents and teachers about child behaviour and are the most conspicuous reasons for referral to clinics (Patterson, Jones, Whittier and Wright, 1965). For example, Lapouse and Monk (1958) found that 49 per cent of children aged six to twelve years were rated as "overactive" by their mothers and 30 per cent were rated as "restless". Stewart, Pitts, Craig, and Dieruf (1966) estimated that 4 per cent of all noninstitutionalized school-aged children were hyperactive. Chess (1960) found that about 10 per cent of the children that she saw in her private practice were referred directly because of hyperactivity.

Hyperactivity is also prevalent among the retarded. Horenstein (1957) described hyperactivity as the most serious management problem in institutions for the retarded. Payne (1968) in a study of institutionalized retardates in 13 western states found that 18 per cent of the over 24,000 individuals in the sample were rated as hyperactive by staff. The phenomenon of hyperactivity in the retarded has been found to be inversely related to CA, MA, and IQ (Cromwell, Palk, and Foshee, 1961). Berkson and Davenport

(1963) and Kaufman and Levitt (1965) have reported that over 60 per cent of institutionalized retarded in the moderate to severe range of retardation engage in high rates of stereotyped movements, particularly body rocking. Gallagher (1960) found a group of organic retarded patients to be rated as more active than those diagnosed as non-organic. Talkington and Hutton (1973) compared two large groups of hyperactive and nonhyperactive retardates on 15 variables and found hyperactivity to be more common in males and the more severely retarded.

Among children of normal intelligence, hyperactivity is seen as part of a syndrome of behaviours associated with learning and behavioural problems. A great deal of research has been done over the past two decades concerning the definition, diagnosis, etiology, and treatment of the syndrome although problems, controversy, and confusion still exist in all these areas.

Hyperactivity among the retarded is an even more diverse phenomenon and more often is related to brain damage. Much of the literature on this subject concerns the stereotyped activity of the blind, brain-damaged, and severely subnormal retarded person (egs., Altman, 1971; Baumeister and Forehand, 1971; Jammes and Rosenberger, 1971; Smeets, 1972). However, hyperactive patients at the moderate or mild level of retardation formed 25 per cent

of the hyperactive sample of Talkington and Hutton (1973) and studies of trainable and educable retarded who are hyperactive form a significant part of the literature on hyperactivity in general. It remains unclear whether the nature of hyperkinetic behaviours in the mildly retarded are essentially different from those of children of normal intelligence.

Hyperactivity is an elusive though very real phenomenon. As Douglas (1972) has said, "a kind of clinical folklore has sprung up about the disabilities that are peculiar to hyperactive children and there has been no way to separate fact from fiction" (p. 261). Various descriptive terms are often used interchangeably, perhaps because they are difficult to define. The hypothetical situation where a child is required to attend to a specific aspect of his environment and make appropriate responses (for example, when performing a paper and pencil task in the classroom), but fails to do so, could be described by an observer in a number of ways. If the child was observed to spend a great deal of his time making motor responses which were irrelevant to the task, it might be concluded that he could not sit still enough to do the task and is, therefore, "hyperactive". It might be noted that he was attending to a large number of different stimuli and, therefore, had a "short attention" span or was "distracted"

by extraneous stimuli. He might be described as unable to control impulses to respond to irrelevant stimuli (i.e., he is "impulsive"). It is clear, then, that unless these terms are operationally defined there is ambiguity as to whether one is describing one phenomenon or another, or whether in fact there is only one behavioural deficit and many terms to describe it.

Excessive motor activity or hyperactivity and short attention span or distractibility are the most frequent symptoms of these children regardless of retardation and would seem to be the problems that would most debilitate learning and performance in school. Therefore, the following review will focus upon these symptoms, their response to drugs and corresponding theoretical formulations. The distinction will be maintained throughout between those studies of retarded hyperactive children and those of hyperactive children of normal intelligence.

Psychotropic Drugs and Hyperactivity

There have been many recent reviews of the literature on the effect of psychotropic drugs with the retarded and children with learning and behaviour disorders (eg³., Connors, 1972; Eisenberg, 1972; Sprague and Sleator, 1973; Sprague and Werry, 1971). In general, this research substantiates the beneficial effects of stimulants with MBD

children and these drugs are widely used. Greenberg and Lipman (1968) reported that 91 per cent of pediatricians, psychiatrists, and neurologists surveyed in Washington, D.C., were using psychotropic drugs with children they considered to be hyperactive. Stephen, Sprague, and Werry (1973) carried out a similar survey in 1970 and included all physicians in the Chicago metropolitan area. These physicians considered less than 25 per cent of the children seen by them to be hyperactive. About 40 per cent of these children were treated with medication. Methylphenidate and dextroamphetamine were prescribed most often and usually in conservative amounts for one school year.

Sprague and Werry (1971) surveyed the area of psychopharmacology of the retarded and lamented the gaps in knowledge. Within this area most studies have focused upon clinical response and have been very weak methodologically. Much less is known about the behavioural and cognitive effects of drugs relevant to learning and education. This dearth of information is in contrast to the widespread use of drugs with institutionalized retarded. Lipman (1967) surveyed the public institutions in the United States with regard to drug use. The most striking feature of the data was the fact that the sedative-type phenothiazines - thioridazine and chlorpromazine - accounted for 58 per cent of all drug usage. Of the two, thioridazine was the more

popular and was given at a median dosage of 400 mgs. per day. Typical duration of thioridazine administration was less than one year for 54 per cent of cases but was more than four years in 25 per cent of cases. There was some tendency for larger institutions to use drugs more and for longer periods of time. Lipman's study sampled a total population of over 148,000 residents about half of whom had received drugs of some kind. Stimulants and antidepressants represented only about 1 per cent of drug usage. Dosages were also more moderate compared to the phenothiazines. Dextroamphetamine, for example, was given at a median dosage of 15 mgs. per day. In 62 per cent of cases the duration was for less than one year and in 19 per cent of cases for four or more years.

In his discussion of the implications of his data for research, Lipman noted that to an overwhelming degree, psychotropic drugs are used for controlling the behaviour of the aggressive, assaultive, difficult-to-manage, hyperactive patient. He noted that the evidence to support the efficacy of the phenothiazines for controlling such behaviour comes from drug studies generally lacking controls and adequate statistical analysis. Nevertheless, the findings of these studies uniformly support their use in the treatment of such behaviour disorders. Lipman could find few controlled studies of the effect of phenothiazines on

cognitive behaviour and those he did find were split between deleterious effects and finding no significant drug-placebo difference. Further, Lipman noted that there were few drug comparison studies to suggest that the phenothiazines were the drugs of choice for the hyperactive child. He suggested that the stimulants were a promising alternative and that the evidence for their use was as extensive as that for sedatives. Finally, Lipman stated that the efficacy of drug use should weigh the influence of the drug upon educability as well as behaviour.

In the following sections, arousal theory as it relates to hyperactivity and mental retardation will be briefly described. Research which has employed objective types of measures of physiological arousal, motor activity, and attention will be reviewed. In addition, those studies which have employed these measures in testing the effects of stimulants (especially methylphenidate) and thioridazine are included.

Arousal Theory and Hyperactivity

In the past, a number of writers have proposed that behaviour can be scaled along an intensive (as opposed to directional) dimension. This dimension has been variously referred to as drive, motivation, energy level, activation, or arousal, and can be thought of as a continuum from death

or coma through sleep, wakefulness, and strong emotion (Lindsley, 1960). By the 1950's, the classical view of activation or arousal had been aligned with the organization and function of the ascending reticular activating system in the brain (Duffy, 1957; Hebb, 1955; Malmö, 1959). Subsequently, the existence of a second arousal system was recognized (Routtenberg, 1968). This system is related to the functions of the limbic system and although it too influences cortical arousal it appears to be important in mediating different aspects of behaviour. Whereas the brain stem arousal system has been shown to be predominantly concerned with drive and the organization for response, the limbic arousal system is concerned with the effects of incentives or rewards upon responses. Routtenberg has suggested that the two systems are organized so as to be mutually inhibitory.

Research with humans has attempted to examine performance at various levels of arousal or activation and has established a relationship between level of arousal and behavioural efficiency. Generally, arousal has been manipulated by instructions (eg. threat of shock), the demands of the task (eg. easy versus difficult tasks), or by sensory deprivation. Behavioural measures of curiosity and exploration (Berlyne, 1960), perceptual thresholds (Patton, 1968), memory (Suedfeld and Landon, 1970), epistemic behaviour (Evans, 1969), looking time (Leckart, Goscinski, and Brayman,

1970), vigilance (Eason, Beardshall, and Jaffee, 1965; McGrath, Harabedian, and Buckner, 1959; Verschoor and Van Wieringen, 1970), etc., have been employed. This research has, in general, supported an inverted-U functional relationship between arousal and performance. With increasing arousal, behavioural efficiency increases to an optimum and then begins to decrease. Within the area of attention, "decaying arousal" has become the main concept in explaining performance decrements over time (Frankman and Adams, 1962), as well as individual differences in performance (Murrell, 1967).

Early reports of hyperactivity viewed it as a result of damage to the developing brain (Strauss and Lehtinen, 1947). Indeed, a variety of mild neurological, electroencephalographic, perceptual, and sensorimotor abnormalities are usually found to be more prevalent among these children than among normal children (Burks, 1960, 1964; Paine, 1963, 1965). Hyperactive children have also been found to have an excess of events in their histories which are likely to cause brain damage (eg. Werry, Weiss, and Douglas, 1964). Ablation studies with animals have established that damage to several areas of the brain, in particular, the frontal lobes, basal ganglia, hypothalamus, and reticular activating system, can produce dramatic changes in activity levels. However,

hyperactivity frequently occurs with only minor or no indications of organic disturbance and the present view is that the symptoms may be a manifestation of some kind of minimal brain dysfunction (MBD) rather than necessarily clear brain damage.

The favourable response of many hyperactive children to stimulants suggests that the syndrome may be, at least in part, the result of a diencephalic (brain stem) dysfunction. The action of amphetamine is thought to be related to the action of norepinephrine, which is concentrated in the brain stem. As previously indicated, the brain stem reticular formation has long been considered responsible for the maintenance of alertness. If amphetamines increase alertness by affecting the reticular activating system, this would explain the "paradoxical" effect of stimulants upon hyperactive children. However, this conceptualization may be over-simplified as amphetamines are known to influence the other catecholamines, dopamine and serotonin. Catecholamine neurons occur throughout the reticular system, diencephalon, basal ganglia, limbic system, and cerebral cortex (Baldessarini, 1972). In any case, there have been recent speculation that hyperkinetic children may suffer from a biochemical abnormality resulting in a lower functioning of brain systems related to arousal.

This conceptualization was somewhat revolutionary because to many these active and distractible children did not appear to be in the least underaroused. In fact, early workers in the field considered hyperactive children to be over-aroused and responsive to stimuli, and consequently continually moving, touching, and looking at all aspects of their environment (Eisenberg, 1966; Strauss and Lehtinen, 1947; Strauss and Kephart, 1955). Clements (1968) warned that these children are hypersensitive to stimuli and that a teacher's bright dress or jewelry may be distracting to the child. A similar view was that the problem was an inhibitory defect which resulted in the child being unable to inhibit responding to irrelevant stimuli (Douglas, 1972; Eisenberg, 1957; Hutt and Hutt, 1964). Recently, however, it has been suggested that the fact that hyperactive children benefit from treatment with stimulant drugs is evidence that they are underaroused (egs., Stewart, 1970; Werry, Sprague, Weiss, and Minde, 1970).

Silver (1971) reviewed neurochemical, pharmacological, physiological, and clinical data in an effort to support the view that an inherited neurohumoral imbalance might be the etiological factor in some children with

behavioural and learning problems. Specifically, Silver focused upon the role of norepinephrine in the reticular activating system and midbrain limbic system. Available evidence implicates the former in regulating overall levels of cortical activation and the latter is associated with motivation, affect, cognition, and memory. Wender (1971) also published a theory of MBD which attempted, in biochemical terms, to explain the symptoms of these children and their response to stimulants. He hypothesized that children with MBD have an abnormality in the metabolism of the monoamines serotonin, norepinephrine, or dopamine. Such an abnormality could impair the reward mechanisms and activating system of the brain. The diminished experience of pleasure and pain leads to reduced responsiveness to rewards and punishment with consequent likelihood of anti-social and "problem" behaviour. In contrast to Silver, Wender suggests that the caudate nucleus produces hyperactivity in animals and this structure has the highest concentration of dopamine in the central nervous system. Wender speculated that reduced amounts of dopamine may be related to hyperactivity.

(Similarly, Buckley (1972) has noted that the behaviour of hyperactive children is similar to that of patients with psychomotor temporal lobe seizures. He suggested that some of these children may have a neurophysiologic deficiency

in the mechanisms which control and inhibit temporal lobe activity. More specifically he proposed that stimulants increase the activity of the ventro-medial nucleus of the hypothalamus which is inhibited by an abnormality in the functioning of the temporal lobe. The effect of increased hypothalamic and temporal lobe activity would be to reduce the activity, impulsiveness, and aggressiveness of these children. Simultaneously, Buckley says, stimulants influence the reticular brain stem and thereby increase alertness and attentiveness.

a) Physiological Indices of Arousal in Hyperactives

The theoretical shift from viewing hyperkinetic behaviour as the sign of a highly aroused organism to that of attributing it to a state (in terms of brain physiology) of chronic underarousal similar to that shown by organisms placed in a very monotonous, unstimulating environments has resulted in both a change in the interpretation of results involving standard laboratory tests, as well as a trend toward employing measures of physiological arousal in studying hyperactive children. A number of recent reports by investigators have employed skin conductance (SC) or heart rate (HR) as measures of "arousal" and, in addition, have related these variables to measures of attention.

Boydston, Ackerman, Stevens, Clements, Peters, and Dykman (1968) compared 26 children manifesting the symptoms

of MBD with 26 control children matched for age, sex, and socio-economic status. There were no significant differences between the groups in tonic SC or HR. Cohen and Douglas (1972) compared 20 children referred for hyperkinesis with 20 normal children matched for age, sex, and I.Q. and failed to find a significant difference in tonic SC. However, when subjects were subsequently required to perform a reaction time (RT) task, only controls showed a significant increase in SC. Satterfield and Dawson (1971) compared 24 hyperkinetic children with 12 controls matched for age and sex and found the former group to have a significantly lower resting SC. In addition, the hyperactive group displayed fewer and smaller nonspecific SC responses during rest than controls. Finally, Spring, Greenberg, Scott, and Hopewood (1974) compared 40 MBD children who responded well to stimulant drug treatment to 20 control children matched for age and I.Q. Twenty of the MBD children were off the drug at the time of testing. There was no significant difference in tonic SC between the control group and the group of MBD children who were not receiving a drug. The controls, however, showed more frequent nonspecific SC responses.

The evidence, therefore, for lower arousal levels as manifested by resting autonomic levels of SC or HR in hyperactive children is not compelling. The fact that two

studies found significant differences suggests that some MBD or hyperactive children may have lower resting levels of autonomic arousal. However, as will be described below, the evidence for an arousal deficit becomes more potent when subjects are observed to either passively or actively respond to stimulation.

In the experiment by Boydston et al. (1968), subjects were required to pull a cord whenever they heard one of two tones varying in frequency. The MBD group displayed significantly smaller SC responses to tones than controls. There were no differences in HR response to tones. Cohen and Douglas (1972) presented a series of 70 dB tones to their subjects and found no difference between hyperactive and controls in either the magnitude or frequency of SC responses. The classical habituation of SC responses (Sokolov, 1963) over repeated tone presentations was evident in both groups. Satterfield and Dawson (1971) also presented tones of 50 dB intensity to their subjects and found that their hyperkinetic group showed smaller SC responses to the first tone during the first testing session. Unfortunately, they do not report on whether the groups differed in their rate of habituation to the series of tones. Spring et al. (1974) presented 40 tones of 85 dB to their three groups of subjects. They were unable to score responses to the first tone and so used the second tone instead.

Normal children manifested larger SC responses to the second tone and tended to habituate more slowly ($p < .10$) than MBD subjects not receiving stimulant medication. Finally, Satterfield, Lesser, Saul, and Cantwell (1973) examined the evoked cortical responses of 31 MBD children and 21 control subjects matched for age and sex. The MBD group showed significantly lower response amplitude and longer latencies for certain components of the evoked response.

The evidence from this small number of studies suggests that although hyperactive children are not likely to differ from normal children in resting or tonic indices of arousal, they may be less responsive in phasic arousal to a single stimulus.

There are two studies which have examined the physiological responses of hyperkinetic and control children while they were required to make an active response to a stimulus. Cohen and Douglas (1972) followed their series of tone presentations by a reaction time (RT) procedure which required subjects to press a button when they heard a tone. Whereas there had been no difference between the two groups in the magnitude of the SC response while passively listening to tones, hyperactive subjects gave smaller SC responses to the first block of tones when they served as reaction signals. There was also a tendency for their responses to diminish more rapidly over RT trials compared

to controls ($p < .08$). It should also be mentioned that the RTs of the hyperactives were longer and more variable. Sroufe, Sonies, West, and Wright (1973), compared 21 MBD children and 17 controls matched for age, sex, and IQ on a standard fixed-foreperiod RT task while monitoring HR. In contrast to the Cohen and Douglas study, the two groups did not differ in RT, however. Furthermore, controls showed greater HR deceleration during the preparatory interval (ie. to the warning signal). Heart rate deceleration is considered as an index of set, expectancy, or attention in RT tasks. The correlation between the magnitude of HR deceleration and RT over trials was significant for control but not MBD subjects.

These data, therefore, lend support to the theory of an arousal deficit in hyperactive children. The evidence for a lower tonic arousal is not as persuasive as that for a deficit in phasic arousal. Apparently, this deficit is more evident when demands are placed upon the hyperkinetic child to respond to stimuli in some way and are also reflected in slower and more variable motor responses to such stimuli. All of the above data support reduced rather than augmented arousal responses in hyperkinetic children.

If the above physiological measures do support the theory of defective arousal functions in hyperactive children, then it would be reasonable to assume that these

measures would also reflect the improved response to stimulant medication so often reported in these children. Cohen et al. (1971) obtained measures of resting SC and HR, and SC responses to a series of nonsignal tones, as well as to tones in a RT task with 20 children diagnosed as hyperkinetic. These measures were obtained on two occasions: once when subjects were receiving the stimulant methylphenidate and once when they were receiving a placebo. Methylphenidate significantly increased resting SC and HR but had no effect upon the frequency of spontaneous SC responses. The magnitude of SCRs to the first nonsignal tone was reduced by methylphenidate but the drug did not effect the rate of habituation to repeated tones. The finding that methylphenidate reduced the magnitude of SC responses to the first tone was considered to be explained by the Law of Initial Values which states that a response to a stimulus decreases as the prestimulus or tonic level increases. Reaction times were shorter and less variable with methylphenidate than with placebo, although there were no differences in the magnitude of SC responses to warning signals as a function of the drug.

The MBD children in the study of Sroufe et al. (1973) were retested following six weeks of treatment with either methylphenidate or placebo. Methylphenidate reduced the median RT but did not effect RT variability. Heart rate

deceleration to the warning signal was also significantly increased by the stimulant. In other words, methylphenidate improved performance on an attention demanding task and this improvement was also reflected in the HR component of the orienting response.

The study of Spring et al. (1974) also provides data with regard to this issue. The study included two groups of twenty MBD children, one of which was currently receiving methylphenidate. The group receiving the drug had more spontaneous SC responses and tended to show slower habituation of the SC response to a series of tones ($p < .10$) than the off-drug group.

Finally, Satterfield, Cantwell, Lesser, and Podosin (1972) selected the six best drug responding and five worst drug responding children from a group of 31 hyperactive children receiving methylphenidate. Drug response was determined by teacher ratings. The eleven hyperactive children were compared to a similar group of eleven nonhyperactive children on a number of measures taken before drug treatment. When compared to the controls, the best-response group tended to have a lower tonic SC while the worst-response group tended to have a higher tonic SC, although the differences were not statistically significant. In the best-response group, the mean resting EEG amplitude, EEG amplitude range, and number of EEG movement artifacts

were all significantly greater than for the worst-response group. The control group had values intermediate to the best and worst responding groups for all these measures. The best-response group also had a significantly higher auditory evoked cortical response amplitude than the worst-response group.

In conclusion, there is some evidence of reduced tonic and phasic arousal in hyperactive children and that the improved behaviour brought about by stimulant medication is accompanied by increased indices of arousal.

b) Arousal Theory and Retardation

Impairment of attention has long been identified as a general trait of the mentally retarded (Crosby and Blatt, 1968). Zeaman and House (1963; Zeaman, 1965) have postulated an initially low probability in the retarded of attending to the relevant dimensions of a stimulus display, rather than an inability to learn the relevant dimension, as responsible for their impaired visual discrimination learning. Denny (1964, 1966) concluded that the attention deficit shown by the retarded is a manifestation of a basic inhibition deficit which renders them "stimulus-bound". Zigler (1966), rather than viewing distractibility as being inherent in the retarded, has suggested that a history of failure when relying upon his own resources teaches the retardate

to look to others for help in problem-solving situations. Similarly, Cromwell (1963) has suggested that retardates tend to look for clues from sources outside the task.

There have been, however, a number of hypotheses similar or identical to those proposed to account for the attentional dysfunction of hyperactive children. Luria (1963) wrote that defective cortical functioning in retardates frequently results in an absence of the orientation reaction (OR) to stimuli of low and medium intensity, coupled with a failure to habituate the OR to strong stimuli, which when irrelevant to the task results in distractibility. Hernandez-Péon (1966a, b) has shown that during attention to a stimulus, sensory impulses evoked by the stimulus are facilitated while other sensory input is inhibited. Abnormalities in the EEG recordings of retardates led Hernandez-Péon to conclude that the cortico-reticular mechanisms necessary for initiating and maintaining attention are defective in such persons.

Recent studies of stereotyped behaviour in the retarded suggest that these behaviours may be an attempt to increase stimulation. Forehand and Baumeister (1969) found body rocking and general activity to be higher in severely retarded subjects following restraint. Ohwaki and Brahlek (1973) showed a greater preference for vibratory over visual stimulation in the severely retarded as

compared to the moderately retarded. Reardon and Bell (1970) demonstrated that music could reduce stereotyped movements in retardates and that stimulative music was more effective than sedative music. Scott (1970) discovered that hyperactive children performed better on arithmetic problems with background music than without. Smeets (1972) compared the effects of a pure tone, white noise, sedative and stimulative music upon the stereotyped rocking of blind retardates. He found an inverted U relationship with rocking reduced by stimulation of 30 to 60 dB and increased by stimulation above 60 dB. Stimulative music was most effective and white noise least effective. These results suggest that the stereotyped activity seen in many of the retarded may be a function of reduced environmental or physiological stimulation.

Several studies have employed measures of physiological responses as indices of arousal in the subnormal. The most frequently employed measures have been those of SC and HR. Reports of tonic SC have generally found retarded groups to have higher resting levels (Berkson, Hermelin, and O'Connor, 1961; Clausen and Karrer, 1970; Ellis and Sloan, 1958; Golkowski, Dadas, and Domanski, 1968; Karrer and Clausen, 1964; O'Connor and Venables, 1956) but two studies reported lower levels (Collman, 1959; Fenz and McCabe, 1971) and one found no difference

(Prideaux, 1922). Berkson et al. (1961) found a tendency for higher resting HR in subnormals and Clausen and Karrer (1970) found a significantly higher HR in their group of retardates. Although there is conflict among these results and among those employing other physiological measures, the trend points towards higher resting levels of autonomic function in the retarded (Karrer, 1966).

The results of investigations of the physiological reactivity of the retarded have also been somewhat diverse. Karrer and Clausen (1964) found significantly fewer non-specific or spontaneous SC responses in the retarded. When stimuli have been presented, they have usually been flashes of light or periodic tones. In six reports retardates showed smaller SC responses to such stimuli (Berkson et al., 1961; Collman, 1959; Fenz and McCabe, 1971; Karrer and Clausen, 1964; Lobb, 1970; Prideaux, 1922), while two report larger responses (Kodman, Fein, and Mixson, 1959; Wolfensberger and O'Connor, 1965) and two no difference (Pilgrim, Miller, and Cobb, 1969; Vogel, 1961). Although Fenz and McCabe (1971) found smaller SC responses in the retarded to stimuli of low and moderate intensity, they found larger SC responses in the retarded when the stimulus was of high intensity. This may account for the finding of greater responsiveness in the retarded by Wolfensberger and O'Connor (1965) who used a high intensity stimulus.

Three studies examined the relative rates of habituation of the SC component of the OR in normals and retardates and in each case the retarded groups habituated significantly faster than the normal groups (Clausen and Karrer, 1968; Kimmel, Pendergrass, and Kimmel, 1967; Lobb, 1970). The available evidence, therefore, suggests a higher level of tonic arousal coupled with reduced responsiveness to stimuli of short duration in mental defectives (Berkson, 1963; Hermelin and O'Connor, 1970).

A logical question is whether or not overactive retardates are differentiable from normoactive retardates in terms of arousal responses. Unfortunately, there is only one report relevant to this question. Tizard (1968c) examined SC and EEG responses to brief tones while awake and asleep in three groups of children: normoactive and overactive retarded children and normal children. No differences were found among the groups in magnitude of SC responses to stimuli while awake but only the normal children showed habituation. The overactive imbeciles were less responsive in terms of alpha-blocking while awake than either of the other groups. There were no differences among the groups in EEG changes to stimulation during sleep. These results are difficult to interpret for a number of reasons. Between-group comparisons were not powerful because each group consisted of only eight

children. While the normal children were able to achieve a relaxed state while awake, this was more difficult with the retarded subjects, especially the over-active ones. Their persistent restlessness may have accounted for the failure to habituate to stimuli, as motor activity is typically accompanied by SC responses. The results for the two measures are also contradictory - the EEG data showing hyperactives to be less responsive and the SC data showing them to be more responsive than normal subjects but equal to their normoactive retarded peers. The question of whether overactive retardates are differentiable from nonhyperactive retardates in terms of arousal measures remains open to investigation.

Hyperactivity and Measures of Motor Activity

Werry (1968a) proposed an operational definition of hyperactivity as a persistent level of motor activity clearly greater than that shown by the child's normal peers provided the child does not manifest clear symptoms of brain damage or psychosis. However, the few studies which have objectively measured the amount of activity of children labelled "hyperkinetic" have failed to show them to be more active over-all.

Atkinson (1971) used small wristwatches (actometers) which had previously been adapted to detect movement

(Schulman and Reisman, 1959) to measure the total activity over two school days of 18 pathologically hyperactive children and 102 normal children. The mean movement score for the hyperactive children was higher than that for the normals but the difference was not significant.

Pope (1970) compared 19 boys who had a medical diagnosis of brain injury or MBD with 19 normal boys. Actometer readings as well as ratings were taken in a large playroom. The total motor activity of the MBD children did not differ from that of controls. However, the clinical group spent more time in locomotion, made contact with more of the toys, and spent less time playing with each individual toy. Another task required each child to remain seated on a chair for five minutes without adults or other children around. The MBD children were significantly less able to do this. Pope suggested a differentiation between hyperactivity as an excessive amount of activity, and restlessness as an excessive proportion of time spent in motion.

Stevens, Stover, and Backus (1970) measured the motor speed of 36 MBD and 36 normal boys. This study is interesting because an increase rather than a decrease in motor activity was required. The task called for alternately tapping two brass plates at the ends of a board with a metal stylus. The two groups did not differ when required

to do the task without instructions to tap quickly. However, two other conditions which included either instructions to tap rapidly or offered pennies as incentive produced increased speed in control subjects but not in MBD subjects. The authors interpreted their results in terms of possible defective arousal functions in the MBD group.

Kaspar, Millichap, Backus, Child, and Schulman (1971) also used the actometer to measure the motor activity of 36 MBD children and 36 normal children while performing a numbers tasks to measure distractibility and while in a free-play situation. There was no difference in activity between the groups in the free-play situation. However, under the constraints of the testing situation the MBD children were more active and distracted more often. This finding may indicate a deficit in the function of inhibiting irrelevant motor activity when required. That is, the excessive activity of hyperactive children becomes noticeable and relevant when they are placed in a situation where movement is incompatible with good performance on a task.

Sykes, Douglas, Weiss, and Minde (1971) monitored the restlessness while seated of hyperactive and control children with a stabilimetric cushion (Sprague and Toppe, 1966). The children were performing the Continuous Performance Test (CPT) which requires looking at a screen

where letters appear for brief periods of time and pushing a button whenever a particular letter appears. Subjects were tested on two occasions and hyperactives were more restless over-all and became even more so during the second session.

Frequent movement and distractibility are often reported in the retarded and has been considered as sign of organic brain damage (Strauss and Lehtinen, 1947). McFarland, Peacock, and Watson (1966) measured activity in three groups of retarded children (mongoloids, cultural familials, and prenatally brain damaged) and a group of normal school children. Measurements of movement were taken via an ultrasonic device (Peacock and Williams, 1962) during a 15 minute period during which the child played with toys in a small room. The three retarded groups did not differ from each other but the normal groups displayed significantly higher activity than any of the retarded groups.

Tizard (1968a) selected two groups of hyperactive and nonhyperactive retardates on the basis of ratings by their teachers and ward nurses. Consensus among raters was required before a child was assigned to one group or the other. The children were subsequently observed in their classrooms and rated on a number of behaviours by two raters over a period of several weeks. The group designated as hyperactive by teachers and attendants were

observed to locomote significantly more often than the control group. In general, the overactive children made little contact with other children and spent their time roaming the room, spending only brief periods with one toy or another. In addition to the above measures, teachers and nurses also rated each child on ten traits commonly associated with hyperactivity. The hyperkinetic syndrome as previously described did not emerge from these ratings. The overactive subjects were, however, more often rated as distractible.

In a further study of the same subjects, Tizard (1968b) recorded activity of singular children in a large playroom. Ratings were taken on a number of occasions, with and without toys in the room. Over-all movement scores were also obtained by a grid of photoelectric cells (Hermelin and O'Connor, 1963). The correlation between these movement scores and those obtained in the classroom in the previous study was positive and significant. The amount of activity scored was not related to the presence or absence of toys in the room and did not habituate over four testing sessions. However, the topography of activity was influenced by the presence of toys as both groups of children spent significantly less time engaging in stereotyped activity, exploring the room, and manipulating fixtures when toys were present. There was a tendency for the subjects

in the hyperactive group to change from playing with one toy or another more often.

In summary, the available studies of the activity levels of hyperactive children indicate that over-all these children are not more active than their peers. Their apparent superactivity is probably an artifact of observation and labelling. Hyperactive children could be more accurately characterized as being less able to reduce their activity with environmental demands, and locomoting and changing their activity or focus of attention more often. Because such behaviour is socially inappropriate and a nuisance, it is more noticeable. To put it another way, hyperactive children are more active only in situations which require attention and the suspension of ongoing activity. Empirical evidence suggests that overactivity and distractibility of hyperactive children is the manifestation of a single symptom: the inability to suspend motor activity (particularly locomotion) in order to attend to tasks for extended periods of time. This conclusion has been alluded to or suggested by various authors in the past (Alabiso, 1972; Cromwell, Baumeister, and Hawkins, 1963; Douglas, 1972; Keogh, 1971; Maccoby, Dowley, Hagen, and Degerman, 1965; McFarland, Peacock, and Watson, 1966; Sprague and Werry, 1971; Tizard, 1968b).

a) The Effect of Drugs upon Motor Activity

There are a few drug studies which have employed objective measures of the effect of stimulants upon the motor activity of MBD or retarded children. Most studies have employed psychological tests or parent and teacher ratings of behaviour in assessing drug effects. The most widely used of the latter is a 39-item scale devised by Connors (1969) which is also available in a shorter 10-item version (Connors, 1970). Since the scale contains several items which refer specifically to the child's motor activity, (restlessness, fidgeting, etc.), the results of those studies which have included it are relevant to the present discussion. In survey of 19 drug studies, Sprague and Werry (1973) found that every well-designed study employing the Connors' Teacher Rating Scale has shown that the teacher can detect stimulant effects in her children. Similarly, Knights (1972) surveyed 18 well-designed studies of stimulant effects on children and found teacher and parent ratings more sensitive to the effects of drugs than psychological tests. While these findings do not confirm the effect of stimulants upon the amount of motor activity of children, they are very suggestive that the quality of activity of children, especially in the classroom situation, is influenced by these drugs.

One of the few studies which included an objective measure of motor activity was that of Connors (1966). Thirty-two children seen at a psychiatric clinic for hyperkinetic behaviour disorder received either amphetamine or placebo and were required to rest their hands on a tremor-graph while performing a discrimination task. There was no significant drug effect upon this measure of motor control.

Millichap, Aymat, Sturgis, Larsen, and Egan (1968) have reported a study in which 30 hyperkinetic children were given a battery of neuropsychological tests while receiving either methylphenidate or placebo. The testing session lasted 45 minutes and subjects wore actometers on the wrist of their nondominant arm during the session. Actometer measures of activity were reduced in the drug group. The effect was not statistically significant.

Sprague, Barnes, and Werry (1970) included a measure of movement in their study of the effects of thioridazine and methylphenidate with 12 emotionally disturbed boys. Subjects sat on a stabilimetric cushion which was sensitive to small movements (Sprague and Toppe, 1966) while they performed a type of stimulus recognition task. Each subject was tested on three occasions: once with each drug and once with a placebo. Motor activity was significantly reduced by methylphenidate but not by thioridazine.

In the study of Sroufe, Sonies, West, and Wright

(1973), MBD children performed a RT task while seated on a stabilimetric cushion. The children were tested a second time (six weeks later) while half of them were receiving methylphenidate and half were receiving a placebo. Drug treatment produced a greater reduction in activity level from the first to the second testing than did placebo.

Ellis, Witt, Reynolds, and Sprague (1974) measured the open-field activity of nine hyperactive children over a period of time. The activity of the children was filmed in a large playroom containing toys and the film was analyzed to yield measures of total distance moved, number and duration of visits to the play equipment, etc. The children were filmed on a number of occasions while receiving either placebo or varying dosages of methylphenidate. There were no significant drug effects on any of the dependent measures.

McConnell, Cromwell, Biales, and Son (1964) studied the effect of amphetamine upon 57 retarded children ranging from profoundly to mildly retarded. Activity was measured by a ballistograph chair suspended on cables. Each child sat in the chair for a few minutes on several occasions prior to receiving the drug and the entire sample was dichotomized into a high and low active group. Subsequently, activity measures were taken while subjects were receiving either amphetamine (7.5 or 15 mg) or placebo. There were no significant drug effects in either the high or low activity groups.

Sprague, Werry and Scott (1967) selected eight retarded boys for their study of learning and activity. The subjects performed a discrimination task while seated on a stabilimetric cushion after receiving either a placebo, 10 mg of dextroamphetamine or no drug. There was no difference between movement scores obtained without the drug and with placebo but amphetamine produced significantly lower activity scores than either of these conditions.

In a second study by Sprague et al. (1967), 24 retarded boys performed a two-choice discrimination task while seated on a stabilimetric cushion. There were no significant drug effects upon activity level.

Breitmeyer (1969) preclassified groups of institutionalized retarded boys on activity level by using a stabilimetric cushion and a motion transducer transmitter. The motion transducer was attached to a hockey helmet worn by the subject during several weeks of pretraining on a discrimination task. All subjects received all three drug conditions: thioridazine, methylphenidate, and placebo. There were no drug effects evident in the movement data.

Davis, Sprague and Werry (1969) investigated the effects of these two drugs on stereotyped behaviour (repetitive often bizarre movements, such as body rocking). Theoretically, retarded children may engage in stereotypy because their arousal level is low and self-initiated

behaviour increases the level of stimulation, or because their arousal level is high and repetitive movement somehow reduces arousal. Nine retardates received either methylphenidate (.4 mg/Kg), thioridazine (1.3 mg/Kg), placebo or no drug. The stereotypy scale of Berkson and Davenport (1962) was modified to produce two composite scores: total stereotypy (which included body rocking, complex hand and head movements, and self-manipulation) and total other behaviour (which included manipulation of the environment and locomotion). Thioridazine was found to significantly reduce stereotyped behaviour but not other behaviour. This was a very desirable result as it is this group of behaviours only that one wishes to eliminate.

In another study by Davis (1970), five severely and five moderately retarded institutionalized boys were required to press a bar or body rock in the presence of one or two discriminative lights. Subjects received candy on a fixed-ratio schedule for these responses. Rocking was measured by a motion transducer transmitter attached to a helmet. All subjects received all drug conditions: thioridazine (1.4 mg/Kg), methylphenidate (.5 mg/Kg) or placebo. Severely retarded subjects had significantly longer response latencies (interval between light onset and response) and methylphenidate significantly increased latencies for bar pressing.

Sprague, Barnes, and Werry (1970) also used the stabilimetric cushion with 12 emotionally disturbed children

performing a picture recognition task. The drug conditions were methylphenidate (.25 or .35 mg/Kg), thioridazine (.75 or 1.00 mg/Kg) or placebo. Methylphenidate significantly reduced in-seat activity as measured by the stabilimetric cushion.

Schickedanz (1967) administered thioridazine (1.3 mg/Kg), methylphenidate (.44 mg/Kg) or placebo to 24 institutionalized mentally retarded boys with double-blind conditions. The well-known marble-dropping task (usually used to investigate social reinforcement effects), as well as stabilimetric cushion measures of activity were employed. Neither drug significantly altered in-seat activity as measured by the stabilimetric cushion.

These studies can be dichotomized so that those which monitored activity while the subject was engaged in performing a task are compared to those which did not place demands upon the subject. In the case of the former, none of the four studies with thioridazine showed reduced activity while four out of nine with stimulants showed reduced activity. In cases where the subject was more or less free to respond, two out of two studies showed no effect of a stimulant upon activity and one study showed a reduction in stereotyped behaviour with thioridazine.

Hyperactivity and Attention and Learning

The literature on attention is substantial, as it has been a subject of investigation for many years. Although there are many definitions of attention, it can be described as the allocation of perceptual processes to part of the environment or sensory input. Attention, therefore, involves the selection of certain of the stimuli impinging on the organism. Attention span is generally used to refer to the length of time that attention is focused upon a particular aspect of the sensory input (although psychologists also use it to denote the number of objects apprehended at a single time). Similarly, when attention is shifted from one aspect of the sensory input to another, the individual may be said to have distracted. Attention although difficult to define, can be operationalized by simple tasks which require subjects to respond to specific stimuli. When the subject fails to respond or is slow in doing so, it can be assumed that he was not attending to the source of the signal stimuli. The present review will be confined to those studies of hyperkinetic children which have employed such objective measures of attention.

The diagnostic category of MBD includes children with a variety of behavioural, perceptual, and educational handicaps. Studies of the psychological test characteristics of this group of children have failed to delineate any uniform

cognitive deficits other than a tendency for a lower IQ (Kenny and Clemmens, 1971; Knights and Hinton, 1969, Palkes and Stewart, 1972; Stevens, Boydstun, Dykman, Peters, and Sinton, 1967). However, none of these test batteries included tests specifically designed to measure attention. Since short attention span and distractibility is one of the most common complaints of adults about these children (e.g., Schragar, Lindy, Harrison and McDermott, 1966) a few investigators have tested their performance on tasks involving RT and vigilance.

Stevens, Boydstun, Ackerman, and Dykman (1968) compared 25 clinically diagnosed MBD children with 25 normal controls on a RT task. The RTs of MBD subjects were significantly longer and more variable. The authors interpreted this finding as illustrating reduced reactivity of the clinical group to the stimuli due to faulty brain stem-cortical coupling.

Cohen and Douglas (1972) compared the performance on a fixed foreperiod RT task of 20 hyperactive and 20 control children. Hyperactive subjects had longer and more variable RTs and their performance tended to get worse over trials.

Sroufe et al. (1973) gave 21 children with learning and behaviour problems and 17 control children a series of RT trials. The clinical group had a longer mean RT but the difference did not reach significance. The RTs of the

hyperactives were significantly more variable, however. Measures of heart rate (HR) were also collected and hyperactives showed significantly less HR deceleration during the preparatory interval between the warning and reaction signals. There is considerable evidence that HR deceleration is an index of set or attention. Sroufe et al. (1973) concluded that their results support a growing body of evidence which indicates that MBD children have difficulty in consistently paying attention.

Spring, Greenberg, Scott, and Hopwood (1973) required children to make quick judgements (by pushing a button) as to whether two visually presented letters were the same or different. Children with reading, spelling, and arithmetic problems, as well as hyperactivity and poor coordination, were compared to children without problems. Although the two groups did not differ in the accuracy of their responses, the children with learning problems had longer RTs and their performance deteriorated more rapidly than that of the controls.

Sykes et al. (1971) employed the CPT in order to detect brief lapses of attention (Rosvald, Mirsky, Sarason, Bransome and Beck, 1956). The performance of 40 hyperactive children was compared with that of 19 normal children matched for age, sex, and IQ. The hyperactive children detected

significantly fewer of the signal stimuli and made more responses to the nonsignal stimuli than did control children. In a second study (Sykes, Douglas, and Morgenstern, 1972) used a number of tasks to look for attentional deficits in 24 hyperactive and 20 normal children. A choice RT task required subjects to press one of up to four buttons which corresponded to a stimulus presented on a screen. A serial RT task required pushing the correct button to turn off one of five lights, each associated with an individual button. Each response turned off one light but turned on another, and so on. In addition, two versions (visual and auditory) of the CPT were presented. There were no differences between the two groups in choice RT. In serial RT, the groups were equivalent in the number of correct responses but the hyperactives made more incorrect responses. On both versions of the CPT, hyperactives made fewer correct responses and more incorrect responses. It was evident then, that the impairment of hyperactives appeared when the task required sustained attention and was paced by the experimenter. The choice RT task only required a few seconds of attention and did not reflect any deficit.

Turning to studies of the retarded, Foshee (1958) reported that a high-active group of retardates performed significantly less accurately on learning tasks. Unfortunately in this study, IQ was confounded with activity

level. Carrier, Malpass, and Orton (1961) compared bright, normal and retarded children on a learning task. As expected, the nonretarded subjects improved over trials at a greater rate than the retarded. However, while performing the task, the retarded moved their heads significantly more often than either of the other groups. Sprague and Toppe (1966) followed this line and had 30 retardates perform a two-choice discrimination while seated in a stabilimetric chair. They ranked the children from highest to lowest in activity as measured by the chair and then examined the performance of the upper and lower quartile subjects (matched for CA and MA) on the task. The highly active group did not improve over trials whereas the low-active group did.

In a subsequent study, groups of institutionalized mentally retarded were classified as to activity level before entering an experiment (Breitmeyer, 1969; Sprague and Werry, 1971). Sixteen retarded boys performed a two-choice discrimination task while wearing a hockey helmet with an attached telemetric motion transducer. Again, the highly active group moved their heads more and learned at a slower rate than the low-active group.

In contrast to studies of motor activity, there is good evidence that the distractibility and short attention span of hyperactive children is real. This deficit is

apparently more obvious in tasks which require sustained attention. In some cases, hyperactive children may do as well as their peers at the outset but their performance tends to deteriorate at a greater rate.

a) The Effect of Drugs upon Attention and Learning

Sykes et al. (1971) retested the 40 hyperactive children in their study on the CPT while half were receiving methylphenidate and half placebo. Those receiving the active drug made significantly more correct responses and fewer incorrect responses. In a subsequent study (Sykes et al., 1972), 24 hyperactive children were compared with 20 normal children on a number of tasks measuring attentiveness and found to be impaired on some (serial RT, and CPT) but not other (choice RT) of the tests. The hyperactives were tested twice more, once while receiving methylphenidate and once while receiving a placebo. Methylphenidate produced improvement in all of the test scores, even in those in which the hyperactives had not been impaired relative to normal control subjects.

Cohen et al. (1971) employed the RT task to measure attention in 20 hyperactive children. Each child was tested while receiving methylphenidate and again when receiving a placebo. Methylphenidate was associated with faster and less variable RTs. Similarly, Sroufe et al. (1973) measured

RT in hyperkinetic boys with and without methylphenidate and found them to have a lower mean RT with the drug. This was interesting because the same subjects when compared to nonhyperkinetic children did not have significantly longer RTs. They had, however, been more variable in RT performance and the drug failed to reduce this variability.

In a RT study Spring et al. (1973) compared 20 hyperactive boys receiving methylphenidate and 19 hyperactive boys for whom stimulant medication had been temporarily discontinued. There was a significant interaction between trial blocks and medication groups due to a deterioration of RT performance in the group not receiving methylphenidate.

In the study of Sprague et al. (1969) the effects of dosage (no drug, placebo, .10 mg/Kg, .20 mg/Kg, .30 mg/Kg, or .40 mg/Kg) of methylphenidate upon the latency and accuracy of 16 emotionally disturbed children performing a visual recognition task requiring close attentiveness were investigated. Pictures of animals and other objects commonly seen in children's books were presented as a matrix of stimuli containing either 1, 2, or 3 pictures. Exposure time was at a rate of 2 seconds per picture. After a 4 second blank period, a single test stimulus appeared and the child pressed a "same" or different" response panel if he thought the picture had or had not

been presented in the previous stimulus matrix. Increasing dosages produced decreased latencies of response. The data showed a significant interaction between dosage level and the number of stimuli presented in a matrix in the accuracy of response. That is, only in the case where 3 stimuli were presented in a matrix was there a reduction in accuracy and this occurred only in the high dose (.40 mg/Kg) condition. At other dosages, accuracy was improved relative to placebo. None of the children showed side effects and this finding may be interpreted to mean that behavioural toxicity can be detected with a sensitive (ie., difficult) learning measure well before drug dosages produce physiological side effects.

Sprague et al. (1970) employed the same visual recognition task used by Sprague et al. (1969) with twelve emotionally disturbed children. All the children performed the task under either a high or low dosage of methylphenidate (.25 or .35 mg/Kg), thioridazine (.75 or 1.00 mg/Kg), or placebo. Methylphenidate significantly increased accuracy of responding and decreased latency of responding. Thioridazine, on the other hand, increased latencies and decreased accuracy.

In Breitmeyer's (1969) research, 16 retarded boys performed several two-choice discrimination tasks under all of the three drug conditions: thioridazine (1.1 mg/Kg), methylphenidate (.4 mg/Kg), and placebo. Fifty trials

were given each day under drug conditions and subjects were tested for retention 48 hours later under no-drug conditions. Subjects had been preclassified on the basis of activity measures into groups of high, medium, and low activity. The high activity group had longer response latencies over all. The finding that subjects made more correct choices during acquisition under the methylphenidate condition very closely approached statistical significance.

It is evident from the preceding review that most research has employed children of normal intelligence and little study of the drug thioridazine has been done (see Sprague and Werry, 1971). Seven out of seven studies with methylphenidate and MBP or emotionally disturbed children found improved RT or CPT performance, as well as increased accuracy on recognition tasks. One study with children of normal intelligence showed that thioridazine reduced speed and accuracy on a recognition task. Breitmeyer's (1969) research is the only study including the retarded and he failed to find effects for thioridazine. Improved performance with methylphenidate approached significance in this study. Research on these two drugs with the retarded is lacking and would seem relevant since methylphenidate has so often been shown to be of benefit but is not used with the retarded. Thioridazine, on the other hand is the most frequently used drug with the retarded while little study of its effects has been done.

Hyperactivity in the retarded has received less attention in terms of research than it has in children of normal intelligence. As previously mentioned, hyperactivity in retarded persons appears to be a more diverse phenomenon and is more frequent among those of low I.Q. and among those who have clearly suffered damage to the brain (Talkington and Hutton, 1973). Research in the area has also tended to focus upon the stereotyped and self-abusive behaviours of this segment of the population. Hyperactivity is also prevalent among those of moderate or mild retardation and little work has been done to establish whether these problems differ qualitatively from those of hyperkinetic children of normal intelligence. Since poorly modulated activity levels and distractibility are characteristics of young normal children, it may be that much of the hyperactivity of the retarded is associated with their reduced level of intellectual functioning. On the other hand, some children may manifest all the symptoms of MBD in conjunction with mild or moderate retardation. Many questions will remain as to the nature of problems of hyperactivity and attention in the retarded until more research is carried out, especially with individuals who are moderately or mildly retarded. In particular, work should be done to examine the relationship between brain damage and hyperactivity in these groups since clear brain damage may or may not be related to mental retardation. Among children

of normal intelligence, brain damage was originally thought to be the cause of hyperactivity (Strauss and Lehtinen, 1947)./ Although evidence of mild brain damage is often found in hyperactive children, the problem is now commonly viewed as being one of a biochemical brain dysfunction which is possibly genetic in origin (eg., Wender, 1971). Since both genetics, brain damage, and biochemical brain dysfunction have all been related to various forms and degrees of mental retardation, the nature and etiological correlates of hyperactivity in the retarded would appear to be a promising area of research.

STUDY I

Purpose

The preceding review of theory and research has focused upon problems of activity and attention in children of normal and subnormal intelligence. The argument was presented that hyperactivity and attentional problems are manifestations of a single phenomenon - the inability to sustain attention to a given aspect of the environment. Since suspension of irrelevant ongoing motor activity is an important component of sustained attention, this attentional inability is often described as excessive movement or hyperactivity. Experimental studies of the effects of two common drugs - methylphenidate and thioridazine - upon measures of motor activity and attention were summarized. There was some evidence of reduced activity with methylphenidate but little work has been done with thioridazine. The effects of both drugs upon these measures with the retarded appears open to further research.

Theoretical speculation relating arousal functions to motor activity and attentional problems were summarized. The response of some hyperactive children to stimulants, as well as the results of physiological studies lend support to the notion of defective arousal responses to stimuli

in these children. This defect is compatible with the poor attentional performance of hyperactives. Arousal theory has also played a prominent role in explained the attentional deficits of the retarded. The question of whether the arousal mechanisms of overactive retardates differentiate them from their peers is unanswered. Furthermore, if weak arousal responses to stimulation characterize the retarded then tranquilizing drugs such as thioridazine would not seem as appropriate as stimulants.

The purpose of the following experiment (Study I) was to answer the following questions:

- 1) Are overactive retarded youngsters differentiable from their normoactive peers in terms of measures of tonic arousal (SC and HR) or in terms of the magnitude and rate of habituation of the orienting response?
- 2) Are overactive retarded youngsters differentiable from their normoactive peers in terms of the quantity and quality of their activity in a free-play situation?
- 3) What are the effects of methylphenidate and thioridazine upon the above measures in overactive and normoactive retardates?

METHOD

Subjects

The intention was to select a group of 15 children who were hyperactive using a 23-item behaviour rating scale (see Appendix A). The scale contained 11 items from a scale by Connors (1969) and 12 were added by the present author as filler. The Connors' scale was one used by teachers and was shown to measure five factors, one of which was "hyperactivity". Items from the Connors' scale which were appropriate for retarded children were selected. By way of interviews with ward and medical staff, 31 children were selected for possible inclusion in the Hyperactive group. Those who were on large amounts of medication for seizures, who had cerebral palsy, or were self-abusive were eliminated from the sample. Twenty possible subjects (Ss) remained. The counsellors of these children completed the behaviour rating scale and a final sample of 15 was selected by utilizing those items which referred to motor activity and poor attention span or distractibility (see items 1, 4, 5, 6, 7, 21, 22, and 23 in Appendix A). In order to be selected, the child had to be rated "Pretty Much" or "Very Much" on each of these items.

A Control group of 23 children of comparable age, I.Q., sex and etiological category to the Hyperactive Group but who were not thought to be excessively active or distractible by ward staff was selected. The counsellors of these children completed the behaviour rating scale and a sample of 17 Ss was selected on the basis of the above items. In order to be selected, the child had to be rated "Just a Little" or "Not at All" on each of the items.

In the Hyperactive Group, six Ss were later dropped when their behaviour in the laboratory (screaming, kicking, crying, pulling off recording attachments, etc.) made data collection impossible. In all cases, more than one attempt was made to complete a laboratory session successfully. Another S was transferred out of the hospital, another was dropped because of repeated crying and withdrawal behaviour, and yet another was dropped because of being allergic to phenothiazine drugs. These difficulties left six Ss in the final sample of "hyperactive" children from whom data was collected. For similar reasons, five Ss were dropped from the Control Group, leaving a total of 12 Ss in this group. The final sample for the study consisted of four girls and 14 boys ranging in age from 7.3 years to 15.5 years with a mean age of 11.6 years. The I.Q.'s of these children as shown on their ward files, ranged from 30 to 93 with a mean of 41.6. In terms of etiological classification,

twelve Ss had suffered some unspecified congenital cerebral defect, two had encephalopathy associated with prematurity, one had suffered a brain hemorrhage, and two were classified as cultural-familial. All but one of the children attended school all or part of the day.

Apparatus

Psychophysiological recording was carried out in a lead-lined room approximately 10 by 13 feet in size. Subjects were seated in a large reclining chair. The experimenter (E) and recording apparatus were situated outside the room but E could view S through a small window.

Measures of HR and skin resistance were recorded onto a Nihon Kohden RM-85 polygraph. Skin resistance was recorded as a DC phenomenon via Lafayette chromeplated electrodes, filled with Beckman sodium chloride electrode paste taped to the middle phalanx of the second and fourth fingers of the left hand. A 2 volt current was passed through the electrodes. Finger pulse was recorded from a Nihon Kohden reflecting plethysmograph attached to the first phalanx of the third finger of the left hand. The R phase of the finger pulse was used to trigger a Nihon Kohden RT5 pulse rate tachometer.

A series of 15 tones were programmed by a Sony TC-252 tape machine. Intertone intervals ranged from 27 to

33 seconds with a mean of 30 seconds. A 600 Hz sine wave of four seconds duration produced by a Heathkit audio generator was driven through a loudspeaker situated approximately 6 ft. to the right of S. Tone intensity measured from the position of S was 80 dB (A-Scale).

Physical activity was later recorded in a playroom nearby. The room was 5 by 13 feet. Two transmitters and two receivers from an ultrasonic motion detector (Peacock and Williams, 1962) were suspended in the center of the room at a height of seven feet. They were pointed downwards at an angle of 30 degrees to the vertical so as to provide a coverage of the entire room. The principle of the motion detector is that a small transmitter produces a high frequency sound (40,000 Hz) which sets up a field in an enclosed space. A receiver picks up the reflected signal and it is rectified and integrated and put through a pulse amplifier. If movement occurs in the sound field, the field is distorted and the intensity of sound reflected back to the receiver varies accordingly. The rate of output pulses of the pulse amplifier is proportional to the rate of modulation of the reflected sound signal. The modulation rate is presumed to be proportional to the rate of movement of a subject within the sound field. Output pulses, in this study were fed to a Hunter Klockounter.

The ultrasonic motion detector has been used in previous studies with the retarded (Forehand and Baumeister, 1969; Switzky and Haywood, 1973). Mulhern and Baumeister (1969) obtained correlations between ultrasonic motion detector scores and direct observations of body rocking in retardates of .85 to .95.

The present author attempted to ascertain the reliability and validity of the motion detector by having an adult repeat stereotyped movements which were recorded at random intervals by the ultrasonic device. Either, 1, 4, 7, or 10 consecutive repetitions of the movement were recorded without the awareness of the subject. These data were collected some months before the present experiment and in a different room. The movements measured varied in magnitude from head turning to alternatively sitting and standing. Product-moment correlations between the number of repetitions of a movement and the score obtained varied from .997 to .999. At high sensitivity settings on the device, small movements were associated with higher correlations than gross movements. Movement scores were larger as the size of the object and its path in space were increased.

At one end of the playroom was a chair on which E sat and at the other end a children's-sized table and chair were located. The table contained a large set of plastic building blocks, paper, and pencils. Two inflated

rubber toys and a stuffed dog were located nearby.

Procedure

Drug administration was carried out by ward staff under the supervision of a physician. Mellinger (1965) has shown that serum concentrations of thioridazine when a single dose in tablet form is taken reach asymptote three to four hours after ingestion. Therefore, Ss re-received thioridazine a minimum of three hours prior to the laboratory session in amounts varying between 25 and 75 mgs. Dosage was calculated by body weight and ranged from 1.06 to 1.46 mg/Kg with a mean of 1.28 mg/Kg.

Information provided by CIBA Pharmaceutical Company showed that blood levels of methylphenidate peak one to three hours after administration. Therefore, methylphenidate was administered 90 to 120 minutes prior to experimental sessions. Methylphenidate was given in amounts of 10, 15, or 20 mg. Dosages for methylphenidate ranged from .34 to .50 mg/Kg with a mean of .42 mg/Kg.

Dosage levels were equivalent to those used in five studies summarized by Sprague and Werry (1971) and described previously in this report. In those studies, dosages for methylphenidate ranged from .10 mg/Kg to .50 mg/Kg and for thioridazine from .75 mg/Kg to 1.4 mg/Kg.

Each child was seen for three experimental sessions. The study was a cross-over design so that each S received either thioridazine, methylphenidate or no-drug prior to each session. A minimum of three days elapsed between sessions and, in most cases it was eight or nine days. This procedure allowed ample time for wash-out of drugs as methylphenidate is 95 per cent excreted in 90 hours and thioridazine is not detectable four days after discontinuation of daily dosages (Mellinger, Mellinger, and Smith, 1965). The sequences of drugs were counterbalanced so that Ss received the drugs in each of the 6 possible orders. In three cases, Ss were already receiving sedative medication. The dosages of these drugs were reduced gradually week by week until discontinued a minimum of one week prior to the first experimental session. No other Ss were receiving medication during the period of research.

Each experimental session consisted of two parts. After the electrodes had been attached and S placed in a semi-reclining position, he was instructed to sit quietly and rest. The importance of keeping his left hand motionless was stressed. The E then left the room and a three-minute adaptation period began. Without interruption a ten minute period of recording followed. The E then re-entered the room and told S that he would hear tones every now and then but that he needn't be afraid of them. One

minute later the series of 15 tones was presented. In most cases, Ss had to be warned with regard to excessive movement during recording. One or two such reminders given by E through the observation window usually were sufficient. However, particularly restless Ss were accompanied by their counsellor or an assistant to E. In these instances, the assistant sat to the left and behind S. The assistant did not interact with S except to place his hand over the left hand of S whenever there was sufficient movement to produce recording artifacts. These procedures were employed an equal number of times (i.e. eight) for each of the three drug conditions.

Subjects were subsequently taken to the "playroom" for the second part of the session. They were told that they had to wait here with E before going back to the ward but that they could play with toys while they waited. The E sat quietly (so as not to produce movement recorded by the motion detector) at one end of the room and interacted with S as little as possible. In most cases, Ss occupied their time by playing with the building blocks or drawing. This period lasted twenty minutes and an activity score was recorded every five minutes. In addition, E recorded the number of times S got out of his seat and the activity in which he was engaged throughout the session. Following the twenty-minute period Ss were returned to their ward.

RESULTS

There were too few Ss in the Hyperactive Group to provide a statistically powerful analysis and the data were initially pooled and analyzed as a repeated-measures design with drugs as the main independent variable. Subsequently, separate means on the various dependent measures were calculated for the Hyperactive and Control Groups and are presented later.

Resting Heart Rate

Average HR for the ten-minute baseline period was calculated by counting the number of pulses for the first 20 seconds of each minute and multiplying by three. An analysis of variance (ANOVA) was performed on these data. The ANOVA was a groups (drug orders) by Drug by Time (minutes of baseline recording) analysis with drug orders being a between-subjects factor and Drugs and Time being repeated-measures factors (See Appendix B-I). Conservative F tests were employed for repeated-measures factors. This analysis showed no significant effects. As can be seen in Figure 1 mean HRs for the methylphenidate sessions tended to be higher, but the difference was not statistically reliable.

Figure 1 : Mean resting heart rates during ten-minute period.

Heart rate variability (HRV) was defined as the difference between the highest and lowest HRs of the first ten consecutive heart beats of each minute of the baseline period (after Clausen and Karrer, 1970). An ANOVA (Appendix B-II) of these values showed no significant main effects of interactions.

Resting Skin Conductance

Skin resistance was read at the onset of each minute of the baseline period to the nearest thousand ohms. These values were then transformed to units of conductance (micromhos) and their logarithms calculated. An ANOVA of these data (Appendix C-I showed a significant Drug effect ($F = 31.15$, $df = 1/12$, $p < .01$)).

It is evident from Figure 2 that SC was markedly lower in thioridazine sessions. Dunnett's Test (Kirk, 1968, p. 94) for comparisons involving a control mean (using the no-drug session as a control) showed that SC in the thioridazine condition was significantly lower ($p < .01$) but the difference between methylphenidate and no-drug conditions was not significant (See Appendix C-II).

Figure 2 : Mean resting skin conductance during ten-minute period.

Nonspecific SC responses were arbitrarily defined as any discrete increase in skin conductance of .0001 microhms or more (ie., a decrease in resistance of 100 ohms or more). The number of nonspecific SC responses occurring in each half of the ten minute baseline recording period were counted. An ANOVA of these data (Appendix C-III) showed a significant Drug Effect ($F = 9.18$, $df = 1/12$, $p < .01$). Figure 3 shows the much lower frequency of nonspecific responses for the thioridazine condition.

The Orienting Response and Habituation

Skin conductance responses elicited by tone presentations were defined as any change of .0001 micromhos or more, the onset of which occurred .8 to 4.0 seconds after tone onset. An ANOVA (Appendix D-I) of the frequency of SC responses showed a significant Drug ($F = 11.96$, $df = 1/12$, $p < .01$) and Tones effect ($F = 16.90$, $df = 1/12$, $p < .01$). Figure 4 illustrates the fact that with thioridazine, Ss gave consistently fewer SC responses to tone onset. It is also apparent that methylphenidate did not reduce the frequency of SC responses as compared to the no-drug sessions. The fact that the analysis showed no significant Drug by Tones interaction indicates that, at least in terms

Figure 3 : Mean frequency of spontaneous skin conductance responses for three drug conditions.

Figure 4 : Frequency of skin conductance responses to fifteen tones.

of response frequency, neither drug differentially affected the rate of habituation of the OR.

Skin conductance response magnitude was defined as the difference between the logarithms of SC at stimulus onset and the logarithm of the maximum SC reached during response. An ANOVA of these data (Appendix D-II) showed a marginal Drug Effect ($F = 4.29$, $Df = 1/12$, $p < .10$) and Tones Effect ($F = 37.07$, $df = 1/12$, $p < .01$). It is evident from Figure 5 that initial SC response magnitudes were about equal for the three drug conditions but that with repeated stimulus presentations, response magnitudes fell to different levels. Dunnett's test (Appendix D-III) showed the mean response magnitude with thioridazine to be significantly less than that with no-drug ($p < .05$). The difference between no-drug and methylphenidate sessions was not significant.

The task of examining the habituation rates of the magnitude of SC responses is influenced by the Law of Initial Values (LIV) which states that the amount of reaction shown by a given effect or system is, in part, a function of the prestimulus level of the system (Lacey, 1956; Lacey and Lacey, 1962). Since the drugs affected resting conductance levels, it is somewhat inappropriate to compare the magnitudes of SC responses under the three drug conditions. Normally, when comparing groups on

Figure 5: Magnitude of skin conductance responses to fifteen tones.

physiological responsiveness, one attempts to match them on basal or prestimulus levels.. If this is not done, analysis of covariance is usually employed in order to adjust for the effects of different basal levels (Benjamin, 1963). However, such an analysis assumes that the covariate (in this case, basal SC) and independent variable (in this case, drugs) are uncorrelated. In the present experiment they evidently were correlated, as thioridazine significantly reduced SC. Analysis of covariance was, therefore, inappropriate (see Lord, 1967; 1969).

Lykken and Venables (1971) have recently argued persuasively for the use of a method of range-correcting SC responses. This method allows for SC responses to be corrected for individual differences in range of SC response magnitude. Skin conductance responses are range-corrected simply by dividing each SC response magnitude by the largest SC response magnitude elicited from a given individual during a given session. Therefore, SC response magnitudes (as defined above) were utilized to range-correct the SC responses of Ss for the three sessions. An ANOVA of these data (Appendix D-IV) showed a significant Drug effect ($F = 7.62$, $df = 1/12$, $p < .05$), and Tones effect ($F = 44.87$, $df = 1/12$, $p < .01$). By Dunnett's test (Appendix D-V), the difference between the average range-

corrected response for thioridazine and no-drug was significant ($p < .05$). Figure 6 again shows that SC response magnitudes were equal initially under the three drug conditions but that they habituated more completely with thioridazine. That is, in all three drug conditions the mean SC response magnitude shown by S for the first block of three tones was about 50 per cent of the largest response shown by the same S during that session. With thioridazine, however, the mean SC response magnitude shown by Ss decreased to about 10 per cent of the largest response shown earlier in the thioridazine session.

There remains some controversy in the literature as to the nature of the HR component of the OR. Some investigators have reported early HR acceleration followed by later pronounced deceleration (eg., Lang and Hnatiow, 1962), or over-all acceleration (Germana and Klein, 1968). Porges (Porges and Rasking, 1969; Porges, 1972) has characterized the HR OR as a reduction in HRV. However, the majority of reports have concluded that early HR deceleration is the essence of the HR component of the OR (Coles, Sossdian, and Isaacson, 1972; Graham and Clifton, 1966; Hare, 1972; Keefe and Johnson, 1970; Klorman and Lang, 1972; Meyers, 1969; and Raskin, Katses, and Bever, 1969).

Figure 6 : Mean range-corrected skin conductance responses to fifteen tones.

Examination of the beat to beat intervals expressed as HR for the three beats preceding and 20 beats following the first tone onset (see Figure 7) showed a pronounced deceleration within three heart beats of stimulus onset. Figure 8 shows the HR response for the fifth tone. The early deceleration although still evident is markedly reduced.

Figures 7 and 8 also indicate possible prestimulus HR differences between the three drug conditions, but an ANOVA (Appendix E-I) of the three prestimulus beats for tones 1, 5, 10 and 15 showed no significant differences among drug conditions ($F = .083$, $df = 1/12$).

Heart rate change scores were computed for tones 1, 3, 5, 7, 9, 11, 13 and 15, by subtracting the lowest HR of the three beat to beat intervals following tone onset from the lowest HR of the three beat to beat intervals preceding tone onset. An ANOVA of these HR change scores (Appendix E-II) showed only a marginal main effect for Tones ($F = 4.47$, $df = 1/12$, $p < .10$). Figure 9 shows that the change scores illustrate a HR deceleration to tone onset which habituated rapidly and irregularly.

A search of the literature revealed two studies with children which employed various HR measures of the OR. Miller and Bernal (1971) compared normal and schizophrenic children using a variety of HR OR measures. The peak-to-

Figure 7 : Heart rate response to first tone.

Figure 8 : Heart rate response to fifth tone.

Figure 9 : Habituation of heart rate change to fifteen tones

valley measure described by Lang and Hnatiow (derived by subtracting the lowest HR 7 to 20 beats following stimulus onset from the highest HR of the first six beats following onset) reliably demonstrated habituation but did not differentiate subject groups or stimulus conditions. Holloway and Parsons (1971) also examined habituation in normal and brain-damaged children using a number of HR measures. The peak-to-valley score showed habituation and differentiated the two groups (the brain-damaged group did not habituate).

Therefore, peak-to-valley scores were calculated for each of the 15 tones and blocked (five blocks of three tones). The mean score for each block was subjected to an ANOVA (see Appendix E-III). There were no significant results. Figure 10 illustrates these data. As habituation is a necessary characteristic of any measure of orienting, the peak-to-valley measure did not seem to be suitable.

Play Activity

The activity scores as measured by the ultrasonic motion detector consisted of the reading taken from the electronic counter at the end of each five-minute period in the playroom. There were four scores for each session. An ANOVA of these data (Appendix F-I) showed no significant main effects or interactions.

Figure 10: Mean peak-to-valley heart rate scores to fifteen tones.

The number of times S got out of his chair during each of the four five-minute periods of the playroom sessions were also subjected to an ANOVA (Appendix F-II). There was a significant main effect for Drugs ($F = 6.61$, $df = 1/12$, $p < .05$). As can be seen in Figure 11, methylphenidate had the effect of reducing the number of times Ss got out of their chairs.

The E had recorded S's activity by noting which toys he played with, as well as other behaviours. Following data collection, seven categories of activity were arbitrarily defined: playing with one of the three toys, drawing, playing with the building blocks, interacting with E, or exploring the room. The E was blind to the drug conditions when scoring these data. In order to be scored as playing with a toy the child must have actually manipulated it - looking at the toy was not enough. Exploring the room included locomoting, touching fixtures, lights, doorhandles, etc. An ANOVA (Appendix F-III) of these data revealed a significant effect for Drugs ($F = 6.16$, $df = 1/12$, $p < .05$). Dunnett's test (Appendix F-IV) showed that methylphenidate was associated with significantly fewer activity changes relative to no-drug ($p < .05$). Figure 12 illustrates these results.

Figure 11: Mean number of times subjects left chairs during five-minute play periods.

Figure 12: Mean number of changes in play activity during five-minute play periods.

Hyperactives versus Controls

Separate means for the behavioral and physiological dependent measures described above were calculated for the Hyperactive and Control Group Ss. The mean age of the Hyperactive Group was 10.7 years. Their mean I.Q. was 36.6. For the Control Group the means were 12.5 and 43.3, respectively.

The means of the behavioural and physiological data for the hyperactives and controls for the No-Drug session are presented in Table I. Whenever means were most discrepant, t tests were calculated. None of the differences between the means for the two groups approached statistical significance but there was a consistent pattern across the dependent measures. The hyperactives as a group were more active on all three measures of physical activity. They appear to have displayed a higher resting sympathetic tonus or higher tonic arousal as evidenced by the resting HR and lower resting skin resistance (ie. higher conductance). The hyperactives as a group may have been slightly less responsive physiologically to the tones presented. Figure 13 shows the mean range-corrected SC responses for the two groups to the 15 tones. These data show that the average

TABLE I

Means of Behavioural and Physiological Data
for Hyperactives and Controls During
Sessions without Drugs

Measure	(N = 6) Hyperactives	(N = 12) Controls	t
Mean Total Ultrasonic Activity Score	1559.33	1338.16	-
Mean Total Times out of Seat	1.83	1.42	-
Mean Total Changes in Play Activity	11.17	7.75	-
Mean Resting Heart Rate (B.P.M.)	93.1	88.7	-
Mean Resting Heart Rate Variability	15.87	18.22	-
Mean Resting Skin Resistance (1000 ohms)	35.22	47.01	-
Mean Total Spontaneous Skin Conductance Responses	35.50	29.00	-
Mean Total Skin Conductance Responses to 15 Tones	9.83	11.33	-

Figure 13: Mean range-corrected skin conductance responses to fifteen tones during sessions without drugs.

SC responses for the Hyperactive Group were smaller for all but one block of tones.

Table II presents the mean values for the two groups during the sessions with methylphenidate. The means show the same pattern as seen in Table I, with the hyperactives more active on two out of three activity measures. Methylphenidate does not appear to have differentially affected the two groups as tonic levels of HR and SC were still higher in the Hyperactive Group and they remained less responsive (in terms of SC responses to the tones). Figure 14 illustrates the depressed magnitudes of SC responses shown by the hyperactives to the series of auditory stimuli.

Table III presents the data for the two groups of Ss during sessions with thioridazine. Again, the Hyperactive Group was more active on two out of three activity measures, had higher resting HR and SC and was less responsive over-all to tones. Figure 15 shows that thioridazine appears to have wiped out the difference in asymptotic level of the SC response between the Hyperactive and Control groups. The Controls are more responsive only to the first block of tones.

Finally, Table IV presents the means for all sessions combined. Figure 16 presents the average range-corrected SC responses for the two groups across all sessions.

TABLE II

Means of Behavioural and Physiological Data
for Hyperactives and Controls During
Sessions with Methylphenidate

Measure	(N = 6) Hyperactives	(N = 12) Controls	t
Mean Total Ultrasonic Activity Score	1543.83	1549.17	-
Mean Total Times out of Seat	1.33	.50	
Mean Total Changes in Play Activity	5.83	2.25	.85
Mean Resting Heart Rate (B.P.M.)	101.1	88.5	-
Mean Resting Heart Rate Variability	15.93	16.15	-
Mean Resting Skin Resistance (1000 ohms)	30.38	41.09	-
Mean Total Spontaneous Skin Conductance Responses	20.17	35.17	.91
Mean Total Skin Conductance Responses to 15 Tones	7.83	11.58

Figure 14: Mean range-corrected skin conductance responses to fifteen tones during sessions with methylphenidate.

TABLE III

Means of Behavioural and Physiological Data
for Hyperactives and Controls During
Sessions with Thioridazine

Measure	(N = 6) Hyperactives	(N = 12) Controls	t
Mean Total Ultrasonic Activity Score	1439.00	1376.42	-
Mean Total Times out of Seat	2.00	0.92	.71
Mean Total Changes in Play Activity	6.50	7.50	-
Mean Resting Heart Rate (B.P.M.)	97.8	87.7	-
Mean Resting Heart Rate Variability	12.73	15.12	
Mean Resting Skin Resistance (1000 ohms)	83.33	112.70	.57
Mean Total Spontaneous Skin Conductance Responses	13.50	8.08	.55
Mean Total Skin Conductance Responses to 15 Tones	5.67	6.83	-

2 3

OF/DE

Figure 15: Mean range-corrected skin conductance responses to fifteen tones during sessions with thioridazine

TABLE IV

Means of Behavioural and Physiological Data
for Hyperactives and Controls for all
Sessions Combined

Measure	(N = 6) Hyperactives	(N = 12) Controls	t
Mean Total Ultrasonic Activity Score	1514.05	1421.25	-
Mean Total Times out of Seat	1.72	.95	-
Mean Total Changes in Play Activity	7.83	5.83	-
Mean Resting Heart Rate (B.P.M.)	97.3	88.3	-
Mean Resting Heart Rate Variability	14.84	16.50	-
Mean Resting Skin Conductance (1000 ohms)	49.64	66.93	-
Mean Total Spontaneous Skin Conductance Responses	23.06	24.08	-
Mean Total Skin Conductance Responses to 15 Tones	7.78	9.91	-

Figure 16: Mean range-corrected skin conductance responses to fifteen tones (all sessions combined).

DISCUSSION

Drug Comparisons

Aside from the failure to attain a large enough and homogeneous sample of hyperactive children, the experimental design provided a repeated-measures comparison of the relative influences of methylphenidate and thioridazine upon tonic and phasic HR and SC responses, as well as other behavioural measures of activity in 18 retarded children.

There were no statistically significant effects of methylphenidate upon resting SC or HR, although there was a tendency for both measures to be higher in methylphenidate than in no-drug sessions. Cohen et al. (1971) found HR and SC significantly elevated by this stimulant while Spring et al. (1974) found no effect of methylphenidate upon basal SC. Knights and Hinton (1969b) reported significantly higher HRs in children receiving methylphenidate. The most likely explanation of these discrepant findings is that a certain dosage level is required before methylphenidate significantly increases HR or SC. Of the above studies, the two which found higher HRs employed dosages averaging between 40 and 57 mg of methylphenidate while the present study and that of Spring et al. used amounts of about 10 to 20 mg.

Thioridazine had the effect of greatly reducing resting SC and the amount of spontaneous electrodermal activity while methylphenidate did not affect either. Both measures are often used as indices of over-all or tonic arousal. It is possible that these findings reflect the effect of the drug upon the autonomic nervous system per se rather than effects upon the central nervous system. Both sympathetic and parasympathetic autonomic function are integrated by nuclei in the hypothalamus, thalamus, and cortex. Therefore, the action of drugs upon the central nervous system can be accompanied by pronounced autonomic effects (Goodman and Gilman, 1970, pp. 389-422). This does not necessarily mean, however, that the effect of thioridazine upon various central nervous system functions is accurately reflected in the accompanying changes in tonic SC. It would have been valuable to have measured tonic SC in these children while they were asleep so that the resting SC level produced by thioridazine could have been compared and its accuracy as an index of general arousal evaluated.

Not only were nonspecific SC responses less frequent with thioridazine but the number of specific SC responses to the tones were also reduced. The analysis of SC response magnitude also showed that neither drug affected the mean response magnitude to the first block of tones but that the responses to later tones were significantly smaller on the average with thioridazine. This result might be interpreted

via the model for the OR advanced by Sokolov (1960; 1963; 1969). According to this theory, incoming stimuli are analyzed in the cortex. If the stimulus is novel there will not be an existing neuronal model of the stimulus in the cortex and the reticular formation will reflexively and nonspecifically excite the cortex. In other words, an OR will occur. The reticular formation is the main activating element in the OR and serves to maintain a certain level of cortical excitability or "tone" following the immediate perception of the novel stimulus. The OR functions to increase the sensitivity of various receptor and muscular apparatus, as well as the cortex, and heightens the organism's ability to perceive and analyze further information about the stimulus and take action of necessary. The brain stem and cortex are connected by ascending and descending chains of neurons. The OR occurs only if there is a discrepancy between the neural model and the perceived stimulus. If the stimulus occurs repeatedly new information is added to the model until it matches the stimulus as perceived. When the incoming stimulus matches the neural model the cortex inhibits the reticular brain stem and the OR does not occur. In this case, the OR is said to have habituated. Both the initial OR and its subsequent habituation are seen as adaptive processes.

The effects upon receptor and muscular apparatus which are part of the OR are partially mediated by the

autonomic (in particular sympathetic) nervous system. Various autonomic responses can therefore be monitored and the occurrence and habituation of the OR can be inferred from these measures. In the present case employing SC, thioridazine did not reduce the magnitude of the OR to the first block of tones. However, thioridazine did reduce the frequency and average magnitude of SC responses to subsequent stimuli. This finding might be interpreted as meaning that the subjects constructed less elaborate central models of the stimulus with thioridazine and, therefore, the OR habituated more quickly. However, SC response magnitudes in the no-drug condition did not eventually drop to the level for thioridazine but rather stabilized at a higher asymptotic level. A second possible interpretation is that thioridazine limited the over-all levels of arousal which could occur in response to the stimuli. This interpretation would rest upon the assumption that the SC component of the OR reflected the degree of activation of the reticular brain stem and its excitation of the cortex. Neither interpretation would view the effects of thioridazine as desirable since there is evidence that some of the retarded show weak ORs relative to normals at the outset.

The HR component of the OR did not provide a clear index of drug effects. The data appear to substantiate the claim that the HR component of the OR includes an initial short-latency deceleration as opposed to a later acceleratory-deceleratory response described by Lang and Hnatiow (1962).

The HR component of the OR has remained the most complex and controversial despite frequent research on the topic. Lacey and Lacey (1958) have described directional fractionation of the HR response depending on whether or not the subject is attending to the internal (cognitive) or external events. That is, attending to internal stimuli is accompanied by HR acceleration and attending to external stimuli by HR deceleration. Intense stimuli elicit the startle or defensive reflex for which HR acceleration is characteristic. It may be that a moderately intense stimulus (such as the tone used in the present study) elicits ORs in some subjects but defensive responses in others.

The different findings of various studies may be due to the different stimuli presented and subject populations used. The present study employed repeated measures of orienting to a very simple stimulus and this may have contributed to a very rapid habituation of the HR OR. The SC response did not habituate as rapidly but the independence of the various physiological systems which reflect the OR is a common observation.

Play Activity

Provided that the motion detector reliably measured movement in the playroom, the results show that neither methylphenidate nor thioridazine has any effect upon the activity levels of retarded youngsters. Experimentation by the present author prior to the present research showed

high correlations between scores on the motion detector and the number of consecutive repetitions of a stereotyped movement (such as raising one arm) performed by an adult subject. However, these data only indicate a reliability within a half-hour period. In the present research, data were collected for different drugs on different days and the effects of changes in temperature and humidity upon the ultrasonic motion detector remained undetermined. It was the subjective impression of the experimenter that the sensitivity of the detector changed within and between sessions.

Johnson (1972) has published data subsequent to the start of the present study which is critical of the ultrasonic motion detector. He compared the ultrasonic device and a photoelectric cell grid in the detection of both gross and fine motor activity. The ultrasonic device was most sensitive in the center of the enclosure. Sensitivity settings high enough to detect movements in the corners of the room also produced spontaneous counts when no movement occurred. There was no correlation between ultrasonic scores and scores from the photoelectric grid when an adult walked across the enclosure. The ultrasonic detector showed great variability within a relatively short period (a few hours) in the scores obtained for the same walking activity. With increased activity beyond a slow walk the device over-

loaded and produced lower activity counts when in fact more activity was occurring. The ultrasonic detector also responded to music, noise, and loud voices but did not respond to slow movements by a subject. Small wrist and finger movements went undetected except in the center of the enclosure.

These data indicate that the ultrasonic motion detector has many drawbacks even as a measure of total gross activity. One could argue that these uncontrolled factors should have been equally represented in all the recording sessions. However, it is probable that these uncontrolled factors contributed more to activity scores than any real activity changes which might have been produced by the drugs employed. The sensitivity of the device in the present study was high enough that it may have been overloaded much of the time and therefore insensitive to real changes in activity levels.

It is possible that the drugs used do not reduce total activity levels irrespective of environmental demands. The playroom situation in the present study placed no constraints or demands upon the subjects other than that they could not leave the room during the twenty-minute period. It may be that drug effects on activity level would have been evident if they had been required to perform some task requiring concentration or motivation. This suggestion is analogous to the finding of Kaspar, Millichap, Backus,

Child, and Schulman (1971) that in a free-play situation control Ss were just as active as brain-damaged children but in a subsequent structured situation controls reduced their activity to a greater degree than the brain-damaged group.

There has been little study of the effects of psychotropic drugs on play behaviour in children. Rapoport, Abramson, Alexander, and Lott (1971), compared dextroamphetamine (0.35 mg/Kg) and chlorpromazine (2.7 mg/Kg) and measured the number of times hyperactive children traversed a grid pattern on the floor of a playroom. Global ratings of over-all activity were also obtained. Dextroamphetamine significantly reduced both measures of activity. Witt (1971) studied the activity of hyperactive children by taking periodic photographs of the playroom and deriving measures such as total distance moved, number of visits to play equipment, average visit length, etc. Children were photographed under conditions of no-drug, placebo, 0.15 mg/Kg, 0.30 mg/Kg, or 0.45 mg/Kg of methylphenidate. Methylphenidate administration had no effect upon any of the dependent measures. In the present study, both measures of the quality of activity which occurred in the play situation, however, showed significant effects for methylphenidate. With methylphenidate, children were more likely to play with each toy longer and to remain seated while doing so.

Play activity might be expected to be reduced by a tranquilizer such as thioridazine. In a few instances subjects who had received thioridazine were asleep when the experimenter arrived at the ward to take them to their testing session. However, once in the play-room these children were as active and restless, in terms of changing their play activity and getting up out of their chairs, as they had been in sessions without the drug.

In conclusion, in this study methylphenidate did not influence resting SC, HR, nor the magnitude and rate of habituation of these components of the OR to simple stimuli. Evidently, the improved performance of subjects given methylphenidate which has been so often reported in other research is not reflected in the passive OR. Methylphenidate did, however, reduce two measures of changes in activity in a free-play situation. Thioridazine on the other hand, had no effect upon these measures of play activity but reduced the level of basal and spontaneous SC activity, as well as the SC component of attentional responses to periodic tones. It was concluded that

additional experimentation was needed to further explore the possible debilitating effects of thioridazine upon attentional performance suggested by these findings.

Methodological Problems

The attempt to collect physiological and behavioural data on a group of hyperactive retarded children was difficult and the problems encountered brought home a number of points. There was the problem of defining and selecting samples of such children given the variety of notions about hyperactivity that are utilized by those in daily contact with the child. On two or three occasions, there were conflicting reports from different ward staff as to which behaviours the child engaged in. What one person described as "hyperactivity" another described as "stealing". Children for whom there was not a consensus were not included in this study. However, in two cases where there was agreement that the child in question was "hyperactive", both children sat perfectly still throughout three half-hour recording sessions. This leads one to speculate that for some children "hyperactive" behaviours may be very much under stimulus control.

Some of the children selected definitely were hyperactive and their behaviour prohibited data collection. These children were severely retarded in addition to being

hyperactive and are a ~~quite~~ challenge to any investigator. They represent a group ~~for~~ whom it is difficult to collect more than the most crude or observational kinds of measures. Further study of the responsiveness of such subjects to stimuli would require measurements to be taken in an open-field situation which were impervious to movement artifacts.

Hyperactive-Nonhyperactive Comparisons

The physiological and behavioural data collected on a group of six hyperactive children do not allow for any conclusive remarks but, nevertheless, are interesting and suggestive. The relative mean scores of the two groups were, in many cases, in the direction predicted by the introductory discussion. Over-all, there were higher movement scores on three different measures of the Hyperactive Group. If these data reflect a reliable finding, it is somewhat at variance with previous ~~studies~~ (Pope, 1970; Tizard, 1968b) which failed to find hyperactives more active in unstructured situations. However, two of the present measures (number of times out of seat and changes in play activity) reflected the quality rather than the quantity of activity and this may be a differentiating factor. The finding of a higher resting level of autonomic arousal is at variance with two reports (Boydstun et al., 1968; Satterfield and Dawson, 1971) with MBD children. However, Berkson et al. (1961), Clausen and

Karrer (1970) and Karrer and Klausen (1964) found that retardates compared to normals, show higher basal levels of HR and SC coupled with reduced responsiveness to stimuli. High indices of tonic arousal are, therefore, not incompatible with low indices of phasic arousal. The lower number of SC responses of the Hyperactive Group to tones suggests a more extreme example of the relatively inert arousal systems found in retardates by Clausen and Karrer (1968, 1970).

Perhaps one of the most interesting aspects of these data is the demonstration of the consistency of group differences in the dependent measures. The differences between the Hyperactive and Control Group means on seven of these measures remained almost without exception, despite the fact that they were collected on three different occasions under different drug conditions. This suggests that such measures may be reliable indices of individual characteristic functioning. More research is needed to see if these measures relate to hyperactivity, drug response, behaviour problems, motivation, learning rate, etc. In particular, research should follow up the line of reasoning described in the introduction - that hyperactive children may be less rather than more responsive to stimuli in their environment.

In other words, the distractibility of the hyper-active child may be explained as the result of the relative weakness of all stimuli (both relevant and irrelevant) in capturing and maintaining his attention, rather than in the child's over-responsiveness to stimuli. This would seem to be an important conception in terms of remediation because it shifts the emphasis from removing distractions to increasing the potency of the relevant aspects of the learning environment.

STUDY II

Introduction

The purpose of Study II was to further investigate the effects of methylphenidate and thioridazine upon the performance of mentally retarded youngsters in tasks requiring the mobilization and maintenance of attention. The studies reviewed in the Introduction to Study I, which attempted to assess drug effects upon attention most often used a measure of response latency (RT) or vigilance. Vigilance is one of the most commonly used tasks in the study of attention. The vigilance task contrasts nicely with RT because it requires sustained rather than short periods of attention, as the occurrence of the signal stimulus is unpredictable. The Continuous Performance Test (CPT) is the most frequently used vigilance task with children. It was originally developed by Rosvold, Mirsky, Sarason, Bransome, and Beck (1956) to measure sustained attention in brain-damaged patients and was found to differentiate normal and brain-damaged samples of children and adults (Rosvold et al., 1956; Schein, 1962). The subject is required to observe a series of briefly presented letters and to respond to a particular one (eg., "X"). Errors of omission and commission are recorded. The second half of the test (the "AX" task) is more difficult

and requires the subject to respond to "X" only when it has been immediately preceded by another letter (eg., "A").

It was decided, therefore, to utilize both the RT and CPT tasks. The drug studies which included these measures were described in the Introduction to Study I but will be briefly summarized below. In addition, experiments which have compared the performance of normal and retarded children on these tasks are also summarized.

Reaction Time and Mental Retardation

There are three basic elements to the simple RT task. The first is the presentation of a warning signal (WS) for some duration which serves the purpose of allowing the subject to prepare to make a response. The preparatory interval (PI) begins with the WS and ends with the presentation of the reaction signal (RS). The subject must make a simple motor response (usually a finger lift or press) to the RS as quickly as possible. RT is the interval between the onset of RS and the subject's response. Covert responses are assumed to follow the WS; these responses are usually referred to as "preparatory sets". Presumably, there are at least two possible preparatory sets. One is a set to perceive the RS and the other is a set to make the overt response.

The bulk of the research of RT in the mentally retarded has been reviewed by Baumeister and Kellas (1968a). Virtually every study comparing normal and retarded subjects has shown the latter to be considerably slower. Recently, there has been more focus upon the variability rather than the mean level of RT performance in retardates. It has been noted that the performance of retardates is considerably more variable than that of normals (Baumeister, 1969; Baumeister and Kellas, 1968a; 1968b; 1968c; Berkson and Baumeister, 1967; Dugas and Baumeister, 1968; Kellas, 1969; Liebert and Baumeister, 1973; Weaver and Ravaris, 1970). Retardates not only have a lower limit of performance but also are less able to maintain their performance near that limit. In other words, they are less efficient. There is also some suggestion that the performance of retardates may deteriorate more rapidly, as one study which employed blocks of 20 RT trials found response latencies to increase significantly during the last ten trials in a retarded but not in a normal group (Bower and Tate, in press). Baumeister (1969) has suggested that arousal, attentional, or motivational processes are less well maintained by retardates from trial to trial.

It is important, therefore, to examine those variables which interact with intelligence in RT performance. One variable which has been found to interact with intelligence is the intensity of the RS. Baumeister, Hawkins, and

Kellas (1965a; 1965b) found faster responding with a louder tone, with retardates benefitting more from increased intensity than normals. They concluded that the retardates may operate with a lower over-all arousal level and, therefore, require a more intense stimulus for optimum performance.

This finding is similar to that of Holden (1965) who discovered that presenting a RS which consisted of simultaneous stimulation of three sensory modalities (visual, auditory, and tactile) vastly improved RT performance and significantly more so for a retarded group.

Another important variable in the RT situation is the length of the PI. The PI must be long enough to allow for the development of a preparatory set while an excessively long PI increases the likelihood of distraction. When PIs vary randomly from trial to trial, RTs are longest for both short and long PIs and optimal for intermediate intervals. When PIs are constant within blocks of trials longer PIs are associated with longer RTs. Presumably this is because of the increased difficulty of estimating when the RS will occur and of maintaining a preparatory set for longer durations. When PIs are constant from trial to trial, (that is, PI duration is varied between blocks of trials) no interaction between intelligence and duration of PI has been found. Length of PI would seem a likely variable to reflect drug effects upon attentional processes.

The Effects of Methylphenidate and Thioridazine
Upon Reaction Time and Continuous Performance

Very few of the drug studies with children have employed the classical RT task described above. There have not been ~~any~~ drug studies of RT in the retarded.

Cohen et al. (1971) employed the RT procedure with 20 hyperactive children whose intelligence was within the normal range. Children were tested once while receiving methylphenidate and once while receiving a placebo. Reaction times were shorter and less variable with methylphenidate. Sroufe et al. (1973) also measured RT in hyperactive boys with and without methylphenidate and found a lower RT with the drug. Variability was unaffected, however. Finally, Spring et al. (1973) compared the RT performance of MBD boys receiving methylphenidate to that of MBD boys whose medication had been discontinued. The performance of the group off the drug deteriorated over blocks while this did not occur for those receiving methylphenidate.

A few studies have employed tasks which included a measure of response latency similar to RT. Sykes et al. (1972) compared MBD children on serial and choice RT tasks with and without methylphenidate. Methylphenidate was associated with fewer incorrect responses in the serial RT task and faster responses in the choice RT task. Sprague et al. (1969) recorded the response latency of emotionally

disturbed children performing a visual recognition task under varying dosages of methylphenidate. Increasing dosages produced decreased latencies of response. In a subsequent study, Sprague et al. (1970) used the same task with emotionally disturbed children, and included thioridazine. Methylphenidate again reduced response latencies while thioridazine increased latencies.

Breitmeyer's (1969) research is the only one which tested retarded subjects. Subjects performed several two-choice visual discrimination tasks and response latencies were recorded. Subjects were tested on three occasions while receiving methylphenidate, thioridazine, or placebo. Neither drug significantly affect response latency.

The improved RT in MBD children with methylphenidate is in agreement with other reports of improved attentiveness and school behaviour in these children with this drug. However, there are no studies of the effect of thioridazine upon RT performance and also lacking are studies of the effects of both drugs upon RT in the retarded.

Similarly, there have not been any studies employing a vigilance task such as the CPT with the retarded or utilizing the drug thioridazine. Sykes et al. (1971) tested 40 nonretarded MBD children on the CPT while half were receiving methylphenidate and half placebo. Those receiving the drug detected more signals and made fewer impulsive

responses to nonsignals. A second study (Sykes et al., 1972) tested MBD children on and off methylphenidate with both visual and auditory versions of the CPT. Again, there were fewer incorrect and more correct responses when subjects were on the active drug.

There is evidence, therefore, of improved RT and CPT performance in hyperactive children of normal intelligence who are receiving methylphenidate. It is a common assumption that this is a paradoxical effect. That is, it is often stated that stimulants have a "calming" or "quieting" effect in hyperkinetic children while having an "exciting" or "stimulating" effect in other children and adults (eg., Lipman, 1972). Wender (1971) has even proposed that the most outstanding of the diverse characteristics of the MBD syndrome is the "paradoxical" response to stimulants. His theory of MBD is based on the assumption that some biochemical imbalance is rectified by stimulants, such as methylphenidate. This assumption seemed somewhat premature in view of the fact there have not been any studies in which normal children who do not show problems of hyperactivity and distractibility have received stimulants. The question remained as to whether stimulant drugs might improve the performance of normal children, retardates and even adults. Again, in spite of the widespread use of thioridazine in retarded populations, little research with this drug has

been done no matter what dependent measure is examined. Breitmeyer's (1969) is the only research with a dependent measure which might be assumed to in part reflect attentional processes and he failed to find effects for either methylphenidate or thioridazine.

The purpose of Study II was to provide additional information about the possible effect of methylphenidate and thioridazine upon attentional processes in retarded youngsters utilizing the CPT and RT tasks. In addition, the duration of PIs and the intensity of the RS were manipulated in order to vary the difficulty of the RT task and allow for the detection of any interactions between difficulty level and drug effects. The results of Study I. and the research reviewed above suggested the following questions:

- 1) Would methylphenidate be associated with shorter and less variable RTs and thioridazine with longer and more variable RTs?
- 2) Would methylphenidate produce fewer errors of omission and commission on the CPT?
- 3) Would thioridazine produce more errors of omission on the CPT?
- 4) Would shorter PIs and louder RSs be associated with shorter and less variable RTs?

METHOD

Subjects

Twenty-nine Ss were selected from institutional wards who did not suffer from any noticeable physical disability, nor did any suffer from Down's Syndrome. All Ss attended school at least part of the day. Four of these Ss were later dropped because of uncooperative behaviour and one for lack of parental consent. The remaining eighteen boys and six girls ranged in age from 10.3 to 18.10 years and in I.Q. from 30 to 70. Ten of these Ss participated in Study I during the previous year. Subjects were then subdivided into two groups of equivalent sex, age, and I.Q. Group M consisted of three girls and nine boys with an average age of 13.9 years and an average I.Q. of 43.7. Group T consisted of three girls and nine boys with an average age of 14.4 years and an average I.Q. of 42.6.

None of these Ss were receiving any medication at the time of the study. However, two Ss in Group M had previously received thioridazine on a regular basis and two others had received other tranquilizing drugs. Only one S had previously received methylphenidate. In Group T, two Ss had previously received thioridazine on a regular basis.

Apparatus

Testing was carried out in a room approximately five by twelve feet in size. Subjects were seated at a table on which there was a three-sided plywood screen 30 inches in depth. In front of S was a metal box with a telegraph key protruding from it and a red jewelled light on top. The experimenter and the rest of the apparatus were situated on the other side of the screen out of S's view.

The telegraph key, a loudspeaker, electronic relay, audio generator, amplifier and power supply were interfaced with a Digital Lab K apparatus to programme the RT trials. Counters in the Lab K controlled the duration of WS and PI, and measured RT to the nearest .001 seconds.

In order to perform on the CPT, S was required to turn his chair 180 degrees and face a 5½ by 6½ inch white screen which was then located 36 inches in front of him. Letters of the alphabet 1½ inches in height were rear-projected onto this screen through a one-way mirror by a Kodak Carousel 800H modified projector located in an adjacent room. The projector was interfaced with a Photocell Reader Control, Lafayette Repeat Interval Timer, and Lafayette six-pen event recorder. Slides on which the letter "X" appeared tripped a relay in the photocell reader and activated one channel of the event recorder. A second channel was activated by a button on the end of

a long cord which ran to the experimental room. The subject was required to push this button whenever he saw an "X". A second button was used by E to record distractions of S from the task and this button activated a third channel on the event recorder.

The Carousel projector contained 80 slides, each showing one letter of the alphabet. The letter "X" appeared on 20 slides while there were six slides for each of ten other letters. These slides were arranged in blocks of eight (see Appendix G) so that two "X"s appeared in each block and with at least one other letter between "X"s.

In addition to measures of RT and CPT performance, ratings by teachers of the S's behaviour while in school were also collected. The rating questionnaire (see Appendix H) consisted of the ten-item abbreviated teacher questionnaire used by Connors (1969) with three additional items taken from a longer version also used by Connors, Taylor, Meo, Kurtz, and Fournier (1972).

Procedure

Drug administration was carried out by ward staff under the supervision of a physician. Subjects received medication twice each day - at eight o'clock in the morning and at noon. All subjects were, tested on the Monday, Tuesday, or Wednesday of each week and received tablets

(drug or placebo) daily beginning on the Thursday of the previous week. This procedure insured that each S had been receiving tablets for a minimum of four days prior to testing.

All Ss received placebo for the first three weeks of testing. The decision as to when to shift to an active drug was based upon RT performance and will be described later. For the fourth week, Group M received methylphenidate and Group T received thioridazine. Dosages were determined with regard to both age and weight. Subjects in Group M received a minimum of 10 mg of methylphenidate in the morning and depending on weight either 5 or 10 mg at noon. Total daily dosages ranged from 15 to 25 mg with a mean of 17.9 mg. When expressed in mg/Kg, daily dosages ranged from .35 to .66 mg/Kg with a mean of .42 mg/Kg. Subjects in Group T received a minimum of 25 mg of thioridazine in the morning and between 10 and 25 mg at noon. Daily dosages, therefore, ranged from 35 to 60 mg with a mean of 53.8 mg (0.77 to 1.26 mg/Kg; mean = 1.23 mg/Kg). During the fifth week all Ss received placebo once again.

Teacher ratings were obtained for all 24 Ss for the week preceding testing, as well as the five weeks of placebo or active drug. A meeting was held with teachers prior to the study in an effort to clear up ambiguities as to the

definitions of behaviours such as "restless", "impulsive", etc. It was recognized that each teacher would employ his or her own definition in each case but they were urged to be as consistent as possible. Each child was rated by his teacher on the thirteen items of the scale on two different days for each week. For some children this rating was based upon only two half days of attendance.

Eleven Ss in each of the groups completed the RT for the five consecutive weeks. Two other Ss were incapable of learning the RT task and were dropped from this part of the study.

Subjects were brought to the experimental room by E, seated in front of the telegraph key and told that they were going to play a game to see how fast they could push a button when they heard a sound. Preliminary testing had shown that some Ss had difficulty in learning to press down the key for the WS and release it quickly for the RS. This procedure was therefore abandoned in favour of requiring only a press response to the RS. The experimenter demonstrated the procedure of watching the red light (WS) and "getting ready" to press when it came on. Subjects were shown that they could turn off the tone which followed the WS by pressing down the telegraph key. They were instructed to turn off the tone as quickly as possible. They were required to make at least three responses with a latency of less than

one second before testing proceeded. It was discovered that it was beneficial in maintaining S's attention to the task for E to say "Ready" prior to activating the WS on each trial.

There were four blocks of 13 RT trials. Inter-trial intervals were 10 to 20 seconds with a one minute rest interval between blocks. The RS consisted of a 600 Hz tone of either low (60 dB) or high (80 dB) intensity (A-Scale). Ambient noise in the room had been measured on a number of occasions and found to be 38 dB. For all Ss, the first two trial blocks employed the low intensity RS and the last two blocks employed the high intensity RS. This procedure was necessary because Baumeister et al. (1965a) have shown that the effects of a loud RS carry over to subsequent trials in which the RS is of lower intensity. The duration of the PI was counter-balanced with RS intensity, so that for each RS intensity, one block of trials had a short PI (three seconds) and the other block had a long PI (eight seconds). For five Ss in each of Groups M and T the first and third trial blocks had a short PI while blocks two and four had a long P.I. This was reversed for the remaining six Ss in each group. The order of presentation of these conditions was constant for each S for all testing occasions.

Subjects were encouraged to respond as quickly as possible and told that if they did well on the tests they would get a prize at the end. In an effort to systematize

praise, Ss were told "That was good" or "You were really fast on that one" following each trial except trials 6, 9, and 12 of each block. On a few occasions when the latency of a response was exceptionally long (ie. at least thrice the preceding RTs) S would be told that he did not do well and should try harder. During the first week, on trials where the RT exceeded 2.0 seconds Ss were told "You weren't ready on that one", "We'll have to take it over". In these cases, the trial was repeated immediately. On subsequent weeks, trials were repeated if the RT exceeded 1.5 seconds.

The decision as to how many weeks of testing were carried out before Ss received active drugs was based upon RT performance. At the end of the second week of testing on placebo, the data were examined for stability. The median RT for each S was calculated and it was apparent that most Ss had responded faster during the second week when compared to the previous testing. The a priori criterion for stability was that the median RT for a given S must not differ from the median RT of his previous week by more than .10 seconds. Eight Ss improved by more than this amount in the second week and, therefore, a third week of testing on placebo was carried out. When performances in the third week were compared to those of the second week, none of the medians differed by more than the criterion amount and the data were considered as having stabilized.

When the RT trials were completed, Ss were told that they were going to play a game called "Find the Xs". On the first week of testing it was necessary to determine whether each S could recognize the letter "X". This was done by asking each S to draw the letter "X". If he failed to do so he was given a few minutes training until he could reproduce the letter when asked. The slide projector was activated and a response button presented. Subjects were trained to press the button only when they saw an "X" appear on the screen. When Ss were able to respond to four consecutive signals ("X"s) without responding to any nonsignals (other letters) testing was begun. Instructions emphasized that to win at the game one must push the button for all the "X"s. Letters were presented continuously for a period of 5 minutes during which 30 signals and 120 nonsignals appeared. Each letter appeared for 1.9 seconds. Inter-letter intervals were .70 seconds.

During testing on the CPT, E sat to the right and slightly behind S. Whenever S removed his gaze from the screen for one second or more E scored the distraction by pressing a silent button which activated one channel of the event recorder.

During the first week of testing all Ss were presented with the AX version of the CPT following the completion of the above series. However, because only three Ss were able

to perform adequately, the AX portion of the CPT was discontinued.

At the end of each testing session, Ss were praised and allowed to choose a prize from a selection of 10 and 15 novelties and candies (Cracker Jacks, Potato chips, chocolate bars, etc.). Subjects were instructed that they would be allowed to try the games the following week and that it was hoped that they could do even better then.

RESULTS

Reaction Time

The first three RTs in each block of 13 trials were considered as practice and excluded from the analysis. The median RT of the remaining ten in each block was calculated and an ANOVA was performed on these medians (see Appendix I). There was one between-subject factor (Groups) and three within-subjects factors (Weeks, RS Intensity, and PI Duration). Conservative F -tests were employed for the within-subject factors. There were significant main effects for Weeks ($F = 23.15$, $df = 1/20$, $p < .01$), RS Intensity ($F = 42.18$, $df = 1/20$, $p < .01$), and PI Duration ($F = 12.40$, $df = 1/20$, $p < .01$). There also were significant interactions between Weeks and RS Intensity ($F = 9.32$, $df = 1/20$, $p < .01$) and between RS Intensity and PI Duration ($F = 7.86$, $df = 1/20$, $p < .05$).

Figure 17 illustrates that median RTs decreased greatly from the first to the fourth week of testing. Reaction times were longer to the less intense RS but response speed to the soft RS improved at a greater rate over weeks. Figure 18 shows that responses were faster following a PI of three seconds than following one of eight seconds and that this effect was more pronounced when the RS was of low intensity.

The standard deviations (SD) for each block of ten

Figure 17: Mean median reaction times to soft and loud reaction signals over five weeks.

Figure 18: Mean median reaction times to soft and loud reaction signals following short and long preparatory intervals.

RTs were computed and subjected to an ANOVA (see Appendix J) with one between-subjects factor (Groups) and three within-subjects factors (Weeks, RS Intensity, and PI Duration). The effects of Weeks ($F = 6.07$, $df = 1/20$, $p < .05$) and RS Intensity ($F = 21.97$, $df = 1/20$, $p < .01$), as well as the interaction between these two factors ($F = 4.58$, $df = 1/20$, $p < .05$) were statistically significant. Figure 19 shows that the variability of RT performance decreased over time and that the rate of decrease was greater in the low intensity RS condition so that by the last three weeks of testing variability under the two RS intensity conditions was about equal.

Because there is a lower limit for response latency in a RT task, distribution of RTs tend to be positively skewed. A decrease in variability would, therefore, reflect a decrease in the frequency of long RTs and an increase in the frequency of those RTs near the S's hypothetical lower limit. The degree of skewness for the distributions of RTs for all Ss under all conditions for each week were calculated (see Appendix K) and decreased from 1.77 on the first week to 1.35 by the fifth week. Figure 20 illustrates the distribution of all RTs for the first and fifth week of testing. As can be seen, over weeks the frequency of long RTs decreased while those near the lower limit became much more frequent.

Figure 19: Mean standard deviations of reaction times to soft and loud reaction signals.

Figure 20: Frequency distributions for all reaction times for first and fifth week of testing.

The Continuous Performance Test

There were three dependent measures of performance on the CPT. Errors of omission (O errors) were occasions when the signal letter "X" appeared and S failed to push the button. Errors of commission (CO errors) were occasions when a nonsignal letter appeared and S responded. The third measure was the number of times S removed his eyes from the screen (distractions).

Eight Ss in each of Group M and Group T completed the CPT and an ANOVA (see Appendix L-I) of the number of O errors during each five minute testing was carried out with one between-subject factor (Groups) and one within-subject factor (Weeks). Figure 21 shows the mean number of O errors made by the two groups over the five weeks. None of the main effects or interactions were statistically significant.

A similar analysis (see Appendix L-II) of CO errors was carried out and means are shown in Figure 22. The apparently large difference between the drug groups was mainly due to the extremely large number of CO errors made by one S in Group M. The difference between Group M and T was not statistically significant nor were any of the other main effects or interactions.

The mean number of distractions of Ss during the CPT are shown in Figure 23. There was a trend (Appendix L-III)

Figure 21: Mean number of errors of omission by drug groups over five weeks.

Figure 22: Mean number of errors of commission by drug groups over five weeks.

Figure 23: Mean number of distractions of drug groups over five weeks.

for distractions to decrease over weeks which was not significant ($F = 2.05$, $df = 1/14$).

Teacher Ratings

Each item on the Teacher Rating Scale had been scored by the teacher to indicate whether the child had displayed the behaviour "not at all", "just a little", "pretty much", or "very much" on that particular day. Each item was given a value from zero for "not at all" up to three for "very much". The total score for each child on the 13 items was used as an index of his level of hyperactivity (all the items related to activity level, attention span, irritability or mood, and sociability). The two daily scores for each child for each week were averaged to produce a more stable index of these behaviours. These data were available for 12 Ss in each of Groups M and T. The mean scores are shown in Figure 24. Higher scores indicate more frequent aberrant behaviour. An ANOVA of these data (see Appendix M-I) showed a significant difference between drug groups ($F = 10.30$, $df = 1/22$, $p < .005$), Weeks ($F = 3.12$, $df = 1/22$, $p < .10$), and a significant interaction between Groups and Weeks ($F = 5.56$, $df = 1/22$, $p < .01$). These three significant F-ratios reflect the higher scores of Ss in Group M as well as the increase in these scores from the first week to

Figure 24: Mean teacher rating of aberrant behaviours over five weeks.

second week of testing on placebo. Individual Newman-Keuls tests (see Appendix M-II) of these means showed that in Group M scores for weeks two, three and four were significantly higher than scores on week one. In addition, scores on week two were significantly higher than on weeks four and five. In other words, scores on teacher ratings of hyperactive, distractible, and antisocial behaviour for Ss in Group M increased markedly following the first week testing and subsequently decreased significantly over the next four weeks of testing. Newman-Keuls tests (see Appendix M-III) for the corresponding scores of Group T showed no significant differences between mean scores across weeks and, therefore, can be considered as having been stable. Individual t-tests for differences between the two groups (Appendix M-IV) revealed that Groups M and T differed significantly ($p < .05$) in mean teacher rating scores for all but the first week of testing.

DISCUSSION

Drug Effects

Neither methylphenidate nor thioridazine significantly influenced any of the dependent measures. This finding is at odds with the majority of studies which have included these drugs. There were a number of factors which may have contributed to this result. One factor was the dosages used. In the case of methylphenidate, the present study employed dosages which were lower than those used in most of the clinical and experimental studies of this drug. Sroufe et al. (1973), for example, used a dosage averaging 1.0 mg/Kg. The research from the Montreal Laboratory (egs., Cohen et al., 1971; Sykes et al., 1971, 1972). employed dosages up to a maximum of 100 mgs./day. The average dosage was 57 mg/day. The present study employed an average dosage of only 18 mg/day. Appropriate dosage appears to be a matter of contention. The present study was modeled after the research of Sprague and colleagues who found dosages of 0.30 mg/Kg methylphenidate to produce increments on a short-term memory task and improvement on clinical ratings by teachers and physicians (Sprague and Werry, 1971). In one case, they found effects with methylphenidate at dosages as low as 0.10 mg/Kg on

teacher and physician ratings. It should be noted that in one study they found no effects upon CPT performance using methylphenidate in 0.1 to 0.7 mg/Kg range, however, (Sprague and Sleator, 1973). Few others emphasize lower dosages and recommend larger dosages up to 2.0 mg/Kg (Goodman and Gilman, 1970).

The present study, like those of Sprague and Werry, also used standardized dosages, whereas most studies employ individual titration so that dosages are gradually increased until a therapeutic response is achieved or side effects occur. The latter procedure provides difficulties from a scientific point of view as drug dosage varies within and between studies. However, it has the advantage of almost ensuring that some drug effects will be observed and is the method employed by physicians in clinical practice. The titration method also allows for individual differences in sensitivity to a drug. This may have been particularly important as the present study employed retarded youngsters. It is possible that the retarded require higher drug dosages on the average to achieve a therapeutic effect.

With regard to thioridazine, the dosages in the present study (1.23 mg/Kg) were, again, similar to those used by Sprague and Werry (1971). Although this dosage level is less than that commonly used within institutions for the retarded (Lipman, 1967), it produced significant

effects in four of the studies described by Sprague and Werry (1971), as well as in Study I by the present author. In conclusion, higher dosages, in particular of methylphenidate, may be necessary to achieve reliable behavioural effects in retarded youngsters such as those who participated in the present study.

A second factor which may have influenced the present findings was the small number of subjects involved. The design of this study differed from Study I in that it was mixed so that each drug was evaluated on a within-subject basis while drugs were compared on a between-subject basis. This design was used in order to avoid possible treatment order effects which might occur when each subject is tested under all drug conditions. The cross-over design would have been more powerful, however. In the present study, there were only eleven subjects in each group on the RT task and eight subjects in each group on the CPT. The drug studies reviewed in the introduction to Study I typically employed 20 to 30 subjects per group. A cross-over design would have greatly increased degrees of freedom and allowed for a more individual analysis of drug effects. It may be that the performance of some subjects was not influenced by one drug but would have been by the other.

A final factor, or group of factors, which have reduced the likelihood of significant drug effects were the

characteristics of the subjects in the samples. It was argued that although it is often claimed that the effects of stimulants upon hyperactive children are paradoxical, this has never been demonstrated because nonhyperactive or normal children have not been tested while receiving such drugs. It was also argued that stimulants may also benefit the retarded who have been shown in some research to be sluggish in response to stimuli, and easily fatigued in performing a task (egs., Clausen and Karrer, 1968; Karrer and Clausen, 1964; Semmel, 1965). In the present research, the demands of the tasks employed resulted in a shift from selecting young hyperactive retarded children to selecting older, less impaired, and predominantly normo-active retarded youngsters. If, however, the effects of methylphenidate and thioridazine upon attention and performance are restricted to, or at least most pronounced in, children who display problem behaviours associated with hyperactivity, this would account for the present negative findings. Most of the children in the present study had good attention span and were quite well-behaved in the classroom, as shown by their CPT performance and teacher ratings. By the fourth week of testing, most of the children may have been functioning near the upper limit of their performance capabilities on the RT and CPT tasks, thus leaving little room for the demonstration of an improvement due to a drug.

In conclusion, it seems quite likely that all three of these factors combined may have reduced the likelihood of the demonstration of drug effects upon the performance measures employed. A larger sample of more hyperactive and distractible children who received larger dosages of both methylphenidate and thioridazine in a cross-over design may well have demonstrated drug effects. The present results do indicate, however, that neither drug, at the dosages used, can be shown to affect the performance of relatively well-behaved retarded youngsters on tasks demanding the mobilization and maintenance of attention.

Reaction Time

The most outstanding characteristic of the RT data was the steady decline in RT which reached asymptote at the fourth week of testing. There are two likely explanations for this improvement. The first is motivational. Subjects were praised by statements such as "Good" or "That was a fast one" following all but three of the trials in each block. The purpose of this procedure was to maintain the motivation of subjects during the task, as it was anticipated that the repeated weekly testing would result in boredom and a decrement rather than a stabilization of performance. This social reinforcement was only partially contingent upon response speed, as the experimenter said "You weren't ready

on that one. We'll have to take it over. You have to push as fast as you can" whenever RT was greater than 1.5 seconds. In addition, in a few instances where a subject's RTs were well under .5 seconds on the average and where on a single trial his response latency was exceptionally long but just under the 1.5 second mark, he was chided and urged to try harder. The trial was not repeated, however. These procedures may have reduced the frequency of exceptionally long RTs and contributed to the decline in median RT.

Children were also told that winning a prize would be contingent on fast responses. They were told that to win at the game they had to push very quickly. They were shown the rewards before the testing session that they could pick out one if they did well. This procedure undoubtedly affected motivation and the experience of receiving a prize following the first testing may have increased motivation on subsequent testing sessions.

In previous research which has compared the RT performance of normal and subnormal subjects, data has been gathered on only one occasion. There is one study, however, in which data was collected over several days and which is relevant to the present discussion. Baumeister and Ward (1967) administered 20 RT trials to two groups of institutional retarded on each of nine consecutive days. One group received only five cents at the end of the session for the first three

days and the other group received the same treatment for the first six days of testing. Mean RT did not change over days in either group. Subsequently, when one or two pennies were offered for each response faster than the previous day's median score, performance improved in both groups. When rewards were withdrawn in one group, RTs returned to the previous level. These results indicate that retarded subjects are capable of improving their RT performance with incentives. However, reward in the Baumeister and Ward study was directly contingent upon RT, whereas in the present study tangible prizes were received only at the end of testing and were noncontingent upon performance.

A second factor which may have contributed to the improvement in RT performance over weeks is learning. Repeated testing undoubtedly allowed for responses to the novelty of the task, equipment, and experimenter to habituate. Since these responses were irrelevant to the task and likely to interfere with good performance, their diminution would likely be accompanied by reduction in the frequency of trials where RT was exceptionally long due to distraction during the PI. The reduction in the variability and skewness of the RT distributions over weeks in the present study are congruent with this hypothesis.

Baumeister and Kellas (1968a) have described the RT task as a good one for research on motivational and attentional variables in the retarded because little practice is required and it is intrinsically interesting to most subjects. However, the results of the present, as well as of other recent experiments indicate that this view may be somewhat over-simplified. It is true that, except for the severely retarded, little practice is required in order to perform the RT task. However, to perform near one's upper limit may require practice in some subjects, in particular the retarded.

In order to perform well on a RT task, the subject must be able to adapt to a novel situation and utilize instructions, as well as three or four practice trials, in order to recognize the WS as a cue to anticipate or attend to the source of the RS and prepare to make the motor response. Instructions alone, therefore, must be adequate to make the WS a cue for the development of sensory and response sets to perceive the RS and respond, respectively. Once the WS is perceived, the PI duration must be estimated so that the subject is prepared at the moment of RS onset. Two recent studies which employed physiological as well as RT measures with retarded and normal subjects help to shed some light on the nature of the retardate's deficit in this situation. Krupski (in press) measured HR and RT in normal

and retarded adults at various PIs. It has been well established that HR decelerates during the PI of a RT task and reaches its nadir at the onset of the RS. Furthermore, RT has been shown to be negatively correlated with the magnitude of deceleration. (egs., Lacey, 1966; Obrist, Webb, Sutterer, and Howard, 1970). Krupski found significantly less HR deceleration in the retarded, as well as variability in the point of maximum deceleration. For some subjects, the nadir occurred before and for others after RS onset. Krupski suggested that part of the retardate's deficit may lie in an ability to accurately estimate the length of the PI.

Bower and Tate (in press) conducted a similar experiment with normal and retarded adolescents and included measures of HR, SC, and finger and cephalic pulse amplitude. Two groups of normal subjects were matched with the retarded for chronological and mental age, respectively. Retarded subjects were slower and more variable in RT than the normal subjects of equal chronological age. Further, their performance deteriorated over blocks of trials. The retarded group also displayed less HR deceleration, smaller SC responses, and smaller constrictions in cephalic pulse amplitude during the PI. They showed a marginally lower tonic SC level over-all ($p < .10$). These data extend those of Krupski considerably. They suggest more than problems of

time estimation in the retarded. The tendency for the retarded subjects to show lower resting SC levels suggests that they were less aroused despite the novelty of the situation and the instructions of the experimenter to respond as fast as they could. Furthermore, their ability to maintain a set to respond quickly appears to have declined over trials. All of the physiological indices, except finger pulse amplitude, reflected a reduced responsiveness and preparation during the PI in the retarded group compared to normals of equal chronological age. The development of a preparatory set to make a rapid motor response appears to be a well-practiced capability in normal subjects which can be achieved by instructions alone. The institutionalized retarded appear to be less able to develop such a set perhaps, in part, because they have had little experience in doing so. However, the present results indicate they can learn to perform quite well if motivated and given sufficient practice.

Reaction times to more intense RS were significantly shorter than those to the less intense tone. This finding is in agreement with those of Baumeister, Hawkins, and Kellas (1965a, b). However, the improvement in RT performance to the low intensity RS over the five weeks of testing was greater than to the high intensity tone, so that by the last two sessions the difference between RTs to the two

tones had essentially disappeared. Baumeister et al. (1965a) found that retardates benefit significantly more from a high intensity RS than normals. In a subsequent experiment (Baumeister, Hawkins, and Kellas, 1965b), RS intensity was varied again but at values much closer to threshold (ie., signals were of low intensity). Higher intensities were associated with faster responses but the interaction between intensity and intelligence did not reach significance. Baumeister et al. (1965b) concluded that retardates benefit from increases in intensity because they employ a sensory set rather than a response set during the task. However, at levels near threshold normals are also forced to employ a sensory set and, therefore, benefit similarly from increments in intensity. The practice effect discussed above may, therefore, reflect a relative shift in retarded subjects toward employing a set to respond rather than a set to detect the RS onset.

As expected, RTs were longer with eight-second PIs than with three-second PIs, presumably because of the difficulty of maintaining preparatory sets during the longer interval and the increased likelihood of distraction. There was also a significant interaction between PI duration and RS intensity, with median RTs being particularly long in the case where a low intensity RS occurred following an eight-second PI. Apparently, in cases where the subject had

been distracted during the PI the louder RS was more readily perceived than the soft RS.

The effects of experimental variables upon median RT and variability of RT were similar. That is, RT variability was less to the more intense RS and decreased over weeks, especially in the low intensity RS condition. Variability was not affected, however, by the duration of the PI.

The greater intra-individual variability in RT performance in the retarded is now seen as an important maladaptive aspect of retardate behaviour (Baumeister and Kellas, 1968a). Over-all performance has been conceptualized as a function of two independent factors - the individual's limit of performance and the consistency with which he responds at or near that limit. Although consistency is not sufficient to achieve an over-all good score, it is necessary. Baumeister (1969) has proposed that the inconsistency of the retardate's performance contributes more to normal-retardate differences than does his upper limit.

Only a few studies have examined intra-subject variability across intelligence groups. Berkson and Baumeister (1967) showed that retardate RT performance was more variable than that of normals and that the effect of increasing the intensity of the RS was to reduce this variability rather than affect the subject's best performance. Baumeister and

Kellas (1968c) obtained hundreds of RTs from six normal and six retarded subjects - the latter were selected as being typical of the retarded population in their performance. The distribution of RTs for the normal subjects was leptokurtic and positively skewed. Retardate distributions were more platykurtic and symmetrical. When fastest responses were considered, the difference between intelligence groups was still significant but less than that between medians. Weaver and Ravaris (1970) similarly collected thousands of RTs from 270 institutionalized retardates. Distributions had greater variance and were more Gaussian in form the more severely retarded the subjects. Liebert and Baumeister (1973) found variability of RT performance to decrease systematically when comparing first, third and fifth grade school children and college students. Baumeister and Kellas (1968b) showed retardates to be more variable than normals in performance on a short-term memory task. Dugas and Baumeister (1968) found multiple measures of auditory difference limens to be more variable in the retarded. Baumeister (1969) has conceptualized this response variability as "... moment to moment fluctuations of excitation within the central nervous system" and suggested arousal, attention, or motivational processes as implicated (p. 483). Whatever the processes, the present investigation indicates that performance variability in the retarded is not

an immutable factor, as it can be reduced with practice. Unfortunately, a group of nonretarded subjects was not included so that it remains unknown whether this improvement interacts with intelligence.

Teacher Ratings

Teacher ratings also failed to detect any drug effects. Subjects in Group T were evidently quite well behaved as shown by their stable and low scores. The behaviour of subjects in Group M, however, showed a dramatic increase in inappropriate behaviours from the first to the second week of testing. Aberrant behaviours gradually subsided week by week, by the fifth they had returned to their initial level. This finding is difficult to explain. One possibility is that the effects of the testing situation "spilled over" into the classroom. Most of the subjects were taken from the classroom by the experimenter each week and returned following testing. It may have been that the effect of an adult praising and rewarding some of the Group M subjects was to increase the frequency of certain taboo classroom behaviours (eg. "showing off" and talking to classmates). Increases in these behaviours would be reflected in ratings of activity level and inattentiveness to normal classroom activity. For one subject in Group M, this definitely was the case, as his teacher complained that

following testing he was extremely difficult to manage for the rest of the day. The fact that the frequency of hyperactive and nuisance behaviour was highest in Group M on the second week of testing and decreased with each successive week is consistent with the above interpretation.

Group M and T differed significantly in their overall classroom behaviour. Although their average scores on teacher ratings did not differ on the first week, those of Group T remained stable while scores for Group M increased. This group difference occurred in spite of the fact that the two groups had been matched for age, sex, I.Q., and median RT performance. Otherwise, assignment to groups was random and the difference between the groups in classroom behaviour can only be interpreted as due to chance assignment of more disruptive children to Group M. In addition, subjects in Group T were remarkably well-behaved, as their average score on the Teacher Rating Scale was only about three out of a possible 39. The experiment cannot, therefore, be considered as a fair test of the possible effects of thioridazine, as there was little room for improvement in this group. It would have been better to have selected groups of subjects who showed frequent hyperactivity and distractibility in the classroom in order to evaluate drug effects. Unfortunately, the process of selecting subjects who were able to perform the experimental tasks involved the elimination of those whose behaviour was most aberrant and representative of the population of residents who receive drugs.

The Continuous Performance Test

There were no significant practice or drug effects upon CPT performance. The task was apparently quite easy for the children as they failed to respond to less than two signals on the average during each five-minute vigil. With the exception of one particularly impulsive subject in Group M, subjects also made few errors of commission.

The difficulty level of the CPT is largely a function of the duration that each stimulus is presented. In the present study, the length of each stimulus presentation was determined by performance of subjects on the first week of testing as well as pilot work. Two factors resulted in a faulty estimate of the mean number of errors of omission that would be made by subjects. One was the fact that subjects improved in their CPT performance from the first to the second week of testing (although this improvement was not statistically reliable). Secondly, those subjects whose performance was poorest were the ones who had to be dropped during the second week of testing on the CPT because of their obstreperous behaviour. The result was that the remaining subjects numbered only eight in each group and were the most proficient at the task. The CPT at this level of difficulty was unlikely to reflect drug effects in the direction of improvement. A third experiment (Study III) was, therefore, conducted and is described in the following section.

In terms of the questions that Study II attempted to answer (p. 107), neither methylphenidate nor thioridazine significantly affected median KT or RT variability. However, both PI duration and RS intensity affected RTs. Neither drug influenced CPT performance.

STUDY III

Introduction

In Study II, the duration of each letter presentation on the CPT was 1.9 seconds. Preliminary testing with three pilot Ss had indicated that shorter exposures might make the task too difficult for some Ss. However, examination of the number of 0 errors at the end of the first week of testing showed that remaining Ss missed between 0 and 9 of the 20 signals (mean = 2.2) during the five-minute vigil. During the next two weeks of testing on placebo, Ss improved their performance even more and the task was evidently quite easy for them. It was evident that the CPT measures were not sensitive to drug effects and, therefore, a third study was carried out with much shorter stimulus presentation intervals.

METHOD

Subjects

The Ss for this study were the same sixteen Ss who had successfully performed the CPT in Study II. That is, Group M consisted of three girls and five boys ranging in age from 10.5 to 16.11 years (mean = 13.7 years) and in I.Q. from 35 to 70 (mean I.Q. = 43.3). Group T consisted of two girls and six boys ranging in age from 13.9 to 18.10 years (mean = 15.6 years) and in I.Q. from 35 to 60 (mean I.Q. = 45.4).

Apparatus

The apparatus was identical to that utilized in Study II. In order to avoid the possibility of Ss learning the stimulus order, the order of slide presentation was changed but still conformed to the characteristics of that used in the previous study (see Appendix N).

Procedure

Subjects were tested on the CPT once on each of three consecutive days. During the first two days, Ss received placebo tablets as they had in Study II. On the third day, Ss in Group M received either 10 or 15 mg

RESULTS

The three dependent measures of performance were the same as those described in Study II. The ANOVA of 0 errors (see Appendix O-I) was identical to that of Study II except that the within-subject variable consisted of scores made on three consecutive days (Days) rather than five consecutive weeks. The mean number of errors made by both drug groups are shown in Figure 25. There were no significant F-ratios in the analysis.

An ANOVA of C0 errors (see Appendix O-II) also failed to show any significant effects. The means for the two drug groups are shown in Figure 26.

Figure 27 shows the mean number of distractions of Ss in the two groups. An ANOVA (Appendix O-III) of these data showed that Ss in Group M distracted more often than those of Group T ($F = 7.01$, $df = 1/14$, $p < .025$).

methyphenidate in the morning and again at noon. Depending on body weight, total daily dosages ranged from 20 to 30 mg (mean = 22.5 mg/Kg). Total dosages ranged from .37 to .76 mg/Kg (mean .53 mg/Kg). All Ss in Group T received 25 mg thioridazine at 8 o'clock in the morning and again at noon. Total dosages ranged from .64 to 1.46 mg/Kg (mean = 1.05 mg/Kg).

Instructions to Ss were the same as those for Study II except that they were told that the letters would appear more quickly and that they would have to be "faster on the button". All Ss were given two minutes of practice on the CPT on the first day before testing began. Letters appeared for only .60 secs. and the duration between letters was .70 secs. Following instructions, the slide projector was activated. When S had made four consecutive correct responses without responding to a nonsignal letter testing was begun and continued for five minutes. During this period 55 signal and 165 nonsignal letters were presented. The experimenter recorded distractions as in the previous study. Following testing, Ss were praised and rewarded as they had been previously.

Figure 25: Mean number of errors of omission by drug groups over three days.

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Figure 26: Mean number of errors of commission by drug groups over three days.

Figure 27: Mean number of distractions by drug groups over three days.

DISCUSSION

Neither methylphenidate nor thioridazine significantly affected CPT performance. Because the groups consisted of only eight subjects each, drug effects would have had to have been quite pronounced in order to achieve significance statistically. It is possible that, at the dosages employed, subjects were capable of performing well at a task at which they were well-practiced. A more extended vigil of 10 or 15 minutes would have been more sensitive to the influences of the drugs.

Decreasing the duration of stimulus presentations may have influenced the strategies employed by the subjects in observing the CPT screen. The mean number of O errors increased from about 1.5 in Study II to about 6.2 in Study III. This increase in the difficulty of detecting the signal letter apparently made subjects more cautious about responding, however, as the mean number of CO errors decreased from about 3.0 in Study II to about 1.5 in Study III. The increased demands on attention were reflected in the number of distractions which decreased from about 11 in Study II to about 7 in Study III. This decrease was most pronounced in Group T, as Group M distracted significantly more often than Group T in Study III.

SUMMARY AND CONCLUSIONS

Restlessness and short attention span are prevalent problems which interfere with learning in many children of both normal and subnormal intelligence. Research and theory were reviewed to support the proposition that "hyperactivity", "motor restlessness", "distractibility", and "short attention span" are labels for behaviours which are symptomatic of a single dysfunction. Since the suspension of ongoing activity is a component of attending, it was argued that "hyperactive" children may be seen as excessively active because they are often locomoting on occasions when they should be attending to the parent, teacher, or classroom assignment. That is, it is the context in which activity occurs rather than the total amount of activity which characterizes "hyperactivity". Studies which have employed measures of activity and attention have generally failed to show that hyperactive children are more active over-all but have shown them to be less attentive. Therefore, hyperactivity might be conceptualized as primarily a disorder of attention.

Recent theoretical speculation about hyperactivity has focused upon the concept of arousal. Briefly, the arousal theory postulates that hyperactive children of normal intelligence suffer from a brain dysfunction of

biochemical origin which is due to subnormal levels of norepinephrine (Silver, 1971), serotonin, and/or dopamine (Wender, 1971). Such biochemical dysfunction could presumably affect the functions of the reticular activating system, limbic system, or caudate nucleus, all of which are known to be involved in the regulation of behaviours related to the hyperkinetic syndrome (alertness, motor activity, aggressiveness, response to rewards and punishments, impulsiveness, etc.). The dramatic improvement of many hyperactive children to stimulant medication, in particular methylphenidate, has provided the basis for this arousal theory of hyperactivity. In addition, a few studies have compared the autonomic responses of hyperactive and nonhyperactive children and have found evidence of low tonic arousal and weak phasic arousal in response to stimulation in the former.

Turning to the retarded, evidence has also been found that retarded persons may show weak attentional responses to stimuli of moderate intensity. However, little study of the effects of methylphenidate has been done with the retarded. The tranquilizer thioridazine has most frequently been used in the treatment of hyperactivity and behaviour problems in the retarded, although little well-controlled research has been done with this drug.

Three studies were carried out to compare the effects of methylphenidate and thioridazine upon measures of attention, arousal, and activity in retarded youngsters. Study I attempted to compare these effects in groups of hyperactive and normoactive youngsters of subnormal intelligence. A number of problems prevented the collection of data, especially for some of the most hyperactive children. Informal comparisons of the differences in the mean scores for the two groups were not statistically reliable but were, however, suggestive.

Relative to the normoactive group, the hyperactive group showed more frequent changes in play activity, higher resting levels of HR and SC, and fewer SC responses to tones. These differences appeared under all drug conditions. These findings suggest that qualitative aspects of motor activity, as well as physiological indices of attention may be reliable individual characteristics which may differentiate children labelled as "hyperactive" from their normoactive peers.

Furthermore, they are supportive of the theory that children who display restlessness and inability to remain attentive for more than short periods of time may be less rather than more responsive to stimuli in their environment. Their activity may be an attempt to increase the level and variety of sensory stimulation. These results also suggest that individuals may exhibit either higher or lower than

normal indices of tonic autonomic arousal in conjunction with weak ORs to stimuli. Further research is necessary to determine the utility of the low arousal explanation of hyperkinesis in children to determine its validity, usefulness in predicting which children will benefit from medication, and so on. The theory is also of importance to education because it shifts the emphasis from eliminating irrelevant and distracting stimuli to increasing the potency of the relevant aspects of the environment.

Study I also provided a comparison of the relative effects of methylphenidate and thioridazine. Methylphenidate at the dosages given did not effect any of the HR and SC measures. However, methylphenidate was associated with fewer instances of children getting out of their chairs and changing their play activity in the playroom situation. Thioridazine, on the other hand, while not significantly affecting play activity, did reduce tonic SC level and the frequency of spontaneous SC responses. Skin conductance responses to tones were also less frequent and of smaller magnitude with thioridazine. In view of findings which suggest that the retarded in general, and hyperactive in particular, may be abnormally unresponsive to stimuli at the outset, these results were interpreted as indicating that thioridazine may not be the most beneficial drug for use with the retarded. The results also suggested that the stimulant

methylphenidate may be more beneficial in the treatment of attentional disorders in the retarded.

Studies II and III were designed to further investigate the effects of these drugs upon performance measures of attention in moderately retarded youngsters. In both experiments, no significant effects of methylphenidate or thioridazine upon simple RT or CPT scores were evident. Teacher ratings of the classroom behaviour of the children also failed to reflect reliable drug effects.

There are several important factors involved in the interpretation of these results. For example, the effects of thioridazine seen in Study I were not reflected in the dependent measures employed in Studies II and III. This may have been due to the fact that the demands of the tasks and nature of the over-all experimental situation were more arousing in the latter studies. In Study I, subjects sat quietly, and in most cases alone, in a sound-attenuated room and were not required to engage in any activity. In Studies II and III, however, the subjects were promised rewards, required to interact with apparatus, and praised throughout the session by the experimenter. These factors may have overcome the arousal-reducing influences of thioridazine. Some evidence of this was also seen in Study I where many subjects appeared to be drowsy prior to sessions with thioridazine but not while playing with toys in the playroom.

Environmental factors may, therefore, overcome the effects of thioridazine. Thioridazine may only reduce tonic and phasic arousal in relatively undemanding situations. However, it is possible that in a less novel situation where the child receives less individual attention, such as the classroom, that the effects of thioridazine would again be evident.

The dosage levels of methylphenidate and thioridazine employed in the present studies were less than those commonly used by clinicians. Lipman (1967) reported a median dosage for thioridazine in his survey of 400 mg per day. This figure coincides with the experience of the present author in the institution in which this research was carried out. Most often dosages for thioridazine were in the range of 50 to 100 mg, given on three or four occasions each day. The present author never encountered a physician's order for thioridazine of less than 25 mg three times a day. Methylphenidate is usually started at 5 mg twice a day and increased until either a therapeutic response or side effects are obtained. Recommendations as to maximum daily dosage vary between about 80 mg (Eisenberg, 1972) and 160 mg (Solomons, 1971).

Larger dosages of both drugs may well have produced effects not detected in the present studies. However, two points should be made in this regard. One is that many

children who receive higher dosages may be getting more drug than is necessary to achieve a satisfactory effect. For example, Sleator and von Neumann (1974) studied 46 hyperactive children on both placebo and methylphenidate. Thirty-six of these children showed improvement on the drug at maximum dosage (ie., 1.0 mg/Kg), less than that of most studies in the literature. A second point is that dosages above those of the present studies may produce suppression of gains in weight and height, as well as other undesirable side effects. Weight gain is not depressed at daily dosages of less than 20 mg, however (Safer, Allen, and Barr, 1972). If higher dosages than presently used are necessary to achieve reliable effects in the retarded, it may be at the expense of side effects such as reduced weight gain, sleeplessness, etc.

A third factor bearing on the present finding is that of the subject characteristics. Significant effects were found on some measures for both methylphenidate and thioridazine in Study I, even though only one third of the subjects were considered to be hyperactive. Studies II and III placed greater demands upon the subjects and resulted in the selection of youngsters who were better able to follow instructions and inhibit grossly disruptive behaviour. The subjects in Studies II and III included ten of the subjects from Study I and both groups were of the same mean I.Q. Subjects in the

last two studies were two and one half years older on the average, however. It may have been that improved performance was not demonstrated because many of the subjects were already performing near their maximum level. This certainly appears to have been the case for the CPT and Teacher Rating measures. Further research of this kind will require selecting subjects who are clearly restless and distractible, but at the same time capable of performing experimental tasks. This will necessitate finding hyperactive subjects of higher I.Q. Since hyperactivity and I.Q. tend to be negatively correlated, the investigator will require a very large initial pool of individuals in order to find enough subjects who meet these requirements.

Further, it may well be as is often claimed, that the effects of methylphenidate and thioridazine are not uniform across individuals. Methylphenidate may indeed improve behaviour in some hyperactive children while debilitating the performance of others. Sleator and von Neumann, for example, found no improvement at all in 10 of 46 hyperactive children at any dosage of methylphenidate. Furthermore, Tecce and Cole (1974) have reported that some normal adults show reduced alertness while others show increased alertness in response to amphetamine. The variables in a child which correlate with a good drug stimulant response have yet to be determined. This issue has been discussed at some length by Fish (1971) and ongoing research comparing hyperkinetic children who show a good drug response with those who do not should soon cast some light in this direction.

The finding of improved RT performance over four weeks in 22 retarded youngsters is a very interesting one and is worthy of further research. For example, a study in which both normal and retarded subjects are repeatedly tested would show whether this practice effect interacts with intelligence. If it does, then at least some of the observed deficit in retarded RT performance must be due to weakness in skills specific to the RT task (ie., developing a response set) rather than to a more over-all dysfunction in attentional processes.

There have been recent outcries against the use of psychotropic drugs in the treatment of learning and behaviour disorders in children. Specifically, these have focused upon the use of stimulants with hyperactive children of normal intelligence (eg., Walker, 1974). Some of this criticism is misinformed and hysterical and some of it is justifiable. The danger of side effects and unknown long-term risks have been pointed out (Grinspoon and Singer, 1973). The evidence for the beneficial effects of stimulants with hyperkinetic children remains, however, and represents some of the best experimental work in psychopharmacology. Nevertheless, it is undoubtedly true that many children receive drugs with little benefit, for too long, or at too high a dosage. Lipman's (1967) study certainly indicates that this also may be the case for the use of Phenothiazines with the

retarded. Solomons (1973) followed a group of hyperactive children receiving stimulant medication. He found that only 55 per cent had been in contact with the physician on three occasions within a year of the drug being prescribed and 25 per cent of the parents were allowed to alter dosage and frequency of medication without consulting their physician. Certainly more careful diagnosis and follow-up of drug treatment is necessary if this study is in the least representative.

More research is needed in some areas. Techniques need to be developed to aid the clinician in determining which children are likely to benefit at all from stimulant medication. Long term effects also must be evaluated. Certainly thioridazine merits further investigation given its widespread use with the retarded, and the little well-controlled research that has been done. Study I indicated its deleterious effects upon one component of the OR. Work needs to be done to find out which kinds of hyperactive-aggressive disorder are alleviated by thioridazine and which are not. In the case of both drugs, further research should probably employ a repeated-measures design and varying dosages to take into account individual differences in response to different drugs and dosages. After surveying a large number of psychotropic drug studies, Connors (1971) has pointed out that "Given the rather unique individual patterns of deficit

found in most children with learning disorders, one may expect changes in certain functions for certain children, but not all functions for every child in a drug study." (p.284).

The discovery of therapeutic effects of drugs such as stimulants and phenothiazines may have led to an overly enthusiastic appraisal of their utility. At small dosages they do not appear to work wonders, as indicated by the literature and the present research. High dosage levels bring undesirable side effects which may, in the long run, be as deleterious as the disorder being treated. The number of children who can be effectively treated by mild to moderate drug dosages may, in fact, be very small. Furthermore, practice but not drugs improved RT performance in the present research with retarded youngsters. In a recent study, Christenden (1973) compared methylphenidate (0.3 mg/Kg) and a token economy classroom programme with 16 mentally retarded hyperactive children and found the latter to be much more potent form of treatment. Environmental influences, although not as easy to prescribe and obtain, may be more potent therapeutic tools than drugs.

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