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AGE DIFFERENCES IN VISUAL REACTION-TIME OF
BRAIN-DAMAGED AND NORMAL CHILDREN UNDER
REGULAR AND IRREGULAR PREPARATORY
INTERVAL CONDITIONS

by

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B.A., University of Windsor, 1963

M.A., Carleton University, 1966

A Dissertation

Submitted to the Faculty of Graduate Studies through the
Department of Psychology in Partial Fulfillment
of the Requirements for the Degree of
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Abstract

A reaction time experiment was carried out in an attempt to validate the findings of Czudner and Rourke (1970). Two groups of children were employed - one with neuropsychological and electroencephalographic evidence of cerebral dysfunction; the other, a control group of normal children. Each group was subdivided into two age classifications: "young" (ages 6-9 years), and "old" (ages 10-13 years). These groups were matched for age, sex, I.Q., and socioeconomic status. The procedure consisted of regular and irregular preparatory interval reaction-time conditions.

The results demonstrated that latency was directly related to length of preparatory interval in the regular procedure for both the normal and the brain-damaged groups. However, in the case of the irregular procedure, there was an inverse relationship between length of preparatory interval and reaction time for the young brain-damaged subjects and the normals. The results gave support to the Czudner and Rourke (1970) findings that young brain-damaged children may recover from the deficit(s) in the ability to develop and maintain attention. The results further demonstrated that a reaction-time procedure can be used as an effective method for the detection of brain dysfunction among young (ages 6-9 years) children.

Preface

Many people have been involved and have been extremely helpful in making this thesis a reality.

The writer wishes to express his gratitude to Dr. B. P. Rourke who, through his creativity and resourceful participation and the help of his staff, made this study possible. In the same spirit of gratitude the comments of Dr. A. Smith, Dr. G. Namikas, and Dr. R. Frisch are greatly appreciated.

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CHAPTER I

INTRODUCTION

Purpose

The main purpose of the study was to investigate set or attentional processes among brain-damaged (BD) and normal children by the use of a reaction time (RT) procedure. The independent variables under investigation were the following: age, neurological dysfunction, regular and irregular RT procedures and length of preparatory interval (PI). This introductory section will deal with the early investigation of attention, some theoretical formulations of attention, RT experiments with BD adults and children, a statement of the problem and hypotheses under investigation.

Early Work on Attention

During the late nineteenth and early twentieth centuries, attention was an important area of psychological investigation. The two main schools of thought regarding attention at that time were the functionalists and the structuralists. The former emphasized selective processes; the latter, introspection or the conscious act of attending. Titchner (1908), a structuralist, concluded that attention was "sensory clearness". He listed six conditions of clearness of the stimulus being attended to: intensity, form or quality, frequency, movement, novelty, and similarity. William James (1890), a functionalist, emphasized the

active, selective nature of attention, a view which served as a precursor to some of the contemporary psychological work on the subject.

Pillsbury (1908) and Geissler (1909) reviewed most of the early work on attention. Geissler listed six ways in which attention had been investigated: by the use of (1) peripheral vision, (2) muscular strength, (3) liminal and differential sensitivity, (4) RT, (5) degree of precision, and (6) graded distraction.

Since the concern in this study is with the use of RT as a dependent variable for the measurement of attention or "set", the remainder of this discussion will deal mainly with the use of RT procedures to measure attention. Obersteiner (1879) was perhaps the first to use RT to measure attention. (RT is the interval between the application of a stimulus and the beginning of the subject's response.) He assumed that retardation of reaction was inversely proportional to the intensity of attention. Swift (1893) was another early investigator who found a small but uniform increase in RT when the subject was required to concentrate on some other task.

Woodrow (1914) reported what appears to be the first systematic work on the application of RT procedures to the study of attentional processes in normal adults. He investigated the effect of variation in PI upon RT. (PI is the time between the warning signal and the RT stimulus.) He found the following: (1) RT is influenced by the duration of the PI; (2) intervals are most favorable near the 2-second interval in the regular procedure ("regular" procedure refers to a method in which the PI remains the same for a fixed number of trials);

(3) the irregular procedure serves as a distractor for attention ("irregular" procedure refers to a method in which the various PIs are presented at random).

In one RT study with normal adults, Saltzman and Garner (1948) showed that the RT required for the correct identification of various numbers of stimulus objects appeared to be a more reliable method to assess attention span than was a tachistoscopic technique. Another exploratory study of visual, auditory, and discrimination RT (Huston, Shakow, & Riggs, 1937) showed that schizophrenic adults had longer RT latencies than did normals. They also showed that schizophrenic subjects reacted slower at every one of the six PIs for both regular and irregular procedures. Plotting the results of the 2-, 3-, 5-, and 10-second intervals of the regular and the irregular procedures showed, in the case of the normals: (1) there was a direct or linear relationship between length of PI and RT in the regular procedure (i.e. as one increased so did the other); and, (2) the slope of the irregular procedure was horizontal (i.e. there was no relationship between length of PI and RT). In the case of the schizophrenics they found: (1) no relationship between length of PI and RT performance in the regular procedure, and (2) the slope of the irregular procedure showed a negative relationship between length of PI and RT (i.e., as PI decreased, RT increased).

Rodnick and Shakow (1940) designed an experiment as an elaboration of the Huston, Shakow, & Riggs (1937) study. Their objective was to employ RT procedures in such a way so as to provide a quantitative measure of the ability of the schizophrenic adult to develop and maintain

a set. They viewed this as one aspect of attention. They developed a formula called the "set index", a mathematical expression which includes the length of the RT and the relationship between the regular and irregular procedures. In applying the set index formula they found that it was possible to differentiate between schizophrenic and normal adults. Hunt and Cofer (1944) have noted that this formula is the only score that has differentiated any diagnostic group from normal groups without any overlapping. Since the last study of Rodnick and Shakow (1940), numerous experiments have corroborated their findings (e.g., Huston & Singer, 1945; Tizard & Venables, 1956; Zahn, Rosenthal, & Shakow, 1961).

Theories of Attention

The theoretical area which bears most closely upon the empirical data outlined above is that which deals with the psychological phenomena of set, expectancy, and attention. After a period of relative neglect (1920-1940), Hebb (1949) aroused new interest in this area. He pointed out that, although in the past selectivity was treated as an experimental error, future research would have to treat selectivity as an independent variable in order to provide understanding of cognitive processes in normals and the mentally ill.

Shakow (1962) couched his own empirical findings in a formulation which he called the "segmental set" theory. The psychological deficit which he discussed was one of the "inability to maintain a major set (Shakow, 1962, p. 8)." Shakow explained this deficit as follows: "It is as if in the scanning process which takes place before the response is made, the schizophrenic is unable to sort out the material relevant

for optimal response (1962, p. 9)." He goes on to list three major variables which could interfere with obtaining an optimal response: (1) chance distractors from the environment; (2) irrelevancies from the stimulus situation; and, (3) irrelevancies from past experience. In his view, responding at optimum level required the following: (1) high arousal focused on the relevant aspect of the situation; and (2) reduced arousal quality of the focal stimulus as the situation is repeated. Shalov's theory is mainly aimed at explaining his empirical findings using RT procedures with schizophrenic subjects. Several other theories had been advanced to explain the more general phenomena of attention.

Berlyne (1951), following Hull's theory, suggested that attention should be regarded as the "momentary effective reaction potential (sEr) of the perceptual response (p. 141)." Accordingly, attention depends on the following: (1) habit strength (sHr); (2) drive (D); (3) stimulus-intensity dynamism (V); (4) inhibition potential (Ir); and, (5) behavior oscillation (sOr). Attention is manifested through: (1) probability -- stimuli receiving more attention will be more likely to be noticed; (2) amplitude -- stimuli receiving more attention will be more clearly perceived; (3) latency -- stimuli receiving more attention will "catch the eye more quickly" (p. 42); and (4) extinction-resistance -- stimuli receiving more attention will ward off distracting stimuli. Thus, with high attention there is high probability, high amplitude, low latency and high extinction-resistance. Accordingly, it could be hypothesized that a deficit in attention is due to one or several deficits in any of the intervening variables. For example, drive which is too low will affect attention in an adverse fashion.

Broadbent's (1958) "filter" model is one of the more fruitful theories of human attention. His model of selective attention contains a "filter-mechanism," the principal function of which is to sift out the relevant stimulus from a number of competing sensory messages. According to this model, the selected data is then fed into a limited capacity decision channel which is, in turn, connected to a long-term memory storage bank. The new information is then integrated with past information in order to facilitate responding.

Another important approach to attention involves the application of neurological models. One of the earliest physiological theories of attention involved the arousal or activation theory of Malmö (1957). The "inverted U" theory assumed that there is an optimum level of performance and, therefore, of attentiveness. If level of arousal is too low, attention will suffer; if it is too high, attention will also suffer. This theory began as a psychological model. However, it also has a reasonably sound physiological foundation. For example, Brain (1958) has suggested that the reticular formation prepares the cortex and other sensory pathways to respond to sensory impulses. Its activity involves the reduction of sensory information which may constitute a competing response and the integration of sensory information with the background of somatic and environmental sensory data. In this formulation, too little or too much input (arousal) may affect attention in an adverse fashion.

Penfield (1954) has advanced an interesting neuropsychological model involving the reticular system and its cortical connections. He suggested

that sensory data is integrated within the centrencephalic system. Some portion of the information is projected to the temporal cortex. There, a comparison and a judgment are made regarding whether or not to respond in terms of familiarity or significance of the information. More recent neurological findings suggest that descending pathways from the cortex to the reticular system allow the cortex to exert both facilitation and inhibition upon the reticular system.

The role of the cortex in attention is evident in some of the neuropsychological theories advanced by the Russian school. Sokolov (1960) assumes that attention is directed in the brain stem reticular formation and the cerebral cortex. Incoming stimuli travel along specialized pathways to the cerebral cortex and to the reticular formation. The ability of the reticular formation to activate the cortex can be seen by EEG changes occurring when attention is applied towards some specific stimulus. According to Sokolov's formulation, if the incoming stimulus is familiar, the cortex sends an inhibiting message which blocks the reception of the stimulus at the reticular formation. If the incoming stimulus is novel, the reticular formation produces the "orientation reaction."

Finally, Deutsch and Deutsch (1953) advanced a very interesting model for selective attention. In their view, a signal coming to the cortex is capable of exerting pressure related to its dimension or strength, and the most important signal will determine the particular level of attention at any unit of time. In order for this process to occur, it must be accompanied by a sufficient level of arousal. In the

investigators' own words, "whether or not alerting will take place then, depends both on the level of general arousal and the importance of the message (p. 215)." This theory predicts that any distracting stimulus will hamper attention, provided its importance in terms of arousal and the level of message is perceived by the individual as equal to or larger than the one previously perceived. Norman (1968) has elaborated on this model to incorporate memory factors as well as attention.

Experimental Studies of Brain-Damaged Populations

(1) Experiments Using Adult Subjects

Benton, Sutton, Kennedy, & Brokaw (1962) examined RT among adult BD subjects as a function of whether the stimulus was preceded by an identical stimulus, a different stimulus of the same modality, or a different modality stimulus. Their main results showed no difference between the BD and normal groups. McDonald (1964) found that BD subjects were able to adapt when the interstimulus interval was varied between trials.

Goldstein (1939), commenting on the attention deficit of BD adults, suggested that they pay too much attention to the inessential elements of the stimulus situation. Other studies employing RT procedures showed that BD adults' performance is slower than normals' performance (e.g., Benton & Joynt, 1959; Blackburn & Benton, 1955; Costa, 1962). Costa also showed that changing the length of the PI appears to affect normals, but has no effect on RT in BD adults. DeRenzi and Faglioni (1965) found a small positive correlation between scores obtained on a visual RT test and degree of brain-damage. They suggested that simple RT may provide a sensitive measure of the presence or absence of neurological damage, and

that latency can be used as a measure of the actual severity of the damage.

Several studies dealing with vigilance are also related to this topic. For example, Rosvold, Mirsky, Sarason, Bransome, & Beck (1956), employing a test that is supposedly a measure of sustained attention, the Continuous Performance Test (CPT), found that groups of BD adults and BD children perform less well on the test than do normal controls. Another group of studies has dealt with attention and vigilance in relation to sub-cortical damage. For example, McDonald and Barn (1964) found that the error rate of signal detection in patients with sub-cortical damage was significantly higher than was the case with patients with lesions located in other parts of the brain. Similarly, Mirsky, Primac, Mason, Rosvold, & Stevens (1960) and Landsell and Mirsky (1964), using the CPT, found that subjects with centrencephalic epilepsy did far more poorly than did patients with cortical focus epilepsy.

Most of the studies cited here found BD adults' performance inferior to that of normal adults. Two studies found that BD adults may do as well or almost as well as do normal adults, and two studies found a significant correlation between site of damage and degree of "attention deficit".

(2) Experiments Employing Children

Research investigating set and attention in children is relatively scarce. Moyer and Gilmer (1954) studied attention span in 681 normal boys and girls, ranging in age from 18 months to 7 years. No increase in attention span of children was found, provided the right toy was used.

However, Grim (1967), in his review of the early findings with normal children, has suggested that the evidence indicates some correlation between age and attention. For example, Miles (1933) found that the amount of time children would watch a jack-in-the-box increased as a function of age. In his own study, Grim (1967) employed first graders, and adults, comparing them on visual RT employing the irregular procedure. He found that RT latencies increased with the length of the PI for children but not for adults, indicating that normal children are somewhat inferior to adults in terms of their ability to maintain a set. This last point was further verified by comparing Rodnick and Shakow's (1940) findings with normal adults and Czudner and Marshall's (1967) findings with normal children. The comparison showed that normal adults did better than normal children on the RT task.

Experimental studies and theoretical explanations of attention in BD children have been summarized by McGhie (1969). Some of the work cited therein is germane to the present study. Poppelreuter (1918), for example, maintained that a failure of figure-ground discrimination is due to an injury to the visual pathways rather than a general feature of brain-damage. Goldstein (1927) disagreed with the specificity proposed by Poppelreuter, arguing that BD involves general loss of discrimination.

Schlanger (1958) assessed the effect of an auditory noise on another auditory discrimination in BD children. He found that the interfering noise did not have a differential effect on BD and normal children.

Werner & Strauss (1939) employed BD and normal children in a task involving the reproduction of patterns on a board with a distracting

background of holes. They found that the normal children tended to adopt a planned approach in constructing the pattern, while the BD children's performance was sporadic and generally inferior. They interpreted the findings as due to the distracting effect of the background holes. They replicated these findings in another study (Werner and Strauss, 1941).

Stevens, Boydston, Dykman, Peters, & Sinton (1967) found that deficiency of attention was one of the primary deficits among "minimally BD children". Luria (1961) has suggested that the two cardinal symptoms of the "cerebroaesthetic" symptom are a "disorder of sustained attention and an impairment in the ability to block any irrelevant responses." He demonstrated his point experimentally by using a task in which the child is required to respond positively to one signal and negatively (no response) to another signal. The BD children performed at a level significantly inferior to that of the normals.

In a more recent study, Schulman, Kasper, & Throne (1965) found a significant relationship between distractibility and the presence of neurological deficit. Camponelli (1968) investigated the relationship between cortical and sub-cortical lesions on sustained attention among three groups of children (two BD groups and one normal control group) ranging in age from 8 to 12 years. His findings showed that the BD groups made significantly more errors on the CPT than did the control group. He also found that BD children with non-focal lesions were more severely impaired than were children with focal lesions.

Investigation that led to the present study began three years ago. It occurred to Czudner and Marshall (1967) that a replication of Rodnick and Shakow's (1940) study, using children instead of adults, may have interesting ramifications in terms of a comparison between the childhood schizophrenia syndrome and that of adult schizophrenia. The results of the 1967 study showed large variability among the schizophrenic children, which led to the hypothesis that there might be different sub-groups within the schizophrenic group. In this connection, Goldfarb (1961) had suggested that variability among schizophrenic children may be due to the possibility that some of them are afflicted with various types of neurological deficits. A close inspection of the Czudner & Marshall (1967) data suggested that the subjects in the sub-group that were suspected of neurological deficit were also inferior in their ability to develop and maintain a set.

Czudner & Rourke (1970) reported a pilot study bearing on the Czudner & Marshall (1967) findings. Their study had two purposes: (1) to compare RT performance of BD and normal children; and (2) to assess the validity of a set index formula for the discrimination of BD and normal children. The set index formula was a slight modification of the one used by Czudner & Marshall (1967).

The idea of a set index formula was first conceived by Rodnick & Shakow (1940). It was designed as an empirical tool that would allow differentiation between schizophrenic and normal adults. The formula was constructed by combining three criteria into a single measure. They were as follows: (1) a minimum reaction at the 2-second interval of the

regular procedure; (2) a mean RT of less than 500 milliseconds at every interval in the experiment; and, (3) no merging of the curves for regular and irregular procedures until after the 15-second interval. The formula obtained was $SI = \frac{1}{2} \left(\frac{M_{7.5R}}{M_{7.5I_r}} + \frac{M_{15R}}{M_{15I}} \right) M_H$. M_H is the highest mean and it was found to discriminate better between schizophrenics and normals than did the general mean. The other factor is the average of the ratios of the means of the 7.5-second and 15-second intervals of the regular procedure to the respective means of the irregular procedure. It was found that the ratio of the means of the regular to those of the irregular procedure at these two points would give the normals a value of less than 1. The ratio of the means for the schizophrenics, on the other hand, would yield a value greater than 1. Hence, multiplying these ratios by M_H would allow better differentiation between the two groups.

The Czudner & Marshall (1967) findings indicated that the curves of the regular and the irregular procedures intersected at the 9-second interval. It was also found that there was a statistically significant difference between the regular and the irregular procedure at the 1-, 2-, 4-, and 7.5-second intervals among the normals, while the schizophrenic subjects' performance indicated no significant difference between the two procedures except at 1-second interval. These findings led Czudner & Rourke (1970) to revise the original set index formula. Their formula was as follows:

$$SI = \frac{1}{2} \left(\frac{M_{2R}}{M_{2I_r}} + \frac{M_{4R}}{M_{4I_r}} + \frac{M_{6R}}{M_{6I_r}} + \frac{M_{8R}}{M_{8I_r}} \right) M_H$$

The rationale in the above formula was essentially the same as that

of Rodnick and Shakow (1940). One interesting finding of the Czudner and Rourke (1970) study was that the BD subjects did better on the regular than on the irregular procedure only at the 2-second interval, while the normals did so at the 2-, 4-, and 6-second intervals. This suggested that the ratio of the 4- and 6-second interval means of the regular to the respective means of the irregular procedure would provide a more sensitive tool for discriminating between the two groups. Hence in the present study the following formula was employed: $SI = \frac{1}{2} \left(\frac{M4R}{M4I_r} + \frac{M6R}{M6I_r} \right) M_H$. The reason for the formula was that each term in the bracket (e.g. $\frac{M4R}{M4I_r}$) would be expected to yield a ratio smaller than one for the normals, and one or larger for the BD subjects. This would allow for finer discrimination between the two groups. The Czudner and Rourke (1970) study showed that the set index formula, when employed for children ages 8 to 10, was very effective in differentiating the BD children from the normals. However, when children ages 10 to 14 were analyzed separately, no such separation was obtained. The somewhat surprising finding of a clear difference between the younger group and the older group of BD children in the ability to develop and maintain a set suggested that BD children may learn to adapt to and/or recover from the deficit(s) involved in the inability to develop and maintain a set.

Summarizing the results of the studies with children, it can be stated that there is general agreement in the literature (with one exception) that there is some correlation between RT latency and age. Research on "attention" with BD children showed that, generally,

children with brain dysfunction perform more poorly than do normal control children on tasks that supposedly measure sustained attention (e.g., the CPT, figure-ground discrimination, or RT).

Problem

As in the Czudner and Rourke (1970) study, the independent variables in the current investigation included presence or absence of neurological dysfunction, regular and irregular RT procedures, and four PIs. Additionally, age was included as an explicit independent variable.

There were two issues under investigation. In the first place, this study was aimed at exploring the developmental aspect of set among BD subjects. That is, it was thought possible that BD children may recover from the deficit in attention associated with brain dysfunction. Such a finding could, conceivably, add to our understanding of the developmental aspects of brain function and, in turn, aid in our understanding of the treatment and training of the BD child. Secondly, it was thought that this RT procedure might provide a quick and relatively simple diagnostic procedure for the detection of brain-dysfunction among young children.

Hypotheses

- (1) The older BD children (ages 10-13) will show faster RT than will the younger BD group (ages 6-9).
- (2) The set index formula will differentiate the younger (ages 6-9) subgroups of the BD and normal subjects but will not differentiate between the older (ages 10-13) subgroups of the BD and normal subjects.

- (3) RT performance for normal children will be superior to that of the BD children.
- (4) The procedure X PI interaction for the BD and normal subjects will be significant.
- (5) There will be a direct relationship between the length of the PI and RT performance for normals but not for BD subjects.
- (6) RT for normal and BD subjects will be faster for the regular than for the irregular procedure.

CHAPTER II

METHODOLOGY AND PROCEDURE

Subjects

Two groups of subjects were employed: (1) a "brain-damaged" (BD) or experimental group, and (2) a normal or control group.

Group 1 consisted of 32 children, aged 6-13 (26 boys and 6 girls). These children were selected on the basis of neuropsychological and electroencephalographic evidence of cerebral dysfunction (see Appendix A). Group 1 was divided into two age classifications, "young" and "old". There were 12 boys and 4 girls in the young age classification, and 14 boys and 2 girls in the "old" age classification. The age range for the young group was 6.6 years to 9.3 years, with a mean age of 7.3 years, and standard deviation (SD) of 2.0 years. The age range for the old children was 10.0 years to 13.6 years, with a mean of 11.5 years and a SD of 1.7 years. For the young group, WISC Full Scale I.Q. ranged from 82 to 109 with a mean I.Q. of 94.5 and a SD of 8.6. For the old group, Full Scale I.Q. ranged from 83 to 115 with a mean I.Q. of 95.2 and a SD of 10.1.

The children in the control group were selected from a public school system and were matched for age, sex, socio-economic status, and I.Q. with the experimental group. Thus, there were 32 children, aged 6-13 (26 boys and 6 girls), in each of the BD and control groups.

These groups were subdivided into two age classifications, young and old. There were 12 boys and 4 girls in the young age classification, and 14 boys and 2 girls in the old age classification. The age range for the young group was 6.9 to 9.0 years, with a mean age of 7.6 years and a SD of 2.1 years. The age range for the old children was 9.9 to 13.7 years, with a mean age of 11.6 years and a SD of 1.2 years. For the young group, WISC Full Scale I.Q. ranged from 88 to 118 with a mean I.Q. of 96.7 and a SD of 7.7. For the old group, Full Scale I.Q. ranged from 78 to 107 with a mean I.Q. of 95.0 and a SD of 8.6. The matching of the experimental and the control groups was done by pairs, and variation between each pair was no more than four months for the age factor and no more than 10 points for the I.Q. factor. No subject with a detectable sensory or motor impairment was included in the control group.

Apparatus

The apparatus consisted of two Hunter Decade interval timers (Model 111C) and one Hunter Klockcounter (Model 120A) with an accuracy of 0.001 second. A reaction time stand was constructed with a telegraph key and two 7.5-W light bulbs, one serving as a warning signal (white light), the other as the RT stimulus (red light). The timers were electrically arranged so that E could, at will, manipulate the length of the PI. The Klockcounter was essentially an electrically operated stop watch arranged in series with a telegraph key in such a way that the subject had to press the key to set the warning signal.

Any release of the key before the appearance of the red light signal stopped the apparatus and the trial would then have to be repeated.

All the subjects were exposed to two procedures. In the regular procedure, the PI (time between the two signal lights) remained the same for a series of 15 trials before an interval of another length was presented. The order of presentation of PIs was from first to last, as follows: the 2, 4, 6, and 8 seconds. In the irregular procedure, the PIs were presented for 15 trials each, but in a random manner. The PIs used were the same as for the regular (i.e., 2, 4, 6, and 8 seconds). There was a 5 second interval between each of the trials all through the experiment. There were 60 trials for each procedure. There was a half-minute rest between each change of PI in the regular procedure, a two-minute rest between the two procedures, and a one minute rest after the first 30 trials of the irregular procedure. Total testing time was 30 minutes.

All subjects received 10 practice trials. The subjects of each group were subdivided such that half began with the regular procedure followed by the irregular procedure, while the order was reversed for the other half.

CHAPTER III

PRESENTATION AND ANALYSIS OF RESULTS

Experimental Design

The data were analyzed by the application of six analyses of variance. Two $2 \times 2 \times 4$ analyses, with repeated measures on the last two factors, were carried out in order to evaluate the BD and normal groups' results separately. There were two levels of age (i.e., the "young" and "old" classification), two levels of procedure (i.e., regular and irregular), and four levels of PI (2, 4, 6, and 8 seconds). The third analysis was carried out in order to assess differences between the two age levels within the two groups (i.e., BD vs. normals) under the eight experimental conditions. Hence, a $2 \times 2 \times 2 \times 4$ analysis was carried out with repeated measures on the last two factors. Finally, the last three analyses compared the sex index (SI) scores, the highest means (M_H) scores, and the general mean (GM) scores of the BD and normal groups. Three 2×2 factorial analyses of variance were employed, with age and BD vs. normal group as the main effects.

Results

Table 1 contains the means and the standard deviations for RT under the experimental conditions for the BD and normal subjects. Data from this table are plotted in Figures 1, 2, and 3. Inspection of

these Figures indicates that there is a direct relationship between RT in the regular procedure and length of PI. That is, as the length of PI increases in the regular procedure, RT increases. In the case of the young BD subjects, the opposite state of affairs is obtained for the irregular procedure. That is, as the length of PI decreases, RT increases. Furthermore, it appears that the slope in the irregular procedure is less steep for the older BD subjects and younger and older normals (Figures 2 and 3), than it is for the young BD subjects (Figure 1). Observation of Tables 2 and 3 and Figures 1, 2, and 3 indicates the similarity of the PI X procedure interaction for both the BD and normal groups' performance.

Considering only the results of the BD subjects, there is statistically significant ($p < .01$) age X procedure interaction. Testing for simple effects, it was found that there were statistically significant ($p < .01$) differences in RT latencies between the regular and the irregular procedure at the 2- and the 4-second intervals for the young BD subjects and at the 2-second interval for the old BD subjects. In these three instances, RT was faster on the regular than on the irregular procedure. The statistically significant ($p < .01$) age main effect indicated that the older BD subjects reacted faster on the RT task than did the younger BD subjects. The significant procedure and PI main effects indicate the following: (1) the BD subjects performed better on the regular than on the irregular procedure; and, (2) over-all latency was directly related to the length of the PI. These main effects, however, include the averaging of the two classification.

TABLE 1

REACTION TIMES (IN MSEC.) OF YOUNG AND OLD BRAIN-DAMAGED AND NORMAL
SUBJECTS FOR REGULAR AND IRREGULAR WARNING PROCEDURES

Interval (sec.)	Regular Procedure		Irregular Procedure	
	M	SD	M	SD
A. 16 Young Brain-Damaged Subjects				
2	441.3	173.1	773.3	147.9
4	536.8	188.0	679.1	166.9
6	581.2	173.7	647.6	150.5
8	643.3	151.2	652.1	189.2
B. 16 Old Brain-Damaged Subjects				
2	291.3	48.8	439.6	98.6
4	339.9	59.0	374.7	86.9
6	359.5	61.3	349.0	64.8
8	392.4	77.4	368.1	86.7
C. 16 Young Normal Subjects				
2	336.3	76.5	428.8	46.0
4	362.3	52.1	379.5	44.0
6	393.8	53.5	397.2	65.1
8	408.9	72.6	406.9	66.3
D. 16 Old Normal Subjects				
2	268.9	47.0	359.4	61.7
4	302.9	55.0	335.9	56.5
6	329.9	56.4	324.3	53.1
8	336.1	55.3	335.5	58.6

FIG. 1. Mean RT of 16 young and 16 old brain-damaged subjects as the various PI of the regular and irregular procedures.

PREPARATORY INTERVAL (SECONDS)

FIG. 2. Mean RT of 16 young brain-damaged subjects and 16 young normals at the various PI of the regular and irregular procedures.

PREPARATORY INTERVAL (SECONDS)

FIG. 3. Mean RT of 16 old brain-damaged subjects and 16 old normals at the various PI of the regular and irregular procedures.

TABLE 2

ANALYSIS OF VARIANCE OF YOUNG AND OLD BRAIN-DAMAGED SUBJECTS'
PERFORMANCE UNDER REGULAR AND IRREGULAR WARNING PROCEDURES

Source	df	MS	F	P
Between Subjects (Ss)	31			
Age	1	4111871.4	38.54	<.01
Subject within group error (a)	30	106682.4		
Within Ss	224			
PI	3	13521.9	4.09	<.01
Age & PI	3	3021.5	0.91	
PI x Ss within error (b)	90	3305.6		
Pr. (procedure)	1	469430.5	27.98	<.01
Age x Pr	1	171023.6	10.19	<.01
Pr x Ss within error (c)	30	16774.8		
PI x Pr	3	181645.6	47.17	<.01
Age x PI x Pr	3	19043.9	4.94	<.01
PI x Pr x Ss within error (bc)	90	7850.4		

TABLE 3

ANALYSIS OF VARIANCE OF YOUNG AND OLD NORMAL SUBJECTS' PERFORMANCE
UNDER REGULAR AND IRREGULAR WARNING PROCEDURES

Source	df	MS	F	P
Between Subjects (Ss)	31			
Age	1	271349.8	15.14	<.01
Subject within group error (a)	30	17914.1		
Within Ss	224			
PI	3	9673.3	9.53	<.01
Age x PI	3	1361.8	1.34	
PI x Ss within error (b)	90	1014.5		
Pr	1	52120.9	13.29	<.01
Age x Pr	1	38.7	0.01	
Pr x Ss within error (c)	30	3920.1		
PI x Pr	3	30669.5	29.57	<.01
Age x PI x Pr	3	475.6	0.42	
PI x Pr x Ss within error (bc)	90	1036.9		

Observation of the data for the normal group indicates trends similar to those evident in the performance of the BD group (Figures 2 and 3 and Table 3). The main difference between the performance of the normal and the BD groups is that, while the age X procedure interaction was found to be statistically significant for the BD group, no such interaction was found among the normals. Furthermore, the age X PI X procedure interaction was significant for the BD subjects (Table 2) but not for the normal subjects (Table 3). This, in conjunction with observation of Figures 1, 2, and 3, suggests that the slope of the irregular procedure was significantly different (steeper) for the young BD subjects than for the old BD and the normal subjects.

Table 4 contains a summary of the analysis of variance of young and old BD and normal subjects' performance under the regular and irregular warning procedures. There was a statistically significant ($p < .01$) age X group interaction. Testing for simple effects indicates the following: (1) statistically significant ($p < .01$) differences between the young BD and the young normals: (2) statistically significant differences ($p < .01$) between the young BD and the old BD subjects: (3) no statistically significant differences between young normals and the old normals: and, (4) no statistically significant difference between the old BD and the old normals.

The significant group main effect indicates that over-all latency of normals is significantly ($p < .01$) faster than that of the BD subjects. The remaining significant and nonsignificant results in Table 4 are essentially the same as those described in Tables 2 and 3.

TABLE 4

ANALYSIS OF VARIANCE OF YOUNG AND OLD BRAIN-DAMAGED AND NORMAL
SUBJECTS' PERFORMANCE UNDER REGULAR AND IRREGULAR
WARNING PROCEDURES

Source	df	MS	F	P
Between Subjects (Ss)	63			
Age	1	3247903.9	52.13	< .01
Group	1	2364741.6	37.95	< .01
Age x Group	1	1135317.3	18.22	< .01
Subject within group error (s)	60	62298.2		
Within Ss	448			
PI	3	20682.8	9.57	< .01
Age x PI	3	2721.1	1.26	
PI x Group	3	2512.4	1.16	
Age x Group x PI	3	1662.3	0.77	
PI x Ss within error (b)	180	2160.0		
Pr	1	417195.5	40.31	< .01
Age x Pr	1	82956.8	8.01	< .01
Pr x Group	1	104355.9	10.08	< .01
Pr x Group x Age	1	88105.5	8.51	< .01
Pr x Ss within error (c)	60	10347.5		
PI x Pr	3	179921.2	73.62	< .01
PI x Pr x Age	3	9708.8	3.97	
PI x Pr x Group	3	32393.8	13.25	< .01
Age x PI x Pr x Group	3	9770.7	3.99	
PI x Pr x Ss within error (bc)	180	2443.6

FIG. 4. Distribution of young brain-damaged and young normal subjects according to the set index formula.

An inspection of Figure 4 indicates that application of the set index formula effects a fairly good separation between the young BD and young normal subjects. Five of the young BD subjects fell within the young normal range. This indicates that the formula is sensitive enough to separate the extremes of the two groups, but not the borderline cases. However, if only the M_H factor is employed (Figure 5), complete separation can be obtained between the young BD and normal subjects. Similarly, if RT latency is plotted in terms of the general mean (Figure 6) (i.e., the mean of the means of the eight PIs) only three young BD subjects fall within the young normal range.

When the young BD subjects are compared to the old BD children on the SI scores (Figure 7), all but one young BD subject were separated.

When the performance of the young BD and old BD children is compared in terms of the highest mean (M_H) (Figure 8), only one young BD subject fell within the old BD range. Comparison between the young and the old BD subjects in terms of the general mean (GM) (Figure 9) shows that only two old BD subjects fell within the young BD range.

Finally, an inspection of Tables 5, 6, and 7 and Figures 13, 14, and 15 indicates similar pattern of interaction. The age X group interaction and the subsequent simple effect analyses indicated the following for the SI, M_H , and GM comparisons: (1) performance of the young normals was significantly better ($p < .01$) than that of the young BD subjects; (2) there was no statistically significant difference between the performance of the old BD subjects and the old normals; (3) the old BD subjects reacted significantly faster ($p < .01$) than did the young BD subjects;

(4) there was no statistically significant difference between the young and the old normals.

Figure 16 contains the means for the 2-second interval of the irregular procedure when followed by the 8-, 6-, and 4-second intervals of the irregular procedure. Tests for trends indicated a significant ($p < .01$) linear trend for the performance of the young BD subjects at the 8-, 6-, and 4-second intervals. There were no significant trends evident in the performance of the other three groups.

● YOUNG BRAIN - DAMAGED
 ▲ YOUNG NORMALS

FIG. 5. Distribution of young brain-damaged and young normal subjects according to the highest mean (MH). (Values are in milliseconds.)

● YOUNG BRAIN - DAMAGED
 ▲ YOUNG NORMALS

FIG. 6. Distribution of young brain-damaged and young normal subjects according to the general mean (GM).
 (Values are in milliseconds.)

●--YOUNG BRAIN - DAMAGED
○--OLD BRAIN - DAMAGED

FIG. 7. Distribution of young and old brain-damaged subjects according to the set index formula.

● YOUNG BRAIN - DAMAGED
○ OLD BRAIN - DAMAGED

FIG. 8. Distribution of young and old brain-damaged subjects according to the highest mean (M_H).
(Values are in milliseconds.)

○ OLD BRAIN - DAMAGED
● YOUNG BRAIN - DAMAGED

FIG. 9. Distribution of old brain-damaged and young brain-damaged subjects according to the general mean (GM).
(Values are in milliseconds.)

FIG. 10. Distribution of old brain-damaged and old normal subjects according to the set index formula.

○ OLD BRAIN - DAMAGED
 ▲ OLD NORMALS

FIG. 11. Distribution of old brain-damaged and old normal subjects according to the highest mean (M_H). (Values are in milliseconds.)

○ OLD BRAIN - DAMAGED
 ▲ OLD NORMALS

FIG. 12. Distribution of old brain-damaged and old normal subjects according to the general mean (GM).
 (Values are in milliseconds.)

TABLE 5
ANALYSIS OF VARIANCE OF BRAIN-DAMAGED AND NORMAL SUBJECTS'
PERFORMANCE ON THE SET INDEX FORMULA

Source	df	MS	F	P
Age	1	431928.3	44.31	< .01
Group	1	388456.1	39.85	< .01
Age x Group	1	120712.8	12.38	< .01
Within cells	60	9748.9		

TABLE 6

ANALYSIS OF VARIANCE OF BRAIN-DAMAGED AND NORMAL SUBJECTS'
PERFORMANCE ON THE HIGHEST MEAN (M_H)

Source	df	MS	F	P
Age	1	750259.1	67.42	< .01
Group	1	705642.0	63.42	< .01
Age x Group	1	306472.9	27.54	< .01
Within cells	60	11126.7		

TABLE 7

ANALYSIS OF VARIANCE OF BRAIN-DAMAGED AND NORMAL SUBJECTS'
PERFORMANCE ON THE GENERAL MEAN (GM)

Source	df	MS	F	P
Age	1	465652.7	55.74	< .01
Group	1	265057.6	31.58	< .01
Age x Group	1	168664.2	20.07	< .01
Within cells	60	8393.3

FIG. 13. Mean set index data of young and old brain-damaged and normal subjects.

FIG. 14. Mean of the highest mean (M_H) latencies of young and old brain-damaged and normal subjects.

FIG. 15. Mean of the general means (GM) of young and old brain-damaged and normal subjects.

FIG. 16. Means for the two-second interval of the irregular procedure when followed by the eight-, six-, and four-second intervals of the irregular procedure.

CHAPTER IV

DISCUSSION

It is clear from the data in Table 1 and from the statistical analyses of these data (Tables 2, 3, and 4) that there is a direct relationship between length of PI and latency. Distractions from the environment as well as a host of other factors may serve to render the maintenance of set more difficult as PI increases.

It is interesting to note that the curves of the regular and the irregular procedures intersect for all groups but the young BD subjects (see Fig. 1, 2, and 3). Also, the slope for the irregular procedure seemed far steeper for the young BD subjects than for the rest of the groups.

These findings are similar to those obtained with schizophrenic adults (e.g., Zahn, Rosenthal, and Shakow, 1963) and BD children (Czudner & Rourke, 1970). In the latter investigation it was hypothesized that the young BD children were more affected by the preceding PI than were the other subjects. To test this hypothesis, the means of the 2-second interval of the irregular procedure that followed the 8-, 6-, and 4-second intervals were calculated (see Figure 16). There was a significant linear relationship evident for the young BD subjects; no such relationship was evident for the older BD subjects or the normal children. As in the

Czudner and Rourke (1970) study, it may be the case that the young BD children experienced a build-up of reactive inhibition (resulting from the expenditure of energy necessary to maintain attention on the previous trial) which did not dissipate as quickly as it did for children in the other three groups. There may also be the possibility that the old BD children and the normal group adopt a more general state of readiness to respond and they are therefore less affected by the previous PI than the young ND children. The young BD subject may be more likely to expect a subsequent interval to be similar to or the same as the interval which he has just experienced.

When PI was short (2 sec. for the young normals and old BD subjects: 2 and 4 sec. for the old normals), the young and old normals and the old BD subjects benefited from the regularity of the procedure (i.e., reacted faster). However, as the PI increased, the difference between the two procedures disappeared. These findings partly support Czudner and Marshall's (1967) and Grim's (1967) findings. Grim, for example, found that RT latencies increased with the length of the PI for children but not for adults, suggesting that children are somewhat inferior to adults in terms of their ability to develop and maintain a set.

However, in the Czudner and Rourke (1970) study, the normal children performed better on the regular than on the irregular procedure at the 2-, 4-, and 6-second intervals. In the current study, the young normals did better on the regular than on the irregular procedure only at the 2-second interval, while the old normals did so only at the 2- and the 4-second intervals, as mentioned above. These differences may be explained in terms of the change in the procedure. In the Czudner and

Rourke (1970) study, only ten trials per PI were used, while in the present study 15 trials per PI were used. Fatigue appears to be the main reason for these differences. The longer procedure may have reduced the capacity of the normals to take advantage of the regularity of the procedure.

The statistically significant age main effect for the BD and the normal subjects (see Tables 2 and 3) indicated a direct relationship between age and RT latency. That is, as children grew older, their RT latency decreased. These findings support earlier reports of a direct relationship between age and RT latency as reported by Woodworth and Schlosberg (1938).

The age X group interaction in Table 4 and the subsequent simple effects analyses are consistent with some earlier studies, but not others. For example, Benton et al. (1962) found no difference in RT performance between adult normals and adult BD patients -- a result consistent with the findings of no differences in RT performance between the old BD and the old normal subjects. However, Costa (1962) found the performance of BD adults to be inferior to that of normal adults and Campanelli (1968) found that BD children made more errors on the CPT than did normal control children. These latter results are consistent with the current findings with respect to young BD children, but not with those regarding old BD subjects.

The fact that the set index formula was relatively ineffective in differentiating the young BD and young normal children (see Figure 4) may have been due to the steepness of the slope found in the RT performance of the young BD subjects in the irregular procedure. This effectively

reduced the ratio of the regular to the irregular procedure in the young BD groups. When only the M_H factor is considered (see Figure 5), a complete separation was obtained between the young BD children and the young normals. It may be that the M_H factor is a clearer reflection of failure in "attention" than is the set index formula. That is, performing for a one-half hour period would increase the likelihood that sooner or later the young BD subjects would demonstrate larger variance and/or longer latencies than the normal children. Further investigation as to the origin of the M_H factor indicated the following: (1) in the case of the BD children, 24 out of 32 cases were drawn from the 2-second interval of the irregular procedure; (2) in the case of the normals, less than half of the cases (14 out of 32) came from the 2-second interval of the irregular procedure.

The results shown in Figure 6 generally indicate that the over-all mean (GM) of RT latencies is a sufficiently sensitive measure to differentiate between young BD and young normal subjects. This lends support to the results of earlier studies by Blackburn and Benton (1955) and DeRenzi and Faglioni (1965) which suggest that simple RT can be used as a sensitive indicator of brain damage. The results in Figures 7, 8, and 9 are similar to each other. Regardless of what measure is employed (M_H , SI, or GM), a good separation between young and old BD subjects can be obtained. These findings are probably the most significant in the present study. They were clearly consistent with the results of the Czudner and Rourke (1970) study which seemed to indicate that BD children may adapt to or recover from the deficit(s) measured by the RT procedure. If we tentatively accept

the contentions of Rodnick and Shakow (1940), Fizard and Venables (1956), and Czudner and Marshall (1967) that the set index or the M_H factor are measures of the ability of the child to develop and maintain attention, it may be argued that BD children may recover from the deficit in attention which is generally considered to be typical of BD children.

A closer inspection of the borderline cases in the comparison of the young or the old BD subjects on the index scores, M_H scores, or GM scores did not yield a systematic relation between nature, location, or extent of the EEG abnormality and presence at the borderline. Future studies should attempt to assess the effects of these factors.

The findings reported in Figures 10, 11, and 12 demonstrated no difference in performance between old BD and old normal children. This can also be seen in the tests for simple effects on the age X group interaction, shown in Tables 5, 6, and 7, and Figures 13, 14, and 15. All the results were similar to those found for the SI scores as discussed in the Results section.

The failure of attention found in the young BD children and the apparent recovery of the old BD children may be explained using a "behavioural model". Czudner and Rourke (1970) hypothesized that the young BD subjects may have been more affected by the preceding PI intervals in the irregular procedure than were the old BD and normal subjects. They suggested that the relative inefficiency on the 2-second interval may have been due to the build-up of excessive reactive inhibition resulting from the expenditure of energy necessary to maintain attention on the preceding trials. It may also be the case that this reactive inhibition

once built up, is less easily dissipated in the young BD children. Recalling that 75% of the M_H cases were found in the 2-second interval of the irregular procedure which is, in a sense, an indicator of "reactive inhibition potential". We may speculate that this excessive build-up of or inefficiency in the dissipation of reactive inhibition may be partly related to the deficit in "attention" among the young BD subjects. Since the old BD children and the normal children seemed to be less affected by the duration of the intervals that preceded the 2-second interval, there may have been less build-up of reactive inhibition which, in turn, may account for their relative efficiency in developing and maintaining attention.

The results of this study demonstrate that the RT procedure can be used as a simple diagnostic device for the detection of brain dysfunction in younger children. It would seem reasonable to include RT measures in batteries of tests used for this purpose.

The results further showed the futility of employing a rather complicated mathematical manipulation to enhance differences between various diagnostic groups. A simple over-all mean seemed to be sufficiently sensitive to separate between the young BD and the young normals, or the young BD and old BD subjects.

The nature of the deficit(s) in attention found in the young BD child leads to the practical suggestion that the BD child should be allowed to develop at his own pace. Emphasis in training should be directed at the child's strength, allowing him to develop a feeling of self worth. Teachers and educators should realize that in time

many younger BD children will learn to adapt and recover from the deficit(s) in attention which at present hamper their progress. The difficulty that some older BD children experience in school and at home may be in part related to earlier frustrations developed as a reaction to excessive and unrealistic demands made upon them.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was one in a series of empirical investigations of set or attention as measured by the use of RT procedures.

An attempt was made to quantify the RT procedure in such a way as to find the best possible measure to assess the child's ability to develop and maintain attention and to provide a means of differentiating between young BD and normal children. In this connection, three measures were employed: the set index (SI), which is a quantitative expression of the length of RT and the relationship between the regular and the irregular procedure; the highest mean (M_H), which is the highest mean of the means for the eight conditions; and, the general mean (GM) which is the overall mean for all eight conditions.

The main purpose of the study was to explore the hypothesis that BD children may adapt to or recover from the deficit of the inability to develop and maintain a state of readiness to respond (attention). The results provided substantial support for the hypothesis.

The hypotheses under investigation were as follows:

Hypothesis 1. The older BD children (ages 10-13) will show faster latency on the RT tasks than will the younger BD group (ages 6-9). This was supported using all the three measures: mean RT or general mean (GM), the set index (SI), and the highest mean (M_H).

Hypothesis 2. The set index formula will differentiate between the young (ages 6-9) classification of the BD subjects and the young normals, but will not differentiate between the older (ages 10-13) classification of the BD subjects and normals. This hypothesis was only partly supported with the use of the set index since there was about 25% overlap between the young BD and the young normals. However, when the M_H factor alone was employed, complete separation was obtained between the two groups. Similarly, when the GM measure was employed, only two young normals fell within the young BD range. In line with expectation, no differentiation was obtained between the old BD subjects and the old normal subjects using the SI formula. Furthermore, no separation between the old BD subjects and the old normals was obtained using the M_H or the GM measures.

Hypothesis 3. Latency on the RT task for normal children will be superior to that for the BD children. This hypothesis was supported. However, the analyses germane to this hypothesis included the averaging of the two age groups and were, therefore, less meaningful than were the interactions of age and group for the BD and normal subjects. The age X group interaction of the RT performance was statistically significant ($p < .01$). The subsequent tests for simple effects indicated: (1) statistically significant ($p < .01$) differences between the performance of the young BD and the young normal subjects; (2) statistically significant differences ($p < .01$) between the performance of the young BD and the old BD subjects; (3) no statistically significant differences between the performance of the old BD and the old normal subjects.

Hypothesis 4. There will be a significant procedure X PI interaction for the performance of the BD and normal subjects. This hypothesis was supported.

Hypothesis 5. There will be a direct relationship between the length of the PI and latency in the RT performance of normals, but not in that of the BD subjects. This hypothesis was only partly supported. In the case of the regular procedure, both groups (normal and BD) demonstrated a direct relationship between RT and length of PI: as the length of PI increased, RT increased. In the case of the irregular procedure, there was an inverse relationship between RT and length of PI for the young BD subjects. No relationship between RT and PI was found for the old BD or the old and young normal children.

Hypothesis 6. The normal and BD subjects will react faster on the regular than on the irregular RT procedure. This hypothesis was supported.

The study generates several problems that warrant further investigation:

(1) Other independent measures of attention should be employed in conjunction with the RT procedure to verify the validity of the use of RT procedure as a reliable measurement of attention.

(2) The relationship between the degree of the build-up of reactive inhibition when performing on the irregular procedure and degree or extent of brain damage should be investigated further.

(3) Investigation of set or attention by using other modalities such as auditory and tactual, as well as crossmodal studies within the visual, auditory and the tactual dimensions would be relevant to the present findings.

(4) A longitudinal study employing a group of young BD subjects would be beneficial in assessing the validity of the present findings.

(5) The deficit in RT latency exhibited by the young BD subjects would appear to be quite reliable. Consequently, this measure might be used to considerable advantage as a dependent variable for the assessment of the effects of various drugs (e.g., methylphenidate, dexedrine) and/or behavioural procedures which are purported to "increase attention".

(6) Future studies should employ as independent variables, factors such as; right versus left hemisphere, or, anterior versus posterior damage, in order to specify more exactly the relationships between brain damage and attention.

APPENDIX A

E.E.G. OPINIONS AND NEUROPSYCHOLOGICAL IMPRESSIONS FOR EACH OF THE BRAIN-DAMAGED CHILDREN

S - 1 (7 years, female)

E.E.G. Opinion

Compatible with epileptic activity arising from the parieto-occipital region of the brain. The abnormality is more marked on the left than on the right.

Neuropsychological Impression

The pattern of the test scores would raise some question concerning the integrity of the temporo-parietal region of the right cerebral hemisphere. There are some indications that the left hemisphere is also involved but these are not as compelling. The hypothesized dysfunction would appear to be mild and chronic in nature. An etiology involving a closed head injury at birth would fit this clinical picture. Seizures and seizure-like activity in cases such as this are common.

S - 2 (6 years, female)

E.E.G. Opinion

Runs of 4 c.p.s. slow waves intermixed with bursts of 4 c.p.s. high voltage waves are noted that seem to irradiate more frequently from the posterior temporal regions. ... Grand mal epilepsy.

Neuropsychological Impression

The pattern of abilities and deficits is consistent with the expected debilitating effects of seizures or seizure-like activity maximally involving the temporal lobes bilaterally. The primary focus would be expected to lie within the left temporal region.

S - 3 (7½ years, female)

E.E.G. Opinion

Over the left temporal region 4 c.p.s. high voltage waves are sometimes strongly suggestive of bitemporal convulsive disorders, mainly left-sided.

Neuropsychological Impression

Mild cerebral dysfunction, maximally involving the temporal region bilaterally. There are some indications that the left temporal region may be more affected than is the right. Convulsive activity is quite typical in cases such as this.

S - 4 (7 years, male)

E.E.G. Opinion

Suggestive of temporal dysfunction and also consistent with a possible convulsive disorder arising from the temporal lobes.

Neuropsychological Impression

Suggestive of cerebral dysfunction within the left fronto-temporal and right frontal and fronto-parietal regions of the brain. None of these deficits are severe enough to warrant the conclusion that this child is suffering from cerebral dysfunction.

S - 5 (9 years, male)

E.E.G. Opinion

Compatible with disturbance of function in the left temporal region of the brain and also epileptic activity which, however, shows poor localization. ...spike and slow wave complexes (appear) from both cerebral hemispheres.

Neuropsychological Impression

Suggestive of mild, chronic cerebral dysfunction, probably maximally involving the superior temporal regions bilaterally. ...Indications of anterior involvement are compelling. ...Expected bitemporal seizures or seizure-like activity. ...Etiology is likely that of a closed head injury.

S - 6 (9 years, female)

E.E.G. Opinion

Paroxysmal dysrhythmia appears from the frontal and temporal leads bilaterally. ...Bitemporal convulsive disorders.

Neuropsychological Impression

These deficits... would raise considerable doubt regarding the integrity of the left temporal and fronto-temporal regions of the brain. ...would not appear to be of an acute nature.

S - 7 (7 years, male)E.E.G. Opinion

The disorganization is more marked over the right anterior region... Suggestive of bitemporal convulsive disorder.

Neuropsychological Impression

...extensive brain damage involving both cerebral hemispheres. ...it would appear that the right cerebral hemisphere is maximally involved.

The fronto-temporal region of the left hemisphere would appear to be more involved than the posterior aspects of that hemisphere. Seizures are characteristic in cases such as this.

S - 8 (7 years, male)E.E.G. Opinion

Irregular activity is present from the right occipital lead. Fast activity appears from frontal leads bilaterally.

Compatible with dysfunction in the left parietal region of the brain and also suggestive of a convulsive disorder, possibly of bitemporal origin.

Neuropsychological Impression

Involvement of the fronto-temporal region of the left cerebral hemisphere and the temporo-parietal region of the right hemisphere. This hypothesized dysfunction ...would appear to be chronic. ...An etiology involving a closed head injury ...would fit this clinical picture.

S - 9 (7 years, male)E.E.G. Opinion

Awake and light sleep recording:

...5 c.p.s. spiked waves are present and seem to irradiate from the fronto-temporal regions. Suggestive of bitemporal convulsive disorder and mild immaturity.

Sleep recording:

Suggestive of bitemporal convulsive disorder.

Neuropsychological Impression

...involvement of the posterior-temporal and adjacent cortical areas of both cerebral hemispheres. However, the left cerebral hemisphere would appear to be somewhat more involved than is the right. The likelihood of sub-cortical involvement would also appear to be quite high.

S - 10 (7 years, male)

E.E.G. Opinion

Awake recording:

Bursts of high voltage 4 c.p.s. waves ...are present over all derivations and more over the posterior regions... Mixed grand mal - petit mal epilepsy.

Sleep recording:

Epilepsy, probably of mixed type: grand mal - petit mal.

Neuropsychological Impression

The patterns of the deficits and abilities raise some question concerning the integrity of the posterior aspects of both cerebral hemispheres. ...the right parieto-occipital area appears maximally involved. ...the probability of seizure activity is high.

S - 11 (7 years, male)

E.E.G. Opinion

Diagnostic of grand mal epilepsy, probably subclinical.

Neuropsychological Impression

There is indication of temporal involvement. The possibility of sub-cortical dysfunction should be investigated.

S - 12 (8 years, male)

E.E.G. Opinion

Right posterior temporal brain dysfunction: may be due to chronic organic lesion.

Neuropsychological Impression

The pattern of the deficits would support an hypothesis of chronic cerebral dysfunction maximally involving the posterior regions of both cerebral hemispheres. ...the left cerebral hemisphere may be somewhat more involved than is the right.

S - 13 (8 years, male)E.E.G. Opinion

Suggestive of mild dysfunction of the left cerebral hemisphere.

Neuropsychological Impression

This pattern ...is consistent with an hypothesis of mild, chronic cerebral dysfunction. The temporo-parietal regions of both cerebral hemispheres would appear to be maximally involved ...the left more than the right...high probability of seizures.

S - 14 (7 years, male)E.E.G. Opinion

Diagnostic of dysfunction and a convulsive disorder, fronto-temporal, left more than right.

Neuropsychological Impression

Most of the deficits are those thought to be dependent upon the adequate functioning of the frontal-temporal region of the left cerebral hemisphere. ...it would appear to be chronic in nature ...seizures are common in cases such as this.

S - 15 (8 years, male)E.E.G. Opinion

...numerous bursts and runs of sharp waves and spike potentials from the anterior leads bilaterally. ...Compatible with a convulsive disorder of frontal lobe region.

Neuropsychological Impression

The pattern of the test scores would raise some question concerning the integrity of the posterior-frontal and adjacent cortical regions of both cerebral hemispheres. ...the left hemisphere appears more involved than the right. This hypothesized lesion would appear to be chronic in nature, but actively debilitating. Seizures and seizure-like activity in cases such as this are common.

S - 16 (7½ years, male)E.E.G. Opinion

...Bursts of 4 c.p.s. waves are present that seem to irradiate from the posterior regions to all derivations. ...Diagnostic of convulsive disorder probably of mesencephalic origin.

Neuropsychological Impression

The pattern of abilities and deficits is suggestive of mild, chronic cerebral dysfunction maximally involving the temporal regions bilaterally. The most probable etiology would be a mild closed head injury. Seizures and seizure-like activity are quite common in cases such as this.

S - 17 (12 years, male)

E.E.G. Opinion

...runs of dysrhythmia ...particularly from temporal leads... Compatible with bitemporal disturbance of function. Also suggestive of epileptoid activity.

Neuropsychological Impression

Implication of the posterior-frontal and parietal areas of the right hemisphere as a locus for possible brain dysfunction ...also involvement of the frontal areas of the left hemisphere ...probably of longstanding, chronic nature.

S - 18 (10 years, male)

E.E.G. Opinion

...3 c.p.s. waves present over the posterior regions... Diagnostic of convulsive disorder, temporo-occipital in origin.

Neuropsychological Impression

Involvement of the fronto-temporal region of the left cerebral hemisphere and the temporo-parietal region of the right cerebral hemisphere. Probable etiology: closed head injury at birth ...seizures are common in such cases.

S - 19 (10 years, male)

E.E.G. Opinion

Compatible with dysfunction in the right temporo-parietal region of the brain.

Neuropsychological Impression

Mild, chronic cerebral dysfunction involving the fronto-temporal regions of both cerebral hemispheres.

Probable etiology: closed head injury at birth or in early childhood.

S - 20 (10½ years, male)E.E.G. Opinion

...spike and slow-wave complexes arise from right fronto-temporal and left posterior temporal leads ...more the right side ...Compatible with dysfunction and epileptoid activity which fails to show focal localization.

Neuropsychological Impression

Mild, chronic cerebral dysfunction implicating the temporal region of the left cerebral hemisphere...

Probable etiology: closed head injury. ...Probability of seizures is high.

S - 21 (13 years, male)E.E.G. Opinion

...numerous runs of slow and sharp waves from both cerebral hemispheres. ...more marked over the left side...

Abnormal recording diagnostic of an organically caused dysfunction localized in the posterior temporal and anterior parietal region of the brain. Also suggestive of focal cerebral seizures of the same localization.

Neuropsychological Opinion

This particular pattern of abilities and deficits is suggestive of chronic cerebral dysfunction, maximally involving the fronto-temporal regions of both cerebral hemispheres. There appears to be more evident impairment within the left cerebral hemisphere. In addition, the hypothesized dysfunction within the left cerebral hemisphere would appear to include the temporo-parietal region. A closed head injury, as a result of an instrument delivery, often results in this pattern of deficits. ...abnormal E.E.G. is expected in such cases.

S - 22 (12½ years, male)E.E.G. Opinion

Abnormal for left brain dysfunction, suggestive of left posterior temporal organic lesion.

Neuropsychological Impression

This pattern of abilities and deficits is suggestive of mild cerebral dysfunction maximally involving the left fronto-temporal region... In the absence of any gross sensory deficits, fine tactile deficits, and considering his superior performance on a test of non-verbal abstract reasoning and his very adequate performance on many of the other tasks, it would appear that this hypothesized dysfunction is the result of a closed head injury, the acute effects of which have subsided. The possibility of seizures or seizure-like activity in this case should be investigated.

S - 23

E.E.G. Opinion

Abnormal for left brain dysfunction, suggestive of left posterior temporal organic lesion.

Neuropsychological Impression

This pattern of abilities and deficits is suggestive of mild cerebral dysfunction maximally involving the left fronto-temporal region if we can assume that the deficit in static steadiness with the left hand is accountable in terms of sub-cortical dysfunction...it would appear that the hypothesized dysfunction is the result of a closed head injury, the acute effects of which have subsided. The possibility of seizures or seizure-like activity should be investigated.

S - 24 (12 years, male)

E.E.G. Opinion

Suggestive of epileptic diathesis, left fronto-temporal in origin.

Neuropsychological Impression

This pattern of abilities and deficits is suggestive of mild, chronic cerebral dysfunction maximally involving the temporal, and possibly the frontal-temporal regions of the right cerebral hemisphere. There are also some less compelling indications of left temporal involvement. It is quite typical in cases such as this that a blow to one side of the head was incurred with resultant contra-coup damage to the opposite side.

S - 25 (10 years, male)E.E.G. Opinion

Compatible with mild dysfunction in the left parieto-temporal region of the brain.

Neuropsychological Impression

We suspect that this child is suffering from cerebral dysfunction localized primarily in the temporal and temporo-parietal areas of the left hemisphere.

S - 26 (11 years, male)E.E.G. Opinion

Wake - Dysfunction, left temporal and parietal regions of the brain.

Sleep - Compatible with mild dysfunction in the left temporal-parietal region of the brain and epileptic activity arising from the right fronto-temporal region.

Neuropsychological Impression

This particular pattern of deficits and abilities raises some question concerning the integrity of the fronto-temporal regions of both cerebral hemispheres. It would appear that the left cerebral hemisphere is more involved than is the right. An etiology involving a closed head injury at birth or in early childhood would fit this clinical picture. The possibility of seizures of seizure-like activity in cases such as this is common.

S - 27 (10½ years, male)E.E.G. Opinion

Awake Recording - Suggestive of bitemporal brain dysfunction of undetermined origin.

Sleep Recording - Bitemporal brain dysfunction of undetermined origin.

Neuropsychological Impression

...this pattern of abilities and deficits points to at least a moderate impairment in those adaptive abilities thought to be dependent

upon adequate brain functioning. It would appear that there is at least mild dysfunction at the level of the cerebral hemispheres. There are indications that the involvement is bilateral, involving the fronto-temporal regions....These conclusions tend to point to some type of closed head injury suffered in the not-too-distant past.... Seizures are typical in such cases.

S - 28 (11 years, male)

E.E.G. Opinion

...sleep and photic stimulation produce atypical bifrontal sharp wave activity... Suggestive of disturbance of function and epileptoid activity, anterior regions of the brain.

Neuropsychological Impression

Left temporal region appears to be the site of maximal involvement. There may be involvement of the right fronto-temporal region, also sub-cortical involvement. Seizures and seizure-like activity may be expected.

S - 29 (10½ years, male)

E.E.G. Opinion

The findings are diagnostic of dysfunction in the left posterior temporal and parietal region of the brain.

Neuropsychological Impression

Suggestive of chronic bitemporal dysfunction, maximally involving the left cerebral hemisphere.

S - 30 (12 years, female)

E.E.G. Opinion

...spike and wave complexes... Abnormal. Suggestive of mild brain immaturity and bitemporalconvulsive disorder.

Neuropsychological Impression

The pattern of the deficits raise doubt concerning the integrity of the posterior temporal and adjacent cortical regions of the right cerebral hemisphere. There are some indications of left temporal involvement, but these are considerably less compelling.

S - 31 (10½ years, male)E.E.G. Opinion

...during hyperventilation, runs of very high voltage 2-3 c.p.s. irregular waves are noted over the anterior and posterior regions....

Generalized mild brain dysfunction, mainly bitemporal and slightly more right-sided. No frank convulsive disorders are registered.

Neuropsychological Impression

The pattern of deficits and abilities would raise some question concerning the integrity of the fronto-temporal region of the right cerebral hemisphere and the posterior temporal and adjacent cortical areas of the left cerebral hemispheres...The left hemisphere is maximally involved. The likelihood of seizures is high. Use of forceps in birth with with consequent brain trauma would fit this clinical picture.

S - 32 (10 years, female)E.E.G. Opinion

...random spiking is noted, mainly over the anterior regions... Strongly suggestive of bifronto-temporal convulsive disorders.

Neuropsychological Impression

Considering the extent of the deficits, a hypothesis of at least moderate cerebral dysfunction would appear appropriate in this case....

The fronto-temporal region of the left cerebral hemisphere would appear to be the area of maximal involvement...some indications, though less compelling, of right hemisphere involvement...

...An etiology involving a long-standing chronic subdural hematoma or a porencephalic cyst within the left fronto-temporal region would fit this clinical picture.

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