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THE NEUROPSYCHOLOGICAL ABILITIES OF CHILDREN WITH LEARNING DISABILITIES WHO DEMONSTRATED DIFFERENTIAL EEG ALPHA BLOCKING PATTERNS TO A COMPLEX AUDITORY STIMULUS

by

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ABSTRACT

34 6- to 14-year old children with learning disabilities were divided into a group which habituated their OR to a complex repetitive auditory stimulus, Group 1, and a group which did not habituate, Group 2, for the purpose of determining possible behavioural differences between the groups. No significant differences were obtained on any of a wide selection of tests. The lack of significant findings were attributed to the inclusion of divergent subgroups for both Group 1 and Group 2. After this observation 28 additional cases were reviewed and new group assignments were made. Altogether, seven groups were defined with each group displaying a different alpha blocking pattern. With the groups defined in this manner, a number of variables, particularly the Deficit Index (Knights, 1970), were found to be significantly discriminating. Of particular interest was the general behavioural superiority of those Ss who demonstrated initial alpha blocking and subsequent habituation and the general inferiority of those Ss who demonstrated bilateral alpha blocking on every trial. These latter groups were thought to represent a refinement of Group 1 and Group 2. The most inferior group of the seven was composed of Ss that displayed little or no blocking for the first two trials. The results were discussed in terms of implications for clinical EEG interpretation and academic management. Other findings, such as unilateral alpha blocking, inconsistant alpha blocking, and prolonged alpha blocking, were discussed.

PREFACE

The role of attention in learning has been the subject of controversy throughout the years. As early as 1890 William James went so far as to define the totality of experience as that to which an individual agrees to attend. The concept of attention was also central to the theorizing of Wundt and Tetchner.

After the rise of behaviourism in the 1920's, the concept of attention fell from favour because at that time it lacked objectivity. Since then, however, the concept has undergone a rebirth primarily in the form of the Pavlovian concept of the orienting reflex with its objective measures. Since 1927, when Pavlov first described the orienting reflex, there has been a prodigious outpouring of research on the subject and many studies have confirmed that the orienting reflex is central to learning (Sokolov, 1960). So convincing has been some of this evidence that the eminent Canadian neurosurgeon Wilder Penfield has written...

> If I had another life to devote to human neurophysiology, I would like to devote it to the neuronal mechanism that makes possible the focussing of attention on a given task or thought for a given time. [Brain mechanisms] develop only in the focussed light of conscious attention....By selecting what he will attend to, the child conditions his own cortex... [and] with the help of parents and teachers, may be said to create his own brain mechanisms.

If Penfield's words can be taken as a reflection of the renewed status the scientific community has given the concept of attention, then it would appear that the community has come almost full circle since the days of William James.

Although this study has investigated only one aspect of what may be considered attentional abilities, it has nonetheless been caught up in this new spirit of importance which seems to have been given to the phenomenon of attention.

The author wishes to express both gratitude and respect to Dr. Byron Rourke who, in the truest sense of the term, is a pedagogue. Sincere gratitude is also expressed to Dr. Robert Orr for his guidance and encouragement. Special thanks are also expressed to Dr. Philip Rennick and Dr. David Reynolds. Thanks also go to Paul and Mary Roach, Mrs. Janet Orr, Marilyn Laforet, Gerald Young, Alan Finlayson, Gwen Paquette, and Julie McManus for their assistance. A very special thank you is extended to Mrs. G. Vanderlinden at Windsor Western Hospital's EEG Department without whose co-operation this study would have been impossible.

Finally a bouquet of thanks is extended to Susan and Josh MacDonald for sharing with the author the life of a graduate student.

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CHAPTER I

INTRODUCTION

This study was designed to investigate whether there may be behavioural differences among children who demonstrated differential rates of habituation of the orienting response (OR) to a repetative auditory stimulus. Electroencephalographic (EEG) alpha blocking was used as the objective measure of the OR.

An appreciation of the extensive literature on the OR and its subsequent habituation is central to a solid understanding of this study. Much of this research, however, does not have a direct bearing on the study and consequently will not be dealt with here but has been included in Appendix A.

The first reason for this investigation was to explore at least one aspect of a clinical phenomenon which mental health professionals refer to as "disorders of attention". Many children, when referred to professional mental health clinics, are described frequently as inattentive, distractible, hyper-aroused, "can't sit still," etc.

The present study did not address itself to the whole problem area of attentional disorder in childhood. Rather, a highly specific form of attentional deficit said to be characteristic of children and various adult clinical populations was dealt with. The deficit in question is the inability to withhold responsiveness to irrelevant stimulation. For example, when a child is described as distractible, this usually means that stimuli, other than those to which he is focusing his attention, can easily attract him.

The problem in this case, then, is not one of attending per se, but rather attending for a "sufficient" period of time to allow for adequate informational processing. In order to attend for the necessary "sufficient" period of time, an individual would have to withhold or suppress an attentional shift to other stimulus events in the environment. Many individuals have had this sort of experience during particularly boring lectures, sermons, etc. but these children are thought to manifest such distractibility more consistantly under typically normal situations.

A second reason for this investigation arises from the controversy and/or confusion encountered in many studies which have dealt with the relationship between various forms of EEG data and behaviour. This state of affairs can be appreciated by reviewing successive Psychological Bulletin articles by Ellingson (1966) and Vogel and Boverman (1966). Ellingson concluded that there was very little ground on which to claim that relationships between EEG data and behaviour exist. Vogel and Boverman criticized Ellingson's review by addressing themselves primarily to what they termed "well-controlled" studies, and these, they maintained, served largely to demonstrate that relationships do, indeed, exist. Both reviews appear to have merit. What is obvious, however, from both reviews is that methodological pitfalls abound in this area and the two greatest pitfalls have included 1) the frequent use of summary impressions (derived clinically or in a computerized manner) or alpha frequency as the EEG data, and 2) the lack of psychological tests which measure specific abilities. In many studies, the only behaviour investigated was a score on an IQ test.

In view of these methodological short comings, EEG alpha blocking was used as the objective measure of the OR since there, by definition, is a certain isomorphism between this phenomenon and behaviour. This isomorphism is lacking in those studies which have attempted to relate a clinical interpretation of EEG disturbance over circumscribed cortical areas to behavioural measures. Additionally many tests which measure specific abilities have been used in this investigation, as well as a computerized Deficit Index (Knights, 1970) which is a summary score of a subject's (S) performance on a neuropsychological test battery.

Studies by Berger (1929) and Rheinberger & Jasper (1937) contributed to the rationale underlying the methodology of this investigation. Berger demonstrated that the EEG tracing during orientation changed from a synchronized, well developed alpha activity (8-12 cps; slow, high amplitude wave) to a desynchronized activity (20-25 cps; fast, low amplitude wave). Berger referred to this change in alpha rhythm as alpha blocking while other terms (such as beta rhythm, arousal reaction and activation pattern) have been employed by later investigators and are generally used interchangeably. Rheinberger and Jasper (1937) observed that this blocking pattern was subject to gradual disappearance which appeared to reflect a waning of interest in the stimulus. This EEG phenomenon appeared to be an objective measure of the behavioural phenomenon of habituation which had earlier been described by Pavlov (1927) as an active inhibitory process of the nervous system as opposed to a passive decay of the stimulus trace due to fatigue.

An investigation of possible behavioural correlates which might be associated with individual differences in the rate of disappearance of this blocking pattern was the subject of this study. Lynn (1966) referred to a number of Soviet studies which investigated individual differences in both the OR and its habituation rate. Although these studies were not outlined in any detail Lynn claimed that the Soviet researchers had found significant differences in habituation rate between certain clinical population and controls. Additionally Lynn suggested that habituation rate may be a function of age since older girls (ranging in age from 18 to 21 years) habituated to a standard auditory stimulus much faster than did a group of younger girls (ranging in age from four to six years).

Studies concerned with individual differences in the OR and its habituation rate have largely been ignored by Western researchers. The research programmes by Maltzman, Raskin and their associates have been notable exceptions.

Maltzman and Raskin (1965) investigated individual differences in the strength of the OR to the initial presentation of a sudden stimulus for the purpose of determining other behavioural differences between strong and weak orienters. They found that Ss with strong ORs tended to show better semantic conditioning of autonomic responses, more verbal awareness of the experimental contingencies, superiority in paired-associate learning and greater differential responsivity to signals.

If behavioural differences could be obtained between strong and weak orienters then perhaps behavioural differences might also be obtained for groups which differ appreciably in their habituation rate to a routine auditory stimulus. If behavioural differences were found to distinguish these groups such findings could have implications for clinical EEG interpretation since a clinician might well be able to make behavioural predictions on the basis of a physiologically based, culture-fair measure. Additionally, if the appropriate behavioural measures were used, classroom teachers might be made more aware of the types of academic skills which are more likely to be affected with individual differences in habituation rate. With such information, educators may be better able to plan more appropriate programmes for children who have difficulty habituating to routine stimuli. No studies have been found in Western literature which have investigated behavioural correlates associated with individual differences in habituation rate. This study was designed to fill this void.

The present investigation employed EEG alpha blocking as the measurement of the OR and separated a group of Ss who habituated within 30 trials to an auditory stimlus from a group which did not habituate to the same stimulus for the purpose of determining other behaviours which might separate the groups. Because of Lynn's (1966) findings which suggested that habituation rate increases with age, this present study used a matched-pairs design in which a child from one group was matched in age (within 6 months) with a child from the other group.

Since it was impossible to determine a priori what behaviours might be affected by a deficit in the ability to habituate, a great many tests of individual skills were used. The Reitan-Indiana Neuropsychological Test Battery, together with other tests (see Appendix B) were used for the behavioural measures since these tests had been shown previously (Kløve, 1963; Knights & Moule, 1967; Reitan, 1966; 1970) to be sensitive to cerebral dysfunction and, furthermore, these tests encompass a wide spectrum of human skills.

It was generally anticipated that fast habituators should outperform slow habituators since Pavlov (1927) had suggested that fast habituation rates reflected a stronger inhibitory ability which in turn was associated in many animals with better attentional skills and faster discrimination learning.

CHAPTER II

METHODOLOGY

Subjects:

Approximately 125 Ss between the ages of six and fourteen formed the original pool of Ss for this study. From these, only 34 Ss (17 in each group) were included in the first phase of this study. Subsequently, 62 Ss were used in the formation of seven groups. Of these seven groups, six can be considered subgroups of the two original groups (as described below). All Ss were referred for a neuropsychological assessment and an EEG investigation because of suspected "perceptual" and/or learning problems. As opposed to a normal population (which would probably require an excessively large sample size) it was felt that children with learning disabilities, who had been referred for the above assessments, would provide an adequate range of Ss differing in degrees of responsiveness to the stimulus since, as discussed previously, the nature of their referral frequently included attentional difficulties.

Apparatus and Testing Materials

An eight-channel Grass (Model six) was used for the EEG tracings. The international 10-20 system for electrode placement was used and a consistant bipolar montage for electrode activation was adopted (see Appendix C for a depiction of the montage and the activated electrodes). The following electrodes were activated for the right hemisphere (RH): 1) frontal polar two to central four ($Fp_2- C_4$); 2) central four to parietal four (C_4-P_4) and 3) parietal four to occipital two (P_4-O_2). The following electrodes were activated for the left hemisphere (LH): 4) frontal polar one to central three (Fp_1C_3); 5) central three to parietal three (C_3-P_3) and 6) parietal three to occipital one (P_3-O_1). The seventh channel was silent and the eighth channel was used to record stimulus onset and offset.

The auditory stimulus was a telephone ring. A complex auditory stimulus was chosen because the results of a pilot study had indicated that most Ss habituated much too quickly (within three to four trials) to pure tones. In the pilot study, however, the sound was presented over speakers as opposed to earphones which might have facilitated habituation. For this study, the sound was presented for a duration of .5 secs at regular 10-sec intervals. The sound was recorded on a Sony stereocorder (Model 230), and presented to the Ss through Selfix high fidelity stereophones (Model 5708) with a frequency range of 20-18,000 cps. The headset was inverted so that no part of it could obstruct the EEG electrodes.

A complete description of the neuropsychological test battery used in this study is contained in APPENDIX B. Generally, these tests can be divided into five main subgroups: the Wide Range Achievement Test (WRAT), the Peabody Picture Vocabulary Test, the WISC, the Kløve-Mathews Motor Steadiness Battery and the Reitan-Indiana Neuropsychological Test Battery.

Procedure:

The neuropsychological tests were administered by experienced technicians trained in the assessment procedures developed by Reitan (1966). The EEG tracings were taken within a period of three months from the date of the administration of the neuropsychological test battery. The EEG recordings taken for the purpose of the present study constituted the first five to ten minutes of total EEG recording time which continued, in each case, for approximately one hour.

Graphs obtained under unfavourable conditions were excluded; these included excessive movement artifacts, prolonged periods with eyes open, the necessity of administering medication (either for excessive movement or for the attainment of a sleep recording), and those graphs which were rated as having less than 40% on-time alpha activity. The per centage on-time alpha was determined by examining three random 10-sec readings for each graph; following this, a simple ratio of total time in alpha to the total time reviewed was computed.

A Sweep Hearing Test was administered to all Ss , only those Ss whose hearing was normal at all frequencies were retained for this study. Before each EEG testing, the Ss were instructed to lay quietly, to open their mouths slightly (to prevent teeth biting artifacts), and to keep their eyes closed.

Previous research was not very helpful in providing methodological guidelines for determining the criterion for habituation. Consequently, habituation was defined operationally to be four successive trials during which alpha blocking did not occur to the stimulus. A trial was determined to be free from blocking if alpha was present for the interval ranging from one sec prior to the onset of the stimulus to one sec following the offset of the stimulus (i.e., a total of 2.5 secs). The EEG testing was arbitrarily terminated after 30 trials.

Because of the pilot study with pure tones, it had been anticipated that 30 trials would be sufficient to yield a normal distribution of habituation. Such was not the case, however, since only 17 of the 125 Ss tested could be called habituators (Group 1). From the much larger non-habituation group (Group 2), 17 Ss were matched in age (within six months) with a S from Group 1.

The methodological guidelines established for this investigation were thought to be quite adequate but it became clear when data were collected that provisions were not made for some unexpected blocking patterns. Within Group 1 were eight Ss who demonstrated either very weak or non-existant blocking patterns on the first two trials, Group NB (see Figure 1), while the remaining Ss performed as expected, i.e., they demonstrated a strong bilateral block on a number of trials, then met the criterion for habituation, Group HB (see Figure 2). Within Group 2, there also appeared to be relatively homogeneous subgroups. Some Ss demonstrated unilateral alpha blocking; these formed the right blocking group, Group RB (see Figure 3) and left blocking group, Group LB (see Figure 4) subgroups respectively. This was a most unexpected event since the previous literature referred to the blocking response as a diffuse reaction involving both hemispheres. The bilateral block, however, was characteristic of the majority. The largest subgroup included those Ss who displayed an inconsistent blocking pattern, Group IB (see Figure 5), i.e., initial blocking followed by failure to block, and then additional blocking never reaching the criterion for habituation. The final subgroup from Group 2 included those Ss who demonstrated a consistant bilateral block on every trial, Group CB (see Figure 6).

The criterion of 40 per cent on-time alpha activity prevented the inclusion of 10 graphs which had otherwise met the remaining criteria for inclusion. These Ss also appeared relatively homogeneous in that the blocking patterns were very prolonged, Group PB (see Figure 7). Group PB, together with the six subgroups from Group 1 and Group 2, were investigated for the purpose of identifying behavioural differences which might distinguish the groups. The breakdown of the original groups is presented in Table 1.

Table 1

Subgroups Derived from the Two Original Groups

Group 1	Group 2
--Group NB	--Group RB
--Group HB	--Group LB
	--Group IB
	--Group CB

The EEG tracings were submitted for three separated ratings by two independent raters. First, a blind (i.e., without knowledge of the times of stimulus onset and offset) assessment for the presence of alpha blocking was carried out. There was a 48 per cent agreement between the raters on the blocking reported. Second, the raters then attended to the times of stimulus onset and offset and determined, independently, which trials were blocked and which were not. The raters obtained a 61 per cent agreement on the trials each described as being blocked. Third, each rater independently decided whether a graph should be placed within Group 1 or Group 2. For this rating, the raters obtained a 96 per cent agreement and cases on which they did not agree were discarded.

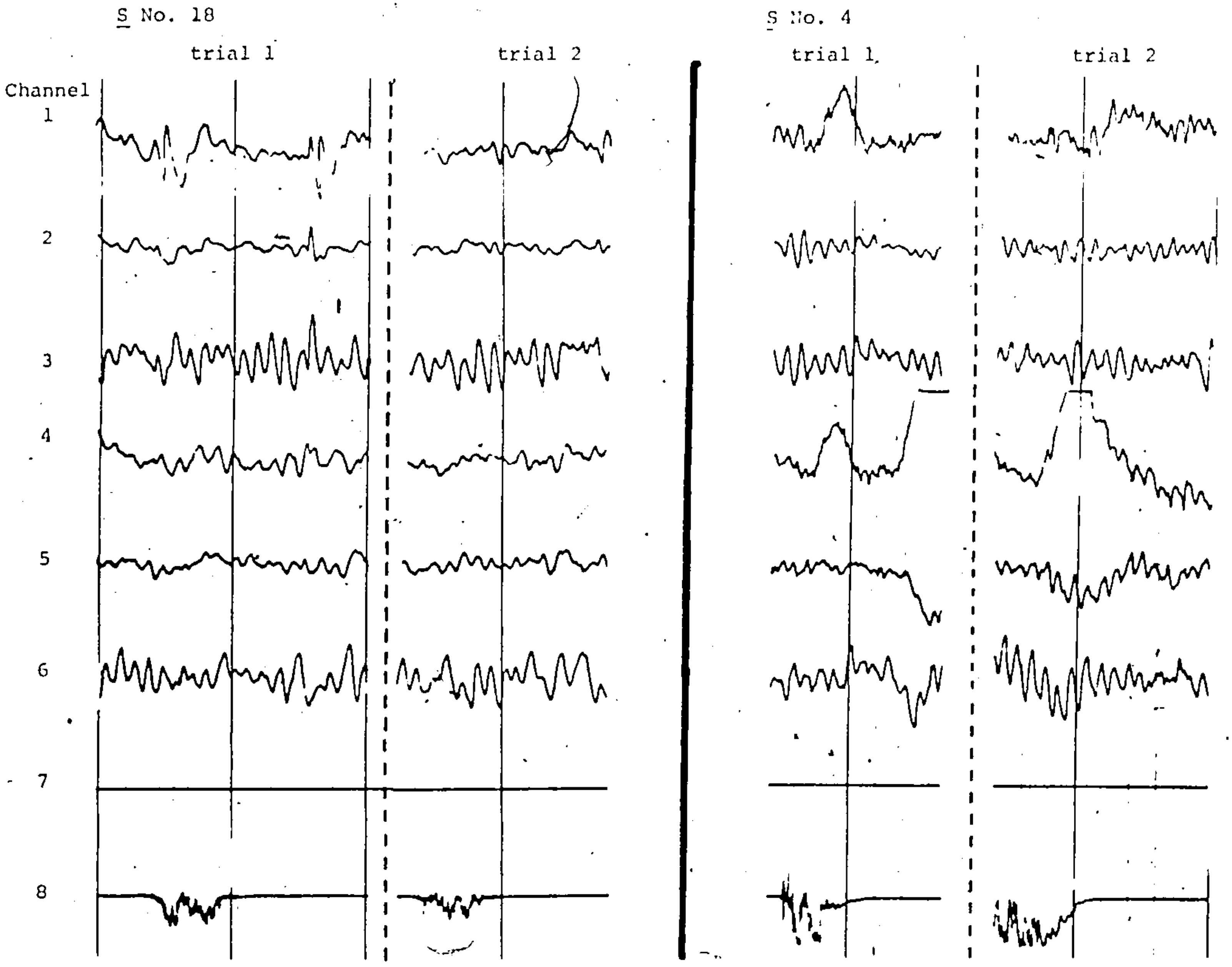

Figure 1. Little or no blocking. This graph depicts the first two trials from the EEGs of two Ss. For Figures 1 through 7, Channels 3 and 6 were used almost exclusively by the raters in their assessement for the presence or absence of alpha blocking.

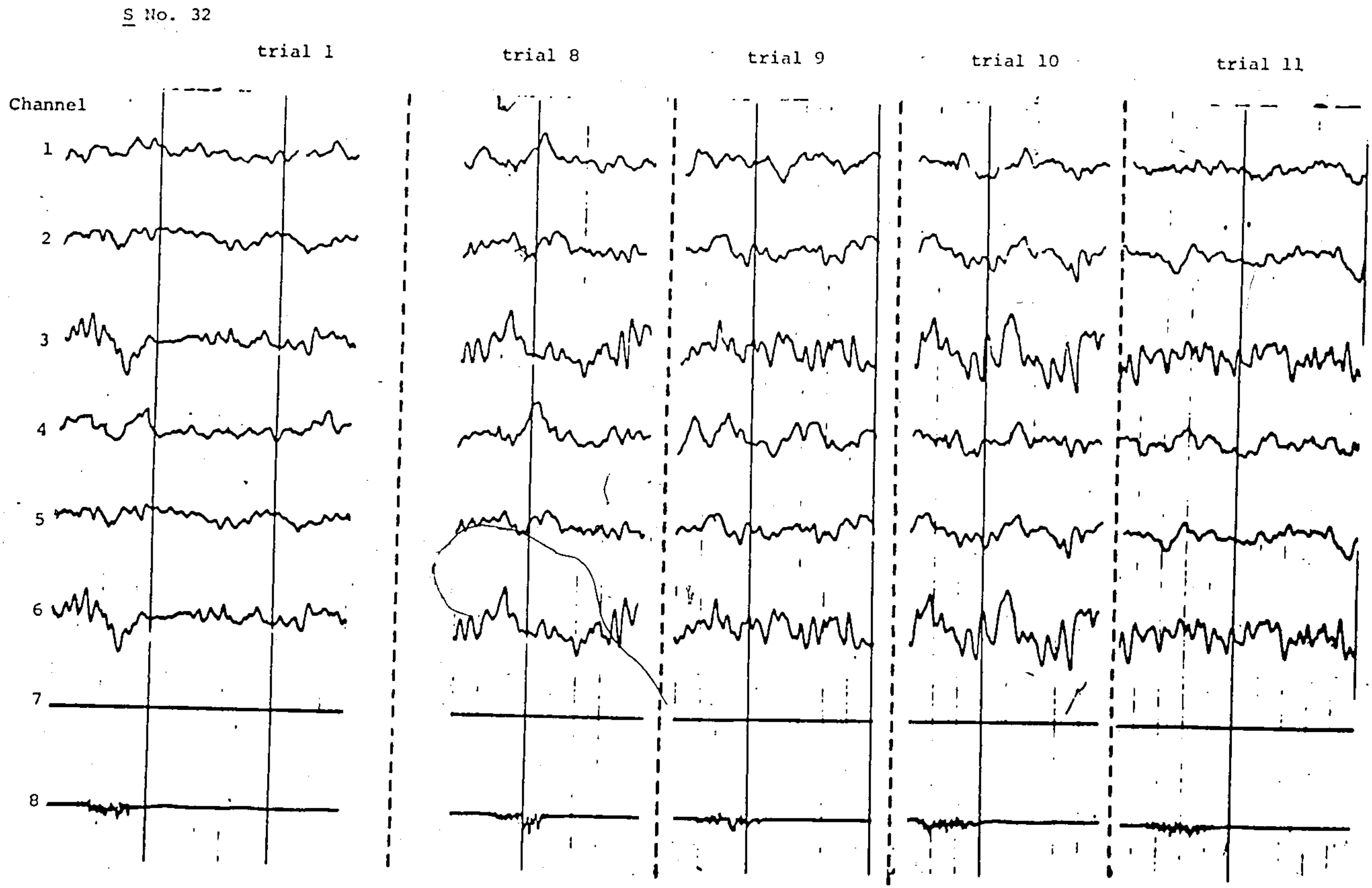

Figure 2. Habituation. Sections of EEG all taken from same S showing arousal on first trial followed by no arousal on trials 8, 9, 10 and 11.

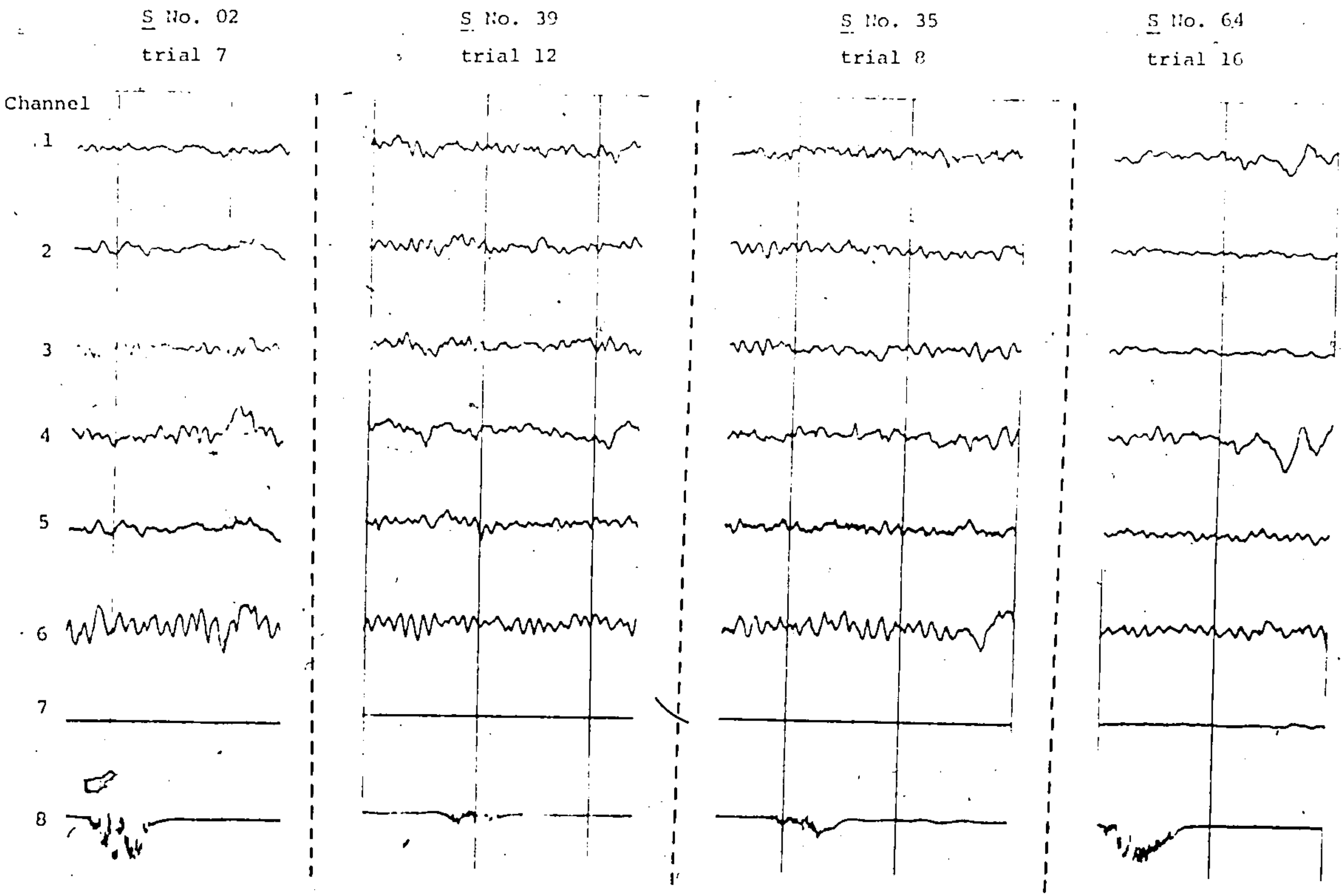

Figure 3. Right hemispheric blocking. Sections taken from four different Ss demonstrating clear blocking from right hemispheric leads while left hemisphere, according to the established criteria, reveals no such blocking.

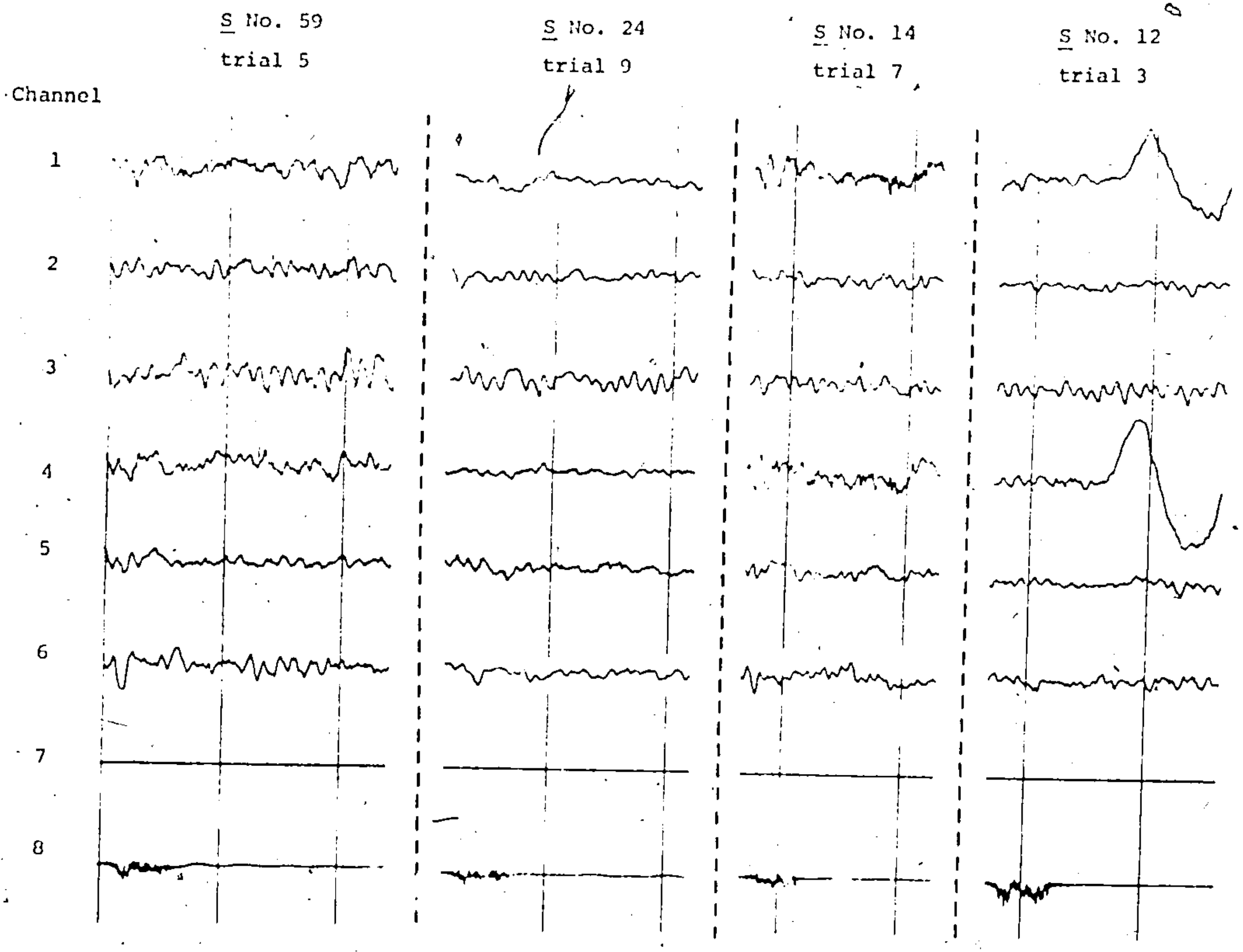

Figure 4. Left hemispheric blocking. Sections from four different Ss demonstrating alpha blocking from left hemispheric leads while right hemisphere, according to the established criteria, reveals no such blocking.

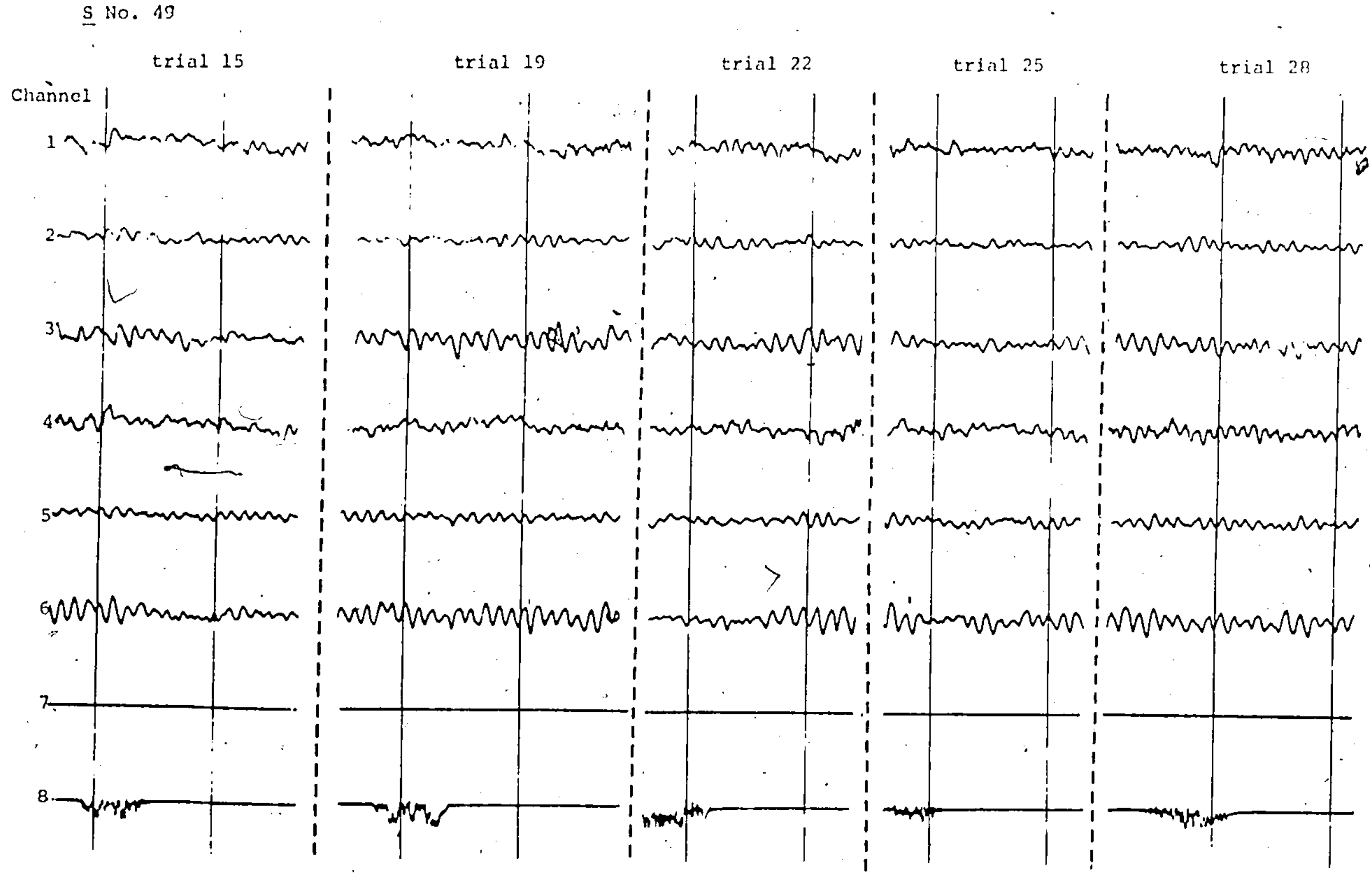

Figure 5. Inconsistant blocking. Sections of EEG all taken from same S. Trial 15 shows blocking, trial 19 no blocking, trial 22 blocking, trial 25 blocking, trial 28 no blocking. This graph never displayed four successive trials free from blocking, although alpha rhythm was present on a number of trials. Consequently, a S with such a graph could not be assigned to Group 1.

S No. 16

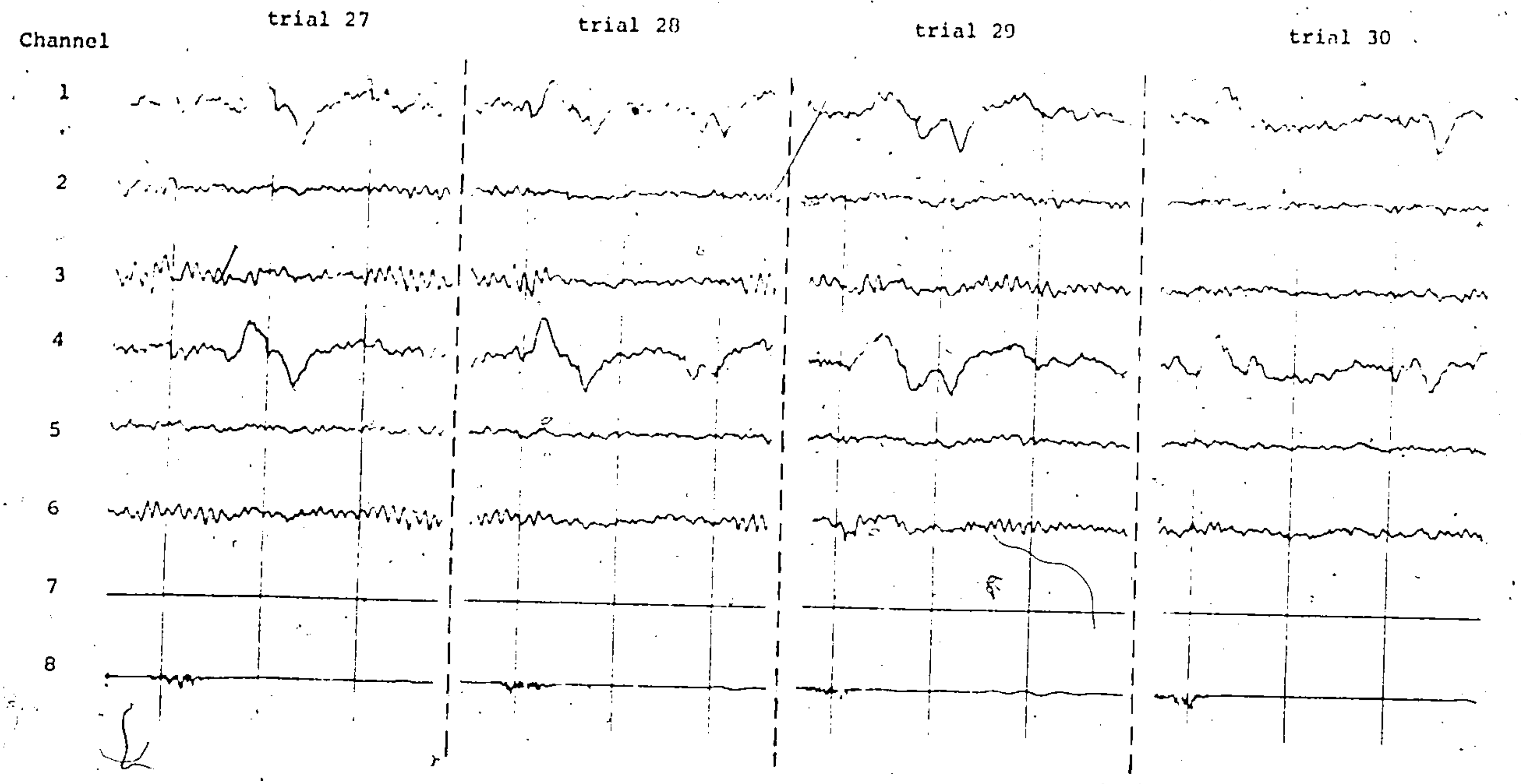

Figure 6. Consistant blocking. All sections from this EEG are from the same S, demonstrating a consistant bilateral block on the last four trials.

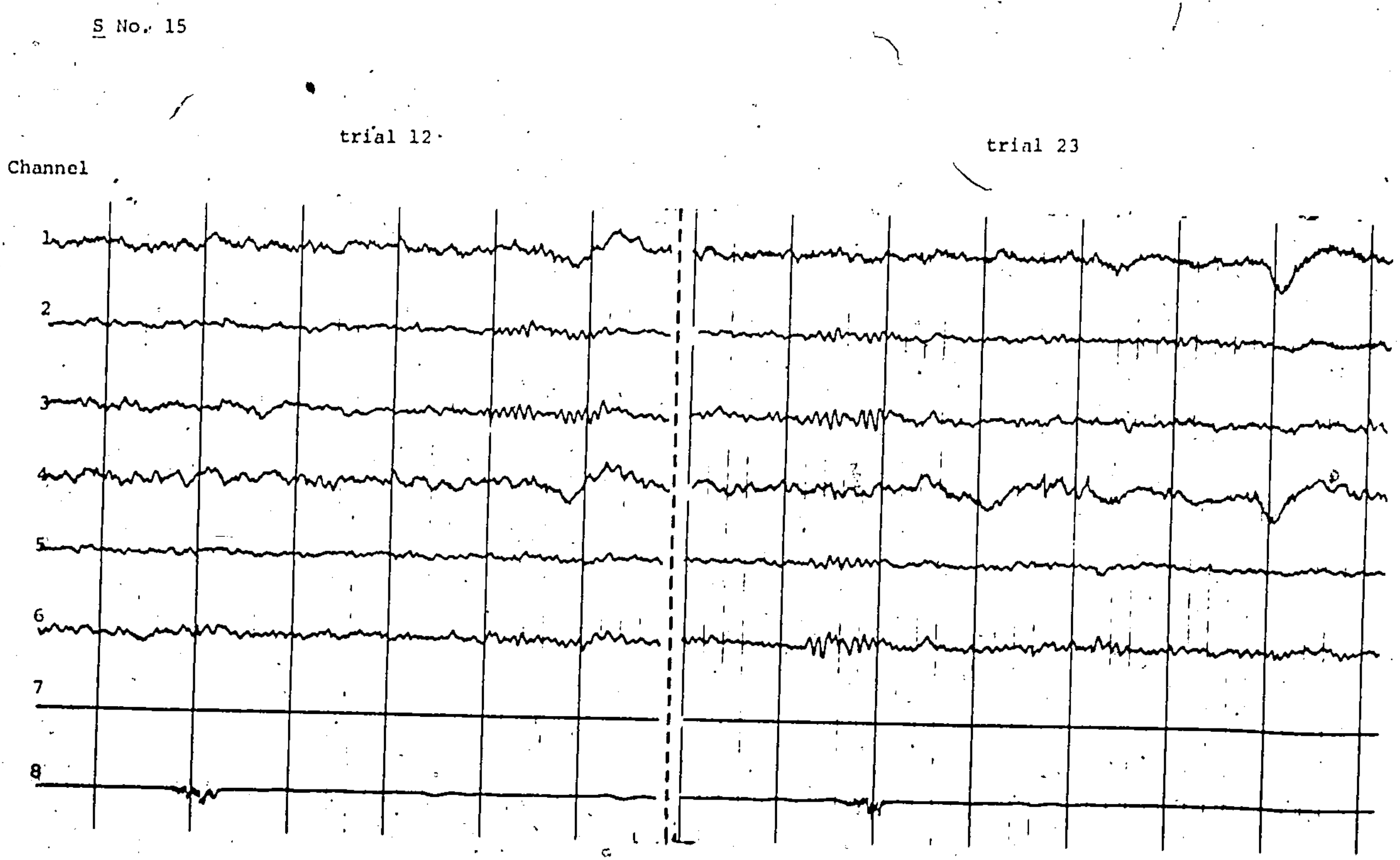

Figure 7. Prolonged blocking. Sections of EEG taken from same S. Trial 12 shows a sustained blocking state which begins well before the onset of the stimulus. Trial 23 demonstrates prolonged blocking which appears to be a result of stimulus onset. The S never did habituate nor could the graph meet the criterion of 40 per cent "on-time" alpha which was necessary for inclusion in either Group 1 or Group 2.

Both raters noted the blocking patterns mentioned previously. They were then instructed to establish the seven subgroups and to review independently all cases and make new group assignments. For this phase, the raters obtained a 91 per cent agreement and as in the case with the formation of Group 1 and Group 2, the graphs on which they could not agree were discarded.

Only 62 of the original Ss examined were retained for this study. Of the remaining 63 Ss, 32 Ss were excluded for having taken some form of medication within the 24 hours prior to the recording, 12 Ss were excluded for having a dominant theta rhythm, 9 Ss were excluded for excessive movement artifacts, 6 Ss were excluded because of rater disagreement, and 4 Ss were excluded for abnormal hearing.

The issue of rater reliability for the three phases is of particular interest in that in spite of the low agreements on the first two phases, rather high agreement was obtained for Group assignment. The reliability issue is central to research involving EEG. Blum (1954) reported low reliability among the interpretations of five competent neurologists. Consequently, this lack of agreement for the first two phases should not be considered uncommon. On the other hand, the high agreement for group assignment is probably a testament to the consistancy of the various patterns described.

CHAPTER III

RESULTS

Ss from Group 1 were matched in age, within six months, with *Ss* from Group 2. The means and standard deviations for age for the two groups are presented in Table 2.

Table 2

Means and Standard Deviations

for Age for Group 1 and Group 2

Group	n	Sex		Age
		M	F	
Group 1	17	12	5	$\bar{X}$:9.81 SD:2.51
Group 2	17	14	3	$\bar{X}$:9.79 SD:2.39

The Deficit Index (DI) is a summary statistic devised by Knights (1970) for use with the Reitan-Indiana Neuropsychological Test Battery and other tests (see Appendix B). The DI was computed from a number of standardized test scores which have been age corrected and represents the per centage of these test scores which fell below two standard deviations from the mean. According to Knights' data, a score from 0-9 is normal; 10-19 mildly impaired; 20-29 moderately impaired and over 30 severely impaired. The differences between the two group means for the DI were analyzed by means of *t* tests. Additionally, *t* tests were carried out on a number of tests which measured specific abilities. The selected tests can be clustered loosely in the following manner: 1) visuo-motor attentional skills; 2) auditory attentional skills; 3) tactile attentional skills, and 4) higher-order cognitive functioning. The *t* tests are presented in Table 3.

Table 3

Means and t values for DI and nine other tests for Group 1 and Group 2

Variables	Group 1	Group 2	t
DI	$\overline{X}$ 19.94	17.41	.521
Category Test (standard scores)	$\overline{X}$ 43.44	45.86	- .539
Seashore Rhythm (errors)	$\overline{X}$ 11.18	9.69	.808
Finger-Tip Symbol Writing Recognition--Right Hand (standard scores)	$\overline{X}$ 43.56	47.70	- .632
Finger-Tip Symbol Writing Recognition--Left Hand (standard scores)	$\overline{X}$ 46.49	41.71	.834
Pegboard Dominant Hand (standard scores)	$\overline{X}$ 42.99	41.51	.253
Pegboard Non-dominant Hand (standard scores)	$\overline{X}$ 40.88	45.90	-1.052
Sentence Memory (standard scores)	$\overline{X}$ 30.79	29.18	.258
WISC Digit Span (standard scores)	$\overline{X}$ 43.13	41.57	.533
WISC Coding (standard scores)	$\overline{X}$ 43.92	45.87	- .507

$t_{.95(32)} = 2.036$

None of the *t* tests were significant at or beyond the .05 level.

As indicated previously, the EEG raters noted six relatively homogeneous blocking patterns which could be considered subgroups of Group 1 and Group 2 (see Table 1 and Figures 1-6). A seventh group, Group PB, was also formed since it had been observed that a prolonged blocking pattern (see Figure 7) was a characteristic response of a number of *Ss*. The raters did not include such graphs in either group since they did not meet the criterion of 40 per cent "on-time" alpha activity.

An analysis of variance for DI across the seven groups was carried out. Additionally there was a more detailed investigation of tests measuring specific abilities. Altogether, twenty-nine single factor analyses of variance, including one for age and one for DI, were carried out for the seven groups and are presented in Table 4.

Table 4

Means and Standard Deviations for the Variables
and *F* Ratios for the Analyses
of Varience for the Seven Groups

		Group HB	Group IB	Group PB	Group RB	Group LB	Group CB	Group NB	*F*
Age	$\bar{X}$:	9.16	10.26	9.41	9.99	10.32	8.91	10.78	.622
	SD:	2.05	2.67	2.29	2.77	1.87	1.83	2.96	
	n:	8	16	10	8	5	7	8	
DI	$\bar{X}$:	6.75	12.31	12.80	18.00	20.00	25.14	34.38	8.615**
	SD:	3.58	7.86	7.97	9.12	11.23	11.11	12.84	
	n:	8	16	10	8	5	7	8	
Category Test	$\bar{X}$:	52.77	50.65	49.62	46.04	48.68	42.15	35.60	2.772*
	SD:	7.60	8.22	11.11	7.72	11.45	9.40	14.96	
	n:	7	16	10	7	5	6	8	
WISC VIQ	$\bar{X}$:	51.43	45.67	45.54	41.25	41.88	38.67	33.51	4.616**
	SD:	6.44	7.79	5.50	10.34	12.20	6.21	5.11	
	n:	8	16	10	8	5	7	8	

Table 4 (continued)

		Group HB	Group IB	Group PB	Group RB	Group LB	Group CB	Group NB	F
WISC PIQ	$\bar{X}$:	57.16	52.30	50.86	47.25	46.10	41.33	35.76	4.913**
	SD:	8.89	6.97	6.51	11.33	18.14	8.97	8.03	
	n:	8	16	10	8	5	7	8	
WISC ARITH	$\bar{X}$:	48.34	46.46	48.34	39.99	38.00	35.71	36.25	4.430**
	SD:	3.08	8.02	9.59	8.54	10.72	8.55	4.15	
	n:	8	16	10	8	5	7	8	
WISC Digit Span	$\bar{X}$:	48.76	42.71	48.01	45.84	43.36	37.61	36.67	2.617*
	SD:	5.02	8.64	9.97	9.23	4.72	6.86	8.61	
	n:	8	16	10	8	5	7	7	
WISC Coding	$\bar{X}$:	51.25	47.71	47.33	43.74	43.98	41.43	35.84	2.092
	SD:	11.95	8.92	9.54	9.99	10.65	12.43	7.92	
	n:	8	16	10	8	5	7	8	
Sentence Memory	$\bar{X}$:	40.13	35.60	37.07	29.25	23.82	28.14	20.96	2.081
	SD:	14.21	14.80	10.70	18.82	11.97	10.53	10.75	
	n:	8	16	10	8	5	7	7	
Seashore Rhythm (Raw Score)	$\bar{X}$:	5.17	8.80	7.63	10.13	8.60	13.83	15.33	4.996**
	SD:	2.93	4.31	4.27	4.16	5.73	2.14	2.50	
	n:	6	15	8	8	5	6	6	
Pegboard Dominant Hand	$\bar{X}$:	49.91	40.06	35.12	39.05	33.94	23.21	29.08	2.011
	SD:	10.31	15.06	14.87	9.93	20.06	25.50	21.59	
	n:	8	16	10	8	5	7	8	
Pegboard Nondominant Hand	$\bar{X}$:	46.20	40.80	36.48	44.29	43.88	39.63	29.09	1.183
	SD:	13.46	15.32	10.72	10.94	17.91	18.70	18.82	
	n:	8	16	10	8	5	7	8	
Finger Tapping Dominant Hand	$\bar{X}$:	47.68	41.96	47.03	46.33	34.90	41.43	34.68	1.039
	SD:	12.05	10.29	9.26	15.70	22.37	20.20	17.61	
	n:	8	16	10	8	5	7	8	
Finger Tapping Nondominant Hand	$\bar{X}$:	47.76	47.08	46.50	53.36	34.42	50.24	39.28	1.463
	SD:	14.10	10.40	12.34	11.96	14.34	18.28	17.03	
	n:	8	16	10	8	5	7	8	
Wepman Dyspraxia	$\bar{X}$:	54.34	45.76	48.72	51.99	43.38	40.01	40.79	1.726
	SD:	9.03	11.65	12.10	8.98	15.71	9.63	13.97	
	n:	8	16	10	8	5	7	8	

Table 4 (continued)

		Group HB	Group IB	Group PB	Group RB	Group LB	Group CB	Group NB	F
TPT Dominant Hand	$\bar{X}$:	47.93	46.43	52.63	49.79	49.38	47.76	38.93	1.129
	SD:	6.47	10.26	6.78	6.33	9.35	5.67	21.99	
	n:	6	15	9	8	5	5	6	
TPT Nondominant Hand	$\bar{X}$:	50.78	47.43	45.84	48.45	49.26	47.54	31.08	1.933
	SD:	7.06	9.64	10.88	5.45	8.74	11.11	24.67	
	n:	6	15	9	8	5	5	6	
TPT Both Hands	$\bar{X}$:	42.35	48.36	46.90	42.23	50.04	51.92	25.45	2.408*
	SD:	18.76	12.54	14.16	13.90	7.86	4.62	21.57	
	n:	6	15	8	8	5	5	6	
Finger Agnosia Right Hand	$\bar{X}$:	44.00	45.63	45.60	34.38	40.00	36.86	29.29	.867
	SD:	18.30	18.35	14.90	18.42	30.30	26.20	17.04	
	n:	8	16	10	8	5	7	7	
Finger Agnosia Left Hand	$\bar{X}$:	50.88	45.37	44.69	37.74	53.20	40.84	27.00	1.878
	SD:	10.88	14.77	17.52	18.36	7.76	20.96	22.89	
	n:	8	16	10	8	5	7	7	
WRAT Reading	$\bar{X}$:	44.91	44.33	43.53	40.33	38.68	34.66	38.00	1.129
	SD:	6.03	14.98	6.33	12.14	5.96	4.78	9.17	
	n:	8	16	10	8	5	7	7	
WRAT Spelling	$\bar{X}$:	43.18	41.09	43.13	39.25	38.92	37.14	36.07	.870
	SD:	7.47	11.56	6.02	9.40	5.14	4.26	6.67	
	n:	8	16	10	8	5	7	7	
WRAT Arithmetic	$\bar{X}$:	46.47	43.25	44.73	40.43	39.18	36.97	34.09	3.739**
	SD:	4.28	6.09	5.42	10.72	6.47	5.60	4.00	
	n:	8	16	10	8	5	7	7	
Target Test	$\bar{X}$:	46.43	42.97	43.55	44.95	33.64	26.84	29.27	3.623**
	SD:	5.54	9.64	15.43	6.08	19.77	13.73	11.20	
	n:	8	16	10	8	5	7	7	
Wepman Aphasia Spelling	$\bar{X}$:	21.13	25.74	42.68	7.58	41.28	28.35	21.42	1.967
	SD:	23.30	20.06	19.40	9.07	13.63	13.88	14.91	
	n:	4	10	5	4	4	4	5	
Wepman Aphasia Dysgraphia	$\bar{X}$:	34.46	32.95	32.87	25.90	19.86	20.01	17.45	.777
	SD:	26.06	25.00	21.93	24.92	19.08	21.33	23.83	
	n:	7	16	10	8	5	7	8	

Table 4 (continued)

		Group HB	Group IB	Group PB	Group RB	Group LB	Group CB	Group NB	F
Wepman Aphasia Dysarthria	$\bar{X}$:	42.90	33.79	42.10	27.88	39.85	43.68	29.24	1.177
	SD:	4.98	13.93	11.88	16.09	12.34	6.47	17.38	
	n:	4	10	5	4	4	4	5	
Wepman Aphasia Dyslexia	$\bar{X}$:	35.29	30.15	39.00	25.18	31.22	22.56	29.65	.577
	SD:	22.42	21.83	19.23	22.56	22.04	18.31	22.63	
	n:	8	16	10	8	5	7	8	
Total Wepman Aphasia	$\bar{X}$:	42.71	30.38	39.37	28.76	24.66	20.73	17.44	2.819*
	SD:	15.42	17.83	9.49	23.25	14.34	10.77	12.47	
	n:	8	16	10	8	5	7	8	

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

Age was not significantly different across the seven groups and contrary to what might have been predicted on the basis of Lynn's (1966) study, Group HB was the second youngest group. However, since this study employed a clinical sample, the generalization of this finding is restricted to this type of population.

Statistically significant differences were found for the DI and 11 additional tests. The mean DIs for the seven groups are presented in Figure 8.

Neuman-Keuls analyses for the DI and the 11 other tests which were found to be significantly discriminating were carried out. The group rank order and significant group differences are presented in Table 5.

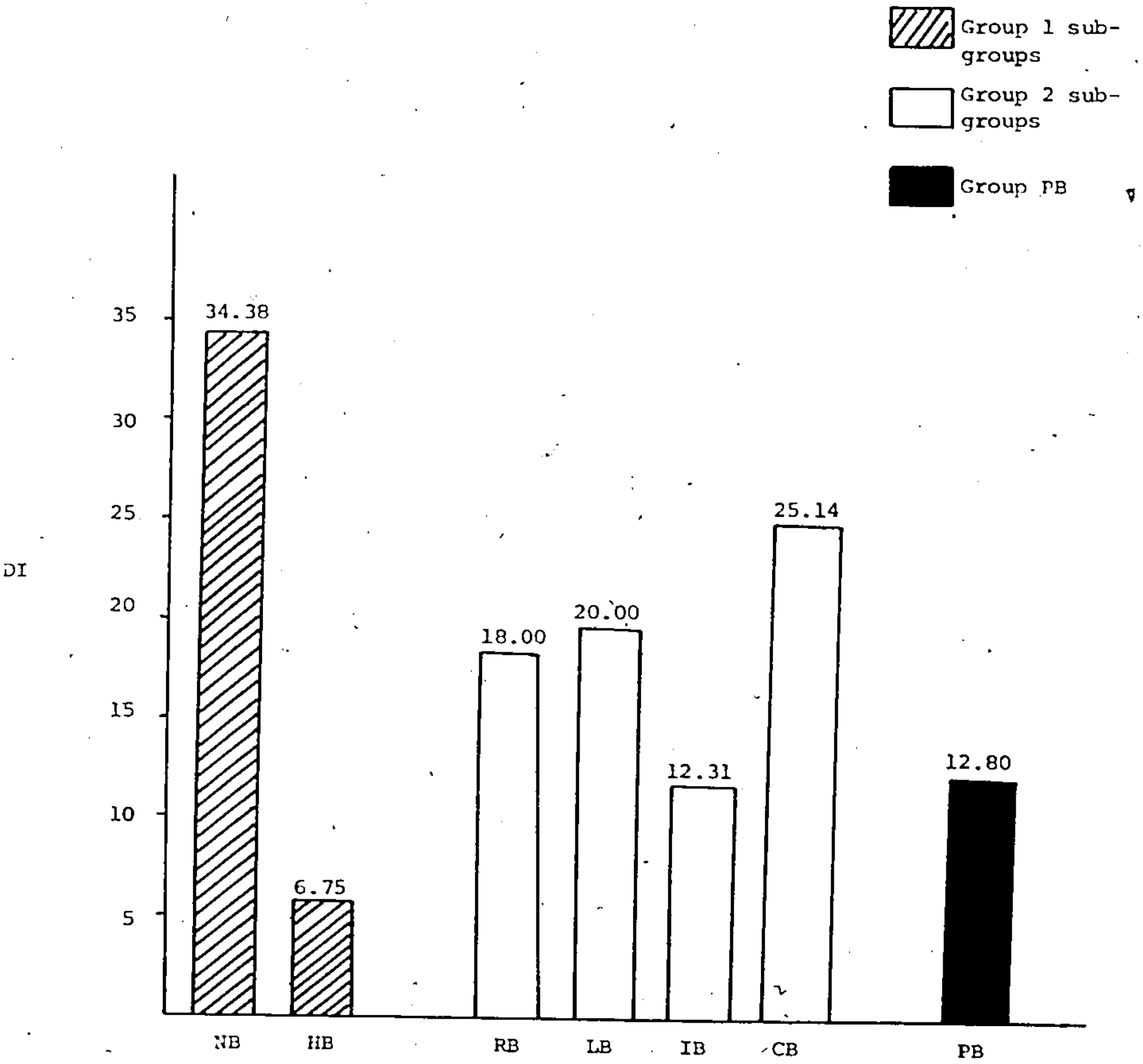

Figure 8. Mean DI for the seven groups (DI is the per centage of scores from a number of neuropsychological tests lying below two standard deviations from the mean.)

Table 5

Group Rank Order and Significant Group Differences Resulting from Neurman-Keuls Analyses for DI and the 11 other Tests

Test	RANK (1 highest performance....7 lowest performance) 1	2	3	4	5	6	7
DI	HB	IB	PB	RB	LB	CB	NB
	HB > NB; HB > CB; HB > LB; HB > PB; HB > IB IB > NB; IB > CB; IB > LB; IB > RB PB > NB; PB > CB; PB > LB; PB > RB RB > NB; RB > CB LB > NB; LB > CB CB > NB						
Category Test	HB	IB	PB	LB	RB	CB	NB
	HB > NB						
WISC VIQ	HB	IB	PB	LB	RB	CB	NB
	HB > NB; HB > CB IB > NB PB > NB						
WISC PIQ	HB	IB	PB	RB	LB	CB	NB
	HB > NB; HB > CB IB > NB PB > NB						
WISC Arithmetic	HB	PB	IB	RB	LB	NB	CB
	HB > CB; HB > NB PB > CB; PB > NB						
WISC Digit Span	HB	PB	RB	LB	IB	CB	NB
	No significant differences between groups were obtained						
Seashore Rhythm	HB	PB	LB	IB	RB	CB	NB
	HB > NB; HB > CB PB > NB LB > NB IB > NB						

Table 5 (continued)

	RANK (1 highest performance....7 lowest performance)						
Test	1	2	3	4	5	6	7
Tactual Performance Test	CB	LB	IB	PB	HB	RB	NB
	CB > NB LB > NB IB > NB PB > NB RB > NB						
WRAT Arithmetic	HB	PB	IB	RB	LB	CB	NB
	HB > NB PB > NB IB > NB						
Target Test	HB	RB	PB	IB	LB	NB	CB
	HB > CB RB > CB IB > CB						
Total Aphasia	HB	PB	IB	RB	LB	CB	NB
	HB > NB						

P < .05

With the exception of scores for the DI and the Seashore Rhythm Test, all other test scores were expressed as T scores.

Mean T scores for Group HB, Group CB, and Group NB on the tests which were found to be significantly discriminating are presented in Figure 9.

Even on those tests which did not significantly discriminate the groups, the rank ordering of the groups was very consistent. By assigning a score equivalent to group rank for the 28 variables (excluding age), mean scores for rank order have been determined and are presented in Table 6.

Table 6

Mean Rank Order for the
28 Variables

Groups	Mean Rank
HB	1.65
PB	2.89
IB	3.20
RB	4.17
LB	4.24
CB	5.20
NB	6.62

This overall consistancy for rank order explains partially the very evident discriminating power of the DI, which discriminated significantly all group comparisons with the exception of the Group RB-Group LB comparison and the Group IB-Group PB comparison.

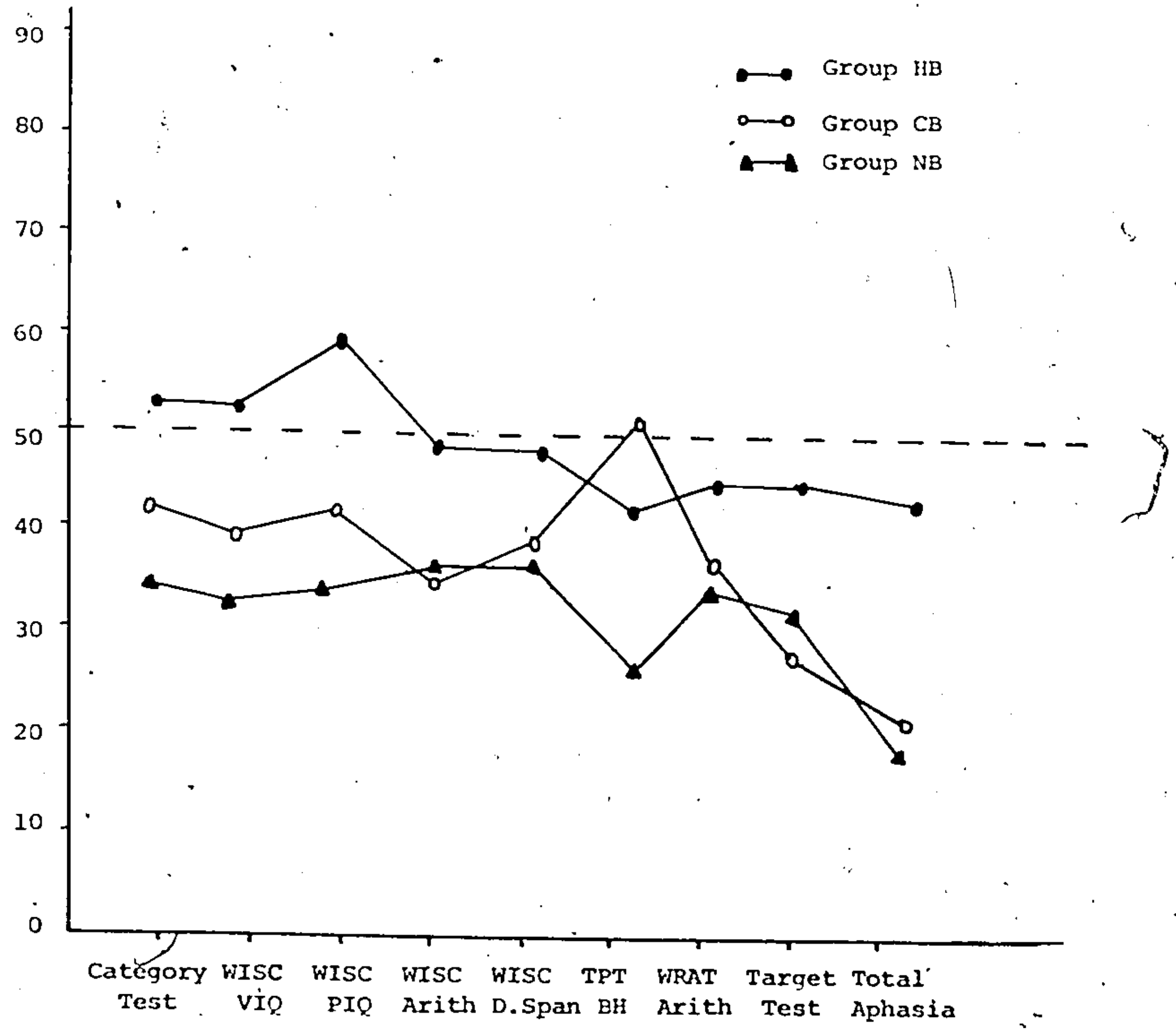

Figure 9. Mean standard scores for Group HB, Group CB and Group NB on those tests which were found to be significantly discriminating (Seashore Rhythm not included).

Analyses of the clinical EEG interpretations and the clinical neuropsychological interpretations were carried out. The major findings from these analyses were as follows: for the eight Ss in Group HB, seven had normal EEG interpretations with one mildly abnormal, while 7 of the neuropsychological interpretations were reported as being "mildly impaired" with one normal.

For the eight Ss in Group NB, four Ss had normal EEG interpretations, one borderline, and three clearly abnormal. The neuropsychological interpretations included three cases of mild impairment, five clearly abnormal with two of the latter described as "acute".

For the seven Ss in Group CB, four had normal EEG interpretations, one borderline, one mildly impaired and one clearly abnormal. The neuropsychological interpretations included three cases which were described as being mildly impaired and four cases clearly abnormal, with two of these described as "acute".

For Group RB, four of the 8 Ss had normal EEG interpretations, one borderline, and three abnormal. The neuropsychological interpretations included 6 cases of mild impairment, one moderate and one clearly abnormal. Of particular interest was the fact that the neuropsychological interpretations had localized the area of dysfunction to the left cerebral hemisphere in five of the eight cases with the remaining three described as having a bilateral dysfunction.

For Group LB, two of the five Ss had normal EEG interpretations, one mild and two abnormal. The neuropsychological interpretations included three cases of mild dysfunction and two abnormal. Localization was not as clear for this group as it was for Group RB since four out of the five Ss were viewed as having bilateral dysfunction while one had left hemispheric dysfunction.

For the 10 Ss in Group PB, five had normal EEG interpretations and five abnormal. The neuropsychological interpretations reported all 10 cases as being mildly impaired.

For Group IB, eight of the 16 Ss had normal EEG interpretations, three borderline, one mildly dysfunctional and four abnormal. The neuropsychological interpretations reported 13 of the 16 cases as being mildly impaired, two abnormal and one normal.

CHAPTER IV

DISCUSSION

This study was designed to investigate whether behavioural differences might occur between a group of Ss who habituated to a complex auditory stimulus, Group 1, and a group of Ss who demonstrated no such habituation, Group 2. Behavioural differences between Group 1 and Group 2 were analyzed by means of t tests (see Table 2). There were no significant group differences for the DI or any of the tests for specific abilities. At the outset of this investigation, the two groupings, in so far as it could be determined from previous research, appeared adequate. However, variations emerged when data were collected. Group 2 contained unanticipated blocking patterns which were consistant enough to form homogeneous subsets of that group. EEG records of some Ss showed blocking predominately confined to one cerebral hemisphere and not the other. This was completely unexpected, since all EEG research reviewed on the OR referred to it as a diffuse bilateral reaction involving the whole brain. Ss demonstrating unilateral blocking patterns were placed into either right blocking, Group RB, or left blocking, Group LB, subgroups. Additionally, there were two other blocking patterns which were relatively homogeneous subsets of Group 2. The most frequently occurring pattern in the study was that displayed by those Ss who blocked inconsistently, Group IB. These Ss exhibited a large number of trials free from blocking, but they did not reach the criterion of four successive trials without blocking. This type of pattern was clearly distinct from the final subgroup of Group 2, which was composed of those Ss who demonstrated a consistant bilateral block on every trial, Group CB.

Ss in Group 1 also demonstrated a heterogeneity in patterns of responsiveness. First, there was a group of Ss who displayed little or no blocking on the first two trials, Group NB. A second subgroup was made up of Ss who displayed initial blocking and subsequent habituation, Group HB. The pattern of responsiveness displayed by Ss in Group HB more closely approximates what many researchers mean by habituation. However, the original criterion for habituation required four trials free from blocking and Group NB certainly qualified in this respect. Additionally, it was thought that the Ss in Group NB might be typical of those whom Sokolov (1960) would refer to as having matched the incoming stimulus with an existing neuronal modal for the stimulus, in which case, the OR would be unnecessary and, therefore, suppressed. (See Appendix A for an elaboration of Sokolov's theory.) Consequently, at the outset, there appeared little reason to exclude such Ss from Group 1.

These six subgroups, two from Group 1 and four from Group 2, together with a seventh group which included Ss who demonstrated prolonged blocking patterns, Group PB, were investigated for the purpose of determining possible behavioural differences which might discriminate the groups.

Reasons for the complete lack of significant differences between Group 1 and Group 2 became much more apparent after the subgroups analyses (see Table 4). Group NB and Group HB were clearly divergent subgroups on all the behavioural measures. This divergence was particularly evident for the DI (see Figure 8). With Group HB and Group NB combined as they were to form Group 1, the effect was to produce an overall group mean which disguised the high performance of Group HB and the low performance of Group NB.

A similar, but less extreme divergence, occurred within Group 2. Group IB performed rather adequately but this performance was offset by the relatively poorer performance of Group RB, Group LB, and Group CB.

The original purpose of this study was to investigate Ss which differed appreciably in their rate of habituation of the OR to a standard auditory stimulus. In view of the above-mentioned variations in responsiveness, the original objectives of this study can best be preserved by an analysis of Group HB and Group CB. Group CB was chosen over Group RB and Group LB simply because the OR was described as a diffuse response involving the whole brain and the inclusion of the unilateral blocking groups would introduce an unknown variable into this particular analysis. Group CB was also chosen over Group IB because Group IB was an artifact of the habituation criterion. If some other researcher wanted to define habituation as one trial free from blocking, all of these Ss would be considered habituators. Consequently, Group HB and Group CB are more in line with what most investigators would call Ss that have habituated the OR and Ss that clearly have not habituated the OR, respectively.

Group HB performed significantly better on the DI than did Group CB. This same relationship was also maintained on tests for the following: WISC VIQ; WISC-PIQ; WISC Arithmetic; Seashore Rhythm Test; and the Target Test. All these tests, particularly the first three, can be considered to involve cognitive abilities. Additionally, the Seashore Rhythm Test requires sustained attention to 30 pairs of rhythmic patterns for the purpose of determining whether these paired stimuli are the same or different. An individual is particularly prone to distractability on this test.

The Target Test requires S to make a delayed response in reproducing visual-spatial configurations of increasing complexity tapped out by the examiner. On this particular test, Group CB performed significantly lower than Group HB, Group RB, and Group IB and ranked last when all groups were considered.

A series of studies by Jacobsen (1935a, 1935b) associated frontal cortical lesions in monkeys with delayed response deficits. Jacobsen attributed this deficit to a short term memory problem. Also, the frontal lobes of the brain are thought by many (French & Harlow, 1955; French, 1959; Glasser & Griffen, 1962; Luria & Homskaya, 1964) to be involved with the ability to habituate. Consequently, delayed response deficits and difficulty with habituation are often related, if not intimately dependent on one another, as a study by Malmo (1942) seemed to indicate. Malmo demonstrated that the delayed response deficit was not significantly different between experimental Ss and controls when the intertrial interval was altered by leaving the Ss in total darkness. The darkness served to reduce the total number of potentially distracting stimuli in the Ss environment. Consequently, Malmo argued that the delayed response deficit was not caused by a short term memory problem but rather the inability to maintain attention which demands the filtering out of irrelevant stimuli. In other words, the delayed reaponse deficit appeared to be a direct result of the inability to habituate to irrelevant stimuli. This same phenomenon could account for Group CB's poor performance on the Target Test.

Clearly then, the differential EEG blocking pattern displayed by Ss in Group CB and Group HB are associated with behavioural differences between the groups. The behavioural differences can be described as a general behavioural inferiority of Group CB as measured by the DI and more specifically there were differences in cognitive abilities as reflected in significantly lower scores for Group CB for the following variables: WISC VIQ, WISC PIQ, and WISC Arithmetic. Additionally, significantly poorer performances were obtained by Group CB on a test requiring sustained attention to non-verbal auditory stimuli (the Seashore Rhythm Test) as well as a test which requires a delayed response in reproducing visual-spatial configurations (the Target Test). These findings are in agreement with the original hypothesis that Ss who habituate to a standard auditory stimlus should demonstrate better attentional skills than Ss who are unable to habituate to the same standard auditory stimulus within 30 trials.

Of considerable interest was the extremely poor performance of Group NB. As discussed previously, Group NB was a subgroup of Group 1. It had been included for two reasons, 1) Ss who demonstrated little or no blocking on the first two trials generally continued on with this lack of responsiveness for 30 trials and clearly met the criterion for habituation which was four successive non-blocked trials and 2) from principles implicit in Sokolov's (1960) theory of arousal, the lack of responsiveness of these Ss could imply that a match was made between the external stimulus and an internal neuronal modal for that stimulus. This sets up a situation in which arousal to the external stimulus is unnecessary and, therefore, actively suppressed by the organism's central nervous system. Viewed in this light, Ss would be considered to have an internal neural model for that external event. This situation then would represent the end of a learning unit, i.e., since there is an internal model for that external stimulus, S has learned something about that stimulus. Consequently, from Sokolov's viewpoint, there would be no reason to exclude such a group from those to be considered habituators and it might be argued further that those Ss who do not orient on the initial presentation of the stimulus might be somewhat superior to other groups because they would have come to the experimental session with "knowledge" of the stimulus.

Nothing would seem farther from the truth, however, for this "no blocking" pattern was associated with extremely poor performance on the neuropsychological tests. The mean performance of Group NB fell well within the severely impaired range on Knights' DI and was significantly inferior to all other groups, including Group LB. Additionally, Group NB was found to be significantly inferior to Group HB, Group IB and Group PB on tests for the following: WISC VIQ; WISC PIQ; Seashore Rhythm; and WRAT Arithmetic. Group NB was significantly inferior to Group HB on the following additional tests: Category Test; WISC Arithmetic; and Total Aphasia. Group NB was also found to be inferior to Groups RB, LB, and CB on the Tactual Performance Test when using both hands simultaneously and was inferior to Group LB on the Seashore Rhythm Test. As with Group CB, significant differences between Group NB and other groups, particularly Groups HB, IB, and PB, were more often observed on tests involving cognitive abilities as well as on tests requiring sustained attention. Group NB ranked last on 20 of the 28 variables investigated and second last on seven. Clearly this lack of blocking during the first two trials of the stimulus is highly associated with severe behavioural deficits.

Of particular interest was the significant superiority of Group CB when compared to Group NB on the Tactual Performance Test when both hands were used simultaneously. An analysis of the individual scores for the Ss in Group CB and Group NB on the TPT-BH revealed a one-S overlap.

The TPT is Halstead's (1947) modification of the Seguin-Goddard formboard. S is blindfolded and not permitted to see the formboard or blocks at any time. S is to fit six blocks into the proper spaces with the dominant hand, then the non dominant hand, then both hands simultaneously.

One possible interpretation of this finding is that the Ss in Group CB performed rather adequately because the total amount of extraneous stimulation was reduced. This finding is somewhat similar to that of Malmo's (1942) findings. Malmo had refuted Jacobsen's (1935a, 1935b) contentions that the impaired performance of frontal-lesioned monkeys on delayed response tests was due to a short-term memory problem. Malmo was able to refute Jacobsen's contention by placing the animals in total darkness for the inter-trial interval. Under these conditions, the frontal-lesioned Ss did not differ from controls. Malmo argued that frontal-lesioned Ss were more prone to distractability and reducing the amount of extraneous stimulation had resulted in allowing the Ss more time for information processing, thus increasing learning efficiency.

It could be argued that since Ss in Group CB were hyper-responsive to the telephone ring, they may be more distractible than most Ss and could benefit from reducing the signal-to-noise ratio. On the other hand, Ss in Group NB appeared to be oblivious to the telephone ring in the first place and this situation of reduced stimulation did not appear to produce any significant gains. If anything, their performance worsened somewhat.

It may be the case that the Ss who demonstrated little or no blocking to the sound of telephone ring would also demonstrate a lack of orientation to many events in their environments. This, in turn, may explain their poor performance on most of these tests.

Sokolov has not addressed himself to this phenomenon (viz., no initial blocking) but it would not appear likely that the Ss from Group NB are the type of Ss who have matched the external stimulus with an internal model. If this is the case, then the non-existant blocking for these Ss cannot be explained in terms of Sokolov's latest model revision (1969).

Group PB and Group IB performed adequately on most of the tests, although the mean DIs of both groups were inferior to Group HB. On tests for specific abilities, neither group was ever found to be inferior to any other group. Consequently, EEG patterns of inconsistant blocking or prolonged blocking should not be viewed as being associated with specific behavioural impairment.

Unilateral alpha blocking is a most interesting finding. However, the data are largely devoid of any association with specific behavioural impairment. The DIs for Group RB and Group LB did not differ significantly when compared with each other but both were inferior to Groups HB, IB and PB. On the other hand, both were superior to Groups CB and NB. This suggests that at least mild behavioural impairment is associated with such unilateral blocking but specific areas of deficit cannot be ascertained from this data. There were no significant lateralizing indicators which might be anticipated if one or the other cerebral hemisphere were impaired. In fact, there were no significant differences between these groups on any of the tests. For this reason, Group RB and Group LB remain largely a curiosity whose full significance is not understood, although it does seem clear that unilateral blocking is associated with a mild to moderate impairment in behaviour as reflected by the DI.

It may be worthwhile at this point to speculate in perceptual terms as to what each S may be experiencing under the seven different blocking conditions. It could be argued that the stimulus for Group CB occupied the figure in the figure-ground perceptual gestalt on every trial and at no time during the 30 trials was there a relegating of that stimulus to the background as was the case with Group IB.

Viewed in this light, Ss from Group IB would appear to be experiencing the normal waxing and waning of attention. Ss from Group NB would appear to be oblivious to the stimulus. Group PB could conceivably represent the patterns of responsiveness of the vigilent S who is constantly anticipating something to occur and Group HB would include Ss whose orientation to the stimulus placed it in the foreground of perception but subsequently habituated to it and thus relegated the stimulus to the background. In this context it is unclear how Group RB and Group LB would be responding to the stimulus other than to state clearly that they were responding.

Implications for Future Research

Perhaps the most important findings of this investigation include the differential performances of Group HB, Group CB and Group NB. The pattern of responsiveness displayed by Group HB was associated with normal neuropsychological test performance as measured by the DI. That pattern displayed by Group CB was associated with moderate impairment while the mean DI for Ss from Group NB was within the severely impaired range.

Hopefully this research will be replicated, particularly with respect to determining whether the same relationships with behaviour hold for the three groups mentioned above.

Additionally, the phenomenon of unilateral alpha blocking should be investigated further, perhaps with a sample containing older children (9 to 14 years old) since previous research has shown that older children demonstrate less variability in performance on these neuropsychological tests than do younger children (Rourke, Dietrich & Young, 1973).

Although there is some doubt that behavioural differences will be found which could significantly differentiate future left from right blocking groups, the phenomenon requires comment in its own right. Unless these findings can be explained away in terms of some methodological artifact, the incidence of unilateral blocking in clinical populations must be reasonably high, assuming, of course, that the sample employed in this study was representative.

As opposed to using the criterion for habituation employed in this study, an alternative may be to calculate a percentage based on the number of blocked trials to the total number of trials and investigate two or more groups varying in this manner.

One final finding in this study merits comment. It is that rather clear associations between some EEG data and behaviour have been obtained. Adtionally, the EEG data has been derived from careful, deliberate visual inspection of a well defined EEG phenomenon, the alpha block. With the greater proportion of EEG research employing computerized summary data, it is felt that important patterns of responsiveness might go unrecognized. Hopefully both a visual inspection and a trial-by-trial analysis will not fall from favour in the future.

Practical Implications of this Study

An academic recommendation for children with learning difficulties, which may be somewhat overused, is to place such children into smaller classes and have them work in private cubicles for short periods of time. The idea, here, is to reduce the number of potentially distracting stimuli in the child's environment. There are undoubtedly many children with learning difficulties who do not require such handling tactics. However, the Ss from Group CB appear to have a bona fide need for this type of recommendation. The fact that these Ss orient to the stimulus consistantly indicates that there is some difficulty with their ability to suppress orientation. Consequently, it would be expected that such a child would experience considerable difficulty in withholding attention to irrelevant stimulation. If background noise and other irrelevant stimulation is kept to a minimum, such a child's learning capacity could increase appreciably.

Another thing to consider is that many more repetitions than average are required for such children to appreciate the stimulus or, in Sokolov's terminology, more repetitions are required for such children to form internal models for the external stimulation. Consequently, basic academic data, such as number facts, should be overlearned.

The Ss from Group NB, although displaying somewhat similar behavioural deficits, would appear to require considerably different handling tactics. As opposed to over-reacting to environmental stimulation, these children appear to be under-reacting. What is required in this case is some form of intervention which will literally force the child to attend to the stimulation. Every attention-getting trick should be employed from surprize to multisensory bombardment. Behaviour modification programs may also be beneficial for operants by definition are observable acts and if such acts increase in frequency because they are followed by reinforcement, it can be said that the child in question is becoming more aware of his environment, albeit slightly. Hopefully the environmental contact could be increased in this manner.

Finally, this research has implications for clinical EEG procedures. Obviously, exposure to an auditory stimulus such as the one in this study would not be much of a burden upon the usual clinical routine. Auditory stimulation was used routinely by a number of labs but has tended to fall from favour in the past two decades. Photic stimulation is, in many instances, the only external form of stimulation used routinely along with having the patient open and close his eyes. Absence of blocking is a pathological sign under the eyes opened condition: absence of blocking, however, rarely occurs with this form of stimulation.

Auditory stimulation, on the other hand, appears to produce a more subtle blocking pattern and is subject to much quicker habituation than is visual stimulation. This alone should argue for its return to the conventional EEG routine. If future research supports the findings of this investigation, EEG records could be screened for the blocking patterns noted and if such support is forthcoming it would appear valid to view Ss who perform like groups HB, PB and IB as being relatively normal while blocking patterns such as those displayed by groups CB and NB can be considered a further pathological sign. Blocking patterns such as those displayed by Groups RB and LB may be considered to be associated with mild behavioural impairment.

Although it would appear somewhat premature to make clinical judgements on the basis of these findings, the generalization of the findings is not impeded by the sample chosen since the Ss in this study were referred because brain dysfunction was thought to be a contributing factor to the child's behavioural difficulties and obviously such would be the case for children referred for EEG testing. However, until other studies can support or disprove the results of this investigation, guarded interpretations must be adopted.

The clinical EEG interpretations and the clinical neuropsychological interpretations of the individual cases involved lent support to the notion that Ss in Group HB were less impaired than those in Group NB and Group CB. Additionally, on the basis of the neuropsychological interpretations, there did seem to be some reason to question the integrity of the left cerebral hemisphere in those Ss who demonstrated right hemispheric alpha blocking. The same pattern, however, did not hold for Group LB.

These various patterns of EEG alpha blocking to a complex repetitive auditory stimulus are not only interesting in their own right but also the findings of this study indicated that there are significant behavioural associations with this type of EEG data. Hopefully, others will investigate these blocking patterns further.

CHAPTER V

SUMMARY AND CONCLUSIONS

Approximately 125 Ss referred for neuropsychological testing within an age range from 6 to 14 years were exposed to a standard repetative auditory stimulus while an EEG recording was simultaneously being carried out. Two independent raters assessed the graphs for the presence or absence of alpha blocking. The stimulus presentation was terminated by trial 30.

The purpose of the study was to separate Ss who were unable to habituate their OR to the stimulus, Group 1, from those that could not, Group 2, in order to determine whether there were behavioural differences between the groups. Habituation was operationally defined as four successive trials during which alpha rhythm was present.

When data were collected, it became apparent that the methodology allowed for heterogeneity in responsiveness and this heterogeneity contributed largely to the lack of significant behavioural differences between Group 1 and Group 2. It was determined that Group 1 contained two basic variations in responsiveness, viz., one group which demonstrated little or no blocking on the first two trials, Group NB, and the other which demonstrated initial blocking followed by habituation, Group HB.

Group 2 was observed to contain four basic patterns of responsiveness. Some Ss demonstrated unilateral alpha blocking. These Ss were placed into either right blocking, Group RB, or left blocking, Group LB, subgroups. Additionally, those Ss from Group 2 with bilateral blocking formed two more subgroups. These Ss demonstrated either inconsistant alpha blocking, Group IB, or consistant alpha blocking, Group CB (i.e. blocking was observed on every trial).

A group of Ss who displayed prolonged alpha blocking was also formed, Group PB, since this response was characteristic of a large number of Ss who were otherwise excluded from Group 2 because they had not met a criterion of 40 per cent "on-time" alpha activity.

Altogether, 28 behavioural measures were examined statistically for the purpose of determining differences among the seven groups.

The Deficit Index (Knights, 1970), which is the per centage of test scores from a neuropsychological test battery lying below two standard deviations from the mean, was the most discriminating variable. The following order resulted when the seven groups were ranked from least impaired DI to most impaired DI: 1) Group HB, 2) Group IB, 3) Group PB, 4) Group RB, 5) Group LB, 6) Group CB, 7) Group NB. The DI discriminated significantly all group comparisons with the exception of the Group IB-Group PB comparison and the Group RB-Group LB comparison.

Furthermore, a number of tests for specific abilities discriminated the groups significantly. Significant group differences were most often observed when Group CB was compared with Group HB and when Group NB was compared with Groups HB, IB and PB. The discriminating measures can be clustered loosely into tests for cognitive abilities and tests requiring sustained attention to visual or auditory stimuli.

This study indicated the following:

1) No significant differences were observed between habituators, Group 1, and non-habituators, Group 2, as these groups were defined initially.

2) The lack of significant findings was attributed to the inclusion of divergent subgroups for both groups, particularly Group 1.

3) When Ss were assigned to seven groups, with each group displaying a different alpha blocking pattern, significant behavioural differences were obtained.

4) The severe behavioural impairment associated with Group NB posed a critical question for Sokolov's (1969) theory of arousal.

5) The demonstration of behavioural associations with these various alpha blocking patterns has implications for academic remediation as well as clinical EEG interpretation.

6) There is a need to crossvalidate the findings of this study.

7) EEG research involving detailed visual analysis can be effective in demonstrating associations with behaviour and must not be completely supplanted by computerized techniques.

8) The observations of unilateral alpha blocking are deserving of comment and/or further investigation.

9) Since auditory stimulation has been effective in producing at least seven variations in alpha blocking patterns, its use as an external form of stimulation for standard clinical EEG procedures should be considered, particularly if other studies crossvalidate these findings.

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APPENDIX A

A number of studies which have investigated the orienting reflex (OR) and/or its subsequent habituation have been reviewed and are presented here.

Behavioural Manifestations of Orientation and Habituation

Under most conditions when a novel stimulus is presented to an animal, or when a constantly presented stimulus is changed, concomitant behavioural responses can be observed, which suggest that the animal is responding to this change in his environment.

Pavlov (1927) was the first to document this response. According to Lynn (1966), Pavlov used the concept of the OR in his explanation of external inhibition, which in turn was used as an explanation for the failure of a number of conditioning experiments. Pavlov's students, eager to please their professor with a conditioning experiment they had perfected, were frequently embarrassed over the sudden failure of their experiment in the presence of the illustrious man. Pavlov explained that his physical presence acted as a novel stimulus within the learning situation which caused the animals to turn their attention to him instead of performing in the required manner.

Thus it was that the OR grew from an inconvenience to a phenomenon of interest in its own right. Concerning this reflex, Pavlov (1927) wrote:

> The biological significance of the reflex is obvious. If an animal were not provided with such a reflex its life would hang at any moment by a thread. In man this reflex has been greatly developed with far reaching results, being represented in its highest form by inquisitiveness.

Significant advances toward an even more objective materialistic grasp of the OR were made by Hans Berger (1929) and Moruzzi and Magoun (1949). Berger demonstrated that the electroencephalographic tracing, during orientation in man, changes from a synchronized, well defined alpha activity (8-13 cps low voltage, high amplitude) to a desynchronized activity (above 20 cps high voltage, low amplitude). Moruzzi and Magoun (1949) demonstrated that they could obtain the same change in pattern by applying electrical stimulation to the reticular formation. Chiefly due to this latter study the important role of the reticular formation in adaptation and learning was acknowledged.

When the OR is examined closely one can observe some or all of the following concomitant behaviours: a) pupil dilation, b) a change in galvanic skin response, c) changes in heart rate, d) momentary arrest of respiration and ongoing activity, e) head turning to the source of the stimulation, f) photochemical changes in the retina lowering the threshold for intensity of light, g) lowering of the auditory threshold, h) vasoconstriction in the limbs and vasodilation in the head, and i) EEG desynchronization.

Konorski (1967) grouped these varied behaviour concomitants of the OR into the following: 1) a targeting reflex, consisting of adjusting the afferent system to the reception of the stimulus, 2) an autonomic response, mostly of the sympathetic type, and 3) EEG desynchronization, either general or limited to a given cortical analyzer.

Earlier researchers (Clark & Ward, 1945; Rheinberger & Jasper, 1937) observed that this EEG activation pattern was also subject to gradual disappearance (habituation) and appeared to reflect a waning of interest in the stimulus. Griffin (1970) related that habituation is the term applied to a gradual quantitative loss or diminution of response to a repeated, standardized stimulus. Habituation is one of the ways an animal may adapt to its environment and to changes in its environment.

An adequate review of the research on the orienting reflex and its subsequent habituation demands fairly detailed coverage of related neurophysiological research. For this reason, a number of studies dealing with electro-neurophysiological methodology have been reviewed.

Research concerning the phenomenon of orientation and its habituation has been limited to two fundamental electro-neurophysiological recording techniques: one which can be considered a broad, general summary impression of a number of electrical events while the second is much more specific since it involves an electrical recording of individual neuronal discharges.

Macro and Micro Analysis of Orientation and Habituation

The studies discussed to this point have been concerned with what may be considered a macro recording technique. These techniques involve the habituation of the cortical OR from alpha to alpha blocking (attenuation) and back to alpha (habituation) again. This "pattern" technique does not reflect individual neuronal discharge. At best, it can be described as an electrophysiological event which is highly correlated with behavioural arousal (orienting) or the lack of it (habituation or complete unresponsiveness).

As recently as the 1950's, it was widely assumed that alpha blocking reflected an increase in neuronal activity. However, many investigators (e.g., Evarts, 1960; Hubel, 1959; Kogan, 1960) have discovered with microelectrode implantation that, during alpha blocking, some neurons are excited, some are inhibited, and still others remain unchanged.

The second method maybe considered a micro recording technique since it involves the implantation of micro electrodes in individual neurons in order to study the habituation of the evoked potential of the actual neuronal discharge. The work of Hernandez-Peon (1961) is an excellent example of the evoked potential recording technique. It is important to bear in mind the distinction between the two techniques, since some evidence (Sharpless & Jasper, 1956) suggests that there is no strict correlation between the two events and, in fact, it may be that the two recording techniques may be measuring quite different phenomena. Many authors have failed to deal with this distinction. The result has been frequently unclear and often contradictory information. The theoretical issue regarding the role of the cerebral cortex in the phenomenon of habituation has been the battle ground on which this lack of distinction has been frequently abused.

For purposes of clarity, those studies which have employed micro electrode implantation will not be reviewed, except in those situations where information obtained from such studies contributed to knowledge of the physiology of certain structures.

As discussed previously, the habituation of the cortical arousal response may prove to be an entirely different phenomenon from the habituation of the evoked potential. Behavioural habituation, more closely parallels the habituation of the cortical arousal response, since both occur in a relatively brief number of trial. The habituation of the evoked potential, on the other hand, requires many more trials (Sharpless & Jasper, 1956).

There is an ever increasing body of literature concerning the relative contribution of various neural mechanisms to orientation and habituation. As new data arrive, current theories frequently have to be revised or discarded. A review of many recent neurophysiological findings and the most consistent theories which have been able to assimilate these findings is presented below.

The Cortical Arousal Response: An Analysis of some of the Possible Neuronal Mechanism Involved

Subcortical Mechanisms:

Sharpless and Jasper (1956) allowed cats to habituate to complex auditory stimuli. The stimuli involved a rising glissando from 200 to 5,000 cps. When the range of frequencies was inversed, a complete arousal response was observed. A change in stimulus pattern, then, in spite of the likely involvement of similar receptors, was sufficient to disinhibit the arousal response. This result indicated that somehow the auditory signal had undergone some analysis before it reached the synapses at which habituation occurred.

In this same experiment (Sharpless & Jasper, 1956), it was demonstrated that lesions in the auditory cortex had no effect on habituation to single tones but an effect was observed on the tonal pattern. When the brachia of the inferior colliculus was cut (depriving both the thalamus and the cortex of specific auditory input) the cats became very difficult to arouse, and dishabituation to new frequencies no longer occurred.

On the basis of this information, Sharpless and Jasper speculated that there were two components of the cortical response to novel stimuli that may respond differentially to habituation. They differentiated between a short (in the order of seconds) phasic response which occurs during and immediately after the presentation of a stimulus and tends to be more resistant to habituation and a more prolonged tonic reaction which may last several minutes and which habituates rapidly. The phasic response will reappear after brief rest periods whereas habituation of the tonic responses tends to be more permanent.

Livanov (1960) related somewhat similar observations of the OR. He observed that initially EEG desynchronization was widespread and covered the whole cortex, but soon desynchronization was confined to the area of the specific cortical analyzer for the sensory stimulus involved.

Sharpless and Jasper suggested that the phasic response may represent an activation of the nonspecific thalamic projection system which is closely related to the classical sensory pathways; the tonic response, on the other hand, may represent a more general influence of the midbrain reticular formation. Thus, in their experiment in which the brachia of the inferior colliculus was severed (thus eliminating the auditory pathways to the thalamus and cortex but not to the reticular formation) no phasic response was observed.

Support for Sharpless and Jasper's contentions have been found in at least two earlier studies (ie prior to 1956) and one later study. Lindsley, Bowden and Magoun (1949) and Lindsley, Schreiner, Knowles and Magoun (1950) have suggested that the generalized cortical arousal response is mediated by the midbrain reticular formation. Gastaut (1958) speculated that the modality-specific local response of the sensory projection areas may represent an influence of the thalamic portion of the reticular formation. Gastaut further suggested that the lower brainstem may be more rapidly inhibited by repetitive stimulation and that this inhibition acts as a facilitating catalist on the thalamocortical influences that are responsible for localized desynchronization. Consequently, it would appear reasonable to suggest that the faster one can habituate the generalized cortical arousal the more quickly the incoming signal can be analyzed by the appropriate cortical receiving area. The likely involvement of both the midbrain reticular formation and the nonspecific thalamic projection system in orientation and habituation became acknowledged by many but subsequent research, presented below, demonstrated that these functional systems were not sufficient in themselves to explain all phenomena related to orientation and habituation. Recently, the role of the hippocampus in arousal and habituation has been acknowledged.

The Hippocampus

Green and Arduini (1954) observed that neocortical desynchronization was always accompanied by the appearance of high amplitude slow waves (theta, 4 to 7 cps) in the hippocampus, even with direct electrical stimulation to the reticular formation. Just the opposite relationship existed during rest or sleep. Thus, when the cortex became desynchronized, the hippocampus became synchronized, and visa versa. Green and Arduini hypothesized that the hippocampal slow waves might represent a specialized paleocortical arousal reaction.

In a review of the literature on electrophysiological correlates of learning, Grossman (1967) noted that Grastyan (1959, 1961) offered a different interpretation of the same findings. He observed that cats stopped all ongoing behaviour and orientated toward a moving object during electrical stimulation of the hippocampal-fornix system. Even when no sensory stimuli were presented, hippocampul stimulation produced a disruption in ongoing behaviour. This suggested to Grastyan that the hippocampul desynchronization reflects activation of that area and that its primary function is of an inhibitory nature. Grossman suggested that this hypothesis was more parsimonious than that of Green and Arduini, since the same electrophysiological pattern (high-amplitude, slow waves) is representative of a state of inactivity of that particular neural structure.

In pursuing this hypothesis, Grastyan (1961) investigated the role of the hippocampus in a series of conditioning studies. He predicted that the initial presentation of the CS would elicit cortical desynchronization and hippocampul slow waves. During the first few presentations of the CS and UCS, alpha blocking was recorded at the level of the cortex. However, the hippocampus maintained its fact activity. Several CS-UCS pairings were required before the reciprocal relationships could be observed. The hippocampal slow waves were in evidence throughout the training period but diminished as CRs to the CS began to be made. (This would suggest that the hippocampus is now performing its active inhibitory function and is contributing to the blockage of irrelevant information.) The hippocampal slow waves disappeared completely after the response-to-be-learned was firmly established.

Grastyan further compared the EEG date with motion pictures of the animals' behaviour during training. Hippocampal slow waves were always associated with overt, behavioural orientation toward the source of the stimulation. Only when the role of the CS as a cue for UCS onset appeared to become appreciated did the behavioural orienting and hippocampal slow wave activity appear. When the CR was firmly established, both the cortex and the hippocampus showed desychronization without the animal orienting noticeably toward the source of the CS. According to Grastyan, the hippocampal slow waye pattern never appeared without clear behavioural orienting. Grastyan concluded that the normal function of the hippocampus may be to prevent the occurrence of behavioural orienting responses to insignificant sensory stimulation.

A number of earlier studies have investigated the behavioural effects of hippocampal ablation (Kluver & Bucy, 1939; Milner, 1958; Schreiner & Kling, 1953). These studies demonstrated profound behavioural alterations in both animals and man. In man, a profound memory loss was in evidence (Milner, 1958). The constellation of atypical behaviours seen in animals was termed the Kluver-Bucy syndrome after the researchers who performed the first reported study on bilateral hippocampal ablation. The behaviours included excessive orality, hypersexuality, and hypermetamorphosis. If the main function of the hippocampus is to inhibit irrelevant stimulation or generally to act as a suppressor mechanism, as suggested by Grastyan, then the failure of such a mechanism would appear adequate in explaining these observed behavioural alterations after bilateral hippocampal ablation.

One final anatomical area, thought by many to be involved with the OR and its habituation, must be considered.

The Frontal Cortical Regions

Primarily due to the Russian researchers insistence on neocortical involvement in arousal and habituation, the role of the frontal lobes has become acknowledged. The Russians point out that learning, particularly human learning, is often based on complex learned distinctions which cannot be made without cortical involvement. For example, Lynn (1966) reviewed a study by Rusinov and Smirnov (1957) which reported that human Ss showed complete habituation to words with similar meaning but different sounds but exhibited immediate dishabituation as soon as a semantically different but similar sounding word was presented. Lynn also related that

Voronin and Sokolov (1960) habituated the generalized (tonic) and localized (phasic) OR to a complex stimulus composed of tactile, visual and auditory stimuli. Subsequent presentation of only one of the three stimuli produced electrophysiological changes in the cortical projection areas for the missing stimuli.

Frequently, the Russian "cortical" position (Luria & Homskaya, 1964; Sokolov, 1960) has been misrepresented and has frequently been compared with the habituation of the evoked potential research of Hernandez-Peon and his co-workers, which rarely makes reference to any neocortical involvement.

Habituation of many different evoked potentials can occur without the neo-cortex, as demonstrated with decrebrated and even spinal animals by Hernandez-Peon and Brust-Carmona (1961). However, habituation of the arousal response and habituation of certain evoked potentials appear to depend directly on neocortical involvement as the following studies demonstrated.

Jouvet (1961) found that cortical mesencephalic and cochlear evoked potentials persisted undiminished after the EEG arousal response had completely habituated, and that complete habituation of the evoked potentials could not be obtained in neodecorticated animals. He concluded that habituation represents an inhibitory effect on the reticular formation by the cortex in the intact animal.

French and Harlow (1955) and French (1959) reported that the activity level of monkeys with cortical area 9 lesions manifested less habituation than did normals. Konorski (1948) demonstrated that the orienting response exhibited markedly reduced habituation following total decerebration in cats. Butler and Harlow (1954) have demonstrated deficits in the ability to habituate in monkeys with frontal lesions. Glasser and Griffen (1962) demonstrated a decrease in the extent of habituation of the heart rate response to the cold-presser test in man and the rat with frontal lesions.

A deficit in the ability to habituate would appear to be an adequate explanation for the delayed response deficits in frontal lesioned animals in the classic studies by Jacobsen (1935a, 1935b). Jacobsen attributed the delayed response deficit to a short-term memory dysfunction in the lesioned animals. Malmo (1942), however, showed that the delayed response deficits were not significantly different between experimental Ss and controls when the intertrial interval was altered by leaving the animals in total darkness. The darkness, of course, would serve to reduce the total number of potentially distracting stimuli in the animal's environment.

Response perserveration on the Wisconsin Card Sorting Test has been noted with frontal-lobectomized humans by Milner (1963, 1964) and by Luria and Homskaya (1964).

Response preseveration is another way of describing an animal's inability to vary its motor movements. If an animal is to vary its motor movements it must somehow call upon a suppressor mechanism in order to terminate the on-going behaviour. Pribram and Mishkin (1956) and Weiskrantz and Mishkin (1958) have demonstrated a deficit in the frontal - lesioned animal's ability to vary its motor movements in discrimination learning experiments of a go-no go variety. This latter type of task demands that the animal withhold a response to the negative stimulus. Mishkin (1964) showed that frontal-lesioned animals perform more poorly than normals in a sequence of learning set experiments which altered two conditions of reinforcement. He described this deficit in terms of the preservation of "central sets" or "central mediating processes." Although one may argue with the specific description of the deficits involved, it would appear difficult to deny the presence of a deficit in a suppressor mechanism responsible for the habituation of the OR with which the frontal areas have an intimate relationship.

Theoretical Models for Habituation of the OR

The OR, together with its resultant habituation, have formed the basis of a number of new neurophychological theories of learning and/or adaptation. From the many theories available in the literature, the conceptual models offered by Sokolov (1960), Grastyan (1959) and Moruzzi (1960) appeared to have particular relevance for the preceding study.

Generally, all three models consist of two stages. The first stage embodies an analysing mechanism to determine whether the stimulus necessitates an OR. The second stage involves excitatory or inhibitory mechanisms which are set to evoke or suppress the orientation reaction. A brief description of each model follows.

Sokolov hypothesized that all incoming stimuli are conveyed to the cerebral cortex for analysis. The cortex, he maintained, contains records or traces of past stimulation. If the stimulus is a novel one it will not match a nervous model; excitatory impulses are then sent to the reticular formation and the OR occurs. The OR is prevented if the incoming information matches an existing neural model. Sokolov speculated that the cortex, under such matched conditions, sends down impulses to the afferent collaterals to block the non-specific input. He suggested that the blocking may take place by hyperpolarization of the synaptic connections.

Sokolov theorized that, for such a model to be plausible, there would have to exist three different types of neurons: 1) neurons which always respond to stimuli (afferent neurons); 2) neurons which begin to respond only after repeated stimulation (extrapolatory neurons) and have the capacity for imitating the afferent neurons if the stimuli being responded to by the afferent neurons has been experienced previously; and, 3) neurons which can compare signals from afferent and extrapolatory neurons. If the signals do not match, the comparator neurons initiate the orienting reaction. With stimulus repetition, the signals from the afferent and extrapolatory neurons come to match and the comparator neurons are not activated.

One source of difficulty for Sokolov's model was its initial inability to explain why significant stimuli, (or, in Russian terminology, stimuli with signal value) continue to elicit orientation reactions after they have ceased to be novel. Sokolov revised his match-mismatch theory to include ambiguous stimuli as well as novel stimuli. By "ambiguous stimuli", he meant those previously neutral stimuli to which an animal is now being conditioned or is learning to discriminate. When learning becomes established, the orientation reaction no longer occurs. An experiment by Sokolov (1963) demonstrated this phenomenon. A regular tone was presented to S for a series of nine presentations. Just after the ninth presentation he is told to clench his fist whenever he hears the tone. This instruction gave signal value or significance to the tenth presentation and an orientation reaction was observed.

Lynn (1966) related that a major fault with Sokolov's model is its failure to explain the onset of drowsiness and sleep with repeated stimulation. Obviously, the simple non activation of the comparitor neurons would not be a sufficient explanation. Lynn argues that Sokolov would have to assume a further process involving the inhibition of the reticular formation itself.

As discussed previously, Grastyan (1959) has argued for the recognition of the hippocampus as an important inhibitory link between the cortex and the reticular system. Although many convincing experiments are offered to demonstrate this inhibitory effect, he does not arrive at any conclusion as to how such an effect may come about. Additionally, he did not attempt to answer this question. Lynn (1966) suggested that the most plausible assumption is that the decision is somehow made in the cortex.

Some very recent evidence, however, has shed new light on Grastyan's model. Vinogradova (1970), employing microelectrode implantation, reported differential hippocampal neuronal reaction to sensory stimuli. She related that more synapses are interposed in the pathways by which sensory information reaches the ventral hippocampus than in those leading to the dorsal hippocampus. Etul (1964) and Gergen (1967) reported higher thresholds and greater latencies for electrical stimulation of neurons of the septum and fornix in the ventral hippocampus. These findings might suggest that sensory integration proceeds from the dorsal part of the hippocampus to its ventral part. Vinogradova suggested that neurons of the dorsal hippocampus perform selective reception of individual stimuli, while the ventral hippocampus with its multi-synaptic organization has the capacity for dealing with whole classes of previously integrated stimuli.

Vinogradova argued that if one accepts Sokolov's (1966) hypothesis that the membrane of the habituated neuron may be regarded as a matrix of synaptic inputs each of which represents different parameters of stimuli then, after habituation to one stimulus, another, slightly different one, should activate the cell preportionally to the number of new synapses activated and fail to excite it preportionally to the number of common synaptic inputs. Thus, the degree to which one stimulus influences the responses evoked by the other may be regarded as a measure of the number of commonly shared synapses.

These recently discovered physiological differences between the dorsal and ventral regions of the hippocampus might suggest that the actual decision making process of whether to orient could be carried out by the hippocampus itself. Not only could such a structure make "hold" or "don't hold" decisions, but it also has the capacity to determine just how extensive orienting must be.

However, a rather crucial experiment by O'Gorman, Mangan and Gowen (1970) presents a logical impass to this reasoning. These researchers tested that aspect of Sokolov's model in which it is suggested that dishabituation will be proportional to the amount of difference between the original stimulus and the current stimulus (or, as Vinogradova (1970) suggests, the extent of arousal will be proportional to the number of shared synapses between the two stimuli). Their design consisted of 16 experimental treatments, three involving frequency, three involving intensity, nine involving both frequency and intensity, and a control condition repeating the presentation of the original stimulus. They reported that, contrary to what one would expect from Sokolov's model, only an increase in intensity had a significantly different effect on the return of the arousal response. Additionally, it was found that fast habituators were less likely to show a return in the arousal responses to stimulus change. It was concluded that individual differences in habituation rate may be more important than stimulus differences in selective habituation.

This study does appear to demonstrate that a strict isomorphic relationship between physical changes in a stimulus and corresponding physiological alterations in synaptic transmission either does not exist or at least that such physiological alterations, per se, are not crucial in determining orientation. Vinogradova's contention, then, appears to be unsubstantiated by the results of this experiment. It must be concluded that certain physical parameters of a stimulus may be more important than others. Whether it is a consistent pattern that stimulus intensity is a more crucial variable in determining dishabituation than is stimulus frequency is a subject for further investigation. Although the above study does not do away with the possibility of a self-sufficient habituation center in the hippocampus, it does render it somewhat less likely.

The neurophysiological model of Moruzzi (1960) proposed the existence of an inhibitory center in the pons which mediates the inhibitory effect of the cortex on the reticular arousal system. This model assumes the existence of separate activating and inhibitory systems in the brain stem. Moruzzi speculated that the inhibitory system is situated at the midpontine level and that the activating system is just above it at the rostropontine level. The model also suggests that repetitive stimulation builds up the inhibitory system by means of collateral input from the sensory tracts as well as from the cortex. When the inhibitory system is activated, it dampens the activating system, first reducing and eventually eliminating the OR, and ultimately inducing sleep.

Moruzzi cited a number of experiments in support of his contentions. One such experiment (Moruzzi, 1960) demonstrated that a transection of the brain stem at the upper level of the pons, which severed the connections between the hypothesized activating system and the cortex, produced sleep. However, a cut just a few millimeters below (in the midpontine pretrigeminal preparation), which hypothetically severed the inhibitory impulses from the inhibitory system, left the animals in a chronic state of activation. Habituation could not be demonstrated in these animals. In another study, Dell, Bovallet and Hugelin (1961) compared habituation rate of the EEG activation pattern in normal and midpontine pretrigeminal preparations. Normals habituated after approximately 20 sec. of stimulation, while no habituation could be obtained up to as long as four and one half minutes in the experimental animals. In order to account for selective habituation of patterns Moruzzi (like Sokolov) assumed that the cortex must initially analyze the stimuli and, having done so, can send down inhibitory or excitatory messages to either brain stem system.

A major concern of this investigation involves individual differences in habituation rate and more specifically how a suppressor mechanism dysfunction would effect the behaviour of the school aged child. Unfortunately much of the literature is barren with respect to such information. The following section represents a review of that literature dealing with variations in habituation rate.

Phylogenetic, Ontogenetic and Individual Differences in Habituation of the Cortical Arousal Response

According to Lynn (1966), Vedyaev and Karmanov (1958) presented visual and auditory stimuli to a variety of animals and reported that rabbits required 6-15 trials to habituate, dogs 20, and the carp 53-172.

Nikitina (1954) reported that puppies aged 3-14 days require some 200 trials to habituate to auditory stimuli, whereas puppies aged 40-60 days require only 15-20 trials. Additionally in a study involving humans, Lynn (1966) confirmed the finding that immature animals habituate slowly. In this study eight girls aged four to six years were compared with ten young women aged eighteen to twenty-one years. Using a criterion of four successive failures of reaction (employing the galvanic skin response as measurement of the dependent variable) the young adults habituated in a mean of 23 trials while all eight children failed to habituate after 60 trials, at which point the experiment was concluded.

Additionally variations in habituation rates have been reported between "normals" and various clinical populations. Kazmein and Fedorov (1951) reported that geriatric patients suffering from senile dementia were deficient in their ability to habituate. Lynn (1963) reported similar deficits in certain schizophrenics (chiefly of the paranoid variety).

The notion that young children have weak inhibitory and strong excitatory processes is widely accepted in Russia and has been argued extensively by Luria (1961). Luria maintains that the late mylenization process of the tertiary cortical areas of the prefrontal cortex is responsible for this strong excitatory process. In support of this idea, he noted that children, as compared with adults, are generally much more active, more distractible, more spontaneous, more prone to emotional outbursts, etc. (i.e. more excitatory). Luria maintains that the striking similarity between this group of behaviours and the behaviours said to be characteristic of adult patients with frontal lobe lesions is no coincidence.

Studies concerned with individual differences in the OR and in particular its habituation rate have largely been ignored by Western researchers. The research programmes of Maltzman, Raskin and their associates have been notable exceptions.

Maltzman and Raskin (1965) classified university students as high or low orienters on the basis of a physiological response to a sudden stimulus. Thus, the strength of the OR was manipulated in an attempt to discover other behavioural differences between high and low orienters. They found that subjects with high ORs tended to show better semantic conditioning of autonomic responses, more verbal awareness of the experimental contingencies, superiority in paired associate learning, and greater differential responsivity to signals. However, these experiments have little to offer vis a vis the issue of habituation.

As can be seen from the cited literature very few studies have focused on individual differences in the habituation rate of the cortical arousal response with humans. Even less is known about the potential constellations of behaviours which may be specifically affected by an inadequate ability to habituate. The early recognition of which types of behaviours are largely impaired and largely free from impairment may contribute to the early educational planning of a more adequate learning environment for "impaired" children.

With these studies as background, the preceding study was carried out.

APPENDIX B

The following is a description of the various tests used in the preceding study.

Wechsler Intelligence Scale for Children. (Wechsler, 1949)

Full Scale IQ. A composite score derived from the total scaled subtest scores. Indicative of overall "intellectual" functioning.

Verbal IQ. A composite score derived from the total scaled scores of six Verbal subtests. Indicative of overall "verbal" functioning.

Performance IQ. A composite score derived from the scaled scores of the five Performance subtests (excluding the Mazes test). Indicative of overall non-verbal, "visual-perceptual" functioning.

Verbal Subtests

Information. 30 questions. Involves elementary factual knowledge of history, geography, current events, literature, and general science. Score: number of items correct. Task Requirement: retrieval of acquired verbal information. Stimulus: spoken question of fact. Response: spoken answer.

Comprehension. 14 questions. Involves the ability to evaluate certain social and practical situations. Score: number of items correct. Task Requirement: evaluation of verbally formulated problem situations. Stimulus: spoken request for opinion. Response: spoken answer.

Arithmetic. 16 arithmetic problems of increasing difficulty. Score: number of problems correctly solved, with time credit. Task Requirement: arithmetic reasoning. Stimulus: spoken (first 13 items) or printed (last 3 items) question. Response: spoken answer.

Similarities. 16 pairs of words. The most essential semantically common characteristic of word pairs must be stated. Score: number correct. Task

Requirement: verbal abstraction. Stimulus: spoken question. Response: spoken answer.

Vocabulary. 40 words. Spoken definition of words. Score: number of words correct. Task Requirement: verbal definition. Stimulus: spoken word. Response: spoken definition.

Digit Span. Repetition in forward order of three- to nine-digit numbers and repetition in reversed order of two- to eight-digit numbers. Score: simple total of forward and reversed digit span. Task requirement: short-term memory for digits. Stimulus: spoken numbers. Response: spoken numbers.

Performance Subtests

Picture Completion. 20 pictures of familiar objects, each with a part missing. The missing part is identified from simple line drawings.

Score: number of missing parts correctly identified. Task requirement: location of missing part on the basis of memory of the whole object. Stimulus: picture. Response: spoken name of missing part.

Picture Arrangement. 11 series of picture cards. Pictures are sequentially arranged to form a story. Score: total credits for speed and accuracy of arrangement. Task Requirement: manipulation of the order of picture cards to form the most probable sequence of events. Stimulus: pictures. Response: simple motor manipulation.

Block Design. 10 designs. Arrangement of coloured blocks to form designs which match those on printed cards. Score: total score for speed and accuracy of block placement. Task requirement: arrangement of blocks to match a printed design. Stimulus: printed geometric design. Response: manipulation and arrangement of blocks.

Object Assembly. 4 formboards (puzzles). Parts of each formboard are to be arranged to form a picture. Score: total score for speed and accuracy of assembly. Task Requirement: spatial arrangement of parts to form a meaningful whole. Stimulus: disarranged parts of picture. Response: complex manipulation and arrangement of parts.

Coding. 93 digits, preceded by a code which relates digits to symbols. Symbols are to be written below digits as rapidly as possible. Score: number of symbols correctly written within a fixed time. Task requirement: association of digits and symbols by direct visual identification or by short-term memorization. Stimulus: printed digits and symbols. Response: rapid coordination of visual identification with a complex writing response.

Wide Range Achievement Test. (Jastak & Jastak, 1965)

Reading. Standardized test of oral word reading achievement. Score: centile score based on total number of words correctly read aloud. Task requirement: association of printed letters with spoken word. Stimulus: printed word. Response: spoken word.

Spelling. Standardized test of written spelling achievement. Score: centile score based on total number of words correctly spelled. Task requirement: written production of spoken word. Stimulus: spoken word. Response: written word.

Arithmetic. Standardized test of written arithmetic achievement. Score: centile score based on total number of correct solutions to progressively more difficult arithmetic problems. Task requirement: Solution of arithmetic problems. Response: written answers.

Older Children's Battery (Ages 9-15)

Tests for Sensory-Perceptual Disturbances. (Reitan, 1965)

Finger Agnosia

S is required to identify (without the aid of vision) the finger which has been touched. Each of the five fingers is stimulated four times in an unsystematic order. First the right hand and then the left hand is stimulated. The score is the number of errors made with each finger for each hand.

Finger-Tip Symbol Writing Recognition

S is required to verbalize (without the aid of vision) which of the numbers 3, 4, 5 or 6 has been written on his finger tips. A different finger of the right hand is used for each trial until four trials had been given for each finger. The procedure is then repeated for the left hand. The score is the number of errors made with each finger for each hand.

Target Test. (Reitan, 1970)

S is required to make a delayed response in reproducing visual-spatial configurations of increasing complexity tapped out by the examiner. The score is the number of items out of 20 correctly reproduced.

Halstead-Wepman Aphasia Screening Test. (Reitan & Heineman, 1968)

Naming (Dysnomia). Five items which require *S* to name familiar objects. Score: number of errors.

Spelling (Spelling Dyspraxia). *S* is required to spell orally three spoken words. Score: number of errors.

Writing (Dysgraphia). Two items. *S* is required to write a word and a sentence which are presented to him orally. Score: number of errors.

Enunciation (Dysarthria). Three items. *S* is required to repeat three increasingly complex words spoken to him by the examiner. Score: number of errors.

Reading (Dyslexia). Six items. *S* is required to read numbers, letters, and words. Score: number of errors.

Reproduction of Geometric Forms (Constructional Dyspraxia). Four items. *S* is required to copy a square, a triangle, a Greek cross, and a key. Score: number of errors.

Arithmetic (Dyscalculia). Two items. *S* is required to solve two problems: one subtraction (written) and one multiplication (oral). Score: number of errors.

Understanding Verbal Instructions (Auditory-Verbal Agnosia). Four items. *S* is required to demonstrate an understanding of four verbal items. Score: number of errors.

Seashore Rhythm Test. (Reitan & Heineman, 1968)

The Rhythm Test is a sub-test of the Seashore Tests of Musical Talent. *S* is required to differentiate between 30 pairs of rhythmic patterns which are sometimes the same and sometimes different. The score is the number of errors.

Sentence Memory. (Benton, 1965)

S is required to repeat sentences of gradually increasing length (from 1 to 26 syllables). These are presented on a tape recorder. The score is the number of sentences correctly repeated.

Finger Tapping. (Reitan, 1966)

For finger tapping *S* uses alternately the index finger of the dominant hand and of the nondominant hand. *S* is given four trials of 10 seconds each for both hands. The score for finger tapping is the average of the best three out of four trials.

Grooved Pegboard Test. (Kløve, 1963; Knights & Moule, 1968)

S is required to fit keyhole-shaped pegs into similarly shaped holes on a 4-in. x 4-in. board beginning at the left side with the right hand and at the right side with the left hand. *Ss* are urged to fit all 25 pegs in as rapidly as possible. Ss perform one trial with the dominant hand followed by one trial with the nondominant hand. The scores obtained are the length of time required to complete the task with each hand and the total number of times the pegs are dropped with each hand.

Tactual Performance Test. (Reitan, 1966)

This test is Reitan's modification for children of the test developed by Halstead (1947). Halstead's test was based in turn, upon a modification of the Sequin-Goddard formboard. S is blindfolded and not permitted to see the formboard or blocks at any time. The formboard is placed in a vertical disposition at an angle of 70 degrees on a stand situated on a table immediately in front of Ss. S is to fit six blocks into the proper spaces with the dominant hand, then with the nondominant hand, and a third time using both hands. After the board and blocks had been put out of sight, the blindfold is removed and S is required to draw a diagram of the board representing the blocks in their proper spaces. In all, six measures are obtained. S is scored for the time needed to place the blocks on the board with the dominant, the nondominant, and both hands. A fourth measure is the sum of the time taken with the right, left and both hands. The Memory component of this test is the number of blocks correctly reproduced in the drawing of the board; the Location component is the number of blocks correctly localized in the drawing.

Halstead Category Test (Reitan & Heineman, 1968)

S is required to respond to 168 visual choice stimuli, mostly geometric forms. Within any series, only one principle applies. But, in successive sequences of trials, the abstraction of principles of numerosity, oddity, spatial position, and relative extent is required for successful responding. The score is the number of errors.

Younger Children's Battery (Ages 5-8)

(A) The following tests are the same as those administered to children 9-15 years of age:

Wechsler Intelligence Scale for Children

Wide Range Achievement Test

The finger agnosia test of sensory-perceptual disturbance

Target Test

Seashore Thythm Test

Sentence Memory

Finger Tapping

(B) The following tests differ somewhat from those administered to children 9-15 years of age:

Finger-Tip Symbol Writing Recognition. The procedure is identical to that described above, except that Xs and Os are used instead of numbers.

Halstead-Wepman Aphasia Screening Test. (Reitan & Heineman, 1968)

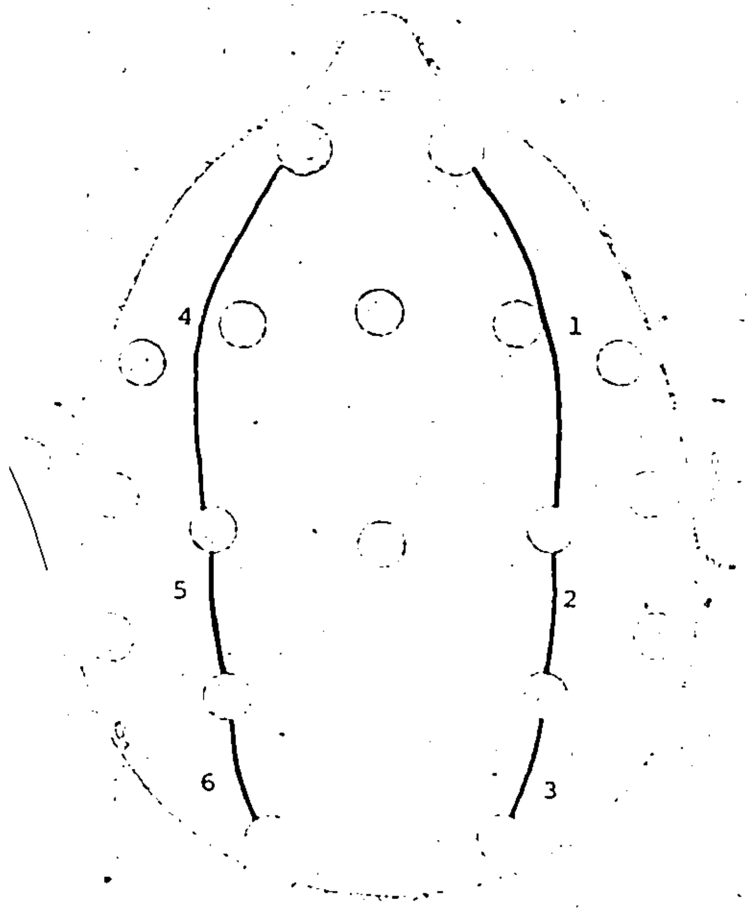
Naming	(Anomia). 4 items. Otherwise, the same.
Writing	(Dysgraphia). 1 item written, 1 item printed. Otherwise the same.
Reading	(Dyslexia). 3 items. Otherwise the same.
Drawing	(Constructional Dyspraxia). 3 items. Otherwise the same.
Arithmetic	(Dyscalculia). 4 items. Otherwise the same.

Pegs. The procedure is identical to that described above except that only the first two rows (ten holes) are used.

Tactual Performance Test. The procedure is identical to that described above except that the formboard is placed in a horizontal rather than a vertical position.

Category Test. The Category Test utilizes the same general appartus and procedure as the Halstead Category Test. The test consists of 80 stimulus figures which are presented to S individually on a milk-glass screen located on the front of the apparatus. An answer panel is provided for S. This consists of four answer buttons which are individually identified by red, blue, yellow, and green lights. S's task is to view the stimulus-figure and to offer his answer by depressing one of the four buttons. The test consists of five subtests in each of which S has the task of attempting to discern an underlying principle as a guide for his answers. The test was developed in such a way that it uses essentially the same principles as were used in the versions of the test for older children and adults. For example, the first group of items, instead of requiring S to match numbers, requires S to match colours. If a red figure appears on the screen, then S's task is to respond by depressing the "red" answer button. The second group of items in the test relates to a quantity concept, much as in the versions for older children and adults. The task for items in this group is to discern the predominant colour on the screen in terms of area and to respond on that basis. Therefore, if a large red square and a small blue square appear in a particular item, the correct response would be to depress the "red" answer button. The third principle is based on a concept of uniqueness or oddity. The task is to respond to the figure in each item which is different in one characteristic or another from the others. Thus, if an item consists of four squares in which three are the same size but the red square is larger than the others, the correct answer would be the "red" answer button. The fourth group of items requires the subject to respond to the colour that is less prominently displayed than the others. For example, if a figure is represented by equal parts of the three colours, green, yellow, and blue, but by a lesser part of the colour is red, the correct response would be the "red" answer button. S is never told the principle that is involved in any of these subtests but instead must develop an understanding of this for himself in accordance with the information provided following each of his responses. This information, communicated in the instructions to S, is that a pleasant bell sounds after each correct response and a harsh buzzer sounds after each incorrect response. The bell and buzzer, therefore, provide the essential information necessary for discerning the concept underlying the stimulus figures. The final subtest of the Category Test is summarical in nature and therefore does not have a principle to be discerned. S is told that he should try to remember the correct answer based on his previous observation of the item and to give that same answer again.

APPENDIX C



The diagram depicts the international 10-20 system for EEG electrode placement. The electrodes joined by lines were those activated for this study and the numbers to the side of these lines correspond to the EEG Channels used for the recordings.

VITA AUCTORIS

1945	Born in Sydney, Nova Scotia, to George and Winnifred MacDonald.
1951-1965	Educated at Constantine School, Park Junior High School, Sydney Academy, and St. Francis Xavier University (Sydney Campus), Sydney, Nova Scotia.
1967	Graduated with the degree of B. A., Major in Psychology (Magna Cum Laude), St. Francis Xavier University, Antigonish, Nova Scotia.
1969	Graduated with the degree of M. A. (Psychology), University of Windsor, Windsor, Ontario.
1969	Registered as a full-time doctoral student at the University of Windsor.
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