STANFORD RESEARCH INSTITUTE
Menlo Park, California 94025 · U.S.A.

24 April 1974

Progress Report No. 2
Covering the Period 1 March to 1 April 1974
Stanford Research Institute Project 3183

not so

PERCEPTUAL AUGMENTATION TECHNIQUES

SG1I

Still no breakdown on the "Applied" vs "Basic" categories and, with respect to the latter, no mention of:
(1) neurophys. testing other than ORNSTEIN + split-brain
(2) in-depth interviews
(3) non-REITAN psych testing (projectives, etc)

by

Harold E. Puthoff

Client Private

I OBJECTIVE

The purpose of the program is to determine the characteristics of those perceptual modalities through which individuals obtain information about their environment, wherein such information is not presented to any known sense.

The program is divided into two categories of investigation of approximately equal effort, applied research and basic research. The purpose of the applied research effort is to explore experimentally the potential for applications of perceptual abilities of interest, with special attention given to accuracy and reliability. The purpose of the basic research effort is to identify the characteristics of individuals possessing such abilities, and to identify neurophysiological correlates and basic mechanisms involved in such functioning.

II PROGRESS DURING THE REPORTING PERIOD

All by Super Star?

A. Applied Research

1. Remote Viewing

(a) Local Targets

An experiment is continuing in which ten sites known to the subject are being visited in random sequence, with replacement, by a target demarcation team. A comparison is to be made as to hit accuracy under conditions of (1) identifying the site by name and, (2) identifying the site by photographs.

Junk!

Trivial - even if demonstrated

(b) Remote Targets

In conjunction with a vacation trip by one of the experimenters (H.P.) to Costa Rica, a week of remote target viewing will be carried out at 1330 local time (1430 Costa Rica time). Pictures of the target locations are to be taken. Upon return and development of the pictures, the subject will be asked to match target pictures with narratives, as will the experimenter, both in blind fashion.

What is application

2. Detection of Variable Density Target Material

An initial experiment with twenty-seven sponsor drawings of variable content and density was completed. The goal was the differentiation of twelve low-density cards, six pencil, and nine blank cards. The numbered envelopes containing the target material, sealed and specially secured by the sponsor, were randomized before each trial and placed inside non-numbered opaque envelopes before being presented to the subject for sorting.

Two series were carried out. The first consisted of 24 runs through the 27 cards, choosing 12 cards each run, the goal being to choose the 12 low-density cards. Out of the 12 x 24 = 288 choices, the expected number of target cards by chance was 128, the observed number chosen, 133. The second series consisted of 18 runs through the 27 cards, choosing 6 cards each run, the goal being to choose the 6 pencil cards. Out of the 6 x 18 = 108 choices, the expected number of target cards by chance was 24, the observed number chosen, 19. Thus, the overall result given the task did not differ significantly from chance.

However, when we examine the ranking of cards by number of times chosen, we observe a significant skew in the distribution. Independent of the assigned task, in the 24-run series of 12 choices each, the expected number of times a given card is chosen is 11.

what was distribution. Not tacks to begin with!

In the 18 run series of 6 choices each, the expected number of times a given card is chosen is 4. In the two series, of the 17 cards chosen more often than expected by chance, the expected number of low density cards is 7.5, the observed number 13, a result significant at the $p = 2 \times 10^{-3}$ level. Thus, in the overall distribution certain of the low-density cards were chosen often enough to yield a significant result in the ranking distribution.

I'd be astonished if this were replicable

It is considered that the initial experiment was unnecessarily complex, there being a mixture of target sizes (2), symbols (3), and ink techniques (3). New experiments are to be carried out to clarify whether a usable talent exists in this area.

B. Basic Research

1. Testing Program

(a) Psychological Testing

Arrangements have been made with Dr. Donald Lim of the Palo Alto Veteran's Administration Hospital for the administration of the Halstead-Reitan neuropsychology test battery. Dr. Lim is experienced in the administration of the battery and has personally consulted with Dr. Reitan on testing procedures and interpretation.

What are the hypotheses?!

In connection with testing hypotheses associated with hemispheric specialization of the brain, Dr. Robert Ornstein of the Langley Porter Neuropsychiatric Institute, University of California, San Francisco, has agreed to administer tests appropriate to testing hemispheric predisposition.

(b) Medical Testing

The physical characteristics part of the program will be administered by the Environmental Medicine facility of the Palo Alto

Medical Clinic. The basic physical includes urinalysis, bloodwork (hemoglobin, STS, CBC, blood pressure pulse), hearing tests (frequency and intensity), eye tests (depth perception, color vision, far and near vision, peripheral vision), pulmonary function test, EKG, tonometry, height, weight, and a physical examination. A consultation appointment has been set up to explore further testing for special areas beyond the basic physical. — Neurological?

2. Measurement Program

(a) EEG Experiment

How did this get included?

A variety of evidence from clinical and neurosurgical sources indicates that the two hemispheres of the human brain are specialized for different cognitive functions. The left hemisphere is predominantly involved in verbal and other analytic functioning, the right in spatial and other holistic processing. (See Appendix.)[1]

In consultation with Dr. Robert Ornstein of the Langley Porter Neuropsychiatric Institute, an hypothesis was formed based on certain observed characteristics that paranormal functioning might involve right hemispheric specialization. To test this hypothesis, the EEG remote strobeflash experiment described in Report No. 1 was repeated three times with monitoring of right and left occipital regions. Each experiment consisted of 20 15-second trials, 10 no-flash trials, and 10 16 Hz trials randomly intermixed. Reduction of alpha activity (arousal response) correlated with remote stimuli was observed as in previous experiments, but essentially only in the right hemisphere (average alpha reduction 16 percent in right hemisphere, 2 percent in left, during the 16 Hz trials as compared with the no-flash trials). Such results indicate initial support for the hypothesis of right hemispheric specialization, and therefore further investigation of right hemisphere specialization seems indicated.

(b) Physical Measurements

A meeting was held with Mr. Stacy Luke of the client's organization in which it was agreed that an experiment shall be carried out utilizing the client's Josephson junction gradiometer. Alternate SRI locations were examined and a suitable one chosen. The purpose of the experiment is (1) to determine whether magnetic field gradients can be established on command by the subject, and, if so, (2) to investigate such effects under conditions of viewing the probe from remote locations, and, if the latter is positive, to examine the effect as a function of subject-probe distance.

And to rule out identifiable magnetic field changes from remote viewing or other paranormal activity

Two additional sensitive instruments are being set up as remote probes. One is a radiation probe box which includes a photo-multiplier and geiger counter. The other is a mechanical force indicator consisting of a torsion pendulum suspended on a metal fiber, enclosed in a bell jar, and monitored by a laser beam reflected from a mirror on the pendulum to a beam-position detector. Baseline data are being taken for these instruments, and experimentation will proceed during April.

This is all related to magnetic distortions being produced by the scientists. How about the reverse eg detection while they are ostensibly doing something correlated with another's EEG's for example.

Reference 1: "Hemispheric Specialization and the Duality of Consciousness," David Galin, M.D. and Robert E. Ornstein, Ph.D., in press in: Widroe, Harvey, M.D., ed. Human Behavior and Brain Function, Published by Charles C. Thomas, Springfield, Illinois, 1973.

APPENDIX

Hemispheric Specialization and the Duality of Consciousness

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University of California, San Francisco

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Hemispheric Specialization and the Duality of Consciousness

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A variety of evidence from clinical and neurosurgical sources indicates that the two hemispheres of the human brain are specialized for different cognitive functions. This evidence has been confirmed in studies of normal subjects. The left hemisphere is predominantly involved in verbal and other analytic functions, the right in spatial and other holistic processing.

The two hemispheres have been surgically separated for the treatment of certain cases of epilepsy; after the operation, it has been found that each hemisphere is conscious, and can carry out complex cognitive processes of the type for which it is specialized. In short, there appear to be two separate, conscious minds in one head. The study of how these two half-brains cooperate or interfere with each other in normal, intact people has just begun. We believe that this work has important implications for psychiatric theory and practice, and education, as well as for clinical neurology.

In our laboratory at Langley Porter we have been studying this lateralization of function with EEG techniques. With the method which we have developed we can distinguish between these two cognitive modes as they occur in normal subjects, using simple scalp recordings.

We will review some of the experiments and clinical observations on this duality in human nature, and mention some of the opportunities for future research that seem to us most promising.

1. Specialization of the two Hemispheres - "Split-Brain" studies:

The asymmetrical localization of cognitive function has long been established. Language was ascribed to the left hemisphere by Dax in 1836 (Benton & Joynt, 1960). Since then clinical work with brain damaged patients has continued to differentiate the cognitive functions of the hemispheres (Semmes et al., 1955, Milner, 1965a, Luria, 1966, Corkin, 1965). For example right temporal lobectomy produces a severe impairment on visual and tactile mazes. In contrast left temporal lobectomy of equal extent produces little deficit on these tasks but impairs verbal memory (Milner, 1965a, Corkin, 1965). In general, clinical work has found verbal and arithmetical functions (analytic, linear) depend on the left hemisphere while spatial relationships (holistic, gestalt) are the special province of the right hemisphere. Sperry, Gazzaniga, Bogen and their associates (1969, Levy, 1970, Bogen, 1969) have had a unique opportunity to study the specialization of the two halves of the brain isolated from each other. They worked with patients who had undergone surgical section of the corpus callosum for the treatment of epilepsy. These "split brain" patients were tested with special apparatus to insure that the task was presented to only one hemisphere at a time. Sperry, Gazzaniga and Bogen have been able to establish that each hemisphere can function independently and is independently conscious. Learning and memory are found to continue separately in each hemisphere. The right hand literally does not know what the left hand is doing. Both halves independently sense, perceive and conceptualize. Unilateral associations between tactual, visual and auditory sensations remain. In these patients, the left hemisphere is capable of speech, writing and mathematical calculation, and is severely limited in problems involving spatial relations. The right hemisphere has use of only a few words and can perform simple addition only up to ten, but can perform tasks involving spatial relationships and music patterns.

It is important to emphasize that what most characterizes the hemispheres is not that they are specialized to work with different types of material, (the left with words and the right with spatial forms); rather each hemisphere is specialized for a different cognitive style; the left for an analytic, logical mode for which words are an excellent tool, and the right for a holistic, gestalt mode, which happens to be particularly suitable for spatial relations, and music. The difference in cognitive style is explicitly described in a recent paper by Levy, Trevarthen, and Sperry, 1972 :

> "Recent commissurotomy studies have shown that the two disconnected hemispheres, working on the same task, may process the same sensory information in distinctly different ways, and that the two modes of mental operation involving spatial synthesis for the right and temporal analysis for the left, show indications of mutual antagonism (Levy, 1970). The propensity of the language hemisphere to note

analytical details in a way that facilitates their description in language seems to interfere with the perception of an over-all Gestalt, leaving the left hemisphere 'unable to see the wood for the trees.' This interference effect suggested a rationale for the evolution of lateral specialization..." (Levy, et al., 1972) (See also Nebes, 1971, Semmes, 1968).

Sperry and his collaborators have found that "in general, the post-operative behavior of (the commissurotomy patients) has been dominated by the major (left) hemisphere..." except in tasks for which the right hemisphere is particularly specialized. (Levy, et al., 1972).

To understand the method of testing and interviewing each half of the brain separately, two points of functional anatomy must be kept in mind. The first is that since language functions (speech, writing) are mediated predominantly by the left hemisphere in most people, the disconnected right hemisphere cannot express itself verbally. The second point is that the neural pathways carrying information from one side of the body and one-half of the visual field cross over and connect only with the opposite side of the brain. This means that sensations in the right hand and images in the right visual space will be projected almost entirely to the <u>left</u> hemisphere. Similarly, the major motor output is crossed, and the left hemisphere mainly controls the movements of the right hand. Therefore, patients with the corpus callosum sectioned can describe or answer questions about objects placed in their right hands, or pictures flashed to the right visual field with a tachistoscope, but can give no correct verbal response when the information is presented to the left hand or the left visual field (they will in fact, often confabulate). The mute right hemisphere can, however, indicate its experience with the left hand, for example, by selecting the proper object from an array.

2. Dissociation of Experience:

The dissociation between the experiences of the two disconnected hemispheres is sometimes very dramatic. A film made by Sperry and his colleagues shows two illustrative incidents.

The film shows a young female patient being tested with a tachistoscope as described above. In the series of neutral geometrical figures being presented at random to the right and left fields, a nude pin-up was included and flashed to the right (nonverbal) hemisphere. The girl blushed and giggled. Sperry asked "What did you see?" She answered "Nothing, just a flash of light," and giggled again, covering her mouth with her hand. "Why are you laughing then?" asks Sperry, and she laughs again and says, "Oh, Dr. Sperry, you have some machine!" The episode is very dramatic, and if one did not know her neurosurgical history one might have seen this as a clear example of perceptual defense: one might infer that she was repressing the perception of the conflictful sexual material--even her final response (a socially acceptable nonsequitur) was convincing (see also Sperry, Am. Psychol, 1968, 23:723-33, esp. p. 732).

In another section of the film a different patient is performing a block design task; he is trying to match a colored geometric design with a set of painted blocks. The film shows the left hand (right hemisphere) quickly carrying out the task. Then the experimenter disarranges the blocks and the right hand (left hemisphere) is given the task; slowly and with great apparent indecision it arranges the pieces. In trying to match a corner of the design the right hand corrects one of the blocks, and then shifts it again, apparently not realizing it was correct: the viewer sees the left hand dart out, grab the block to restore it to the correct position--and then the arm of the experimenter reaches over and pulls the intruding left hand off-camera.

3. Psychiatric Implications:

There is a compelling formal similarity between these dissociation phenomena seen in the commissurotomy patients and the phenomena of repression; according to Freud's early "topographical" model of the mind, repressed mental contents functioned in a separate realm, which was inaccessible to conscious recall or verbal interrogation, functioning according to its own rules, developing and pursuing its own goals, affecting the viscera and insinuating itself in the stream of ongoing consciously directed behavior.

This parallel suggests that we examine the hypothesis that in normal, intact people mental events in the right hemisphere can become disconnected functionally from the left hemisphere (by inhibition of neuronal transmission across the corpus callosum and other cerebral commissures), and can continue a life of their own. This hypothesis suggests a neurophysiological mechanism for at least some cases of repression, and an anatomical locus for the unconscious mental contents.

What are the circumstances under which such a dissociation could take place? There are several ways in which the two hemispheres of an ordinary person could begin to function as if they had been surgically disconnected, and cease exchanging information. The first way is by active inhibition of information transfer because of conflict. Imagine the effect on a child when his mother presents one message verbally, but quite another with her facial expression and body language; "I am doing it because I love you, dear", say the words, but "I hate you and will destroy you" says the face. Each hemisphere is exposed to the same sensory input, but because of their relative specializations, they each emphasize only one of the messages. The left will attend to the verbal cues because it cannot extract information from the facial gestalt efficiently; the right will attend preferentially to the non-verbal cues because it cannot easily understand the words (Levy et al., 1972). Effectively a different input has been delivered to each hemisphere, just as in the laboratory experiments in which a tachistoscope is used to present different pictures to the left and right visual fields. We offer the following conjecture: In this situation the two hemispheres might decide on opposite courses of action; the left to approach, and the right to flee. Because of the high stakes involved each hemisphere might be able to maintain its consciousness and resist the inhibitory influence of the other side. The left hemisphere seems to win control of the output channels most of the time (Sperry, 1968), but if the left is not able to "turn off" the right completely it may settle for disconnecting the transfer of the conflicting information from the other side. The connections between hemispheres are relatively weak compared to the connections within hemispheres(Bogen 1969) and it seems likely that each hemisphere treats the weak contralateral input in the same way in which people in general treat the odd discrepant observation which does not fit with the mass of their beliefs; first we ignore it, and then if it is insistent, we actively avoid it (Stent, 1972).

The mental process in the right hemisphere, cut off in this way from the left hemisphere consciousness which is directing overt behavior, may nevertheless continue a life of its own. The memory of the situation, the emotional concommitants, and the frustrated plan of action all may persist, affecting subsequent perception and forming the basis for expectations and evaluations of future input.

But active inhibition arising from conflicting goals is not the only way to account for a lack of communication between the two hemispheres, and a consequent divergence of consciousness. In the simplest case, because of their special modes of organization and special areas of competence, the knowledge which one hemisphere possesses may not translate well into the language of the other. For example, the experience of attending a symphony concert is not readily expressed in words, and the concept "Democracy requires informed participation" is hard to convey in images. What may be transmitted in such cases may be the conclusion as to action, and not the details on which the evaluation was based. It is possible to convey some of the richness of the holistic consciousness in words, but it requires a great artist.

4. Neo-Phrenology:

It is not clear to what extent specific cognitive performances can be said to depend on specific areas of the cerebrum, beyond the gross distinction between left and right hemispheres. Without going too far in the direction of assigning "centers" to each mental quality in the manner of the phrenologists, there seems to be some evidence for within-hemisphere localization. For example, Milner (1965b) has correlated disorders in specific kinds of language processing with lesions in specific areas of the left hemisphere; verbal memory deficits with anterior temporal lesions, speech deficits with posterior temporal lesions, fluency deficits with frontal lesions and reading deficits with lesions in the region of the parieto-occipital junction.

The difficulties inherent in "localizing" complex functions are exemplified in the conflicting literature on the lateralization of arithmetic calculation. Luria finds "primary acalculia" or primary arithmetical disturbances with lesions of the left infero-parietal lobe (Luria, 1966), but Kinsbourne finds no systematic lateralization for arithmetic (1972).

The problem is complex, according to Critchley (1953) because calculation may entail more than one type of mentation and different people seem to employ different methods. Lesions in different areas would be expected to produce dyscalculia insofar as a person depended on the use of specific visual symbols or notation, or on rote memory (e.g. multiplication tables) or on an ideokinetic factor based on concrete manipulation such as counting on fingers. The horizontal and vertical arrangement of numbers to represent units, tens, hundreds, etc., depends on spatial and constructional factors. Vivid imagery for numerical forms and sequences may be important to some people (Humphrey and Zangwill, 1952). Critchley concludes, "Nonetheless, there are certain 'vulnerable' regions of the brain, wherein a lesion is more apt to be followed by a severe dyscalculia bearing certain clinical hallmarks. Thus disease of the dominant left hemisphere is more often followed by severe disorders of calculation." (Critchley, 1953)

5. <u>Evidence for Lateral Specialization in Normal People:</u>

Some caution should be exercised in making the inference of lateral specialization of cognitive function in normal people from lesion studies alone. One might consider whether the 'split' functions are due in some part to the radical surgery, or to the other disturbances in these patients. The study of neurological disorders or surgical preparations cast light on normal functioning, but the most important and most practical question is whether the normal brain, engaged in everyday activities is organized around lateralization of cognitive function.

Recent research with normal subjects provides support for the inference that the intact brain does in fact make use of lateral specialization. With normal subjects, Filbey and Gazzaniga have measured the time required for information presented to one hemisphere to be acted upon by the other. A verbal reaction to information presented to the non-verbal right hemisphere took longer than a non-verbal response. (Filbey and Gazzaniga, 1969). McKeever found faster tachistoscopic word recognition for words projected to the left hemisphere than to the right (McKeever and Huling, 1970). In dichotic listening tasks, normal subjects have better recall for verbal material presented to the right than to the left ear and better recall for melodies presented to the left. (Kimura, 1961).

Other laboratories have used electrophysiological techniques such as evoked potentials and DC potentials. Buchsbaum recorded averaged visual evoked potentials from the left and right occipital areas in response to words and geometric stimuli (Buchsbaum and Fedio, 1969). The responses to these two classes of stimuli were the same in the right hemisphere, but different in the left hemisphere. Wood et al.(1971) found similar results with auditory stimuli; subjects listened to verbal stimuli under two conditions; to process them for speech cues (stop consonants) and for non-speech cues (pitch). The evoked responses were the same in the right hemisphere, but different in the left hemisphere.

Morrell and Salamy (1971) reported that evoked potentials to speech sounds were larger in the left hemisphere leads than in the right, and Vella et al. (1972) reported that responses to complex visual forms were larger in the right. McAdam and Whitaker recorded DC potentials over the left and right fronto-temporal areas. Just before subjects spoke, a negative shift appeared, more pronounced on the left than on the right. No shift was seen preceding non-verbal vocal tract activities (voluntary coughing, spitting) (McAdam and Whitaker, 1971).

In the past three years we have applied EEG methods to the study of this lateral specialization in normal people. By studying EEG asymmetry we were able to distinguish the two cognitive modes as they occur in normal subjects using simple scalp recording (Galin and Ornstein, 1972). In brief, we examined the EEGs of subjects performing verbal and spatial tasks to determine whether there were differences in activity between the appropriate and inappropriate hemispheres. We recorded from the temporal and parietal areas since clinico-anatomical evidence indicates that these areas should be differently engaged in these tasks. We found that during verbal tasks the integrated whole-band power in the left hemisphere is less than that in the right, and during spatial tasks the integrated power in the right hemisphere is less than in the left. Most of the task-dependent asymmetry appeared to be in the alpha band. Our method of analyzing the ratios of right to left EEG power was adopted by McKee, Humphrey and McAdam (1973) in a study contrasting musical and verbal processing. They confirm our general finding that the ratio is higher in the verbal tasks compared to the non-verbal task.

Table 1 summarizes some of the results from two of our experiments. The average alpha ratios (right/left) were computed for temporal, parietal, and central recordings during verbal and spatial tasks intended to engage primarily the left or the right hemisphere. Spatial tasks included building geometric designs from memory with blocks, mirror drawing and a mental Form Board task. Verbal tasks included composing a letter mentally and in writing, and memorizing and writing the main facts from a text passage. The task pairs which were selected differ in their requirement for motor output, and for memory. The attention-to-breathing task was included as a "neutral" non-cognitive condition. (For further details of the methods and results of Experiment I, see Galin and Ornstein, 1972, Doyle, Ornstein and Galin, 1973).

TABLE I Inter- and Intra-hemispheric Specialization for Cognitive Mode: Differences between Electrode Locations - Alpha ratios*

Experiment I

N=10	Motor tasks: Blocks	Motor tasks: Written Letter	p	Mental tasks: Form Board	Mental tasks: Mental Letter	p	"Non-cognitive": Attention to-Breath
P4/P3	0.97	1.09	.01	0.81	0.98	ns	0.94
T4/T3	0.68	1.06	.01	0.79	1.06	.05	0.87

Experiment II

N=35	Memory tasks: Blocks	Memory tasks: Write from Memory	p	Non-memory tasks: Mirror Drawing	Non-memory tasks: Text Copying	p	"Non-cognitive": Attention to-Breath
P4/P3	0.99	1.19	.0003	1.01	1.07	.04	1.20
T4/T3	0.77	1.12	.00003	0.75	0.94	.0004	0.88
C4/C3	0.79	1.17	.0003	0.83	1.03	.0006	0.97

* Geometric means over all subjects of EEG power ratios (right/left)

** Significance of differences tested by Wilcoxon Matched-Pair Signed-Ranks Test, all P values two-tailed, ns = .05.

Fig. 1 shows a sample from the EEG from one subject during the Blocks and Written Letter tasks. Fig. 2 shows the results of frequency spectrum analysis of the EEG from which Fig. 1 was taken.

Insert Figures 1 and 2 about here

The second experiment confirms the main effect found in the first; higher ratios are found during verbal tasks than during spatial tasks. All three lead pairs show the task-dependent asymmetry in both comparisons (Blocks vs. Write-from-Memory, and Text Copying vs. Mirror Drawing).

There are systematic differences between the leads. The parietal leads, in all comparisons, in both experiments, exhibit the least task-dependent asymmetry, i.e. the difference in alpha ratio on the verbal task and the spatial task is smaller on the parietal leads than on the temporal and central leads. The temporal and central leads appear to behave similarly in this respect.

The Attention-to-Breath task most closely approximates the conditions under which clinical EEGs are recorded; i.e. little information processing, passive, unstructured. Clinical EEG texts generally state that alpha amplitude is normally higher on the right than the left. We find this to be so for the parietal leads, but consistently reversed for the temporal leads. Table II shows the results from the Breathing task of Experiment II. Most subjects have predominant right parietal alpha and predominant left temporal alpha. The central leads show an equal distribution. This reversal between parietal and temporal alpha predominance can also be seen during the active cognitive tasks. (Table 1, all tasks except Mental Letter)

TABLE II

Differences between electrode locations in "resting" alpha asymmetry

	Parietal	Temporal	Central
Higher Right Alpha	27	9	16
Higher Left Alpha	6	24	15

The functional significance of this reversal of asymmetry is not yet clear, but it precludes classifying a person simply as "right dominant" or "left dominant"; intrahemispheric specialization must be taken into account.

Previous investigators have sought to relate electrophysiological recordings to cognitive functions. A major effort has been devoted to relating the EEG to "intelligence" (see review by Vogel, et al., 1968). Our approach to this problem takes into account three factors which seem to have been neglected in the past:

1. Recording while the subject is engaged in a task, rather than trying to relate a "resting" EEG or averaged evoked potential to subsequent performance.

2. Selection of cognitive tasks which clinical evidence has shown to depend more on one hemisphere than the other, and which therefore should be associated with a predictable distribution of brain activity.

3. Selection of electrode placements on clinico-anatomical grounds. A wealth of evidence suggests that temporal and parietal leads should be the

most functionally asymmetrical, and occipital leads the most similar. Unfortunately, occipital leads have been used most often in the past, probably because they are not as sensitive to eye movement and muscle artifacts. Usually recordings have been made only unilaterally.

Now that we have established a method for determining lateralization of cognitive function in normal Ss, several major areas of concern can be studied: the generality of lateral specialization of cognitive function in the population, the role of lateral specialization in critical academic skills, the effect of social drugs on hemispheric interaction, and the possibility of training voluntary control over patterns of lateral asymmetry using the feedback EEG.

6. Lateralization in Left Handed and Ambidexterous People:

The lateralization of cognitive functions described above is characteristic of right handed people. The cerebral lateralization of left handed people is more complex. Hecaen (1964,1971) has provided an extensive review of the neurological literature and a summary of his own clinical studies, and concluded that left handers show a greater cerebral ambi-laterality, not only for language, but also for gnosic and praxic functions. Hecaen distinguishes between left handedness which is familial and that which follows a perinatal injury to the left hemisphere. The familial type may or may not have reversed language lateralization.

These conclusions were generally confirmed by Satz et al. (1967) in a study of a neurologically normal population. They used the dichotic listening test to assess language lateralization and carefully tested manual superiority rather than relying on the subjects' self-classification as to handedness.

Following the hypothesis of Orton that stuttering and dyslexia can be due to poorly established cerebral specialization, many studies have found high incidences of left handers and ambidexterous people among these clinical groups. Hecaen (1964) concludes that while no convincing direct relation has been demonstrated, "disorders of laterality can play a part in a certain number of these cases."

The nature of these "disorders of laterality" is not clear. To our knowledge there have been no attempts to quantitatively evaluate the interaction between the verbal-analytic and spatial-holistic cognitive systems in normal daily activities. Our opinion is that in many ordinary activities normal people simply alternate between cognitive modes rather than integrating them. These modes compliment each other but do not readily substitute for each other. Although it is <u>possible</u> to process complex spatial relationships in words, it would seem much more efficient to use visual-kinesthetic images. For example, consider what most people do when asked to describe a spiral staircase; they begin using words, but quickly fall back on gesturing with a finger.

Processing in the inappropriate cognitive system may not only be inefficient; it may actually interfere with processing in the appropriate system. This 'interference hypothesis' is supported by a study of left-handed subjects who were presumed to have bilateral language representation (Levy, 1969). Levy compared left-handed and right-handed subjects with equal WAIS verbal scores and found that the left handers had significantly lower performance scores, which she attributed to interference from the presumed ambilaterality of language. Her observation has been confirmed by Miller (1971). Similarly, in a group of patients in whom right-hemisphere language was demonstrated with carotid amytal, Lansdell(1969) found a negative correlation between language ability and spatial performance scores. Brooks (1970) presents additional support for the hypothesis of "interhemispheric interference". Reading a description of spatial relations interferes with the subsequent manipulation of those spatial relations. DenHyer and Barrett (1971) demonstrated selective loss of spatial and verbal information in short term memory by means of spatial and verbal interpolated tasks. Levy has in fact suggested that verbal and non-verbal functions evolved in opposite hemispheres to reduce interference of one system with the other (Levy, 1969).

This evidence of interference between the right and left cognitive modes provides a new kind of support for the hypothesis of Orton, that lack of cerebral lateral specialization plays a major role in dyslexia and stuttering. This hypothesis has continued to sustain interest, in spite of a lack of convincing direct evidence. Until recently, the only generally available index of cerebral lateralization was handedness, and people with little hand preference, or left handers who were "switched" or those with mixed hand and eye preference were considered to be "high risk". The incidence of such people in clinical categories such as stuttering, dyslexia, and specific learning disability is usually found to be higher than in the normal population.

Our EEG method for studying lateralization of cognitive function, along with the dichotic listening test, can provide a much more direct and presumably more sensitive means for investigating disorders of laterality than measures based on hand, eye, or foot dominance. Our present proposal to extend our measures to left handed and ambidexterous populations will lay the groundwork for these clinical studies.

7. Biofeedback Training for Voluntary Control of EEG Asymmetry:

Our research has demonstrated characteristic patterns of activity and inactivity for both the verbal and the spatial cognitive modes. It is reasonable to suppose that more selective inhibition and facilitation of each hemisphere can improve performance. It has been shown in many laboratories that, when subjects are given exteroceptive feedback on the state of a physiological variable, they can learn control of the variable, e.g. EEG alpha, heart rate, EMG (Nowlis and Kamiya, 1970; Budzynski, Stoyva and Adler, 1970; Hnatiow and Lang, 1965). For example, O'Malley and Conners (1972) have reported a pilot case of a dyslexic boy who was given lateralized alpha feedback training, and showed significant changes in EEG asymmetry. Therefore, with the aid of feedback from our electrophysiological index of cognitive mode, subjects may be able to learn to reduce the interference between hemispheres, and thereby improve cognitive performance.

8. Implications for Education:

Our EEG and eye movement studies (Kocel et al., 1972; Galin & Ornstein, 1973) provide potential methods of assessing an individual's preferred cognitive mode. An individual's preferred cognitive style may facilitate his learning of one type of subject matter, e.g., spatial, relational, and hamper the learning of another type, e.g., verbal analytical. A student's difficulty with one part of a curriculum may arise from his inability to change to the cognitive mode appropriate to the work he is doing.

Studies by Cohen (1969), Marsh _et al_. (1970), and by Bogen _et al_. (1972), have indicated that subcultures within the United States are characterized by a predominant cognitive mode: the middle class is likely to use the verbal-analytic mode; the urban poor is more likely to use the spatial-holistic mode. This results in a cultural conflict of cognitive style and may in part explain the difficulties of the urban poor children in the school system oriented toward the middle class. There seems to be a new recognition among educators of the importance of both modes of experiencing the world (J. Bruner, _On Knowing; Essays for the Left Hand_, 1965). Many new programs (e.g., Sesame Street) emphasize helping verbal-analytically oriented children to develop holistic mode skills as well as helping holistically-oriented children to make use of the traditional verbal-analytic materials. If our project is successful, it may make it feasible to train an individual child to enter both cognitive modes appropriately. With EEG feedback an individual may be able to learn to sustain a pattern of brain activity and the concommitant cognitive mode which is appropriate to reading and arithmetic on the one hand and painting and construction on the other.

Our approach may also be of use in the study of cognitive development. Since brain injuries before the age of 12 rarely result in permanent aphasia, it is reasonable to suppose that the lateralization of cognitive function is still in flux in young children after the acquisition of speech and even after the acquisition of written language. The maturation of the child's cognitive power may be paralleled by, and perhaps even depend upon, increasing lateral specialization with a resulting decrease in interference between cognitive systems. Our EEG measures of cognitive functioning could be powerful tools for mapping the course of this growth. These measures could be used in diagnosing aberrations in cognitive development. For example, certain forms of dyslexia may be caused by interhemispheric interference. Perhaps "feedback" training to improve selective inhibition of the inappropriate cognitive mode would prove useful in therapy.

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Figure Legends

Figure 1. Change in EEG asymmetry during the Blocks and Written Letter Tasks: P_3 = left parietal, P_4 = right parietal, T_3 = left temporal, T_4 = right temporal. The ratio of power in homologous leads T_4/T_3 and P_4/P_3 is greater on the spatial task than on the verbal task.

"Reprinted from Galin and Ornstein, 1972."

Figure 2. Sample Fourier power spectra for Blocks and Written Letter tasks. For each lead EEG power is plotted versus frequency in 1 Hz intervals from 1-29 Hz; the last point on each plot is an average for frequencies 30-64 Hz. The ordinate is scaled in arbitrary units in which a 10 Hz sine wave of 80 microvolts p-p corresponds to 80,000 units. The ratio of alpha-band power from homologous leads T_4/T_3 and P_4/P_3 is greater on the Blocks task than on the Written Letter task. These spectra correspond to the sample EEG tracings shown in Figure 1.

"Reprinted from Doyle, Ornstein and Galin, 1973."

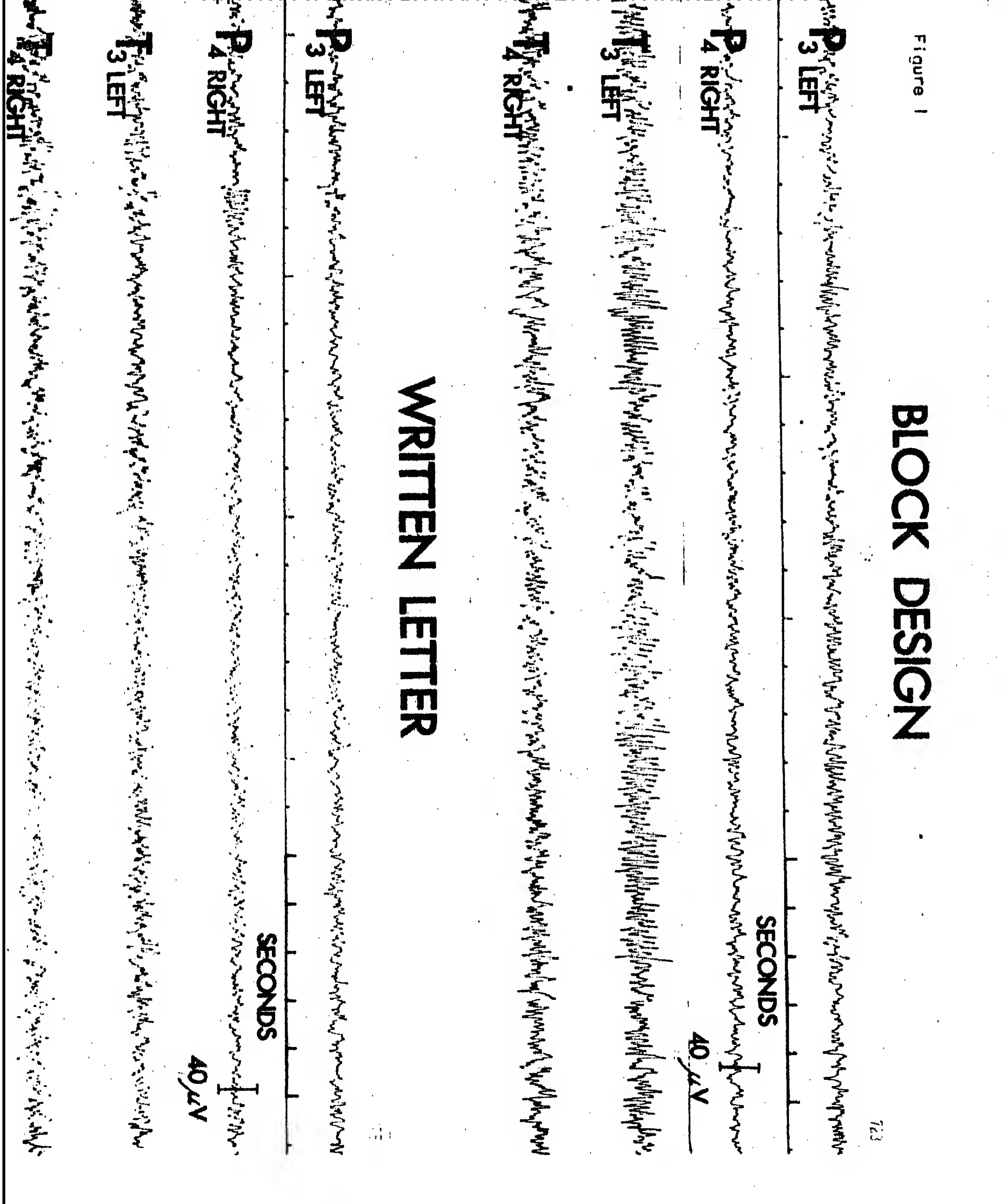
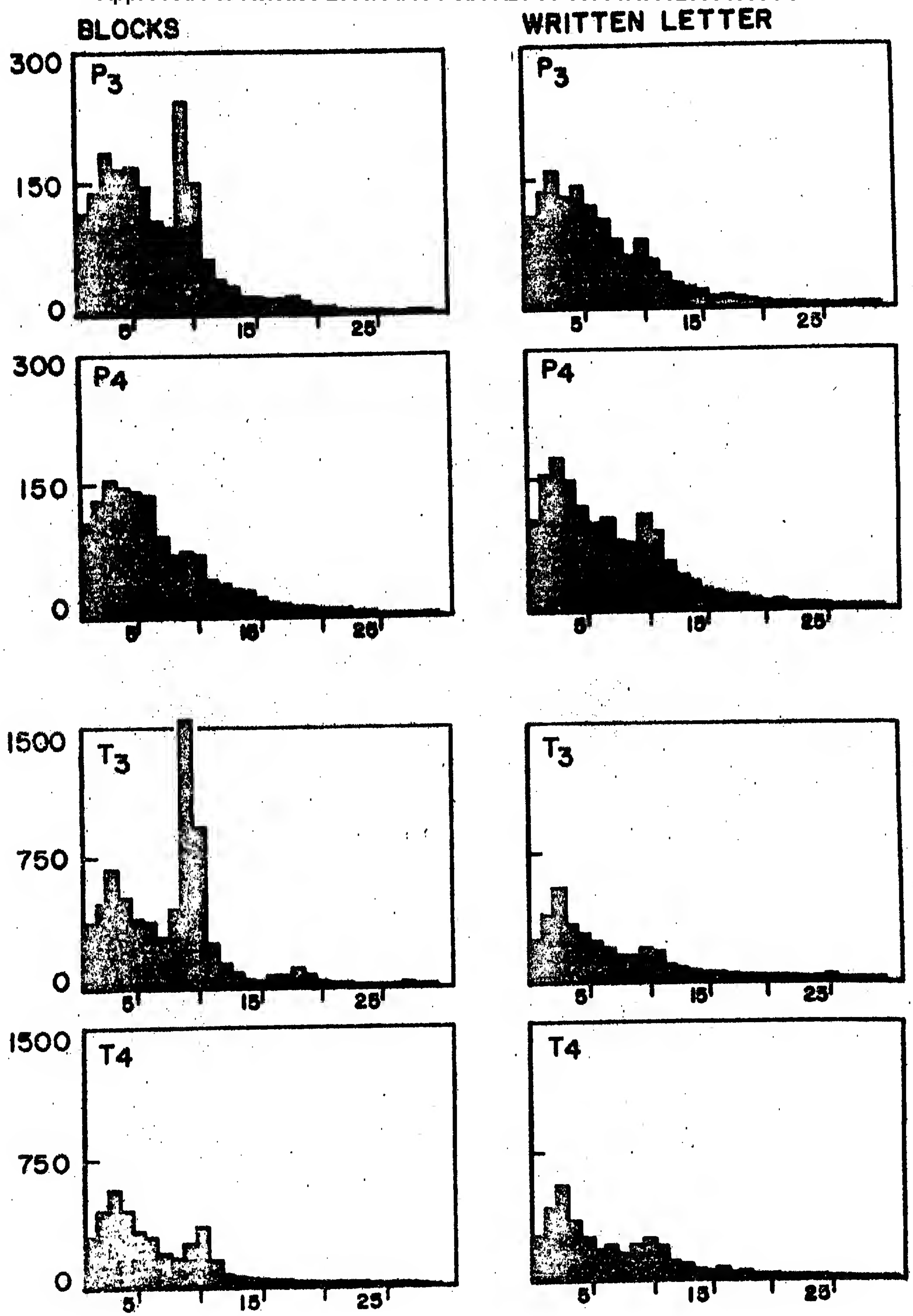


Figure 1
BLOCK DESIGN
P3 LEFT
P4 RIGHT
T3 LEFT
T4 RIGHT
SECONDS
40 µV
WRITTEN LETTER
P3 LEFT
P4 RIGHT
T3 LEFT
T4 RIGHT
SECONDS
40 µV

Figure 2 SAMPLE FOURIER POWER SPECTRA



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