USE OF LINC-8 FOR EEG DATA REDUCTION

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USE OF LINC-8 FOR EEG DATA REDUCTION

Background

Interpretation of EEG Waveforms for information relating to subject state has been an area of long interest to people outside of the neurophysiological field. A dozen years ago, Norbert Wiener conducted investigations of brain records. He sought to apply to EEG interpretation, some of the statistical communication theory developed by his circle at MIT. This theory has been set forth by Y. W. Lee.[1] In 1954 Dr. Weiner was particularly interested in "a nominal 10 cps clock pulse" which he hypothesized, formed the basic timing for serial re-ordering of the brain processing organization; he noted state differences associated with this part of the spectrum in different subjects.

Detailed specific statistical reduction techniques are laid out by Dr. [redacted] by Dr. [redacted] The former attacks reduction in a classical statistical approach, dealing with power spectral estimates, phase functions, autocovariance and cross covariance functions, transfer functions, coherency, etc. He uses these descriptors to determine significant factors associated with EEG responses. A large number of variables can be treated simultaneously.

The latter attacks the problem principally from a "period analysis" standpoint. The basic waveform is clipped and zero-crossover intervals are scrutinized. Similarly, the first and second derivatives are processed for clipped periods. The investigator utilizes all three of these on the same time base to examine the spectrum for state evaluation.

The references also give summaries of other recent techniques applied to EEG analysis.

It is intended here to present the results of a modest study carried out on a set of data furnished through the courtesy of Drs. [redacted] for educational purposes. The subject was recorded, in three states, on 1/4", 2 track, FM tape run at 7 1/2"/sec as follows:

(a1) Drowsy	5 min.	(a-2)	1 kcps tone
(b1) Alpha	5 min.	(b-2)	"
(c1) Light sleep and Alpha		(c-2)	"

Editing and Reduction

The tape was played into the A/D channels of the LINC-8 for editing, using the SCOPE-8 program. The three 5 minute samples were examined for gross characteristics. Comments were as follows:

(a) Drowsy: 30-60 second amplitude (long term) modulation was noted to be present in addition to the 7-10 cps dominant component band.

(b) Alpha: more extreme excursion; less pronounced long term modulation; pronounced short term modulation or beating.

(c) Light Sleep: less pronounced excursions.

The data was visually edited again and a run made to store the data. This is given in the column labelled Run I of Table I. It was attempted to recover representative samples of high, intermediate and low signal power. Block storage numbers are shown.

Next the stored data was examined for spectral content using the program FRQANA; scope camera pictures were taken for comparison in matrix form for significant differences in the various states.

Repeats of data taking was next performed in Runs II and III. Run III was sampled at a lower rate; this gives a longer sample interval.

Next, selected blocks were differentiated once and stored in locations corresponding to start point 100 (000 waveform sample, 100 first derivative, etc.)

It was feasible to make certain preliminary evaluations of the data at this point. These were:

1. Signal content for discrimination between states was highest for the high points of the long term modulation.

2. A finer frequency resolution was (1/2 cps) more relevant than the 1 cps resolution.

Finally a set of runs were made for oscilloscope pictures to show the below format:

1. sampled waveform
2. frequency analysis of (1)
3. first derivative of (1)
4. frequency analysis of (3)

Results and Conclusions

Figures 1, 2, and 3 show three representative outputs which appeared tentatively as "typical":

1. Drowsy: this is sample 060, 160 of the data, taken at a high point. The waveform is shown at the top; its spectrum is immediately below shown out to ________ 32 cps. A dominant spike shows up at 9 cps; a plateau from 8-13 cps is present. A "characteristic" hump showed up in the region 14-20 cps.

2. Alpha: this is sample 062, 162; a reduction of the hump at 14-20 cps was noted. A bifurcation or "forking" appeared in the alpha region at the depression at 9 cps. This would explain the beating or short term modulation.

3. Light Sleep and Alpha: this is sample 072, 172; predominance of the alpha tones is noted with a general shift in energy to the lower end of the spectrum.

For all three samples the first derivative spectrum shows up as expected; namely, the "bluing" of the spectrum by applying a derivative function.

It would appear that a parametric study of BW, frequency, accenting functions (S, S^2, etc.), examination of phase relationships, reduction techniques, and other processing would be meaningful. This might permit the design of a real time EEG analyzer which would not require a high level of training for operation.

REFERENCES

1. MIT Report # 181, Y. W. Lee

2. [redacted]

3. [redacted]

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RUN I		RUN II		RUN III	
Block #	DESCRIPT.	Block	TYPICAL DESCRIPT.	Block	TYPICAL DESCRIPT.
000-001	DROWSY	030-031	PEAK POWER	054-055	LOW POWER
002-003	(LONG TERM	032-033	LOWEST	056-057	MED.
004-005	MODULATED)	034-035	INTERMEDIATE	060-061	HIGH
		036-037	MAX.		
006-007	ALPHA	040-041	MODULATED	062-063	MODULATED - HIGH CARRIER
010-011		042-043	(min) (HG)	064-065	(min) (HG) MED [POWER
012-013				066-067	MED.
014-015					
016-017	LT SLEEP # α	044-045	LOW	070-071	LOW
020-021		046-047	HIGH	072-073	HIGH WITH MODULATION
022-023		050-051	INTERMED.		
024-025		052-053	LOW		
026-027					
500 SAMPLES/SEC		500 SAMPLES/SEC		250 SAMPLES/SEC	
512 SAMPLES		512 SAMPLES		512 SAMPLES	
≈ 1 SEC		≈ 1 SEC		≈ 2 SEC	

NOTE: 1.00 CONTAINS FIRST [illegible] OF [illegible], ETC.

TABLE I

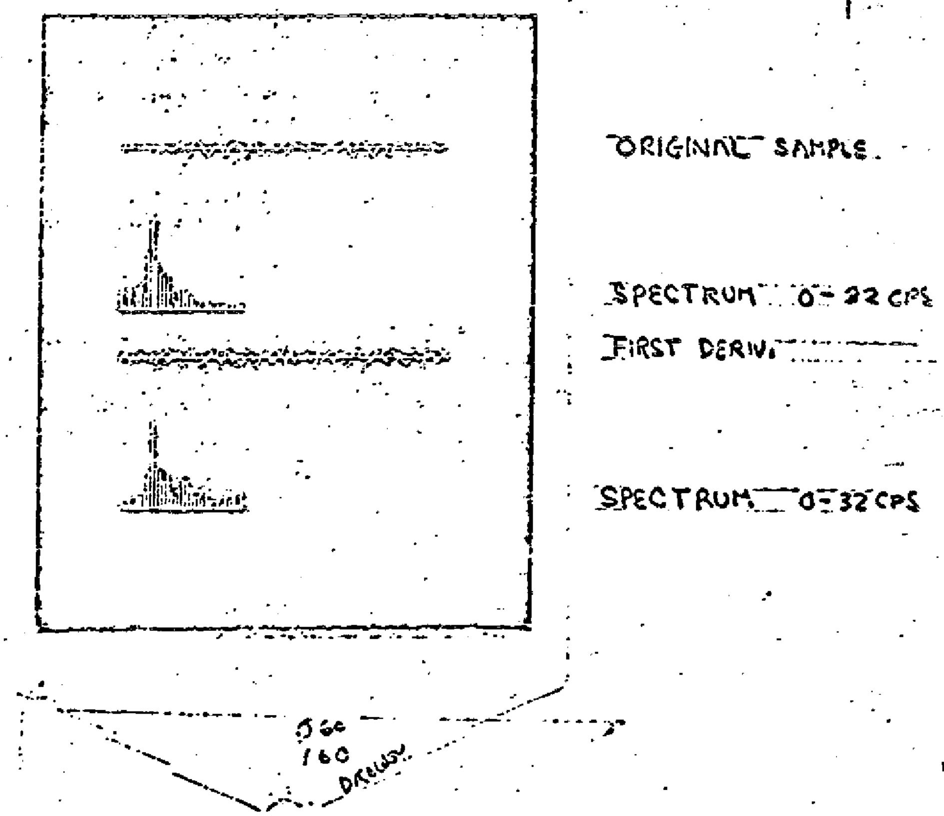

FIGURE 1

DROWSY STATE – 2 SEC SAMPLE

0 - 32 cps

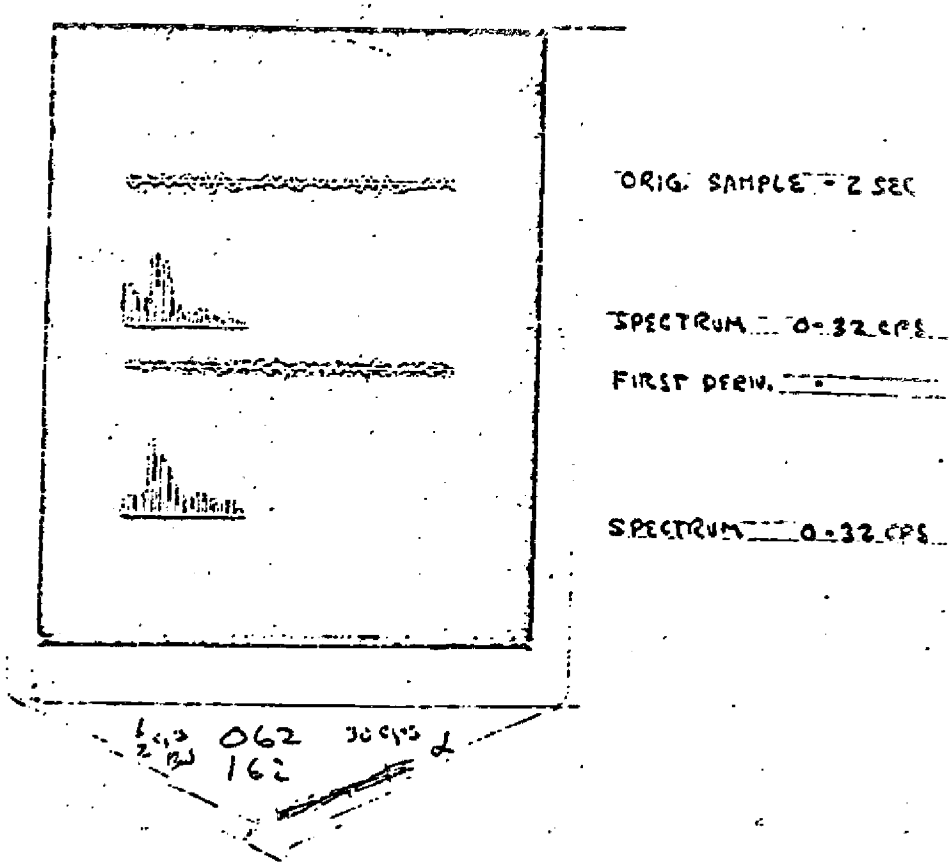

FIGURE 2

ALPHA

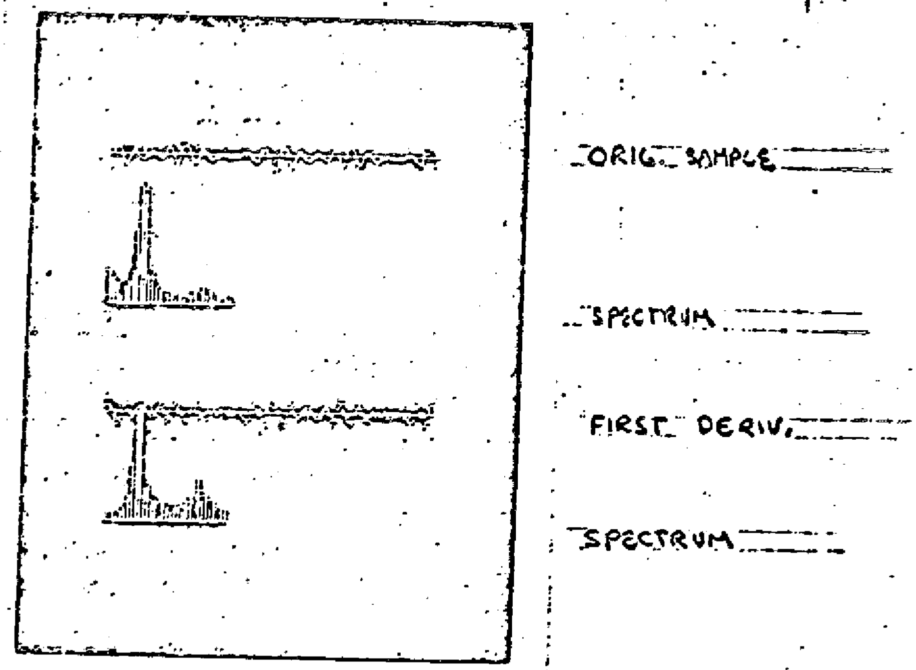

FIGURE 3

LIGHT SLEEP AND ALPHA