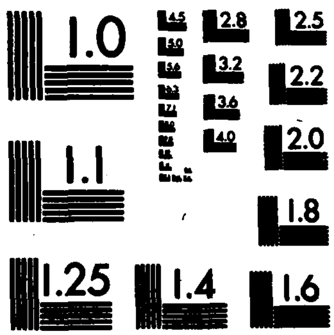
AD-A135 263 NEUROPHYSIOLOGICAL BASES OF EVENT-RELATED POTENTIALS (U) SRI INTERNATIONAL MENLO PARK CA LIFE SCIENCES DIV C S REBERT ET AL. JUN 83 AFOSR-TR-83-0902 1/1

UNCLASSIFIED F49620-82-K-0016 F/G 6/16 NL

END
FILMED
1-84
DTIC



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AFOSR-TR- 83-0902

(3)

NEUROPHYSIOLOGICAL BASES OF EVENT-RELATED POTENTIALS

Annual Report No. 1

June 1983

By: Charles S. Rebert and William J. Donovan
SRI International

and

Karl H. Pribram and Jeffrey E. Evans
Stanford University

Prepared for:

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Life Sciences Directorate
Bolling AFB, D.C. 20332

Attention: Dr. Alfred R. Fregly
Program Manager

AFOSR Contract No. F49620-82-K-0016

SRI Project LSU 4373

SRI International
333 Ravenswood Avenue
Menlo Park, California 94025
(415) 326-6200
TWX: 910-373-2046
Telex: 334 486

SRI International

NEUROPHYSIOLOGICAL BASES OF EVENT-RELATED POTENTIALS

Annual Report No. 1

June 1983

By: Charles S. Rebert and William J. Donovan
SRI International

and

Karl H. Pribram and Jeffrey E. Evans
Stanford University

Prepared for:

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH
Life Sciences Directorate
Bolling AFB, D.C. 20332

Attention: Dr. Alfred R. Fregly
Program Manager

AFOSR Contract No. F49620-82-K-0016

SRI Project LSU 4373

Approved by:

Gordon T. Pryor, Director
Psychobiology and Physiology Department

W. A. Skinner
Vice President
Life Sciences Division

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER AFOSR-TR- 83-0902	2. GOVT ACCESSION NO. AD-A135263	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Neurophysiological Bases of Event-Related Potentials		5. TYPE OF REPORT & PERIOD COVERED Annual: 1 May 1982 - 30 April 1983
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Charles S. Rebert, William J. Donovan, Karl H. Pribram and Jeffrey E. Evans (Stanford University)		8. CONTRACT OR GRANT NUMBER(s) F49620-82-K-0016
9. PERFORMING ORGANIZATION NAME AND ADDRESS SRI International, Life Sciences Division, 333 Ravenswood Ave., Menlo Park, CA 94025		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS 61102F 2313/A4
11. CONTROLLING OFFICE NAME AND ADDRESS Air Force Office of Scientific Research/NL, Bolling AFB, D.C. 20332		12. REPORT DATE June 1983; 13. NO. OF PAGES 81
		15. SECURITY CLASS. (of this report) Unclassified
14. MONITORING AGENCY NAME & ADDRESS (if diff. from Controlling Office)		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this report)

Approved for public release. Distribution unlimited.

Accession For
NTIS GRA&I
DTIC TAB
Unannounced
Justification
By
Distribution/
Availability Codes
Dist | Avail and/or Special
A-1

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from report)

DTIC COPY INSPECTED 2

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Neurophysiology	Monkeys	Intention
Event-Related Potentials	Workload	Reaction Time
Brain Slow Potentials	Biocybernetics	Massed-Unit Activity
Subcortical Nuclei	Cognition	P300

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In order to more fully understand the physiological and psychological significance of event-related potentials, cortical and subcortical recordings are being obtained from monkeys performing in operant-conditioning tasks. Six animals were trained on initial phases of the cued reaction-time task at SRI International and were subsequently implanted with electrodes capable of recording transient and sustained evoked potentials and massed-unit activity. Two monkeys were trained on initial phases of an "oddball" task at Stanford University, and

(Continued on reverse)

DD FORM 1473 1 JAN 73

EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

ABSTRACT (Concluded)

electrodes are being prepared so that the subcortical generators of the P300 wave can be assessed in these animals. An LSI-11/23 computer system was installed at SRI to implement the cued reaction-time task and to collect event-related potentials. Preliminary recordings of slow potentials and massed-unit activity were collected from the lateral geniculate nucleus of one cat to evaluate the performance of modified amplifiers, and transient (P300) and sustained (contingent negative variation) evoked potentials were recorded from the scalps of human subjects to confirm appropriate performance of the laboratory system.

Table of Contents

List of Figures

Acknowledgments

The authors thank Ms. Margaret Harrington for her participation in the work at Stanford, and Ms. Rosie McCormick and Ms. Amy Olson for typing this report.

A. Background and Purposes

1. Man-Machine Systems

The modern fighter pilot is primarily an "executive"--an information-processing and decision-making element of a complex man-machine system. The almost overwhelming amount of information to be processed from displays related to flight-systems status, navigation, communications, weapons-threat warning, radar, imaging sensor systems, and situational displays has precipitated the need for improvements in the engineering of cockpit displays and in the understanding of the human operator's information-processing characteristics (Reising, 1980; Furness, 1980) and workload parameters (Moray, 1978). Although the human operator is generally regarded as the weakest link in man-machine systems, the human element is critical if systems are to retain the capability of reacting intelligently and imaginatively to unanticipated conditions (Gomer et al., 1979).

Because pilot workload is now primarily "mental," the concepts and procedures of cognitive psychology are particularly relevant to the solution of workload problems and man-machine interfacing. Cognitive psychology has undergone a striking revolution within the last quarter century, involving greater emphasis on concepts such as information-processing (Simon, 1980) and intention (Jung, 1981; O'Connor, 1981). Early behaviorists generally considered "cognitions" such as thoughts, feelings, evaluations, and expectancies as epiphenomena that had no relevance to the mechanics of actual behavior, which was conceived to flow from particular stimulus events. However, as recently emphasized by O'Connor (1981) , Jung (1981), and Donchin (1980), intentions and goals precede and precipitate (rather than result from) perceptual, attentional, and behavioral strategies.

Although the information-processing revolution has led to a synthesis of several dimensions of psychological research, there remains a large gap in explanations of cognition in that little is known about its neural substrates. A complete understanding of human thinking will probably not be possible until the neural processes underlying symbol manipulations can be specified (Simon, 1980). Obviously, the more complete our knowledge of cognitive processes, the more thorough will be the solution of problems relating to the efficiency of man-machine systems.

2. Event-Related Brain Potentials

The only direct indications of brain function routinely available to the psychophysiologist are electric fields accompanying "spontaneous" and event-related intracerebral activity. The slow-wave (1-20 Hz) electroencephalogram (EEG) provides a very general index of the patterning of "activation" across the cerebral mantle. Such measures can be useful in assessing the extent to which various cortical regions—for example, the left and right hemispheres—are differentially involved in various types of tasks (Rebert, 1980a).

Event-related potentials (ERPs) are patterns of electric change associated with the occurrence of fairly discrete external or internal events—a flash of light, a decision. Various components of ERPs reflect activity in different regions of the brain and different information-processing functions, but—with few exceptions—the exact source of the potentials and their precise relationships to cognition, effort, motivation, and overt behavior are unknown. These potentials range from the very specific click-evoked, high-frequency burst of waves generated in brainstem auditory structures (volume-conducted to scalp electrodes) to long-lasting DC potentials of the cortex related to anticipatory processes. Although ERPs are composite reflections of a myriad of intracerebral transactions and their true form is distorted by tissues between the cortex and scalp recording electrodes, they are extremely useful tools for assessing the functional integrity of the nervous system (Regan, 1972; Aminoff, 1980; Rebert, 1980b). ERPs have been the focus of interest of many psychophysiologists interested in the neural correlates of cognitive processes (e.g., Donchin and Lindsley, 1969; Kornhuber and Deecke, 1980). Picton and Stuss (1980) have thoroughly summarized the component structure of the known ERPs, their sensitivities to various types of experimental manipulations, and their presumed relationships to psychological processes. The component structure of ERPs varies as a function of stimulus modality, recording location, task parameters, and subject state variables, among many other factors. In a situation requiring the detection of a rare event, a prominent positive wave (P300) occurs, with latency of about 300 msec. This may represent the response to disconfirmation of expectancy and is influenced by other subjective factors such as decision confidence (Hillyard et al., 1978).

In the cued reaction-time (RT) task, one stimulus acts as a warning that a second stimulus, which has significance for the subject, will subsequently appear. During the few seconds of the interstimulus interval, there appears a slow negative potential shift, called the contingent negative variation (CNV). This event is probably a nonspecific sign of localized cortical activation (Rebert, 1980c). A slow potential shift, the Bereitschaftspotential (BP), which is morphologically similar to the late portion of the CNV, occurs when a S prepares, in the absence of any preparatory or imperative cues, to carry out a behavioral act.

3. Basic Research in Animals

Although studies of human electrocortical activities demonstrate the validity of the "biocybernetic" concept (Donchin, 1980; Rebert, 1980a), a complete knowledge of ERPs using just those procedures is precluded by a number of limitations in human scalp-recording methods. For example, scalp recordings provide an extremely limited view of brain activity (i.e., scalp potentials are not precise reflections of the underlying cerebral activity because of distortions produced by intervening tissues); many cortical events are not apparent in scalp recordings; and ERP components recorded from the scalp are unlikely to be due to discrete generators, but probably reflect overlapping sources of potentials.

The foregoing considerations point clearly to the need for studies of ERPs in animals. The advantages of using animal subjects lie, of course, in the wide variety of procedures and experimental manipulations that can be carried out--e.g., intracerebral recording and stimulating (either electrically or pharmacologically), disruption of known neural pathways, histological evaluations, long-term study of a subject, systemic injection of a variety of pharmacological agents, direct manipulation of biological drive states by deprivation, and rigorous control over the experimental experiences of the subjects.

4. Choice of Experimental Paradigm

A host of experimental paradigms can be employed with animals to study ERPs. The one selected should cognitively engage the animal and closely approximate paradigms used in human research. Most preferred is a paradigm that is sufficiently general to include a variety of psychological processes and ERP components, is rigorous in terms of good control over the behavioral sequences and psychological sets induced in the animal, and is flexible in terms of the ability to manipulate a variety of experimental variables while not altering the basic logical structure of the task. In addition, because homology between animal and human ERPs is important, advantages should accrue from the use of a behavioral paradigm for which there already exist data indicating a close homology of ERPs elicited by the situation (Rebert, 1972).

The cued RT task meets the foregoing criteria and was considered to be the most promising one to use in early studies of the electrogenesis of ERPs in animals.

Another major paradigm of interest in this research was the "oddball" task wherein rare and common events elicit different ERPs, the former evoking the P300 component, which appears to follow disconfirmation of expectancy and which might be involved in mnemonic processes (Donchin, 1979). To facilitate study of this process, funds were made available to Dr. Karl Pribram at Stanford University to begin experiments using visual stimuli to which monkeys make behavioral responses. The paradigms, equipment, and preliminary behavioral training at

Stanford are described later in this report. In addition, a passive P300 paradigm (not requiring behavioral responses from the monkeys) using tone stimuli has been implemented at SRI.

5. General Purposes

The broad goal of the proposed research is to describe the dynamics of the general cerebral system that is operative in the cued RT task, using as a primary tool the recording of ERPs and associated neuronal activity in various regions of the monkey's brain. Thus, the intracerebral distribution of ERPs, their behavioral significance and similarity to human ERPs, their relationship to neuronal activity, and mediation by chemical transmitter/modulator substances are to be studied. Later stages of the research will be directed toward discovering some of the anatomical/neurochemical pathways by which ERPs become modulated during the cued RT task.

This research will provide information that is necessary to a fuller understanding of ERPs, and thus will contribute to a more substantial understanding of brain processes involved in a variety of cognitive acts. Such an understanding should contribute to a more solid foundation for using ERPs in a biocybernetic system.

B. Preparation of Facilities and Equipment

1. General Stages of Preparation

The SRI laboratory facility used for this research was developed in two stages. First, equipment previously used for similar purposes, including an Iconix Logic unit and Linc-8 computers, was configured so that preliminary training of six monkeys could be undertaken early in the project period. Subsequently, a DEC LSI-11/23 computer system, purchased by SRI for use on this project, was installed, and software and hardware elements were configured to provide more automatic and comprehensive experimental control, data acquisition, and analysis than that provided by the older equipment.

2. Iconix Logic Unit for Preliminary Training

A schematic representation of the logic of the cued RT task is shown in Figure 1. A trial can be initiated if the animal has maintained a specified hand posture (holding on to a round knob attached to the primate chair) for at least 5 sec. After a period of training, the position is usually maintained throughout the intertrial interval (ITI). This contingency assures a greater homogeneity of RT because the instrumental response is always made from the same starting position. Tone bursts (1 or 3 kHz), 100-msec and 72 dB (re: 20 $\mu N/m^2$), constitute warning or discriminative stimuli (WS and DS, respectively). The WS is followed by an imperative stimulis (IS), a light, which indicates to the monkey that it can obtain reinforcement by making the appropriate operant response (a bar press in this case). The interstimulus interval is typically 1.5 sec, but can be manipulated for experimental reasons. If the monkey releases the "hold" position any time before onset of the IS, the trial is aborted and no reward is available. Correct performance allows the monkey to receive 1 ml of an orange-flavored drink (Tang®) for each bar-press made during the 12 sec that the IS remains on (usually a total of 15-20 ml).

The DS occurs in isolation--i.e., it is not paired with any other cue--and provides a comparison for assessing ERP components related to the associative responses elicited by the WS. Typically, CNVs are evoked by both the WS and DS early in the training period, but later only by the WS. Thus, this paradigm permits assessment of the development of associative and discriminative events in several regions of the brain (Rebert, 1977).

The many contingencies in this paradigm required an elaborate and fairly time-consuming programming of the Iconix unit. For example, trials are not initiated unless the animal has sustained a fixed position of the right hand for at least 5 sec, the availability of reinforcement is contingent on the presence of the IS, trials are

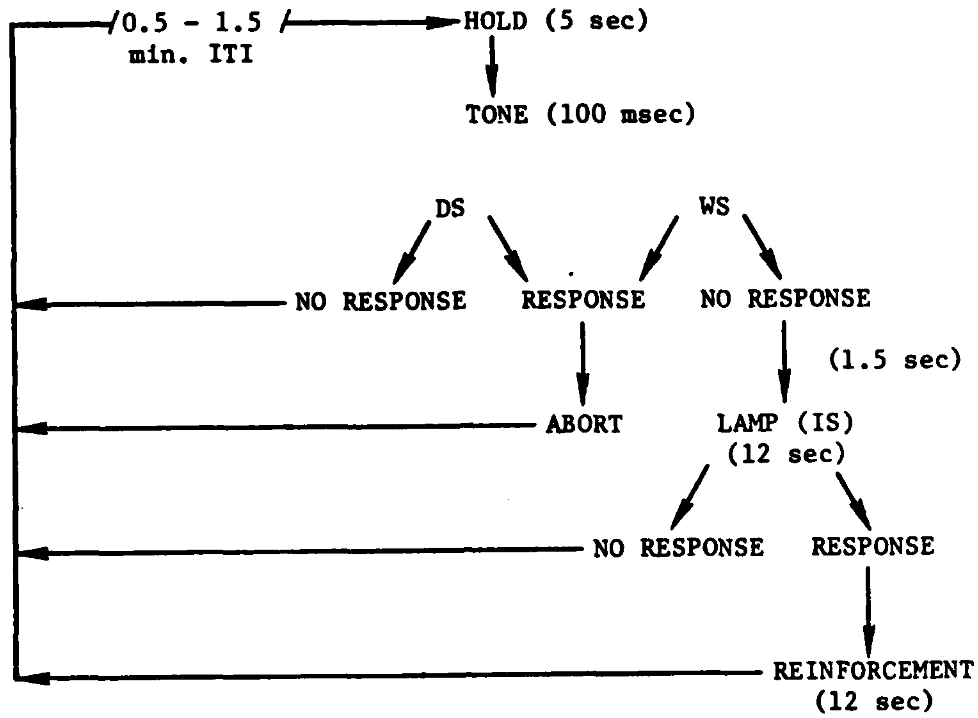


FIGURE 1 LOGIC OF THE CUED REACTION TIME TASK

aborted if a premature response occurs, and the IS terminates if a response is not made quickly enough. The logical configuration of this system is presented in Appendix A.

Associated with the Iconix unit were three counters that measured reaction time and counted the total number of bar presses and reinforcements. Liquid was delivered through a solenoid, which gated a gravity or pressurized flow system so that 1 ml of juice was delivered with each bar press.

Several limitations of this preliminary system mandated an upgrading of the facility. These limitations included the following:

- A hard-wired system is inherently inflexible; therefore, new wiring configurations have to be done to implement even trivial experimental changes.

- The logical control system was only indirectly tied to the electrophysiologic data-acquisition system; so automatic tagging of data, automatic sorting, and selective averaging could not be accomplished.
- Behavioral data had to be tabulated manually.
- Tone frequencies had to be changed manually, requiring a manual system for keeping track of WS and DS trials.
- Summary statistics of behavioral data could not be obtained immediately after a test session.
- The gravity and pressure flow systems were cumbersome and messy.
- Obsolete Linc-8 computers were inadequate for modern requirements of data analysis.

Consequently, SRI purchased the LSI-11/23 computer system described below for use on this project.

3. LSI-11/23 Computer and Related Components

a. Hardware Configuration

The configuration of this system is schematized in Figure 2. It consists of an LSI-11/23 processor with extended memory (256 KB), clock board, analog-to-digital converter and associated direct memory access board, a digital-to-analog converter, contact closure detector, latched open-collector board for operating external devices, a 30-MB Winchester disk with associated 1-MB floppy, a 9-track digital tape recorder, and VT640 graphics terminal. Associated devices include solid-state tone generators under computer control, a circuit interface between the computer and liquid delivery system (a Valcor 5P94R-7 metering pump), a gain and DC-offset control panel, indicator panel, H-P model 7034A X-Y plotter, and TTY Model 43 printer.

The Winchester disk is used to store programs and, temporarily, single-trial data during testing. At the end of the test session, the single-trial data are transferred to digital tape. The floppy discs are used to store waveform averages and summary statistics of behavioral data for the session. The summary statistics are printed on the TTY-43 printer at the end of the session, and waveform averages are plotted on the HP plotter. Listings for the programs developed for this system are provided in Appendix B.

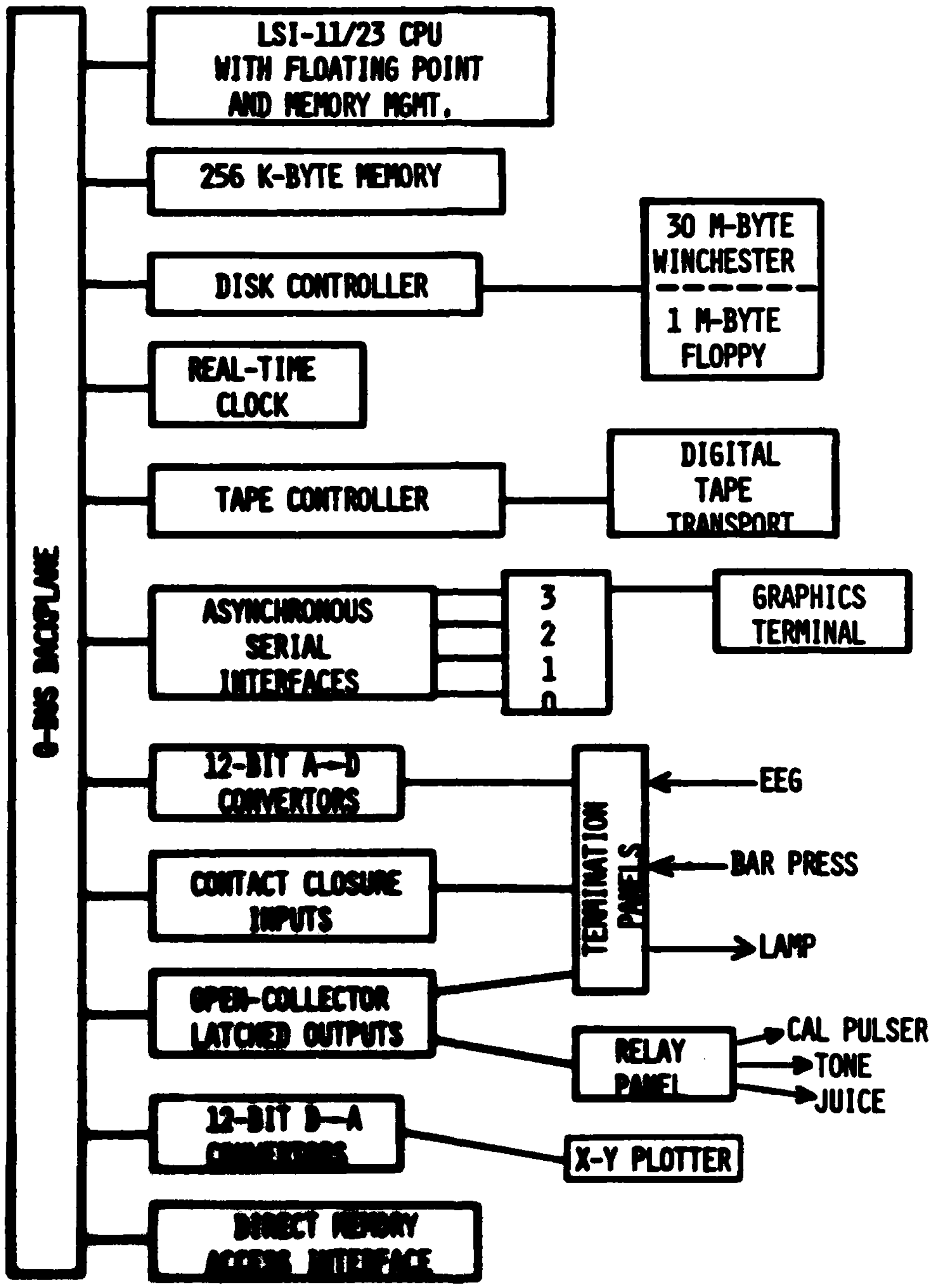


FIGURE 2 SCHEMATIC OF COMPUTER SYSTEM

The central processing unit is a digital equipment corporation Model LSI-11/23 with extended memory and floating point enhancement. It's Q-Bus backplane holds an array of special-purpose hardware boards to operate peripheral devices.

b. Software Development

CNV paradigm. A program was written to implement the logical paradigm shown in Figure 1. The program was designed to provide all record-keeping and summary statistics of behavioral data and to execute the paradigm while obtaining the ERP data. Thus, the parameters of stimulation and recording, sampling rates, artifact-reject criteria, experimenter remarks, ratios of WS and DS trials, date, experimental conditions, and so on are stored with each set of waveforms so that manual notations and paper records are minimal.

Program "CNV" implements a cued RT paradigm by controlling the sequence of stimulus events, acquiring data from each of up to 8 electrode input channels, monitoring responses by the subject (S) and input from the experimenter (E), and labeling and storing all results on Winchester and floppy disks.

E begins each session by calling up "CNV" and responding to its queries regarding:

- Name of the subject
- Date
- Experimental condition and day within the condition
- Channels that are to be sampled.

Also, E has a chance to modify the values of various trial parameters:

- Probability that each trial will have a WS rather than a DS tone
- Longest RT following light (IS) onset that will still be rewarded
- Smallest voltage that will be considered an "artifact"
- Channel to be automatically displayed at the end of each trial
- Amplitude of the calibration pulse for each channel
- Interval between tone onset and light onset
- Duration of the IS light
- Speed mode--i.e., whether optional ITI activities are conducted.

Each trial is begun by E's pressing a button when the computer, E, and S are all ready. Seated at the computer terminal, E can watch S on closed-circuit TV, supervise the flow of the computer program, and access the polygraph or other equipment, as needed. Trial-by-trial results are reported on the terminal screen, including the number of bar presses by S, reaction time, duration of ITI, and number of ITI responses.

The program logic considers each trial to consist of seven consecutive "phases," demarcated by experimental events: onset and offset of a tone, onset of the IS light, termination of sampling, etc. To time both the sampling (one set of A-D conversions every 10 msec; 400 consecutive sets per trial) and the stimulus events, a clock is set to overflow once per millisecond. Every 10th overflow, sampling is executed and the obtained values are stored in a buffer. Between samples, a contact closure register is polled to see if any bar presses have occurred. If S presses the response bar while the IS is on, then the metering pump is operated to provide a juice reward to S. Bar presses at earlier times during a trial are tabulated according to the trial phase in which they occur; also, they cancel the IS and the opportunity to earn juice. If there is a contact closure--on a separate circuit--due to E rather than S, an ongoing trial is aborted.

After checking for contact closures, "CNV" evaluates whether it is time to begin the next phase of the trial, as follows:

Phase	Time (msec)	Event
1	0	Begin sampling
2	400	Begin trigger for CAL pulse
3	450	End trigger for CAL pulse
4	1000	Turn on tone
5	1100	Turn off tone
6	2500	Turn on IS (if WS trial)
7	4000	Stop sampling

On WS trials, unless S has bar-pressed prematurely, the IS appears during Phase 6 and the reaction time to bar press is recorded. (On DS trials, although no IS is presented, responses are nevertheless recorded for all seven phases of the trial.) If a bar press happens within a 3000-msec, "limited-hold" interval after IS onset, the IS remains on for a total of 12 sec and each subsequent bar press is rewarded. If no bar press is made in time, the IS ends and the ITI begins. At the end of each trial, E has a chance to insert a comment that will be stored with the data of the previous trial.

To detect bar presses during the ITI, the contact-closure register is set so that all bar presses are noted (including when they occur), meanwhile enabling the system to perform other tasks. Data from the foregoing trial are screened for artifacts, and their maxima, minima, and DC levels are computed. All this information, along with E's comments, settings of all parameters, and the waveform data, is written--as a single record--into the session's file on disk.

Next, the waveform data are added into an averaging buffer; separate buffers are used for data from WS vs. DS trials. However, if there were too many artifacts or if the trial was aborted (due to premature bar press, too slow RT, or E's intervention), then the data are not added to these buffers.

Unless E has opted for "high-speed" mode (short ITIs), waveform data from one of the channels is displayed on the graphics terminal. E can opt to review single-trial data from any channel or cumulative averages for WS or DS on any channel. When E is finished displaying data, he then selects the next task, from a menu:

Hit RETURN for next trial, or select item from menu:

??---Explain menu
QT---Quit session; delete data
EX---Exit session; save data
DS---Display single-trial data
DA---Display average data
CP---Change parameters
PL---Plot waveform

Unless the session is over, E ordinarily waits out a variable ITI and then proceeds to the next trial. Occasionally, to review/modify the trial parameters, E selects "CP" and then, interactively, changes any or all (or none) of them. If a hard-copy of a waveform is needed, "PL" initiates that interactive sequence.

When the sample sizes for WS and DS trials are adequate (e.g., n > 15), E selects "EX" from the menu. This causes the session's single-trial data and information to be saved as a file on the Winchester disk. Later, E will transfer this file to magtape. Next, a summary is prepared of the statistics and parameters for the session, including:

- Total number of trials
- Sample sizes for WS and DS trials
- Number of trials aborted for each possible reason
- Mean RT
- RT standard deviation
- Mean number of reinforcements
- Total number of bar presses
- Number of bar presses during ITIs
- Number of artifact-rejected trials
- Mean number of artifact-rejected trials
- Mean number of deviant data per artifact-rejected waveform per channel

The WS and DS averages, along with the session's parameters and statistics, are stored as a file on floppy disk. Finally, a session summary and a listing of E's comments are output on a line printer.

P300 paradigm. A program was written to carry out preliminary studies of the P300 evoked by tones of different frequencies in a "passive" paradigm--i.e., no responses are required of the monkeys. However, when the program wes used with human Ss, the Ss were asked to count the rare tones because we were primarily interested in verifying the adequacy of the program.

Program "P300" implements a P300 paradigm in which 100-msec tone pips are presented at a fixed rate (e.g., once per second). Differently pitched tones are included in each series; "common" tones occur more often than "rare" tones. No overt response by S is required.

Four channels of the A-D converter are used to sample potentials from various electrode sites. Each "trial" consists of an epoch of 1000 msec during which 400 samples per channel (4 channels) are acquired, one set of samples every 2.5 msec.

To begin a P300 session, E calls up "P300," enters the name of S, and inputs a name for the file to which data will be written. Then, E has a chance to interactively modify any of the following parameters:

- Percentage of common tones
- Minimum value that will be considered an "artifact"
- Amplitude of each channel's calibration pulse
- Duration of recording epoch
- Interepoch interval
- Speed mode--i.e., whether optional activities occur between epochs
- Number of the upcoming tone series.

At the beginning of each tone series, E decides whether the more highly pitched of two tones will be common or rare. E then specifies how many trials are desired. The sample size for the rare tone is computed so that it can be used as a criterion for completing a tone series. Subsequently, if the waveforms for some rare tone epochs are artifact-rejected, the series will be continued until the sample size for the rare tone is adequate. When E, S, and the computer are all ready, E begins the tone series by pressing a button.

On each trial, as sampling is begun, a relay is used to trigger a delayed calibration pulse. About 200 msec later, one of two relays is operated--to deliver a common or rare tone, depending on the output of a random number generator and on the percent of common tones previously requested by E. Sampling continues for about 625 msec after the offset of the tone.

Between samples (every 2.5 msec), the values produced by each set of A-D conversions are stored in a buffer. Then the time is checked to see if the next event in the trial is due. After the 400th set of samples is in, all the data are reviewed for artifacts while their maxima, minima, and DC levels are being computed. Unless too many artifacts occurred, the data are added to another buffer, for averaging; separate buffers are used for the common and rare tone data. If more rare tone samples are needed, the next trial begins as soon as the interepoch interval has elapsed. Between trials, E is informed of the tone type for the next trial, the current sample sizes, and the DC levels.

Following the completion of each tone series, E has a variety of options: to add more trials and extend the tone series; to write the data--along with parameter information--as a record in the session's file; to begin the next tone series; to list the current parameter values; to display either the common or rare tone averages (or the most recent single-trial data) for any of the four channels; to plot any of these waveforms on an X-Y recorder; to get a status report on the just-completed tone series; or to end the session.

As each set of data is written to disk, a summary of the experimental conditions is printed out. It includes items such as:

- Date and name of subject
- Number of preceding tone series
- Name of data file on floppy disk
- Amplitudes of calibration pulses on each channel
- Common vs. rare tone sample sizes
- Total number of trials
- Numbers of common vs. rare tones presented
- Smallest voltage value to be deemed an "artifact"
- Number of samples artifact-rejected
- Time between samples
- Time between epochs.

Data retrieval program. Data analysis software is being developed that will enable us to reopen any data file written during a CNV, P300, or other class of experiment, recall what conditions were employed, review the data obtained, and sort or analyze the waveforms as needed. Currently, we are able to display waveforms off-line on our graphics terminal and "score" the voltage values at any point along the waveform. With a graphics printer slaved to the terminal, we will soon be able to obtain report-quality hard copies of anything (text, graphs, bar charts, or waveforms) that can be displayed on the terminal. In the meantime, we are operating an analog X-Y plotter with our D-A converter to plot waveforms recorded during pilot experiments. A line printer is used to print out textual information.

C. Verification of System Performance

Electrodes somewhat different from those used previously for recording subcortical slow potentials (SPs) from monkeys are now being employed (see Section E, Surgical Preparations; briefly, the pipettes were sharpened so that multiple units as well as SPs could be obtained), and the low-frequency filters on the EEG amplifiers (Grass Model 7P511) were modified to 0.01 Hz to allow measurement of SPs. Therefore, recordings were made from the lateral geniculate of one acutely prepared cat to check these items. Because of the fairly high electrode impedance, a major purpose of the check was to ensure that recordings without excessive noise could be obtained.

The cat was anesthetized with sodium pentobarbital (42 mg/kg, i.p.) and placed in a stereotaxic instrument. An incision was made in the scalp, and fascia was cleared from the skull. A small hole was drilled in the skull at coordinates appropriate for approaching the lateral geniculate nucleus (LGN), and a saline-filled pipette with a 100-μ tip was lowered into the LGN while flashes from a Grass PS-2 photostimulator were being presented.

We could not conveniently average the ERPs at this time, but multiple-unit activity comparable to that observed in earlier studies

(Rebert, 1973) was obtained and slow potential ERPs could be observed sufficiently frequently in the raw records to confirm the adequacy of the amplifier low-frequency modification. Thus, both slow and massed-unit responses were obtained through the same electrode and amplifier with adequate resolution, except that the 60-cycle filter had to be used for ERP recording.

Several human Ss were tested in both the CNV and P300 paradigms to evaluate the computer program performance as well as the amplifiers. Beckman Ag-AgCl discs were placed on the mastoids for reference and above and below the left eye for recording the vertical electrooculogram (EOG). A stretchable cap containing a conductive gel-filled tube attached to another Ag-AgCl disc was used to obtain vertex records. The forehead was grounded via another Ag-AgCl disc. The warning and discriminative tones, the imperative stimulus (light), and the response manipulandum to be used with the monkeys were also employed to test the human Ss. The same tones were used in the P300 paradigm, and Ss were instructed to count the rare tone.

Figure 3 shows CNVs from two Ss; the first was tested with an interstimulus interval (ISI) of 1500 msec, and the second with an ISI of 2500 msec. Recording was with one of the Grass 7P511 amplifiers modified to have a low-frequency cutoff of 0.01 Hz. These are very typical CNVs. The CNV in the long ISI exhibits some decay consistent with the amplifier time-constant shown in the lower part of the figure. We determined that this time-constant was consistent across the eight channels to be used with the monkeys.

Examples from one S of P300 responses associated with several proportions of rare tones are shown in Figure 4. The inset shows a typical decline in N200-P300 amplitude as the proportion of rare tones increases.

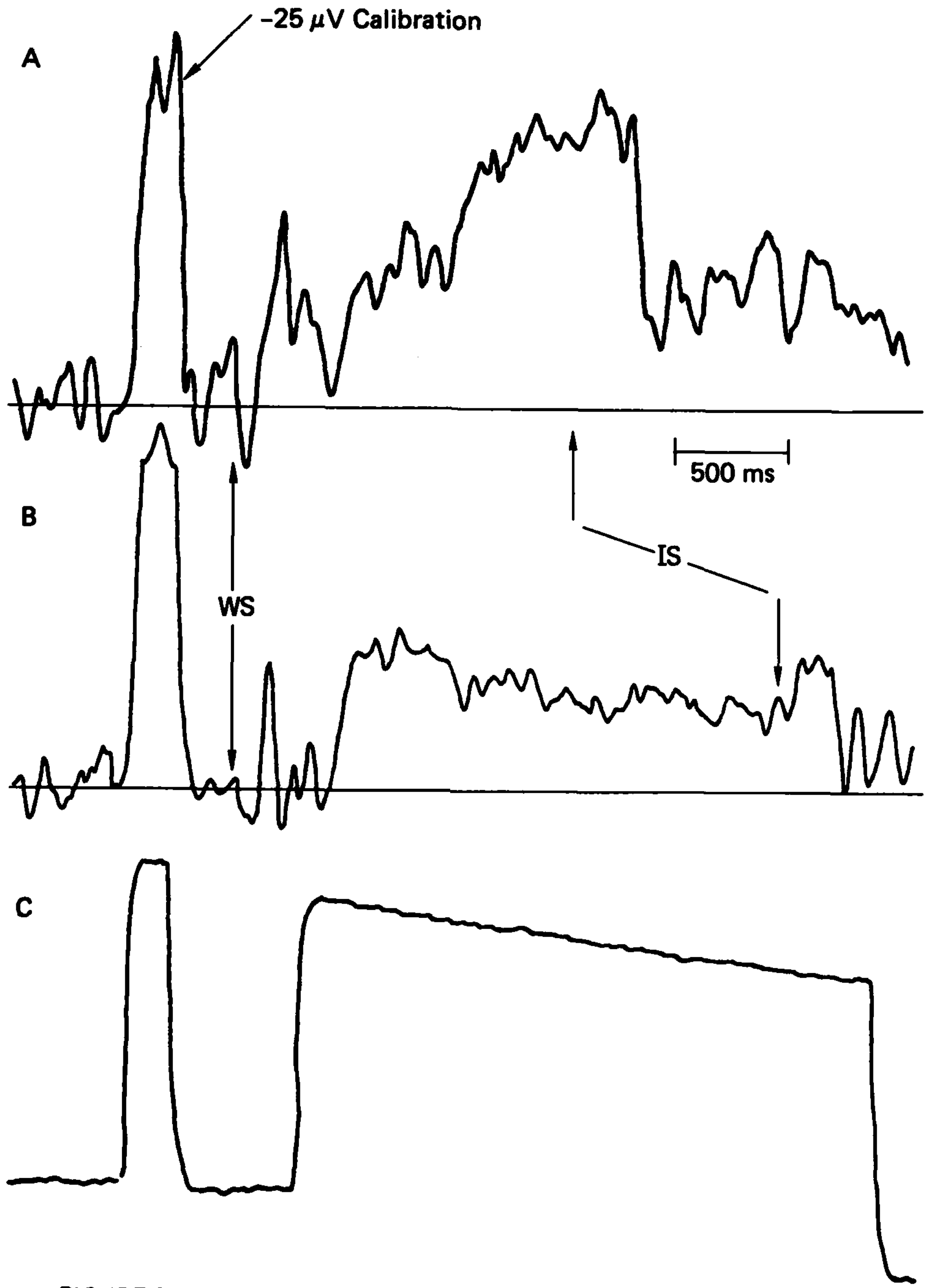


FIGURE 3 CNV AND SQUARE WAVE RECORDINGS WITH 0.01 to 100 Hz BANDPASS

A. CNV from one S with 1500 ms interstimulus interval. B. CNV from another S with 2500 ms interstimulus interval. C. Square wave showing time-constant of the recording system.

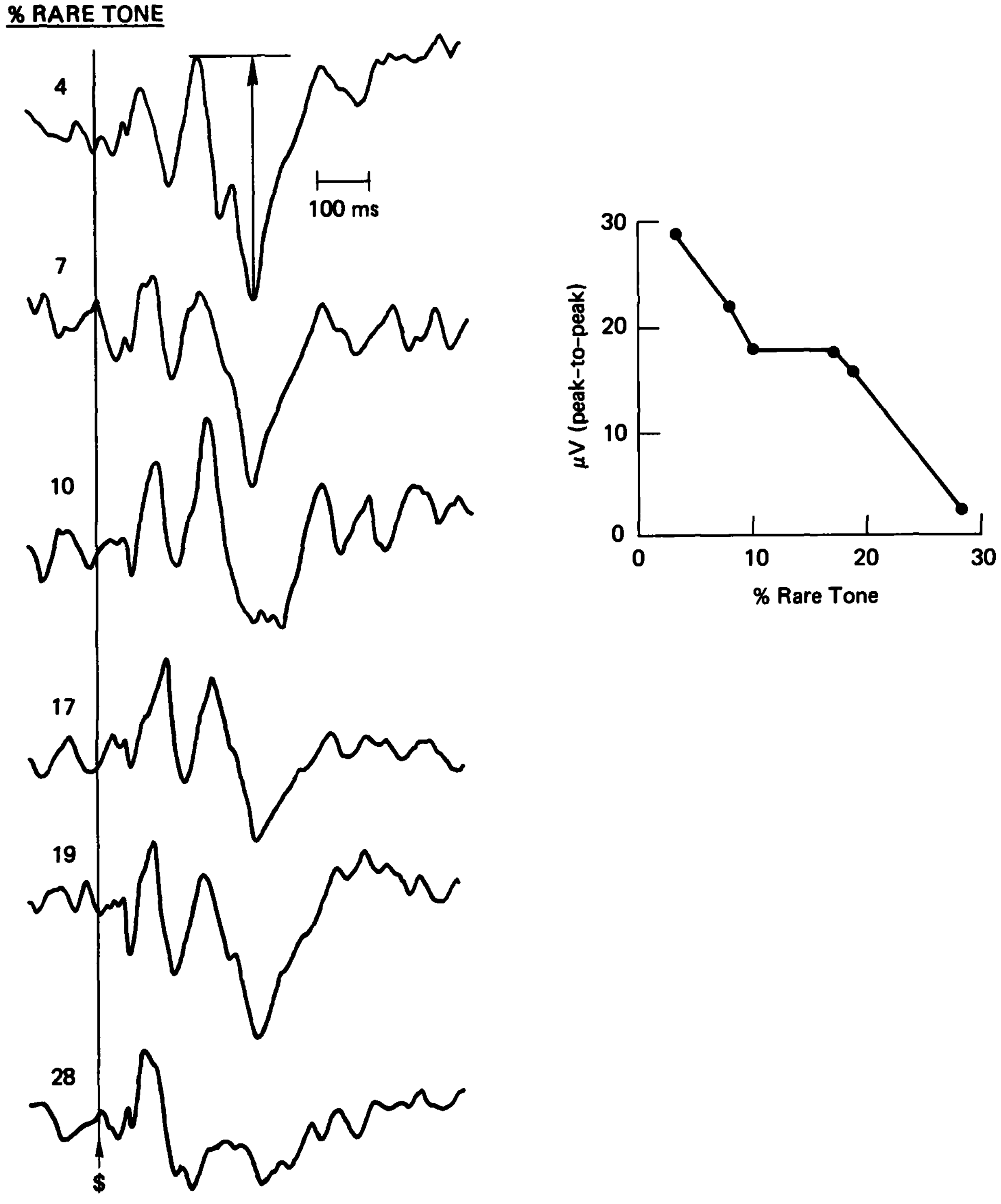


FIGURE 4 EXAMPLES FROM ONE S OF VERTEX POTENTIALS EVOKED BY RARE TONES IN AN "ODDBALL" TASK, AND THE PEAK-TO-PEAK P300 AMPLITUDE AS A FUNCTION OF THE PERCENTAGE OCCURRENCE OF RARE TONES

D. Preliminary Activities with Monkeys

1. Quarantine, Housing, and Care

Six adult male cynomolgus monkeys were received on 10 June 1982. In accordance with legal requirements, the monkeys were quarantined for one month. During this time they were weighed periodically and tested for communicable diseases and general health. One monkey exhibited anemia, lack of appetite and diarrhea for about a week. Mean individual weights of the six monkeys during quarantine ranged from 4.3 to 6.1 kg. The individual weights were very stable during this time. Housing was in standard monkey cages with automatic watering. Chow was given twice per day.

2. Preliminary Training

The monkeys were released from quarantine on 20 July 1982. Chair training for three monkeys was started on 30 July. Two monkeys could not be handled because of their aggressiveness and large canines. The canines were cut on 6 August. During this time we were able to train only four monkeys because considerable time was devoted to general handling, taming, and inhibiting the fierce aggressiveness of one monkey (Samurai). During the first week of August, juice, raisins, grapes, and bananas were given to the monkeys while they were chaired. Reactions were highly mixed; M22 (E.T.) ate or drank anything proffered, but M24 (Mickey) would partake of nothing. Although quite aggressive and noisy while being handled, all the monkeys were quiet when chaired, exhibiting very little struggling or turning.

3. Operant Conditioning

During training sessions a monkey was placed in a primate chair with some special features. A drinking tube was mounted so that it was readily accessible to the monkey, and an inverted, metal U-bolt covered with tygon tubing arched over the monkey's snout and prevented turning of the head. A Plexiglas partition to the left of midline of the belly plate kept the arms separated and encouraged the pressing of the response bar with the right hand. The bar--a 5-cm wide piece of stainless steel--protruded 5 cm from the Plexiglas plate on the front of the chair, 27 cm from the monkey's stomach. A ball mounted on the midline of the belly plate 12 cm from the monkey's stomach provided a place for the monkey to put its right hand prior to a trial in order to stabilize reaction times. A light box (4.5 x 4.5 cm square) with a white plastic front was mounted on the chair 27 cm away from the monkey's brow and 10 cm above eye level. Intensity of the light, which constituted the IS, was 400 ft-lamberts. Two video cameras and monitors were used to obtain (1) a wide-angle view of the monkey and (2) a close-up of the ball so that trial initiation by E could be made contingent on a proper placement of the monkey's hand.

Training proceeded in three phases: (1) bar-pressing for reward, (2) light-contingency, and (3) pretrial placement of the hand. During Phase 1 successive approximations of the bar-press response were reinforced until the bar was consistently pressed. In Phase 2 the delivery of reward was made contingent on presence of the IS. This involved extinguishing responses during dark periods and training the monkeys to tolerate widely varying interstimulus intervals so that they would be responding to the IS rather than in a temporal pattern. Phase 3 was initiated during early stages of Phase 2--when the monkeys indicated some awareness of the meaning of the light. This phase involved using the IS as a secondary reinforcer to reward placing the right hand on the ball. Later in this phase, RTs were recorded and a limited-hold contingency was included so that slow RTs resulted in extinguishing of the IS and unavailability of reward. This procedure is included so that, if necessary, the RT can be pushed to the point where use of the warning signal (WS) is necessary in order to have an RT sufficiently short to obtain reward (there is nothing else in this paradigm that requires the monkeys to pay attention to, or utilize, the WS, although in previous work they did so).

Bar-press training was initiated with E.T. on 9 August and he almost learned the response on that day--he did learn that a reaching movement was required, and the next day he began to bar-press. By 16

August, M23 (Conan) had also learned to bar-press and the two others (Samurai and Smacker) were making arm movements to precipitate a reward. Large individual differences in motivation were evident at this time. E.T. would press immediately and rapidly upon availability of the bar, registering, for example, 849 responses in 15 min. However, neither Samurai nor Smacker was very motivated. Conan exhibited intermediate behavior, pressing about 450 times in 15 min. By 26 August, Samurai and Smacker were partially on the bar, pressing occasionally but they subsequently regressed and would not perform. These monkeys were then deprived of all water and were required to satisfy their liquid needs in the experimental environment. Smacker responded to this satisfactorily and began to bar-press consistently at 200-300 responses in 15 min. Samurai, however, was extremely erratic and developed a peculiar pattern of not responding unless an E was inside the chamber with him. We concluded that this monkey might not be satisfactory in the long run. E.T. was started on light-contingency training on 27 August and progressed satisfactorily.

Monkeys 24 and 25 (Mickey and Grey) were first chaired on 13 September, having been liquid-deprived for 48 hr. Although Mickey was very calm in the chair, he was not the least interested in drinking. In contrast, Grey was well motivated and learned to move his arm to receive reinforcement. He again exhibited diarrhea and was not studied until 28 September, when he learned to bar-press moderately well.

We discovered that the monkeys would lick and pick small drops of water off their cages whenever the cages were rinsed. This made no difference to either E.T. or Grey but was sufficient to make Mickey totally uninterested in the experimental situation. We then ensured that the cages were dried before the monkeys were replaced.

Training continued through 8 December, progressing through the several phases until all the monkeys were placing the hand on the ball and exhibiting relatively short RTs. They were then tested only on Mondays for three weeks, with liquid deprivation only over the weekend, to determine whether they would retain their performance after such layoffs, which would occur during the later test sessions following electrode implantation. Performance was maintained. On the last day of testing, mean RTs over trials ranged, among the monkeys, from a low of 894 msec (SD = 164) to a high of 1812 msec (SD = 950). The rate of bar-pressing ranged from 1.0/sec (SD = 0.1) to 1.7/sec (SD = 0.2). For the five monkeys consistently responding (all except Samurai), mean RT was 1389 msec (SD = 342, SEM = 153) and the mean rate of pressing was 1.4/sec (SD = 0.3, SEM = 0.1).

E. Surgical Preparations

1. Placements

Preparations for surgery were initiated during the last week of December 1982. They involved calculation of electrode placements and construction of electrodes. Because no stereotaxic atlas was available for the size of cynomolgus monkey (Macaca fascicularis) being used, estimates of placements were determined from atlases for M. fuscata (7.4 kg) and small M. fascicularis (3.5 kg) and from sections of M. arctoides from a previous study. These last sections were critical to a determination of placement depths because other atlases do not show the cortical surface, and the dura must be used for M. fascicularis because of extreme interanimal variability of brain placement with respect to the stereotaxic landmarks--auditory meatus and inferior orbit (Dubach and Bowden, unpublished manuscript).

Because we were unable to study the number of monkeys originally proposed, the strategy for studying different placements was altered. We decided to put electrodes bilaterally over premotor (arcuate region), motor, and parietal cortices, in the CA1 region of the hippocampus, and in the caudate nucleus, substantia nigra, midbrain reticular formation, and n. ventralis anterior of the thalamus. Two references were used in case one became dysfunctional; these were placed in anterior and posterior white matter. An electrode was also implanted in the superior bony orbit to record the EOG.

2. Electrodes

Electrodes capable of simultaneously recording DC potentials, transient ERPs, and massed-unit activities were constructed of glass pipettes and cells housing commercially available sintered Ag-AgCl pellets. These were like the electrodes described by Rebert and Irwin (1973). The tips were sharpened to 100 μ by pulling 0.7-mm O.D. pipettes to very small tips and then, under a microscope, chipping away the tip to the 100-μ size. This was facilitated by first etching a 100-μ diameter platinum wire to a gradual taper and inserting it into the pipette. The wire provided a means of determining when the tip diameter was the right size. A short piece of shrink tubing was applied to the upper shank of the pipette to prevent its slippage in the stereotaxic electrode carrier during surgery. The pipettes were then filled and sterilized by boiling in normal saline.

Electrode cells, which are placed over the top of the pipette during surgery, were constructed of 1-cm lengths of 4-mm O.D. glass tubing. One end of each tube was fire-polished to an inside diameter of 1 mm (just large enough to slip over the pipette). These tubes were half-filled with Agar-saline followed by normal saline when the agar had set. A Ag-AgCl pellet was then placed in the tube, resting on the agar, and the upper opening was closed with dental acrylic. These cells were stored in a freezer until used.

3. Surgery

Monkeys were deprived of food the night before surgery. Ketamine hydrochloride, a fast-acting nonbarbiturate anesthetic, was administered intramuscularly (i.m.) at a dose of 14 mg/kg, which was sufficient to heavily tranquilize the monkey for preparatory activities. A dose of atropine sulfate (a 0.2-ml solution of 120 g/ml) was administered i.m., the head and calves were shaved and cleansed, and then the monkey was placed in the stereotactic apparatus. A catheter was placed in the right small-saphenous vein, through which sterile saline was dripped at a rate of 16 drops/min--sufficient to keep the catheter clear and provide some hydration during the 4-5 hr of surgery. The electrocardiogram (EKG), and the electromylogram (EMG) of the right triceps, were recorded. The EMG was used to monitor state of alertness, and 0.2 to 0.3 ml of sodium pentobarbital (65 mg/ml) was administered through the catheter as required. Typically, an infusion was required each half-hour. Rectal temperature was also monitored; it was very stable during surgery and ranged from 32.5 to 34.5°C in the six monkeys.

Muscle and fascia were cleared from the skull and the small blood vessels were cauterized. Then, stereotaxic coordinates for the anterior-posterior and lateral planes were marked on the skull. Four 6-32 stainless-steel bolts were threaded into burr holes, and bone primer and a layer of dental acrylic were applied. The EOG electrode was inserted into a burr-hole in the frontal bone, then the remaining holes were drilled. After the stereotaxic reading for the dura was obtained the electrodes were lowered into the brain. The electrode cells were then attached and wired to a 14-pin plug. The assembly was encased in acrylic, the wounds were sutured, and 0.5 ml of penicillin-G in dihydrostreptomycin sulfate was administered i.m. Furacin (nitrofurazone) antibiotic salve was applied around the headplug.

Antibiotic was given for 2 to 5 days postsurgically. Each day, the head was washed, and the wound was infiltrated with Liquimast (oxytetracycline HCl).

F. Electrode Tests in Monkeys

Several weeks following surgery, the electrodes of each monkey were tested one at a time with a DC amplifier to check offset, drift, and noise. The monkey was restrained in the chair but the manipulandum was not present and no stimuli were given during the electrode checks.

DC offsets were usually less than 10 mV and were mixed with respect to polarity. Four electrodes in E.T. were 13.0, 13.2, 14.0, and 14.8 mV, and two in Smacker were 21.3 and 11.3 mV. Drift was generally negligible in terms of the 4-sec sampling epoch for the CNV program and expected amplitudes of slow potentials (drift less than 20 µV/sec, with expected amplitudes of several hundred µV). Drift will be attenuated by the capacity-coupling to be used. Occasionally, drift was much as 50 μV/sec at the beginning of the test, but this subsided with continued recording--a common characteristic of Ag-AgCl electrodes. Most of the subcortical electrodes picked up 60-cycle line noise, requiring the use of the 60-cycle filter on the amplifiers. In two monkeys two and four of the subcortical electrodes were very noisy and possibly open for unknown reasons (perhaps bubbles in the pipette). We are in the process of constructing cable from microdot wire and rearranging the laboratory cabling to improve the recording environment for these high impedance electrodes. If necessary, preamplifiers with very-high-input impedance will be employed, or more drastic filtering of the EEG (e.g., with a low-pass setting of 40 Hz) will be used.

After the preliminary electrode tests had been completed, the WS and DS tones were presented to observe tone-evoked potentials. Examples from one of the monkeys are shown in Figure 5. For these examples the EOG, a cortical placement (right parietal), subcortical nucleus (midbrain reticular formation), and subcortical white matter (anterior reference) were used. The cortical placement showed a response very similar to that recorded in the EOG channel, and there were similarities to the EOG in the other placements as well, although the number, latencies, and polarities of components were different than would be expected if they were just EOG artifacts. These transient potentials are obviously recorded from intracerebral tracts (anterior reference) as well as from the nuclei. That the EPs recorded were probably not EOG artifacts is suggested by Figure 6, which shows the raw EEG tracings from these placements in the absence of tone pips. Whereas the EOG channel exhibits blinks of about 250 μV and eye movements, these events are not clearly present in the EEG records, although there are some later-occurring shifts that might be neural events time-locked to the blinks (e.g., the slow shift in parietal cortex). The slow eye movements have little or no effect on the recordings. To more thoroughly examine the effects of blinks and eye movements on the EEG records, we will use a continuous sampling routine, which is terminated

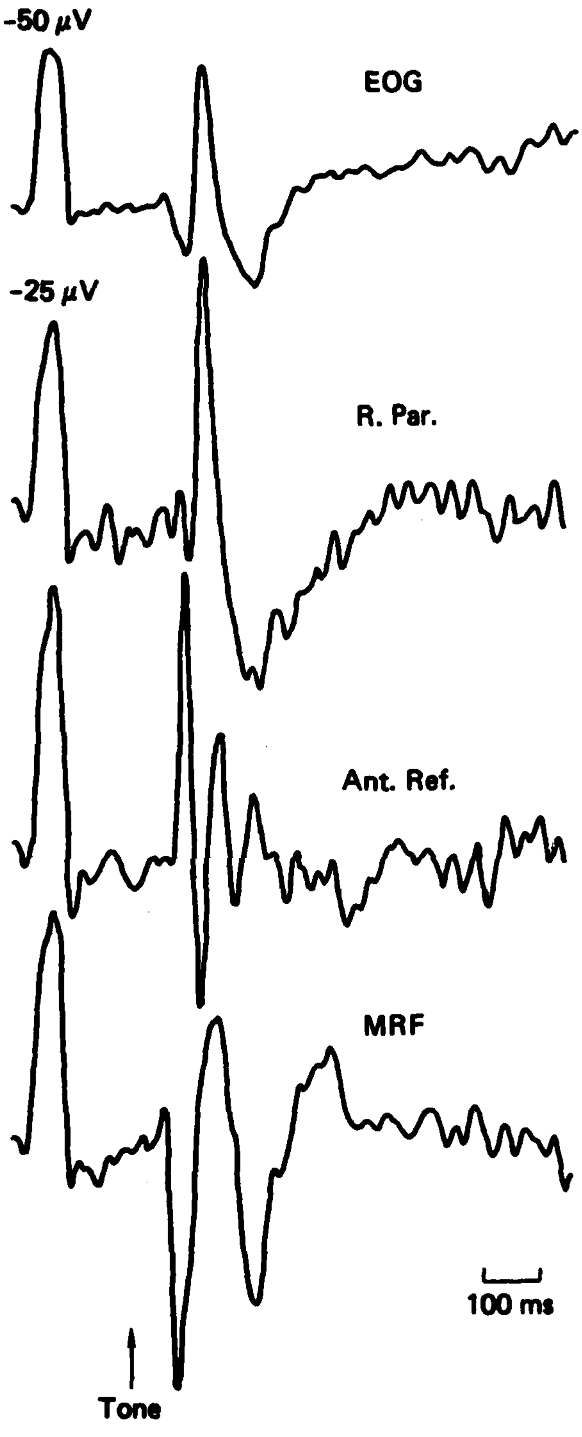


FIGURE 5 TONE EVOKED POTENTIALS FROM SUPRAORBITAL RIDGE (EOG), RIGHT PARIETAL CORTEX (R. PAR.), ANTERIOR WHITE MATTER REFERENCE (ANT. REF.), AND MIDBRAIN RETICULAR FORMATION (MRF), WITH RESPECT TO THE POSTERIOR WHITE MATTER REFERENCE

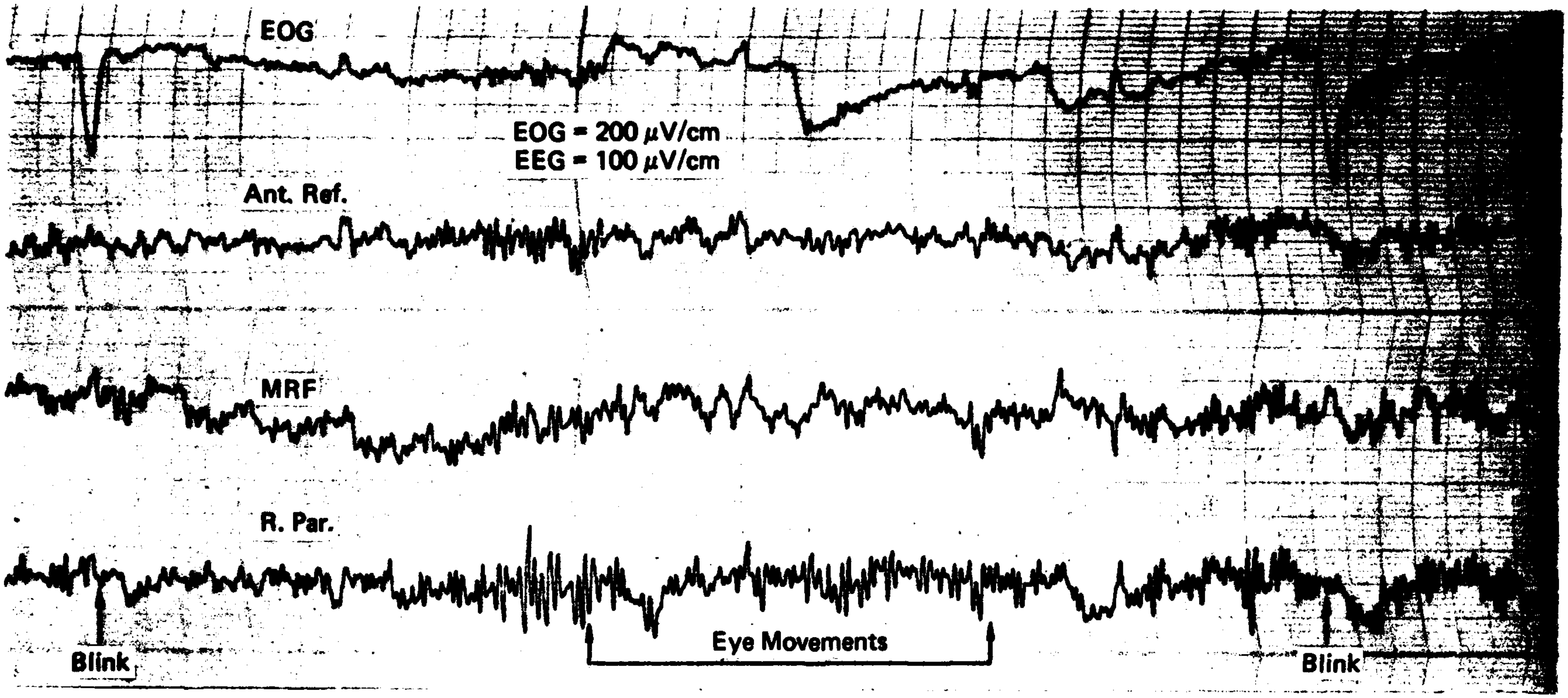


FIGURE 6 EEG RECORDS FROM ONE MONKEY SHOWING MINIMAL EFFECTS OF BLINKS AND EYE MOVEMENTS ON CORTICAL AND SUBCORTICAL RECORDINGS

EOG = electrooculogram; Ant. Ref. = reference in anterior white matter; MRF = midbrain reticular formation; R. Par. = right parietal cortex. All recordings, including the EOG, were made with respect to the reference electrode in posterior white matter.

on detection of a blink so that averages time-locked to the blinks can be obtained.

G. P300 in Monkeys in Response to Visual Cues (Stanford University)

1. Background

Of the several transient potentials of the brain associated with the perception and processing of environmental events, the P300 "component" (a complex of late positive waves) is the most clearly associated with cognitive events. This "component" seems to reflect only the general informational properties of stimuli and is uninfluenced by informationally irrelevant physical characteristics or by specific behavioral response requirements (Pritchard, 1981). These characteristics have made the P300 complex particularly relevant to the evaluation of workload, to the general field of biocybernetics (e.g., Donchin et al., 1982), and to clinical research on cognitive disorders (Hillyard and Kutas, 1983). Consequently, an interest in obtaining a more complete understanding of the intracerebral sources of the P300 complex has developed (Galambos and Hillyard, 1981). However, to date the results of research provide only hints about the electrogenesis of the P300. For example, Halgren et al. (1980) recorded P300-like activity in amygdala and hippocampal gyrus, Wood et al. (1980) noted the lack of polarity reversals of P300-like events in depth recordings above the hippocampus, and Okada et al. (1983) concluded from magnetic field recordings that the P300 is generated in anterior hippocampus. On the other hand, Johnson (NIMH, personal communication) has recorded the P300 complex from human patients with hippocampal lesions. But there is little concrete evidence localizing the sources of the P300 phenomenon and, clearly, invasive studies in animals are necessary to systematically study this point.

2. Facilities and Equipment

A behavioral testing system used extensively in a variety of neurobehavioral studies of monkeys at Stanford University (Kimble et al., 1965; Bagshaw et al., 1965; Grandstaff and Pribram, 1971; Pribram et al., 1980) is being employed in this investigation. The system hardware consists of PDP-11/34 and Apple computers implementing a "discrimination apparatus for discrete trial analysis - sixth version" (DADTA-VI--Cutcomb et al., 1981). Nine translucent panels in front of a color television set, controlled by the Apple II microprocessor, serve as both stimulus display and response panels. The PDP-11/34 controls the Apple II and records panel press position, reaction time, error scores, and electrical brain activity during task performance. During testing, a monkey is restrained in a primate chair noused in a modified refrigerator. Correct responses result in the delivery of liquid reinforcement.

3. Test Paradigms

Two "oddball" procedures--behaviorally nondiscriminative and discriminative--are being implemented. Although stimulus relevance is an important parameter in P300 genesis, the attribution of significance to a stimulus by requiring an overt response leads to confounding of motor and cognitive processes. Thus, in the first task being studied, no differential responses to rare and common stimuli are being required. After the monkey presses a central panel to initiate a trial, one of the remaining eight panels (randomly selected) lights up and the monkey must press the lighted panel. The response panel lights red a designated percentage of the time and lights green on other trials. Although this paradigm involves behavioral responses, it is equivalent to passive tasks shown by others to produce P300-like events in monkeys (H. J. Neville; S. A. Hillyard; personal communications) in that the two stimuli provide no differential instructions to the animal with respect to performance. Nevertheless, we expect the color novelty to elicit a P300-like potential. In a second task the monkeys will respond to only one color and the proportion of trials on which that color occurs will be varied. We expect P300-like potentials to occur to either the red or green stimulus when it is the rare event, but the potential should be larger in response to the behaviorally relevant stimulus when it occurs only occasionally than to the nonresponse stimulus when it is rare

(Hillyard and Kutas, 1983). In addition, the cortical and subcortical distributions of the "P300" complex will probably vary as a function of those manipulations.

4. Electrodes and Placements

Electrodes like those described by Barna et al. (1981) are being constructed. The electrode consists of 30-gauge stainless-steel tubing, tapered at the tip and housing a maximum of 16 electrode wires. The desired number of wires are tied into a bundle and threaded through the tubing and fixed in place with epoxy. When this has partially set, the wires are stripped from the bundle, bent at right angles to the shaft, and cut flush with the outer surface of the tubing. The surface is then smoothed to form a pointed shaft. This array provides the capability for searching out dipoles indicative of generator sources and recording massed-unit activity, which is also helpful in source localization (Vaughan, 1981). These types of electrodes, with varying numbers of leads, will be placed in the three major nuclei of the amygdala, in the caudate nucleus, and in the anterior hippocampus and dentate gyrus.

5. Preliminary Behavioral Results

Two female *M. fascicularis* monkeys have been trained on initial parts of the "passive" P300 task described above. Training proceeded in four phases: (1) chair taming, (2) trial initiation, (3) sequential start and panel-pressing, and (4) color cue contingency. During Phase 1 the monkeys received apples and Tang® while in the chair. This training occurred on most weekdays for about a month. Behavioral training in Phase 2 involved teaching the monkeys to press the central panel of the 3 x 3 matrix when a small white circle appeared. This stimulus-response sequence ensures that the monkey is attending to the display panel. During Phase 3, presses on panels other than the central one, following the central press, were rewarded. This training also involved making only a subset of the panels relevant to prevent position habits. Finally, in Phase 4 the animals were trained to make the second press on the panel behind which a green square was presented and response latencies were required to be less than 3 sec. Variation of latencies between the center press and lighting of the second panel was also introduced to reduce any tendencies to "time" the interval and produce unusually low reaction times. The number of trials per session was extended beyond 100 as the monkeys became used to obtaining most of their daily liquid in the testing situation.

As of the end of April 1983, both monkeys were responding near the 90%-correct and 250 msec response-latency criteria and are ready for electrode implants. Presentation of the two different colors will begin only after the electrodes have been implanted so that the initial responses to the novel red stimulus can be assessed.

H. Problems Encountered and Solutions

The surgical preparation and study of electrophysiology was delayed for two reasons. First, we were concerned that the electrode headplug would be jeopardized when we were handling monkeys that were not tamed--i.e., it might be dislodged if the monkey escaped or struggled while being removed from the cage. This was a distinct possibility with at least three monkeys, two of which turned somersaults in their cages when being retrieved, and another often escaped. Second, we felt that the electrodes might deteriorate during the long training period prior to CNV recordings.

A related problem was the extreme aggressiveness of two monkeys, precipitating attempts to tame all the monkeys by handling them a lot, giving them fruit while they were being handled, etc. The handling problems were minimized considerably by hanging short chains from the necks. This obviated the need to grasp an arm and helped immensely in removing the monkeys from their cages (most either walk or leap out), in preventing their biting (by grasping the chain closely under the chin), and in putting them in the primate chair. Because of these developments and because the monkeys were quiet once they were in the chair, extensive chair training and other taming are unnecessary. Consequently, with subsequent groups formal experimentation can be initiated much more quickly.

Motivating some of the monkeys also proved to be a problem. All except two had to be on a schedule that required obtaining their total daily fluid intake in the testing situation (when daily training was in progress, a quart of water provided Friday night was usually fully consumed by Saturday afternoon). Subsequently, we were able to test successfully just on Monday, with ad-lib watering Tuesday through Friday afternoon. Thus, after training, performance appeared to be somewhat less dependent on the state of deprivation.

During training two problems occurred. First, although the monkeys very rapidly learned to make some operant response with the right hand (in one training session if motivated), shaping to press the small bar used was too lengthy a process. A different manipulandum will be used with subsequent groups.

Shaping to maintain a hold on the ball was also difficult. One oddity is that the monkeys attributed to the ball characteristics of the bar. That is, they would move back from the bar to the ball, or pat the ball in an attempt to get reward rather than press the bar. This confusion is understandable because the IS did have characteristics of a reinforcer (secondary). Using a manipulandum that has to be held during the ITI, rather than having separate devices to hold and press, should alleviate this problem and should also facilitate operant training.

Some difficulty was encountered in using commercially obtained software to operate the analog-to-digital converter. The software had to be modified at the level of assembly language to allow sequential sampling across channels in response to a single clock overflow flag. A hardware problem was encountered in the digital-to-analog converter when we attempted to plot waveforms. An SRI engineer traced the problem to a faulty voltage regulator, which was repaired.

The lack of an appropriate stereotaxic atlas required a more extensive effort to determine electrode coordinates than would ordinarily be required, and the placements may not be where they were aimed. A related problem is that the cynomolgus' vertical brain placement in the cranium varies greatly from one monkey to the next, requiring the placement of depth electrodes with respect to the dura. Significant variability in the anterior-posterior plane cannot be compensated without technically demanding X-ray techniques.

Impedances were above 100 kΩ in subcortical electrodes in several monkeys and in similar electrodes placed in normal saline. However, some of the placements appear to be open and unusable, not just of high impedance. We plan to explore the use of a preamplifier with a very-high-input impedance to examine this problem further. During one phase of electrode placement, the pipette must be cut about 1 cm above the skull. This is done with a cutting wheel, and the vibration often causes saline to be extruded from the pipette, leaving bubbles. The bubbles are usually successfully removed by inserting a small wire into the pipette and adding saline. However, some bubbles could have escaped below the level of the dental cement holding them and hence remained in the pipette.

Two monkeys are being trained in a visual RT task at Stanford. For those monkeys as well, rigorous control of fluid intake was required to obtain adequate performance. Modification of computer programs and improvement of the reinforcement mechanism solved other problems encountered at Stanford.

I. Plans for the Coming Year

During the coming year, the monkeys now implanted will be retrained on the bar-pressing task and pairing of the WS with the IS will begin. A first task will be to determine the extent to which blinks and eye movements affect the intracerebral electrodes. This will be done by time-locking EEG samples to the occurrence of blinks. Task-related electrophysiological recordings will then begin, involving, first, attempts to obtain P300-like responses in the passive paradigm. If this is not immediately successful, we will continue with our original emphasis on the CNV, with study of the P300 in active tasks at Stanford and later at SRI by varying the proportions of WS and DS trials in the CNV paradigm.

We will record daily for two weeks to observe acquisition of the slow potentials. Once stable responses are observed, massed-unit activity will be monitored. Next, we will use systemic injections of some synaptic blocking agents (e.g., atropine) to obtain preliminary estimates of neurochemical systems involved in the CNV--in anticipation of later work using intracerebral perfusions. During this next year we will also begin working with the push-pull perfusion apparatus.

At Stanford, the monkeys now being trained in a visual RT task will be implanted with multistrand electrodes and tested in the two types of P300 paradigms described above.

J. Publications and Presentations

Rebert, C. S., and Donovan, W. J. Cortical and subcortical event-related potentials in monkeys performing the cued reaction-time task. To be presented at the Seventh International Congress on Evoked Potentials, Florence, Italy, September 1983.

Rebert, C. S. Chairman's remarks and summary. Symposium on ERPs in relation to biochemistry and pharmacology. Florence, Italy, September 1983.

K. List of Professional Personnel

Charles S. Rebert, SRI International

William J. Donovan, SRI International

Edward E. Davis, SRI International

Karl H. Pribram, Stanford University

Jeffrey E. Evans, Stanford University

REFERENCES

Aminoff, M. J. (1980). Electrodiagnosis in Clinical Neurology. New York: Churchill Livingstone.

Bagshaw, M. H., Kimble, D. P., and Pribram, K. H. (1965). The GSR of monkeys during orientation and habituation and after ablation of the amygdala, hippocampus and inferotemporal cortex. Neuropsychologia, 3: 111-119.

Barna, J. S., Arezzo, J. C., and Vaughan, H. G. (1981). A new multielectrode array for the simultaneous recording of field potentials and unit activity. Electroencephalogr. Clin. Neurophysiol., 52: 494-496.

Cutcomb, S. D., Bolster, R. B., and Pribram, K. H. (1981). DADTA VI: A minicomputer-based video control system for the analysis of behavioral and electrophysiological data. Behav. Res. Methods Instrum., 13(3): 337-340.

Donchin, E. (1979). Event-related brain potentials: a tool in the study of human information processing. In: H. Begleiter (Ed.), Evoked Brain Potentials and Behavior. New York: Plenum Press, pp. 13-88.

Donchin, E. (1980). Event-related potentials - inferring cognitive activity in operational settings. In: F. E. Gomer (Ed.), Biocybernetic Application for Military Systems. St. Louis: McDonnel Douglas, pp. 69-99.

Donchin, E., and Lindsley, D. B. (Eds.) (1969). Average Evoked Potentials. Washington, D.C.: NASA.

Donchin, E., Wickens, C., and Coles, M.G.H. (1982). The Event Related Brain Potential as an Index of Information Processing, Cognitive Activity, and Skill Acquisition: A Program of Basic Research. Annual Progress Report, AFOSR Contract F49620-79-C-0233. Champaign, Ill: University of Illinois.

Furness, T. A. (1980). Visually-coupled information systems. In: F. E. Gomer (Ed.). Biocybernetic Application for Military Systems. St. Louis: McDonnel Douglas, pp. 23-52.

Galambos, R., and Hillyard, S. A. (Eds.) (1981). Electrophysiological Approaches to Cognitive Processing. Cambridge: MIT Press.

Gomer, F. E., Beideman, L. R., and Levine, S. H. (1979). The Application of Biocybernetic Techniques to Enhance Pilot Performance During Tactical Mission. St. Louis: McDonnel Douglas.

Grandstaff, N., and Pribram, K. H. (1971). Habituation: Electrical changes in the visual system. Neuropsychologia, 10: 125-132.

Halgren, E., Squires, N. K., Wilson, C. L., Rohrbaugh, J. W., Babb, T. L., and Crandall, P. H. (1980). Endogenous potentials generated in the human hippocampal formation and amygdala by infrequent events. Science, 210: 803-805.

Hillyard, S. A., and Kutas, M. (1983). Electrophysiology of cognitive processing. Ann. Rev. Psychol., 34: 33-61.

Hillyard, S. A., Picton, T. W., and Regan, D. (1978). Sensation, perception, and attention: analysis using ERPs. In: E. Callaway, P. Tueting, and S. H. Koslow (Eds.). Event-Related Brain Potentials in Man. New York: Academic Press, pp. 223-321.

Jung, R. (1981). Perception and action. Adv. Physiol. Sci., 1: 17-36.

Kimble, D. P., Bagshaw, M. H., and Pribram, K. H. (1965). The GSR of monkeys during orientation and habituation after selective partial ablations of the cingulate and frontal cortex. Neuropsychologia, 3: 121-128.

Kornhuber, H. H., and Deecke, L. (Eds.) (1980). Motivation, Motor and Sensory Processes of the Brain: Electrical Potentials, Behavior and Clinical Use. Amsterdam: Elsevier.

Moray, N. (Ed.) (1978). Mental Workload. New York: Plenum.

O'Connor, K. P. (1981). The intentional paradigm and cognitive psychophysiology. Psychophysiology, 18: 121-128.

Okada, Y. C., Kaufman, L., and Williamson, S. J. (1983). The hippocampal formation as a source of slow endogenous potentials. Electroencephalogr. Clin. Neurophysiol., 55: 417-426.

Picton, T. W., and Stuss, D. T. (1980). The component structure of human event-related potentials. In: H. H. Kornhuber and L. Deecke (Eds.). Motivation, Motor and Sensory Processes of the Brain: Electrical Potentials, Behaviour and Clinical Use. Amsterdam: Elsevier, pp. 17-49.

Pribram, K. H., Spevack, A., Blower, D., and McGuinness, D. (1980). A decisional analysis of the effects of inferotemporal lesions in the rhesus monkey. J. Comp. Physiol. Psychol., 94: 675-690.

Pritchard, W. S. (1981). Psychophysiology of P300. Psychol.Bull., 89: 506-540.

Rebert, C. S. (1972). Cortical and subcortical slow potentials in the monkeys's brain during a preparatory interval. Electroencephalog. Clin. Neurophysiol., 33: 389-402.

Rebert, C. S. (1973). Slow potential correlates of neuronal population responses in the cat's lateral geniculate nucleus. Electroencephalogr. Clin. Neurophysiol., 35: 511-515.

Rebert, C. S. (1977). Intracerebral slow potential changes in monkeys during the foreperiod of reaction time. In: J. E. Desmedt (Ed.). Attention, Voluntary Contraction and Event-Related Potentials. Basel: Karger, pp. 242-253.

Rebert, C. S. (1980a). Electrocortical correlates of functional cerebral asymmetry: relevance to performance in operational environments and to personnel selection. In: F. E. Gomer (Ed.). Biocybernetic Application for Military Systems. St. Louis: McDonnel Douglas, pp. 203-229.

Rebert, C. S. (1980b). The brainstem auditory evoked response as a tool in neurobehavioral toxicology and medicine. In: H. H. Kornhuber and L. Deecke (Eds.). Motivation, Motor and Sensory Processes of the Brain; Electrical Potentials, Behaviour and Clinical Use. Amsterdam: Elsevier, pp. 458-462.

Rebert, C. S. (1980c). Neurobehavioral aspects of brain slow potentials. In: H. H. Kornhuber and L. Deecke (Eds.). Motivation, Motor and Sensory Processes of the Brain; Electrical Potentials, Behaviour and Clinical Use. Amsterdam: Elsevier, pp. 381-402.

Rebert, C. S., and Irwin, D. A. (1973). Simple electrode configuration for chronic or acute recording of DC potentials from subcortical nuclei of the brain. Electroencephalogr. Clin. Neurophysiol., 34: 440-442.

Regan, D. (1972). Evoked Potentials in Psychology, Sensory Physiology and Clinical Medicine. London: Chapman Hall.

Reising, J. M. (1980). General information requirements for pilots of advançed tactial aircraft. In: F. E. Gomer (Ed.). Biocybernetic Application for Military Systems. St. Louis: McDonnel Douglas, pp. 9-21.

Simon, H. A. (1980). The behavioral and social sciences. Science, 209: 72-78.

Vaughan, H. G. (1981). Intracranial generators of ERPs in animals. Neurosci. Res. Program. Bull., 20: 184-189.

Wood, C. C., Allison, T., Goff, W. R., Williamson, P., and Spencer, D. C. (1980). On the neural origin of P_{300} in man. Prog. Brain Res., 54: 51-56.

Appendix A

ICONIX LOGIC SCHEMATIC

ICONIX CNV PROGRAM

TIMER OUTPUTS

	START Report Synch	1 CAL	2 WS	3 ABORT OFF	4 IS ON	5 IS TIMEOUT	6 IS OFF
TIME (MS)	00000	00100	00700	02690	02700	04700	14700

<u>SYNCH</u>

PI (Start Report) → M11 (One Shot)
  M13 (Out) → H19 (Synch:28v pin 4 J2, yellow) → back pin 16, jump F2-G2 → OUT PIN 17

→ O14 (One Shot)
  O16 (Out) → A19 (Relay: RT & Reinf. counter reset, from J9 blk & blue stripes across rest and 5v: parallel to reinf. counter

→ G8 (Flip Flop Set)
  G10 (Out) → F5 (AND)
    F7 (Out) → I1 (sys. stop)
      J1 (sys. reset)

<u>CAL</u>

AI (Time pulse no. 1) → M14 (One Shot)
  M16 (Out) → E20 (48v pin 5 J2: blue to Emde calibrator)

<u>WS/DS & Time Out Set</u>

BI (Time pulse no. 2) → S14 (One Shot: WS/DS)
  S16 (Out) → A22 (pin 21 back panel to gate Beckman Audio)

→ I8 (Flip Flop Set): time out)
  I10 (Out) → G5 (AND)
    G7 (Out) → E12 (OR: TIME OUT)
      E14 (Out) → D8 IS and reinf.
        → F8 flip flop resets
        → A12 (OR: RT CNTR STOP)

<u>ABORT OFF</u>

CI (Time pulse no. 3) → H8 (Abort flip flop reset)

ICONIX CNV PROGRAM (Continued)

IS ON/RT START

DI (Time pulse no. 4) → C11 (OR)
C14 (Out)
└ F22 (External Switch)
rear pins
26 ●—●
27 ●
↓
G22 (Out)

REMOTE IS ON

Rear pin 17 (G2) → C12 (OR)
from EXT. Push Button Switch

G22 (Out) → C8 (Flip Flop Set)
C10 (Out) → B19 (Relay for IS: J9 Green: orange stripe)

→ Q11 (One Shot)
Q13 (Out) → E19 (12 v pin 1 J2 grey → rear pin 31, JMP 21A&B, out rear pin 32: RT Start)

Connect J1-J11 for Normal operation J1-J12 for Contin. Reinf. { K22 (front jack 11) (front jack 1) K21
L22 (front jack 12)
└ → L3(ground)

IS TIME OUT

EI (Time pulse no. 5) → G4 (AND)

K21 → E8 (Flip Flop Set: reinf. contingency)
E10 (Out) → E5 (AND)
E7 (OUT) ┐

RESPONSE BAR

BAR → rear pin 23
(front panel C22) → B12 }
Hand Switch → rear pin 25 } OR
(E22) → B11 }
B14 (Out) ┐

→ F20 (48v out pin 6 J2: white → rear pin 28, JMP 122 & H22, out rear pin 29) ┐
REINF CNTR ←

L21 (front jack 2) } For normal operation connect J2-J3;
M21 (front jack 3) } For continuous juice flow connect J3-J12 (ground)
└ → C19 (Relay for reinf. solenoid: J9 solid blk & blue)

→ S11 (One Shot)
T13 (Out) → G19 (28 v pin 3 J2, red: total bar press CNTR)
→ J8 (Reset timeout FFlop)

→ O11 (One Shot)
O13 (Out) → E6 (AND: reinf. contingency)
→ F6 (AND: for abort)
→ A11 } (OR: RT Counter Stop)
→ A12 }
A14 (Out) → Q14 (One Shot)
Q16 (Out) → F19 (12 v pin 2 J2, brown) → BERL CNTR "STOP"

IS OFF

FI (Time pulse no. 6) → E11 (OR)
E14 (Out) → D8 } (IS & Reinf. FFlop resets)
→ F8 }

REMOTE IS OFF

EXT. SWITCH → rear pin 16 (F2)
OUT → E13 (OR)
E14 (Out) ┘

Appendix B

LSI-11/23 PROGRAM LISTINGS

- CNV
- P300
- PLTCNV

```
C       PROGRAM CNV2 IS THE MASTER PROGRAM FOR RUNNING
C       THE CUED REACTION TIME STUDY, SAMPLING EIGHT
C       CHANNELS OF EITHER EVENT RELATED POTENTIALS OR
C       MULTIPLE UNIT ACTIVITY, AND ALL RELATED DATA
C       MANIPULATION AND STORAGE, VIA MENU SELECTION.
C       SOFTWARE TRIGGER INITIATES SAMPLING EVERY 10 MSEC.
C       DIGITIZED WAVEFORMS STORED IN MATRIX AS INTEGERS,
C       PRIOR TO DISPLAYING AND WRITING TO WINCHESTER DISK.
C       AT END OF SESSION,AVERAGES WRITTEN TO FLOPPY DISK;USER
C       TRANSFERS SINGLE-TRIAL DATA FROM WINCHDISK TO MAGTAPE.
        PROGRAM CNV2
        EXTERNAL WATCH,ITISUM
        COMMON /BLOCK1/MSNEW,ISI/BLOCK2/ITIRSP/BLOCK3/IDIS/BLOCK4/MSROFF
        VIRTUAL WSAVG(8,400),DSAVG(8,400),YVAL(400),XVAL(400)
        VIRTUAL MATRIX(8,400),TAGS(68)
        REAL*8 FNAME(2)
        REAL YVAL,XVAL,RLSTAT(14),WSAVG,DSAVG,PREADJ,ADDEND,WSCNT,DSCNT
        REAL SQRTOT,TOTMS
        LOGICAL*1 YESNO,TASK(3),GONOW,IDMONK(8),TYPE,EXTMSG(34),COMENT(60)
        LOGICAL*1 FSTRNG(14),TONE(3),NUFILE(14)
        LOGICAL*1 FSPEC1(4),FSPEC2(7),FSPEC3(4),FSPECA(10),FSPECB(13),ERR1
        INTEGER*2 MSOLD,MSNEW,ISI,NRESP(7),MSECRT,IDIS,CALUV(8)
        INTEGER*2 MATRIX,ISTAT,IBUFF(8),IBFCNT,ICHAN,TAGS,INSTAT(30)
        INTEGER*2 MONTH(12),WINCHD,LCH(8),LIMAX(8),LIMIN(8),KLIPT(8)
        INTEGER*4 ITIME
        DATA WINCHD/3RDL1/,FNAME(1)/12RDL1FTN3  DAT/,RLSTAT/14*0.0/
        DATA IBUFF/8*0/,NRESP/7*0/,INSTAT/30*0/
        DATA MONTH/31,28,31,30,31,30,31,31,30,31,30,31/
        DATA FSPEC1/'D','L','1',0/,FSPEC3/'D','A','T',0/
        ITRIAL=0                 ! Counter for # of trial
        LIMIT=3770               ! Artifact window size(+ or -)
        NDAYS=0
        ITIRSP=0
        ITISEC=0
        LOOK=0                   ! Automatically displayed channel
        INTGR1=0
        INTGR2=0
        DSCNT=0                  ! Zero out DS sample size
        WSCNT=0                  ! Zero out WS sample size
        ISPEED=0
4       TYPE 8
8       FORMAT(' NAME OF MONKEY IS: ',$)
        CALL GETSTR(5,IDMONK,7,ERR1)     ! Input up to 7 letters of name
        IF(ERR1) GOTO 4
D       CALL SCOPY(IDMONK,IDMONK,2)      ! Store initial 2 letters only
        CALL SCOPY('DY:XXTABL.DAT',FSTRNG)      ! Initialize filename
        CALL INSERT(IDMONK,FSTRNG,4,2)  ! Insert 1st 2 letters of name
        CALL IDATE(MON,IDAY,IYEAR)       ! Access date entered upon boot
        TYPE 12,MON,IDAY,IYEAR
12      FORMAT(' IS TODAY''S DATE:',I3,'/',I3,'/',I3,' (Y or N)?',$)
        ACCEPT 16,YESNO
16      FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 24       ! If date OK, proceed
        TYPE 20
20      FORMAT(' YOU FORGOT TO ENTER DATE; START ALL OVER ',/)
        GO TO 832
```

```
24      OPEN(UNIT=2,NAME=FSTRNG,TYPE='OLD',DISPOSE='SAVE')
        READ (2,*) MONKEY,LMON,LDAY,LYEAR,KONDTN,KONDAY,LIMHLD,
        9ISTIMI,ISDURA,KPCTUS,CALUV
        REWIND 2
        CLOSE(UNIT=2,DISPOSE='SAVE')
        TYPE 28,LMON,LDAY,LYEAR
28      FORMAT(/,' LAST SESSION WAS ON:',I3,'/',I3,'/',I3,/)
        LMON=MON                ! UPDATE DATE OF MOST RECENT SESSION
        LDAY=IDAY
        LYEAR=IYEAR
        KONDAY=KONDAY+1         ! UPDATE THE # OF DAYS WITHIN THIS CONDITION
        TYPE 32,KONDAY,KONDTN
32      FORMAT(/,' THIS WILL BE DAY #',I3,' OF CONDITION #',I3,' ;CHANGE? ',$)
        ACCEPT 36,YESNO
36      FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 500
        TYPE 40
40      FORMAT(/,3X,'#1---IS-RT TESTING',/,3X,'#2---PSEUDOCONDITIONING',/,3X,
        9'#3---WS-DS TESTING',/,' WHICH # FOR NEXT CONDITION? WHAT # DAY?',
        9'(e.g.,4,1): ',$)
        ACCEPT 44,KONDTN,KONDAY
44      FORMAT(I3,I3)
        GO TO 500
48      CALL PUTSTR(7,' ENTER CHANNELS IN ASCENDING ORDER',' ')
52      DO 56 I=1,8
        LCH(I)=0                ! Zero out channel pointers
56      CONTINUE
        NCHS=0
        TYPE 60
60      FORMAT(' WHICH CHANNELS ARE TO BE SAMPLED(1,2,...,8/):',$)
        ACCEPT *,LCH(1),LCH(2),LCH(3),LCH(4),LCH(5),LCH(6),LCH(7),LCH(8)
        LHIGH=LCH(1)    ! Initialize high channel pointer to 1st channel
        DO 68 M=1,8
        IF(LCH(M) .EQ. 0) GOTO 72       ! Stop at empty pointer
        IF(LCH(M) .LT. LHIGH) GOTO 48   ! Only ascending order OK
        LHIGH=LCH(M)
        NCHS=NCHS+1
        TYPE 64,LCH(M)
64      FORMAT(10X,'CHANNEL',I2)
68      CONTINUE
72      TYPE 76
76      FORMAT(' IS THIS LIST CORRECT ? (Y or N):',$)
        ACCEPT 80,YESNO
80      FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 52
        IF(MOD(IYEAR,4) .EQ. 0) MONTH(2)=29     ! If leap yr, Feb has 29
        NYEAR=MOD(IYEAR,10)             ! Which year of the decade
        DO 84 JMON=1,MON
        NDAYS=NDAYS+MONTH(JMON)
84      CONTINUE
        NDAYS=NDAYS+IDAY-MONTH(MON)             ! Which day of the year
        IPART=(NDAYS-MOD(NDAYS,100))/100
        JPART=(MOD(NDAYS,100)-MOD(NDAYS,10))/10
        KPART=MOD(NDAYS,10)
```

```
      FSPEC2(1)=IDMONK(1)
      FSPEC2(2)=IDMONK(2)
      ENCODE (4,88,FSPEC2(3)) IPART,JPART,KPART,NYEAR
88    FORMAT(4I1)
      FSPEC2(7)=0
      CALL CONCAT(FSPEC1,FSPEC2,FSPECA,9)
      CALL CONCAT(FSPECA,FSPEC3,FSPECB,12)
      CALL IRAD50(12,FSPECB,FNAME(2))         ! Store file name
      CALL SCOPY('DL1:XXXXXX.DAT',NUFILE)
      CALL INSERT(FSPEC2,NUFILE,5,6)
      DO 96 L=1,400
      DO 92 K=1,8
      MATRIX(K,L)=0            ! Zero out single-trial matrix
      WSAVG(K,L)=0             ! Zero out WS average matrix
      DSAVG(K,L)=0             ! Zero out DS average matrix
92    CONTINUE
      YVAL(L)=0                ! Zero out display matrix
      XVAL(L)=0
96    CONTINUE
      DO 100 M=1,NDAYS+5
      WSORDS=RAN(INTGR1,INTGR2)        ! Start RAN subrtn at new point
100   CONTINUE
      NWSRUN=0
      NDSRUN=0
      ID0="0
      ID1="4000
      ID2="44
      ID3="10000
      ID5="400

      PAUSE   'HIT RETURN TO GO'
      CALL DEVICE(-1,ID0,"164000)
      CALL IPOKE("170420,"0)           ! Turn off clock
      OPEN(UNIT=3,NAME='DL1:FTN3.DAT',FORM='UNFORMATTED',INITIALSIZE=500)
108   ITRIAL=ITRIAL+1                  ! Set next trial #
      TYPE 112,ITRIAL
112   FORMAT(/,' NEXT TRIAL IS #',I3)
      IF(KPCTWS .LT. 100) GOTO 116     ! If not all WS trials, skip ahead
      GO TO 124
116   IF(KPCTWS .EQ. 0) GOTO 132
      WSORDS=RAN(INTGR1,INTGR2)
      CUTOFF=FLOAT(KPCTWS)/100.
      IF(WSORDS .GT. CUTOFF) GO TO 128        ! If true, DS tone next
120   NDSRUN=0                         ! Otherwise, WS tone next
      NWSRUN=NWSRUN+1
      IF(NWSRUN .GT. ((KPCTWS/10)+3)) GOTO 128! 3 too many WS tones ?
124   CALL SCOPY('WS',TONE)
      IF(MONKEY .GT. 1024) GOTO 140    ! Counterbalance
      GO TO 136
128   NWSRUN=0
      NDSRUN=NDSRUN+1
      IF(NDSRUN .GT. 3) GOTO 120       ! Already had 3 DS tones ?
132   CALL SCOPY('DS',TONE)
      IF(MONKEY .GT. 1024) GOTO 136    ! Counterbalance
      GO TO 140
```

```
136     ID4="100010
        GO TO 144
140     ID4="20002
144     TYPE 148,TONE
148     FORMAT(' Next trial:',3A1,'tone')
C       HERE REPORT, THEN INITIALIZE OTHER STARTING VALUES
        IF(ITRIAL .EQ. 1) GOTO 168
        TYPE 152
152     FORMAT(/,' BAR-PRESSES FOR LAST TRIAL BY PHASE : ')
        DO 160 J=1,7              ! Zero out counters for bar-presses
        TYPE 156, J,NRESP(J)
156     FORMAT(' DURING PHASE',I2,' :',I3,' RESPONSES')
        NRESP(J)=0
160     CONTINUE
        MSECRT=MSECRT-2500
        TYPE 164,MSECRT
164     FORMAT(/,' REACTION TIME FOR LAST TRIAL WAS ',I5,' MSEC')
168     MSECRT=17500              ! Default for when no response
        JPHASE=1                  ! Reset trial phase indicator
        JDATUM=0                  ! Reset pointer for storing data
        MSOLD=0                   ! Counter for every msec in trial
        MSNEW=0                   ! Updated msec counter
        ISI=0                     ! Counter for every 10 msec
        ISYNOT=0                  ! Initialize reject reason code
        MSROFF=20000              ! Initialize reinforcement timer
        IDIS="40000
        CALL DEVICE(-1,ID1,"164000)
        IF(ITRIAL .EQ. 1) GOTO 180
        CALL CCSETI(0)            ! Disable ITI response counter
        CALL GTIM(ITIME)
        CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITCK)
        JTIRSP=ITIRSP             ! Store # of responses in last ITI
        ITISEC=(3600*IHRS)+(60*IMIN)+(ISEC)-ITISEC      ! Msec since
        TYPE 176,ITISEC,ITIRSP                          ! last trial
176     FORMAT(' LAST ITI OF',I4,' SEC INCLUDED',I4,' BAR-PRESSES',/)
        ITIRSP=0                  ! Reset ITI response tally
D       NOW=0
C       CLOCK WILL RUN AT 10 KHz, OVERFLOW EACH 1 MSEC
C       CLOCK INTERRUPT WILL ONLY BE USED TO UPDATE MSNEW AND ISI
180     CALL CCREAD(MBPRSS,MYET,MSTILL,"164010)
        IF((MBPRSS+MYET+MSTILL).GT.0) GOTO 180
        CALL CLOCKW(1,3,-10,,WATCH,"170420,"440)        ! Start clock
184     IF(MSNEW .LE. MSOLD) GOTO 184   ! Wait for next clock overflow
        MSOLD=MSNEW                     ! Resynch msec counters
        IF(ISI .LT. 10) GOTO 208        ! Sample or check for bar-presses
        ISI=0
        JDATUM=JDATUM+1
        CALL AREADP(ISTAT,IBUFF,8,-7)   ! Sample channel(s)
        CALL EXTS12(IBUFF,8)
188     IF(ISTAT .EQ. 0) GOTO 188       ! Wait until sampling all done
        IF(ISTAT .EQ. 1) GOTO 196       ! Without any errors ?
        TYPE 192
192     FORMAT(' ERROR IN DATA COLLECTION ',/)
        CALL IPOKE("170420,"0)  ! Turn off clock, then abort trial
```

```
         ITRIAL=ITRIAL-1
         GO TO 448           ! Terminate trial
196      DO 200 K=1,8
         MATRIX(K,JDATUM)=IBUFF(K)         ! Transfer data to full matrix
200      CONTINUE
         IF(MSNEW .GE. MSROFF) CALL ROFF
         GO TO 184

204      ISYNOT=3                    ! Experimente  ats to abort
         GO TO (216,220,224,228,232,236), JPHASF ! Continue aborted trial
208      CALL CCREAD(MBPRSS,MYET,MSTILL,"16401(  ! Any contact closures?
         IF(MYET .GE. 4096) GOTO 204       ! Chan .3-16;Experimenter aborted
         IF(MBPRSS .EQ. 0) GOTO 212        ! If none, time for next event ?
         NRESP(JPHASE)=NRESP(JPHASE)+1     ! Bar-press
         IF(IDIS .NE. "40200) GOTO 212     ! If DS, or abort, or phase<6
         CALL REINF
         IF(MSECRT .EQ. 17500) MSECRT=MSNEW       ! Note reaction time

C        TRANSITION TO NEXT PHASE OF TRIAL YET ?
212      GO TO (216,220,224,228,232,236), JPHASE
216      IF(MSNEW .GT. 400) GOTO 240       ! Begin CAL trigger pulse
         GO TO 184
220      IF(MSNEW .GT. 450) GOTO 244       ! End CAL trigger pulse
         GO TO 184
224      IF(MSNEW .GT. 1000) GOTO 248      ! Begin tone
         GO TO 184
228      IF(MSNEW .GT. 1200) GOTO 252      ! End tone
         GO TO 184
232      IF(MSNEW .GT. ISON) GOTO 256      ! Turn on light
         GO TO 184
236      IF(MSNEW .GT. 4000) GOTO 264      ! Stop sampling
         GO TO 184
240      JPHASE=2
         CALL DEVICE(-1,ID2,"164000)       ! CAL pulse ON
         GO TO 184
244      JPHASE=3
         CALL DEVICE(-1,ID3,"164000)       ! CAL pulse OFF
         GO TO 184
248      JPHASE=4
         CALL DEVICE(-1,ID4,"164000)       ! Tone ON
         GO TO 184
252      JPHASE=5
         CALL DEVICE(-1,ID5,"164000)       ! Tone OFF
         GO TO 184
256      JPHASE=6
         IF((NRESP(1)+NRESP(2)+NRESP(3)+NRESP(4)+NRESP(5)) .EQ. 0) GOTO 260
         ISYNOT=2                    ! Premature bar-press
260      IF(ISYNOT .GT. 0) GOTO 184
         IF(SCOMP('WS',TONE) .NE. 0) GOTO 262    ! If DS trial, no IS
         IDIS="40200
262      CALL DEVICE(-1,IDIS,"164000)      ! Phase 6 events begin
         GO TO 184
```

```
264     JPHASE=7                  ! No more sampling but trial not over yet
        IF(ISYNOT .GT. 0) GOTO 296
        IF(IDIS .EQ. "40000) GOTO 293   ! If DS trial, skip ahead
        IDWSOK=IDIS-16384+512           ! Switch indicator lights: 6th to 7th
        CALL DEVICE(-1,IDWSOK,"164000)  ! Without altering ongoing reinf
        IDIS="1200
        IF(NRESP(6) .EQ. 0) GOTO 268    ! If no 1st bar-press yet, skip ahead
266     IF(MSROFF .EQ. 20000) GOTO 280
        GO TO 276
268     CALL CCREAD(MBPRSS,MYET,MSTILL,"164010)
        IF(MYET .GT. MSTILL) GOTO 272   ! Was there a contact closure?
        IF(MSNEW .LT. LIMRT) GOTO 268   ! More time left ?
        ISYNOT=1                        ! Too slow reaction time
        GO TO 296
272     MSECRT=MSNEW              ! Record reaction time to 1st bar-press
        CALL REINF
        NRESP(7)=1
276     IF(MSNEW .LT. MSROFF) GOTO 276  ! Wait for reinforcement delivery
        CALL ROFF
        GO TO 280
278     IF(IDIS .NE. "1200) GOTO 278
280     CALL CCREAD(MBPRSS,MYET,MSTILL,"164010)
        IF(MBPRSS .EQ. 0) GO TO 284     ! If no bar-press, skip ahead
        NRESP(7)=NRESP(7)+1
        CALL REINF
284     IF(MSROFF .EQ. 20000) GOTO 292
288     IF(MSNEW .LE. MSROFF) GOTO 288  ! Wait for reinf relay offset
        CALL ROFF
292     IF(MSNEW .GE. ISOFF) GOTO 296   ! End of trial yet ?
        GO TO 280

293     IDIS="1000
        CALL DEVICE(-1,IDIS,"164000)    ! Phase #7 light on
294     CALL CCREAD(MBPRSS,MYET,MSTILL,"164010)
        IF(MBPRSS .EQ. 0) GOTO 295
        NRESP(7)=NRESP(7)+1
295     IF(MSNEW .LT. ISOFF) GOTO 294

296     CALL DEVICE(-1,ID0,"164000)     ! Light OFF, end reinf
        CALL IPOKE("170420,"0)  ! Turn off clock during ITI
        CALL GTIM(ITIME)
        CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITCK)
        ITISEC=(3600*IHRS)+(60*IMIN)+(ISEC)
        NOW=ITISEC                ! Store time at end of this trial
C       BEGIN INTER-TRIAL INTERVAL RESPONSE-COUNTING,
C       THEN REVIEW DATA FOR ARTIFACTS, THEN STORE RAW DATA
C       TEMPORARILY ON WINCH DISK AS A SINGLE RECORD PER TRIAL.
        CALL CCSETI(ITISUM,"164010,"270)    ! Count # ITI bar-presses
        CALL WINDOW(MATRIX,LHIGH,LIMIT,LCH,LIMAX,LIMIN,KLIPT)
        TYPE 300
300     FORMAT(/,' ENTER COMMENT(up to 59 chars) FOR THIS TRIAL:',/)
        CALL GETSTR(5,COMENT,59)
        CALL STRPAD(COMENT,59)
```

```
      TAGS(1)=MONKEY
      TAGS(2)=MON
      TAGS(3)=IDAY
      TAGS(4)=IYEAR
      TAGS(5)=KONDTN
      TAGS(6)=KONDAY
      TAGS(7)=KPCTWS
      TAGS(8)=LIMHLD
      TAGS(9)=ISTIMI
      TAGS(10)=ISDURA
      TAGS(11)=LIMIT
      TAGS(12)=NCHS
      DO 304 I=13,20
      TAGS(I)=LCH(I-12)
304   CONTINUE
      TAGS(21)=WSCNT
      TAGS(22)=DSCNT
      TAGS(23)=MSECRT-2500
      TAGS(24)=ID4
      TAGS(25)=JTIRSP
      TAGS(26)=NOW
      TAGS(27)=ITRIAL
      TAGS(28)=ISYNOT
      DO 308 I=29,35
      TAGS(I)=NRESP(I-28)
308   CONTINUE
      DO 312 J=36,43
      TAGS(J)=LIMAX(J-35)
      TAGS(J+8)=LIMIN(J-43)
      TAGS(J+16)=KLIPT(J-51)
      TAGS(J+24)=CALUV(J-59)
312   CONTINUE
      WRITE (3) TONE,TAGS,((MATRIX(LCH(M),K),K=1,400),M=1,NCHS),COMENT
      IF(ISYNOT .GT. 0) GOTO 324
      DO 320 I=1,8
      IF(KLIPT(LCH(I)) .GT. 5) ISYNOT=4        ! More than 5 artifacts?
      IF(LCH(I) .EQ. LHIGH) GOTO 324
320   CONTINUE
324   GO TO (328,364,372,380,388),(ISYNOT+1)

328   IF(SCOMP('DS',TONE) .EQ. 0) GOTO 348     ! If DS trial,update DSAVG
      DO 340 L=1,8
      MCH=LCH(L)
      DO 332 N=1,400
      PREADJ=WSAVG(MCH,N)
      ADDEND=MATRIX(MCH,N)
      WSAVG(MCH,N)=(PREADJ*WSCNT+ADDEND)/(WSCNT+1.0)
332   CONTINUE
336   IF(MCH .EQ. LHIGH) GOTO 344
340   CONTINUE
344   WSCNT=WSCNT+1.0
      GO TO 396
```

```
348     DO 356 L=1,8
        MCH=LCH(L)
        DO 352 N=1,400
        PREADJ=DSAVG(MCH,N)
        ADDEND=MATRIX(MCH,N)
        DSAVG(MCH,N)=(PREADJ*DSCNT+ADDEND)/(DSCNT+1.0)
352     CONTINUE
        IF(MCH .EQ. LHIGH) GOTO 360
356     CONTINUE
360     DSCNT=DSCNT+1.0
        GO TO 396

364     TYPE 368
368     FORMAT(/,' TOO SLOW REACTION TIME; DATA NOT ADDED TO AVERAGE')
        PAUSE  'HIT RETURN'
        GO TO 396
372     TYPE 376
376     FORMAT(/,' PREMATURE BAR-PRESS; DATA NOT ADDED TO AVERAGE')
        PAUSE  'HIT RETURN'
        GO TO 396
380     TYPE 384
384     FORMAT(/,' EXPERIMENTER INTERVENED; DATA NOT ADDED TO AVERAGE')
        PAUSE  'HIT RETURN'
        GO TO 396
388     TYPE 392
392     FORMAT(/,' TOO MANY ARTIFACTS; DATA NOT ADDED TO AVERAGE')
        PAUSE  'HIT RETURN'

396     IF(ISPEED .EQ. 1) GOTO 448
        IDCH=LOOK
400     DO 404 N=1,400
        YVAL(N)=MATRIX(IDCH+1,N)+380
        XVAL(N)=N+150+N
404     CONTINUE
408     CALL GINIT(1)            ! Set default parameters
        CALL GEND                ! Go to transparent mode
        CALL STXOX
        CALL STOTU(7)            ! Graphic output on console
        CALL STERR(2)            ! Print error and warning messages
        TYPE 412
412     FORMAT(25(/))            ! Clear screen
        DO 416 M=1,400
        CALL POINT(XVAL(M),YVAL(M))     ! Plot values
416     CONTINUE
        CALL GEND                ! Go to transparent mode
        CALL HOLD                ! Wait for carriage return
        CALL ERASE               ! Clear screen
        CALL GEND                ! Go to transparent mode
        TYPE 420
420     FORMAT(' VIEW MORE SINGLE-TRIAL DATA (Y or N) ? ',$)
        ACCEPT 424,YESNO
424     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 464
```

```
        TYPE 428
428     FORMAT(' VIEW MORE AVERAGE DATA (Y or N) ? ',$)
        ACCEPT 432,YESNO
432     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 476
D       GO TO 448
D436    TYPE 440
D440    FORMAT(/,' Enter "G" to start next trial, "M" for menu',$)
D       ACCEPT 444,YESNO
D444    FORMAT(A1)
D       IF(YESNO .EQ. 'G') GOTO 108

448     TYPE 450
450     FORMAT(/,' HIT RETURN FOR NEXT TRIAL, OR:')
        TYPE 452
452     FORMAT(' PICK FROM MENU : ??,QT,EX,DS,DA,CP,PL,...',$)
        ACCEPT 456, TASK(1),TASK(2)
456     FORMAT(2A1)
        IF(SCOMP('??',TASK) .EQ. 0) GOTO 458    ! Display menu
        IF(SCOMP('QT',TASK) .EQ. 0) GOTO 656    ! Quit session
        IF(SCOMP('EX',TASK) .EQ. 0) GOTO 660    ! Exit session
        IF(SCOMP('DS',TASK) .EQ. 0) GOTO 464    ! Display data
        IF(SCOMP('DA',TASK) .EQ. 0) GOTO 476    ! Display average
        IF(SCOMP('CP',TASK) .EQ. 0) GOTO 500    ! Change parameters
        IF(SCOMP('PL',TASK) .EQ. 0) GO D 648    ! Plot data
        GO TO 108
458     TYPE 460
460     FORMAT(' MENU IS AS FOLLOWS: ??---EXPLAIN MENU',/,23X,
        ?'QT---QUIT SESSION(DELETE DATAFILES)',/,23X,'EX---EXIT ',
        ?'FROM SESSION(SAVE DATAFILES)',/,23X,'DS---DISPLAY SINGLE
        ?TRIAL DATA',/,23X,'DA---DISPLAY AVERAGES',/,23X,
        ?'CP---CHANGE PARAMETERS',/,23X,'PL---PLOT DATA',/,/)
        GO TO 448

464     TYPE 468
468     FORMAT(' VIEW DATA FROM WHICH CHANNEL (1-8) ? ',$)
        ACCEPT 472,IDCH
472     FORMAT(I3)
        IDCH=IDCH-1
        IF(IDCH .LT. 0 .OR. IDCH .GT. 7) GOTO 464
        GO TO 400

476     TYPE 480
480     FORMAT(' WS OR DS ? WHICH CHANNEL ? (e.g. W4 or W8 or D1)',$)
        ACCEPT 484,TYPE,NUMCH
484     FORMAT(A1,I1)
        IF(TYPE.NE.'W' .AND. TYPE.NE.'D') GOTO 476
        IF(NUMCH.LT.1 .OR. NUMCH.GT.8) GOTO 476
        IF(TYPE .EQ. 'D') GOTO 492
        DO 488 K=1,400
        YVAL(K)=WSAVG(NUMCH,K)+380.
        XVAL(K)=K+150+K
488     CONTINUE
        GO TO 408
```

```
492     DO 496 K=1,400
        YVAL(K)=DSAVG(NUMCH,K)+380.
        XVAL(K)=K+150+K
496     CONTINUE
        GO TO 408
500     TYPE 504,KPCTUS,LIMHLD,LIMIT,(LOOK+1)
504     FORMAT(/,' PARAMETERS ARE AS FOLLOWS:',/,' 1) % OF US TRIALS= ',I4,
       9/,' 2)LIMITED HOLD(msec)= ',I5,/,' 3)ARTIFACT LIMIT= +/- ',I6,/,
       9' 4)CHANNEL DISPLAYED AT END OF EACH TRIAL= ',I2,/,' 5)CAL PULSES:')
        DO 512 M=1,8
        TYPE 508,M,CALUV(M)
508     FORMAT(3X,'CH',I2,': ',I5,'uV')
512     CONTINUE
        TYPE 516,ISTIMI,ISDURA,ISPEED
516     FORMAT(/,' 6)INTER-STIMULUS INTERVAL(210-2990 msec)= ',I5,/,
       9' 7)IS DURATION(>2800 msec)= ',I6,/,' 8)SPEED(0=slow;1=fast)= ',I2)
        TYPE 520
520     FORMAT(' ENTER NUMBER OF ITEM TO BE CHANGED, OR 0 IF NONE : ',$)
        ACCEPT 524,NPARAM
524     FORMAT(I2)
        GO TO (644,528,540,552,564,596,608,620,632), (NPARAM+1)

528     TYPE 532
532     FORMAT(' WHAT %(0-100) TRIALS SHOULD BE US ? ',$)
        ACCEPT 536,KPCTUS
536     FORMAT(I4)
        GO TO 500
540     TYPE 544
544     FORMAT(' HOW MANY MSEC FOR LIMITED HOLD ? ',$)
        ACCEPT 548,LIMHLD
548     FORMAT(I5)
        GO TO 500
552     TYPE 556
556     FORMAT(' NEW WINDOW LIMIT= ',$)
        ACCEPT 560,LIMIT
560     FORMAT(I6)
        GO TO 500
564     TYPE 568
568     FORMAT(' CHANNEL TO LOOK AT FIRST(1-8) = ',$)
        ACCEPT 572,LOOK
572     FORMAT(I2)
        LOOK=LOOK-1
        GO TO 500
576     DO 584 J=1,8
        TYPE 580,J,CALUV(J)
580     FORMAT(3X,'CH ',I1,' CAL= ',I5,'uV')
584     CONTINUE
        TYPE 588
588     FORMAT(/,' CHANGE CAL uV VALUES ? ',$)
        ACCEPT 592,YESNO
592     FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 500
596     TYPE 600
600     FORMAT(' ENTER CHANNEL #,THEN NEW uV CALIBRATION,e.g. 5,75 : ',$)
```

```
      ACCEPT 604,K,CALUV(K)
604   FORMAT(I2,I4)
      GO TO 576
608   TYPE 612
612   FORMAT(/,' ENTER NEW INTER-STIMULUS INTERVAL(210-2990 msec): ',$)
      ACCEPT 616,ISTIMI
616   FORMAT(I5)
      IF(MOD(ISTIMI,10) .EQ. 0) GOTO 500
      CALL PUTSTR(7,' MULTIPLES OF 10 ONLY',' ')
      GO TO 608
620   TYPE 624
624   FORMAT(/,' ENTER NEW IS DURATION(>2800 msec): ',$)
      ACCEPT 628,ISDURA
628   FORMAT(I6)
      IF(MOD(ISDURA,10) .EQ. 0) GOTO 500
      CALL PUTSTR(7,' MULTIPLES OF 10 ONLY',' ')
      GO TO 620
632   TYPE 636
636   FORMAT(/,' Enter "1" for fast, or "0" for slow mode: ',$)
      ACCEPT 640,ISPEED
640   FORMAT(I2)
      GO TO 448
644   ISON=ISTIMI+1000          ! Compute when to turn light on
      ISOFF=ISON+ISDURA         ! Compute when to shut light off
      LIMRT=ISON+LIMHLD         ! Compute limited hold cutoff(msec)
      IF(ITRIAL .EQ. 0) GOTO 52
      GO TO 448

648   TYPE 652
652   FORMAT(' THIS OPTION NOT YET AVAILABLE ',/)
      GO TO 448
656   CLOSE(UNIT=3,DISPOSE='DELETE')
      CALL IPOKE("170420,"0)          ! Shut off clock
      CALL CCSETI(0)
      GO TO 832
660   TYPE 664
664   FORMAT(' OK TO END THIS SESSION (Y or N): ?',$)
      ACCEPT 668,YESNO
668   FORMAT(A1)
      IF(YESNO .NE. 'Y') GOTO 448
      CLOSE(UNIT=3,DISPOSE='SAVE')    ! Save single-trial data
      ICHANL=IGETC()
      IF(ICHANL .LT. 0) STOP   'NO CHANNEL'
      IF(IFETCH(WINCHD) .NE. 0) STOP   'FATAL ERROR FETCHING HANDLER'
      CALL IRENAM(ICHANL,FNAME)
      CALL ICLOSE(ICHANL)
      CALL IFREEC(ICHANL)
      CALL IPOKE("170420,"0)          ! Shut off clock
      CALL CCSETI(0)                  ! Ignore contact closures
C     An "ok" trial: neither aborted, nor rejected due to artifacts
      TOTMS=0         ! Sum RTs for ok WS trials
      SQRTOT=0        ! Sum squared RTs
      NREINF=0        ! Total # reinforcements
      DO 672 J=1,8
      KLIPT(J)=0      ! Total # artifacts on art.-rej. WS trials
672   CONTINUE
```

```
D       PAUSE   ' UPDATE TABLE'
        OPEN(UNIT=2,NAME=FSTRNG,TYPE='OLD',DISPOSE='SAVE')
        WRITE (2,*) MONKEY,LMON,LDAY,LYEAR,KONDTN,KONDAY,LIMHLD,
        9ISTIMI,ISDURA,KPCTWS,CALUV
        CLOSE(UNIT=2,DISPOSE='SAVE')

D       PAUSE  ' NOW REOPEN RENAMED FILE'
D       OPEN(UNIT=3,ERR=725,NAME=NUFILE,FORM='UNFORMATTED',TYPE='OLD')
        OPEN(UNIT=3,ERR=725,NAME=NUFILE,READONLY,TYPE='OLD',
        7FORM='UNFORMATTED',DISPOSE='SAVE')
D       PAUSE  ' NOW REVIEW RECORDS'
        DO 724 NREC=1,ITRIAL
        READ (3) TONE,TAGS,((MATRIX(M,K),K=1,400),M=1,NCHS),COMENT
        NBP5=0          ! # of bar-presses in phases 1-5
        IF(TAGS(27) .GT. 1) GOTO 684
        DO 680 I=1,20
        INSTAT(I)=TAGS(I)       ! Session-wide parameters
680     CONTINUE
        INSTAT(21)=WSCNT
        INSTAT(22)=DSCNT
684     INSTAT(23)=INSTAT(23)+1 ! # of trials
        INSTAT(30)=INSTAT(30)+TAGS(25)  ! # ITI bar-presses
        DO 688 L=29,33
        NBP5=NBP5+TAGS(L)       ! # phase 1-5 bar-presses
688     CONTINUE
        NBPIS=TAGS(34)+TAGS(35) ! # IS bar-presses
        INSTAT(29)=INSTAT(29)+NBP5+NBPIS+TAGS(25)       ! All bar-presses
        IF(SCOMP('DS',TONE) .EQ. 0) GOTO 716    ! If DS, skip ahead
        INSTAT(24)=INSTAT(24)+1         ! # of WS trials
        IF(TAGS(28) .GT. 0) GOTO 692    ! If not ok trial, skip ahead
        TOTMS=TOTMS+TAGS(23)            ! RT tally for ok WS trials
        SQRTOT=SQRTOT+FLOAT(TAGS(23))**2        ! RT squared tally
        NREINF=NREINF+NBPIS             ! Reinforcement tally

692     GO TO (724,696,700,704,708),(TAGS(28)+1)        ! ISYNOT value?
696     INSTAT(25)=INSTAT(25)+1         ! WS reject--too slow RT
        GO TO 724
700     INSTAT(26)=INSTAT(26)+1         ! WS reject--premature bar-press
        GO TO 724
704     INSTAT(27)=INSTAT(27)+1         ! WS reject--E opted to abort
        GO TO 724
708     INSTAT(28)=INSTAT(28)+1         ! WS reject--too many artifacts
        DO 712 J=1,8
        KLIPT(J)=KLIPT(J)+TAGS(J+51)    ! Artifact tally:WS reject;not aborted
712     CONTINUE
        GO TO 724
716     IF(ISYNOT .GT. 1) GOTO 724      ! Skip DS trials with problems
720     RLSTAT(6)=RLSTAT(6)+NBPIS       ! DS trial bar-presses:phases 6+7
        GO TO 724
724     CONTINUE
        CLOSE(UNIT=3,DISPOSE='SAVE')
        GO TO 727
725     TYPE 726
726     FORMAT(' ERROR REOPENING FILE ON DL1 ')
        GO TO 832
```

```
D       PAUSE   ' COMMENT HEADER'
727     PRINT 728
728     FORMAT(5(/),15X,'LISTING OF SESSION COMMENTS:',/)
D       PAUSE  ' REOPEN DL1 FILE'
        OPEN(UNIT=3,NAME=NUFILE,FORM='UNFORMATTED',TYPE='OLD')
732     READ(3,END=740) TONE,TAGS,((MATRIX(LCH(M),K),K=1,400),M=1,NCHS),COMENT
        PRINT 736,TAGS(27),(COMENT(K),K=1,LEN(COMENT))
736     FORMAT(' TRIAL #',I3,' : ',59(A1))
        GO TO 732
740     CLOSE(UNIT=3,DISPOSE='SAVE')
D       PAUSE   ' COMPUTE STATS'
        X1=INSTAT(24)                   ! Total # of WS trials
        X2=INSTAT(25)                   ! # of WS aborts due to slow RT
        X3=INSTAT(26)                   !   "    due to premature response
        X4=INSTAT(27)                   !   "    due to E intervention
        X5=INSTAT(28)                   ! # of WS rejects due to artifacts
        X6=X1-X2-X3-X4-X5               ! X6 (=WSCNT) : # of ok WS trials
        IF(X1 .LE. 0) GOTO 752
        RLSTAT(1)=((X2+X3+X4)/X1)*100.  ! % of WS trials aborted
        RLSTAT(2)=(X5/X1)*100.          ! % of WS trials artifact-rejected
        IF(X6 .LE. 0.) GOTO 744         ! If no WS trials OK,skip ahead
        RLSTAT(3)=TOTMS/X6              ! Mean RT for ok WS trials
        RLSTAT(4)=SQRT(SQRTOT/X6-(RLSTAT(3)**2))        ! Stand. dev.
        RLSTAT(5)=FLOAT(NREINF)/X6      ! Avg # of reinf per ok WS trial
744     IF(X5 .LE. 0.) GOTO 752         ! If no WS artifact-rejects,skip ahead
        DO 748 I=1,8
        RLSTAT(I+6)=FLOAT(KLIPT(I))/X5  ! Avg # artifacts per WS reject
748     CONTINUE
752     IF(DSCNT .LE. 0.) GOTO 756
        RLSTAT(6)=RLSTAT(6)/DSCNT       ! Avg # resp(phases 6+7)for ok DS
D       PAUSE  ' PRINT STATS'
756     PRINT 760
760     FORMAT(5(/))
        CALL PUTSTR(6,IDMONK,' ')
        PRINT 764,(INSTAT(I),I=1,4)
764     FORMAT(/,' Monkey #',I5,5X,'Date:',I3,'/',I3,'/',I3)
        PRINT 768,(INSTAT(J),J=5,7)
768     FORMAT(/,' Condition #',I2,' ; Day #',I3,' ; % WS trials=',I3)
        PRINT 772,(INSTAT(K),K=8,10)
772     FORMAT(/,' Limited hold(ms)=',I5,/,' Inter-stimulus interval(ms)=',
        9I5,/,' IS duration(ms)=',I6)
        PRINT 776,(INSTAT(L),L=11,(INSTAT(12)+12))
776     FORMAT(/,' Artifact limit= +/-',I6,/,/,' Sampled the following',I2,
        9' channels:',8(1X,I2))
        PRINT 780,INSTAT(21),INSTAT(22)
780     FORMAT(/,' Sample size for WS average=',I3,' ; for DS average=',I3)
        PRINT 784,INSTAT(23),INSTAT(24)
784     FORMAT(/,' Total # trials=',I3,/,' # of WS trials=',I3)
        PRINT 788,(INSTAT(M),M=25,28)
788     FORMAT(/,' # aborts due to slow RT=',I3,/,' # aborts due to premature
        9 bar-pressing=',I3,/,' # aborts due to E opting to abort=',I3,/,
        9' # rejects due to artifacts=',I3)
        PRINT 792,INSTAT(29),INSTAT(30)
792     FORMAT(/,' Total # bar-presses=',I5,/,' All bar-presses during
        9 ITIs=',I5)
```

```
      PRINT 796,RLSTAT(1),RLSTAT(2)
796   FORMAT(/,' % US trials aborted=',F4.0,/,' % of US trials rejected
     9 due to artifacts=',F4.0)
      PRINT 800,RLSTAT(3),RLSTAT(4)
800   FORMAT(/,' Mean RT(ms) for "ok" US trials=',F7.1,/,
     9' Standard deviation for these RTs=',F10.4)
      PRINT 804,RLSTAT(5),RLSTAT(6)
804   FORMAT(/,' For ok US trials,mean # reinforcements=',F6.3,/,
     9' For ok DS trials,mean # bar-presses(in phases 6+7)=',F6.3)
      PRINT 808,(RLSTAT(K),K=7,14)
808   FORMAT(/,' For artifact-rejected US trials,mean # deviant points:',
     9/,2X,'Chan 1',2X,'Chan 2',2X,'Chan 3',2X,'Chan 4',2X,'Chan 5',
     92X,'Chan 6',2X,'Chan 7',2X,'Chan 8',/,8(2X,F6.3))

D     PAUSE   ' CREATE BY FILE'
      CALL INSERT(FSPEC2,FSTRNG,4,6)
      OPEN(UNIT=2,NAME=FSTRNG,TYPE='NEW',FORM='UNFORMATTED',DISPOSE='SAVE')
      WRITE (2) (INSTAT(M),M=1,30),(RLSTAT(N),N=1,14)
      DO 816 I=1,NCHS
      DO 812 J=1,400
      YVAL(J)=USAVG(LCH(I),J)          ! MULT BY USCNT?
812   CONTINUE
      WRITE (2) (YVAL(N),N=1,400)
816   CONTINUE
      DO 824 K=1,NCHS
      DO 820 L=1,400
      YVAL(L)=DSAVG(LCH(K),L)          ! MULT BY DSCNT?
820   CONTINUE
      WRITE (2) (YVAL(N),N=1,400)
824   CONTINUE
      CLOSE(UNIT=2,DISPOSE='SAVE')

      TYPE 828
828   FORMAT(/,' SESSION IS OVER; PUT NEW FILE ON MAGTAPE BY TYPING:',/)
      CALL SCOPY('COPY DL1:XXXXXX.DAT MT:XXXXXX.DAT ',EXTMSG)
      CALL INSERT(FSPEC2,EXTMSG,10,6)
      CALL INSERT(FSPEC2,EXTMSG,24,6)
      CALL PUTSTR(7,EXTMSG,' ')
832   CALL EXIT
      END

      SUBROUTINE WATCH
      COMMON /BLOCK1/MSNEW,ISI
      MSNEW=MSNEW+1              ! Update msec counter
      ISI=ISI+1                  ! Update inter-sample interval timer
      CALL IPOKE("170420,"133)       ! Clear overflow flag
      RETURN
      END
```

```
      SUBROUTINE ITISUM
      COMMON /BLOCK2/ITIRSP
836   CALL CCREAD(MBPRSS,MYET,MSTILL,"164010)
      IF(MSTILL .GT. 0) GOTO 836
      ITIRSP=ITIRSP+1          ! Update # of ITI bar-presses
      CALL IPOKE("164010,"100)
      RETURN
      END

      SUBROUTINE WINDOW(MATRIX,LHIGH,LIMIT,LCH,LIMAX,LIMIN,KLIPT)
      VIRTUAL MATRIX(8,400)
      INTEGER*2 MATRIX,LCH(8),LIMAX(8),LIMIN(8),KLIPT(8)
      DO 844 L=1,8
      IF(LCH(L) .EQ. 0) GOTO 848       ! End at 1st null pointer
      NX=LCH(L)                ! Point to next channel with data
      LIMTOP=MATRIX(NX,1)      ! Initial max value
      LIMBOT=MATRIX(NX,1)      ! Initial min value
      KLIPT(NX)=0              ! Reset artifact counter
      DO 840 M=1,400
      IF(IABS(MATRIX(NX,M)) .GT. LIMIT) KLIPT(NX)=KLIPT(NX)+1
      LIMTOP=MAX0(MATRIX(NX,M),LIMTOP)
      LIMBOT=MIN0(MATRIX(NX,M),LIMBOT)
840   CONTINUE
      LIMAX(NX)=LIMTOP         ! Store highest datum for Chan n
      LIMIN(NX)=LIMBOT         ! Store lowest datum for Chan n
844   CONTINUE
848   RETURN
      END

      SUBROUTINE REINF
      COMMON/BLOCK1/MSNEW,ISI/BLOCK3/IDIS/BLOCK4/MSROFF
      INTEGER*2 IDIS
      IDTANG=IDIS+1024                 ! Set bit #10 of HCO register
      CALL DEVICE(-1,IDTANG,"164000)
      MSROFF=MSNEW + 50                ! Set relay operation time
      RETURN
      END

      SUBROUTINE ROFF
      COMMON/BLOCK3/IDIS/BLOCK4/MSROFF
      INTEGER*2 IDIS
      CALL DEVICE(-1,IDIS,"164000)     ! Clear bit #10 of HCO register
      MSROFF=20000
      RETURN
      END
```

```
C       PROGRAM P300 IS THE MASTER PROGRAM FOR RUNNING
C       THE UNCUED TONE PROTOCOL, SAMPLING FOUR
C       CHANNELS OF EITHER EVENT RELATED POTENTIALS OR
C       MULTIPLE UNIT ACTIVITY, AND ALL RELATED DATA
C       MANIPULATION AND STORAGE, VIA MENU SELECTION.
C       SOFTWARE TRIGGER INITIATES SAMPLING EVERY X MSEC.
C       DIGITIZED WAVEFORMS STORED IN MATRIX AS INTEGERS,
C       ARTIFACT-REJECTED AND, OPTIONALLY, DISPLAYED.
C       AT END OF EACH SET, AVERAGES WRITTEN TO FLOPPY DISK.
C       *********C=common ; Higher probability***************
C       ***********R=rare ; Lower probability****************

        PROGRAM P300
        EXTERNAL WATCH
        COMMON /BLOCK1/MATRIX,JDATUM,IBUFF
        VIRTUAL HISUM(4,400),LOSUM(4,400),YVAL(400),XVAL(400)
        REAL YVAL,XVAL,HISUM,LOSUM,HICNT,LOCNT
        LOGICAL*1 YESNO,TASK(3),IDSUBJ(8),TYPE,ICHAR
        LOGICAL*1 FSTRNG(14),TONE(4),FSPEC(7),ERR1,ERR2,IDHIHZ
        INTEGER*2 ISTAT,IBUFF(4),IBFCNT,ICHAN,INSTAT(30),CALUV(4)
        INTEGER*2 MONTH(12),LEVEL(4),KLIPT(4),MATRIX(4,400)
        INTEGER*4 ITIME
        DATA IBUFF/4*0/,INSTAT/30*0/,CALUV/4*25/
        DATA MONTH/31,28,31,30,31,30,31,31,30,31,30,31/
        DATA LEVEL/4*0/,KLIPT/4*0/

        LIMIT=4000                ! Artifact window size(+ or -)
        NDAYS=0
        ITISEC=0
        LOOK=0                    ! Automatically displayed channel
        INTGR1=0
        INTGR2=0
        ISPEED=1                  ! Skip single-trial display
        IEPOKI=0                  ! 0 sec between epochs
        NTIX=25                   ! Sample every 2.5 msec
        IEPOCH=1000               ! Epoch lasting 1000 msec
        ITIX=-25                  ! Clock overflow every 2.5 msec
        NTRIAL=1                  ! Total # trials
        ID0="0                    ! Bit pattern during ITI
        ID1="4000                 !  "     "      "  phase 1
        ID2="44                   !  "     "      "    "   2
        ID3="10000                !  "     "      "    "   3
        ID5="400                  !  "     "      "    "   5
        NSET=0                    ! Initialize counter for data sets
        KHIPCT=80                 ! Initialize % of common tones

4       TYPE 8
8       FORMAT(' NAME OF SUBJECT IS: ',$)
        CALL GETSTR(5,IDSUBJ,7,ERR1)    ! Input up to 7 letters of name
        IF(ERR1) GOTO 4
        CALL SCOPY('DY:XXXXXX.DAT',FSTRNG)      ! Initialize filename
```

```
        CALL IDATE(MON,IDAY,IYEAR)        ! Access date entered upon boot
        TYPE 12,MON,IDAY,IYEAR
12      FORMAT(' IS TODAY''S DATE:',I3,'/',I3,'/',I3,' (Y or N)?',$)
        ACCEPT 16,YESNO
16      FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 22        ! If date OK, proceed
        TYPE 20
20      FORMAT(' YOU FORGOT TO ENTER DATE; START ALL OVER ',/)
        GO TO 832

22      TYPE 24
24      FORMAT(/,' ENTER NEW FILE NAME (up to 6 letters/numbers) : ',$)
        CALL GETSTR(5,FSPEC,6,ERR2)
        IF(ERR2) GOTO 22
        FSPEC(7)=0
        TYPE 26,(FSPEC(J),J=1,6)
26      FORMAT(/,2X,6A1,'.DAT WILL BE WRITTEN ONTO FLOPPY DISK')

        NCHS=4
        TYPE 38
38      FORMAT(/,' FOUR CHANNELS ARE TO BE SAMPLED: 1,2,3, and 4')

        IF(MOD(IYEAR,4) .EQ. 0) MONTH(2)=29      ! If leap yr, Feb has 29
        NYEAR=MOD(IYEAR,10)                      ! Which year of the decade?
        DO 40 JMON=1,MON
        NDAYS=NDAYS+MONTH(JMON)
40      CONTINUE
        NDAYS=NDAYS+IDAY-MONTH(MON)              ! Which day of the year

        DO 44 M=1,NDAYS+5
        RANNUM=F`N(INTGR1,INTGR2)        ! Start RAN subrtn at new point
44      CONTINUE

C       ****************OPEN DATA FILE FOR THIS SESSION*****************
        CALL INSERT(FSPEC,FSTRNG,4,6)          ! Open session's data file
        OPEN(UNIT=2,NAME=FSTRNG,TYPE='NEW',FORM='UNFORMATTED',DISPOSE='SAVE')

C       **************************RESET PARAMETERS************************
50      NSET=NSET+1
51      TYPE 52,KHIPCT,LIMIT,(LOOK+1)
52      FORMAT(/,' PARAMETERS ARE AS FOLLOWS:',/,' 1) % OF COMMON TONES
        9 = ',I4,/,' 2)ARTIFACT LIMIT= +/- ',I6,/,
        9' 3)CHANNEL DISPLAYED AT END OF EACH TRIAL= ',I2,/,' 4)CAL PULSES:')
        DO 54 M=1,4
        TYPE 53,M,CALUV(M)
53      FORMAT(3X,'CH',I2,': ',I5,'uV')
54      CONTINUE
        TYPE 55,(NTIX*40),IEPOKI,ISPEED,NSET
55      FORMAT(/,' 5)EPOCH DURATION = ',I5,' msec',/,' 6)Inter-
        9epoch interval = ',I6,' sec',/,' 7)SPEED(0=slow;1=fast)= ',I2,
        9/,' 8) # OF NEXT DATA SET = ',I4)
        TYPE 56
56      FORMAT(' ENTER NUMBER OF ITEM TO BE CHANGED, OR 0 IF NONE : ',$)
        ACCEPT 57,NPARAM
57      FORMAT(I2)
```

```
      GO TO (90,58,61,64,67,75,78,81,86), (NPARAM+1)
58    TYPE 59
59    FORMAT(' WHAT % OF OCCURRENCE (50< % <100) FOR COMMON TONES ? ',$)
      ACCEPT 60,KHIPCT
60    FORMAT(I4)
      IF(KHIPCT .LT. 50) GOTO 58
      GO TO 51

61    TYPE 62
62    FORMAT(' NEW WINDOW LIMIT= ',$)
      ACCEPT 63,LIMIT
63    FORMAT(I6)
      GO TO 51

64    TYPE 65
65    FORMAT(' CHANNEL TO LOOK AT FIRST(1-4) = ',$)
      ACCEPT 66,LOOK
66    FORMAT(I2)
      LOOK=LOOK-1
      GO TO 51

67    DO 69 J=1,4
      TYPE 68,J,CALUV(J)
68    FORMAT(3X,'CH ',I1,' CAL= ',I5,'uV')
69    CONTINUE
      TYPE 70
70    FORMAT(/,' CHANGE CAL uV VALUES ? ',$)
      ACCEPT 71,YESNO
71    FORMAT(A1)
      IF(YESNO .NE. 'Y') GOTO 51

72    TYPE 73
73    FORMAT(' ENTER CHANNEL #,THEN NEW uV CALIBRATION,e.g. 3,75 : ',$)
      ACCEPT 74,K,CALUV(K)
74    FORMAT(I2,I4)
      GO TO 67

75    TYPE 76
76    FORMAT(/,' ENTER NEW EPOCH DURATION (msec): ',$)
      ACCEPT 77,IEPOCH
77    FORMAT(I5)
      NTIX=IEPOCH/(40)
      ITIX=-1*NTIX
      GO TO 51

78    TYPE 79
79    FORMAT(/,' ENTER NEW INTER-EPOCH INTERVAL (sec): ',$)
      ACCEPT 80,IEPOKI
80    FORMAT(I6)
      GO TO 51

81    TYPE 82
82    FORMAT(/,' Enter "1" for fast, or "0" for slow mode: ',$)
      ACCEPT 84,ISPEED
84    FORMAT(I2)
      GO TO 51
```

```
86      TYPE 87
87      FORMAT(/,' WHAT IS THE # FOR THE NEXT SET OF AVERAGES? ',$)
        ACCEPT 88,NSET
88      FORMAT(I4)
        GO TO 51
90      TYPE 91
91      FORMAT(/,' MAKE HIGHER-PITCHED TONE COMMON(C) OR RARE(R)? :  ',$)
        ACCEPT 92,IDHIHZ          ! Identify C or R for high-pitch tone
92      FORMAT(A1)

        IEPOCH=40*NTIX            ! Reentry point after setting parameters
        NCTONE=0                  ! # of common tones presented
        NRTONE=0                  ! # of rare tones presented
        NRSAMP=0                  ! # of rare samples needed
        HICNT=0                   ! Zero out common sample size
        LOCNT=0                   ! Zero out rare sample size
        ITRIAL=0                  ! Counter for # of trial

        DO 94 I=1,4
        LEVEL(I)=0                ! Estimator of waveform DC level
94      CONTINUE
        DO 96 L=1,400
        DO 95 K=1,4
        MATRIX(K,L)=0             ! Zero out single-trial matrix
        HISUM(K,L)=0              ! Zero out common summing matrix
        LOSUM(K,L)=0              ! Zero out rare summing matrix
95      CONTINUE
        YVAL(L)=0                 ! Zero out display matrix
        XVAL(L)=2*L+150           ! Initialize abscissa values
96      CONTINUE
        ITIX=-1*NTIX              ! Update # ticks before clock overflow
97      TYPE 98
98      FORMAT(/,' HOW MANY TRIALS ? (e.g., 35): ',$)
        ACCEPT 99,NTRIAL
99      FORMAT(I3)
        NRSAMP=NTRIAL-(NTRIAL*KHIPCT)/100
        PAUSE  'HIT RETURN TO GO'

        CALL DEVICE(-1,IDO,"164000)      ! Turn off all devices
        CALL IPOKE("170420,"0)           ! Turn off clock

C       ****************EACH TRIAL BEGINS HERE******************
108     IF(LOCNT .GE. NRSAMP) GOTO 382   ! Already have enough R samples?
        ITRIAL=ITRIAL+1                  ! Set next trial #
        RANNUM=RAN(INTGR1,INTGR2)
        CUTOFF=FLOAT(KHIPCT)/100.
        IF(RANNUM .GT. CUTOFF) GO TO 128        ! If true, R tone next
        CALL SCOPY('COMN',TONE)
        NCTONE=NCTONE+1                  ! Count # of common tones presented
        IF(IDHIHZ .EQ. 'R') GOTO 140
        GO TO 136
128     CALL SCOPY('RARE',TONE)
        NRTONE=NRTONE+1                  ! Count # of rare tones presented
        IF(IDHIHZ .EQ. 'R') GOTO 136
        GO TO 140
```

```
136     ID4="20002
        GO TO 144
140     ID4="100010
144     TYPE 148,ITRIAL,TONE
148     FORMAT(/,' Trial #',I3,' : ',4A1)

C       HERE, INITIALIZE OTHER STARTING VALUES
        JDATUM=0                 ! Reset pointer for storing data
        ISYNOT=0                 ! Initialize reject reason code
        IF(IEPOKI .EQ. 0) GOTO 185

        IF(ITRIAL .EQ. 1) GOTO 180
160     CALL GTIM(ITIME)
        CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITCK)
        ITISEC=(3600*IHRS)+(60*IMIN)+(ISEC)-NOW ! Sec since last epoch
        IF(ITISEC .LE. IEPOKI) GOTO 160

180     NOW=0
185     CALL DEVICE(-1,ID1,"164000)      ! Turn on phase #1 indicator light

C       ***********CLOCK WILL RUN AT 10 KHz, OVERFLOW EACH 1 MSEC************
C       ******CLOCK INTERRUPT WILL ONLY BE USED TO UPDATE MSNEW AND ISI******
        CALL CLOCKW(1,3,ITIX,,WATCH,"170420,"440)       ! Start clock

214     IF(JDATUM .LT. 1) GOTO 214       ! Begin CAL trigger pulse ?
        CALL DEVICE(-1,ID2,"164000)      ! CAL pulse ON
218     IF(JDATUM .LT. 25) GOTO 218      ! End CAL trigger pulse ?
        CALL DEVICE(-1,ID3,"164000)      ! CAL pulse OFF
222     IF(JDATUM .LT. 100) GOTO 222     ! Begin tone ?
        CALL DEVICE(-1,ID4,"164000)      ! Tone ON
226     IF(JDATUM .LT. 150) GOTO 226     ! End tone ?
        CALL DEVICE(-1,ID5,"164000)      ! Tone OFF
230     IF(JDATUM .LT. 400) GOTO 230     ! End trial; Stop sampling ?

        CALL IPOKE("170420,"0)  ! Turn off clock between epochs
        CALL DEVICE(-1,ID0,"164000)      ! Turn off all devices
        IF(IEPOKI .EQ. 0) GOTO 300
        CALL GTIM(ITIME)
        CALL CVTTIM(ITIME,IHRS,IMIN,ISEC,ITCK)
        ITISEC=(3600*IHRS)+(60*IMIN)+(ISEC)
        NOW=ITISEC               ! Store time at end of this trial
C       *************BEGIN INTER-TRIAL INTERVAL ACTIVITIES:***************
C       ******************REVIEW DATA FOR ARTIFACTS*********************
300     CALL WINDOW(MATRIX,LIMIT,LEVEL,KLIPT)
        TYPE 310,(LEVEL(N),N=1,4)
310     FORMAT(/,' DC LEVELS:',3X,I4,10X,I4,10X,I4,10X,I4)

        DO 320 I=1,4
        IF(KLIPT(I) .GT. 5) ISYNOT=4     ! More than 5 artifacts?
320     CONTINUE
        IF(ISYNOT .EQ. 4) GOTO 370
```

```
328     IF(SCOMP('RARE',TONE) .EQ. 0) GOTO 348  ! If R trial,update LOSUM
        DO 340 L=1,4
        DO 332 N=1,400
        HISUM(L,N)=HISUM(L,N)+MATRIX(L,N)       ! Might need to convert
332     CONTINUE                                ! integer-to-real
340     CONTINUE
344     HICNT=HICNT+1.0
        GO TO 380

348     DO 356 L=1,4
        DO 352 N=1,400
        LOSUM(L,N)=LOSUM(L,N)+MATRIX(L,N)       ! Might need to convert
352     CONTINUE                                ! integer-to-real
356     CONTINUE
360     LOCNT=LOCNT+1.0
        GO TO 380

370     DO 374 I=1,4
        DO 372 J=1,400
        MATRIX(I,J)=MATRIX(I,J)         ! Keep time between tones equal
372     CONTINUE                        ! to when data are added to average
374     CONTINUE
        TYPE 376
376     FORMAT(/,' TOO MANY ARTIFACTS; DATA NOT ADDED TO AVERAGE')

380     TYPE 381,IFIX(HICNT),IFIX(LOCNT)
381     FORMAT(' SO FAR:  C =',I4,5X,'R =',I4)
        IF(ISPEED .EQ. 0) GOTO 395
        ICHAR=ITTINR()                  .! Last ASCII character entered on TT
        IF(ICHAR .GT. "100) GOTO 382    ! If LETTER there, then quit speedmode
        IF(LOCNT .LT. NRSAMP) GOTO 108  ! Not enough rare tone samples ?
382     TYPE 383,NCTONE,NRTONE,IFIX(HICNT),IFIX(LOCNT)
383     FORMAT(/,' # Presented : C=',I4,5X,'; R=',I4,/,
        7' # Averaged   : C=',I4,5X,'; R=',I4)
        TYPE 385
385     FORMAT(/,' HOW MANY MORE TRIALS ? (0 if averages final) : ',$)
        ACCEPT 387,NMORE
387     FORMAT(I3)
        NTRIAL=NTRIAL+NMORE             ! Set new max # of trials
        NRSAMP=(NTRIAL*KHIPCT)/100      ! Adjust rare-sample size criterion
        IF(NMORE .GT. 0) GOTO 448       ! Continue with current averages
        TYPE 388
388     FORMAT(/,' PUT CURRENT AVERAGES ON FLOPPY?  ',$)
        ACCEPT 389,YESNO
389     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 670
        TYPE 390
390     FORMAT(/,' BEGIN NEW SET OF AVERAGES ?  ',$)
        ACCEPT 391,YESNO
391     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 50
        GO TO 448
```

```
395     IDCH=LOOK
400     DO 404 N=1,400
        YVAL(N)=MATRIX(IDCH+1,N)+390.
404     CONTINUE
408     CALL GINIT(1)            ! Set default parameters
        CALL GEND                ! Go to transparent mode
        CALL STXOX
        CALL STOTU(7)            ! Graphic output on console
        CALL STERR(2)            ! Print error and warning messages
        TYPE 412
412     FORMAT(25(/))            ! Clear screen
        DO 416 M=1,400
        CALL POINT(XVAL(M),YVAL(M))      ! Plot values
416     CONTINUE
        CALL GEND                ! Go to transparent mode
        CALL HOLD                ! Wait for carriage return
        CALL ERASE               ! Clear screen
        CALL GEND                ! Go to transparent mode
        IF(SCOMP('DS',TASK) .EQ. 0) GOTO 464
        IF(SCOMP('DA',TASK) .EQ. 0) GOTO 476

448     TYPE 450
450     FORMAT(/,' HIT RETURN FOR NEXT TRIAL, OR:')
        TYPE 452
452     FORMAT(' PICK FROM MENU : ??,QT,EX,#T,NU,DS,DA,LP,WD,PL,...',$)
        ACCEPT 456, TASK(1),TASK(2)
456     FORMAT(2A1)
        IF(SCOMP('??',TASK) .EQ. 0) GOTO 458    ! Display menu
        IF(SCOMP('QT',TASK) .EQ. 0) GOTO 656    ! Quit session
        IF(SCOMP('EX',TASK) .EQ. 0) GOTO 660    ! Exit session
        IF(SCOMP('#T',TASK) .EQ. 0) GOTO 382    ! Trial # status
        IF(SCOMP('NU',TASK) .EQ. 0) GOTO 50     ! Begin new set
        IF(SCOMP('DS',TASK) .EQ. 0) GOTO 464    ! Display data
        IF(SCOMP('DA',TASK) .EQ. 0) GOTO 476    ! Display average
        IF(SCOMP('LP',TASK) .EQ. 0) GOTO 600    ! List parameters
        IF(SCOMP('WD',TASK) .EQ. 0) GOTO 670    ! Write data to disk
        IF(SCOMP('PL',TASK) .EQ. 0) GOTO 648    ! Plot data
        GO TO 108

458     TYPE 460
460     FORMAT(' MENU IS AS FOLLOWS: ??---EXPLAIN MENU',/,23X,'QT---
     7 QUIT SESSION (DELETE DATAFILES)',/,23X,'EX---EXIT FROM SESSION
     7 (SAVE DATAFILES)',/,23X,'#T---# EACH TONE TYPE SO FAR',/,23X,
     7'NU---START NEW DATA SET',/,23X,'DS---DISPLAY SINGLE TRIAL DATA',
     7/,23X,'DA---DISPLAY AVERAGES',/,23X,'LP---LIST PARAMETERS',/,23X,
     7'WD---WRITE DATA TO DISK',/,23X,'PL---PLOT DATA')
        GO TO 448

464     TYPE 468
468     FORMAT(' VIEW DATA FROM WHICH CHANNEL (1-4) ? ',$)
        ACCEPT 472,IDCH
472     FORMAT(I3)
        IDCH=IDCH-1
        IF(IDCH .LT. 0 .OR. IDCH .GT. 3) GOTO 448
        GO TO 400
```

```
476     TYPE 480
480     FORMAT(' C OR R ? WHICH CHANNEL # ? (e.g. C2 or C3 or R1)',$)
        ACCEPT 484,TYPE,NUMCH
484     FORMAT(A1,I1)
        IF(TYPE.NE.'C' .AND. TYPE.NE.'R') GOTO 448
        IF(NUMCH.LT.1 .OR. NUMCH.GT.4) GOTO 476
        IF(TYPE .EQ. 'R') GOTO 492
        DO 488 K=1,400
        YVAL(K)=HISUM(NUMCH,K)/HICNT+390.        ! Display C average
488     CONTINUE
        GO TO 408
492     DO 496 K=1,400
        YVAL(K)=LOSUM(NUMCH,K)/LOCNT+390.        ! Display R average
496     CONTINUE
        GO TO 408
600     TYPE 602,KHIPCT,LIMIT,(LOOK+1)
602     FORMAT(/,' PARAMETERS ARE AS FOLLOWS:',/,' 1) % OF C TONES= ',I4,
        9/,' 2) ARTIFACT LIMIT= +/- ',I6,/,' 3) CHANNEL DISPLAYED AT END
        9 OF EACH TRIAL= ',I2,/,' 4) CAL PULSES:')
        DO 606 M=1,4
        TYPE 604,M,CALUV(M)
604     FORMAT(3X,'CH',I2,':',I5,'uV')
606     CONTINUE
        TYPE 608,(NTIX*40),IEPOKI,ISPEED
608     FORMAT(/,' 5) EPOCH DURATION= ',I5,' msec',/,' 6) INTER-EPOCH
        9 INTERVAL = ',I6,' sec',/,' 7) SPEED (0=slow;1=fast) = ',I2)
        TYPE 610,IDHIHZ
610     FORMAT(/,' THE HIGHER-PITCH TONE IS THE ',A1,' TONE')
        GO TO 448

648     TYPE 652
652     FORMAT(' THIS OPTION NOT YET AVAILABLE ',/)
        GO TO 448

656     CALL IPOKE("170420,"0)          ! Shut off clock
        CLOSE(UNIT=2,DISPOSE='DELETE')           ! Delete datafile from DYdisk
        GO TO 832

660     TYPE 664
664     FORMAT(' OK TO END THIS SESSION (Y or N): ?',$)
        ACCEPT 668,YESNO
668     FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 448
        CALL IPOKE("170420,"0)          ! Shut off clock
        GO TO 828
C       ************GENERATE LABELS FOR CURRENT DATA SET***************
670     INSTAT(1)=300           ! This was a P300 session
        INSTAT(2)=MON
        INSTAT(3)=IDAY
        INSTAT(4)=IYEAR
        DO 672 J=1,6
        INSTAT(J+4)=FSPEC(J)
672     CONTINUE
```

```
      DO 673 M=1,5
      INSTAT(M+10)=IDSUBJ(M)
673   CONTINUE
      DO 675 K=1,4
      INSTAT(K+15)=CALUV(K)
675   CONTINUE
      INSTAT(20)=HICNT          ! Common tone sample size
      INSTAT(21)=LOCNT          ! Rare tone sample size
      INSTAT(22)=NTRIAL         ! Total # of trials
      INSTAT(23)=NCTONE         ! Total # common tone trials
      INSTAT(24)=NRTONE         ! Total # rare tone trials
      INSTAT(25)=NSET           ! Which # set of averages is this?
      INSTAT(26)=LIMIT          ! Artifact window size
      INSTAT(27)=NTRIAL-IFIX(HICNT+LOCNT)      ! # rejects
      INSTAT(28)=NTIX           ! Tenths of msec per sample
      INSTAT(29)=IEPOKI                ! Inter-epoch interval
      INSTAT(30)=NCHS           ! # of sampled channels

D     GO TO 800
756   PRINT 760
760   FORMAT(3(/))
      CALL PUTSTR(6,IDSUBJ,' ')
      PRINT 764,(INSTAT(I),I=1,4)
764   FORMAT(/,' P',I3,5X,'Date:',I3,'/',I3,'/',I3)
      PRINT 768,INSTAT(23),INSTAT(24)
768   FORMAT(/,'  # of common tones=',I3,' ; # of rare tones=',I3)
      PRINT 772,INSTAT(28),INSTAT(29)
772   FORMAT(/,' Tenths of msec per sample(ms)=',I5,/,' ; Inter-epoch
     9 interval (sec) = ',I6)
      PRINT 776,INSTAT(26)
776   FORMAT(/,' Artifact limit= +/-',I6,/,/,' Sampled the first four
     9 channels only')
      PRINT 780,INSTAT(20),INSTAT(21)
780   FORMAT(/,' Sample size for C average=',I3,' ; for R average=',I3)
      PRINT 784,INSTAT(22)
784   FORMAT(/,' Total # trials=',I3)
      PRINT 788,INSTAT(27)
788   FORMAT(/,' Total # rejects due to artifacts=',I3)
      PRINT 796,INSTAT(16),INSTAT(17),INSTAT(18),INSTAT(19)
796   FORMAT(/,' For each channel, CAL signal amplitude :',
     9/,6X,'Chan 1',6X,'Chan 2',6X,'Chan 3',6X,'Chan 4',/,4(6X,I6))
      PRINT 798,INSTAT(25)
798   FORMAT(/,' THAT WAS THE #',I4,' SET OF AVERAGES')

C     *****************WRITE DATA RECORD TO DY FILE*******************
800   WRITE (2) (INSTAT(M),M=1,30)
      DO 816 I=1,4
      DO 812 J=1,400
      YVAL(J)=HISUM(I,J)/HICNT                  ! Divide sum by sample size
812   CONTINUE
      WRITE (2) (YVAL(N),N=1,400)
816   CONTINUE
```

```
        DO 824 K=1,4
        DO 820 L=1,400
        YVAL(L)=LOSUM(K,L)/LOCNT                ! Divide sum by sample size
820     CONTINUE
        WRITE (2) (YVAL(N),N=1,400)
824     CONTINUE

        TYPE 825
825     FORMAT(/,' BEGIN NEW SET OF AVERAGES ? ',$)
        ACCEPT 826,YESNO
826     FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 448
        GO TO 50                           ! Go start next set of averages
828     CLOSE(UNIT=2,DISPOSE='SAVE')       ! End this session

832     CALL EXIT
        END

        SUBROUTINE WATCH
        COMMON /BLOCK1/MATRIX,JDATUM,IBUFF
        INTEGER*2 MATRIX(4,400),IBUFF(4)
        CALL AREADP(ISTAT,IBUFF,4,-3)
        CALL EXTS12(IBUFF,4)
        JDATUM=JDATUM+1
        MATRIX(1,JDATUM)=IBUFF(1)
        MATRIX(2,JDATUM)=IBUFF(2)
        MATRIX(3,JDATUM)=IBUFF(3)
        MATRIX(4,JDATUM)=IBUFF(4)
        CALL IPOKE("170420,"133)           ! Clear overflow flag
        RETURN
        END

        SUBROUTINE WINDOW(MATRIX,LIMIT,LEVEL,KLIPT)
        INTEGER*2 MATRIX(4,400),LIMIT,LEVEL(4),KLIPT(4)
        DO 844 L=1,4
        KLIPT(L)=0                  ! Reset artifact counter
        LEVEL(4)=0                  ! Reset DC level estimator
        DO 840 M=1,400
!       IF(IABS(MATRIX(L,M)) .GT. LIMIT) KLIPT(L)=KLIPT(L)+1
        LEVEL(L)=LEVEL(L)+MATRIX(L,M)
840     CONTINUE
        LEVEL(L)=LEVEL(L)/400       ! Calculate mean integer value
844     CONTINUE
848     RETURN
        END
```

```
      PROGRAM PLTCNV
C     PLTCNV EMPLOYS VERTICAL CURSOR ONLY
C     Y VALUES ARE FROM ORIGINAL DATA, NOT INTERPOLATED
      EXTERNAL WATCH
      COMMON /BLOCK1/JDATUM
      VIRTUAL WSAVG(8,400),DSAVG(8,400)
      REAL RLSTAT(14),WSAVG,DSAVG,WSCNT,DSCNT,PARAM(6)
      REAL XTABL(10),YTABL(10),XVAL(400),YVAL(400)
      LOGICAL*1 YESNO,TYPE,ICHAR,FSTRNG(14),LFILE(6),LABELX(13),LABELY(10)
      LOGICAL*1 STROFF(4),STRON(4)
      INTEGER*2 INSTAT(30),LCH(8),NUMCH
      DATA RLSTAT/14*0.0/,INSTAT/30*0/
      CALL SCOPY('Milliseconds',LABELX)       ! Abscissa label
      CALL SCOPY('Microvolts',LABELY) ! Ordinate label
      CALL SCOPY('DY:MIXXXX.DAT',FSTRNG)      ! Initialize filename
      STROFF(1)="033
      STROFF(2)="057
      STROFF(3)="061
      STROFF(4)="144
      STRON(1)="033
      STRON(2)="057
      STRON(3)="060
      STRON(4)="144

1     TYPE 5
5     FORMAT(' Enter 6-character file code, e.g. "MI0553" : ',$)
      ACCEPT 10,(LFILE(N),N=1,6)
10    FORMAT(6A1)
      CALL INSERT(LFILE,FSTRNG,4,6)

      DO 20 L=1,400
      DO 15 K=1,8
      WSAVG(K,L)=0               ! Zero out WS average matrix
      DSAVG(K,L)=0               ! Zero out DS average matrix
15    CONTINUE
      YVAL(L)=0                  ! Zero out display matrix
      XVAL(L)=0
20    CONTINUE

      PARAM(1)=460.    ! XMAX
      PARAM(2)=0.      ! XMIN
      PARAM(3)=0.      ! YORDLO
      PARAM(4)=500.    ! YMAX
      PARAM(5)=-500.   ! YMIN
      PARAM(6)=-500.   ! XORDLO
      MMFLG=1

      OPEN(UNIT=2,NAME=FSTRNG,FORM='UNFORMATTED',TYPE='OLD',DISPOSE='SAVE')

      READ (2) (INSTAT(N),N=1,30),(RLSTAT(N),N=1,14)
      NCHS=INSTAT(12)
      DO 35 K=1,8
      LCH(K)=INSTAT(K+12)
35    CONTINUE
```

```
      DO 45 I=1,NCHS
      READ (2) (YVAL(N),N=1,400)
      DO 40 J=1,400
      WSAVG(LCH(I),J)=YVAL(J)
40    CONTINUE
45    CONTINUE

      DO 60 K=1,NCHS
      READ (2) (YVAL(N),N=1,400)
      DO 55 L=1,400
      DSAVG(LCH(K),L)=YVAL(L)
55    CONTINUE
60    CONTINUE

      WSCNT=INSTAT(21)
      DSCNT=INSTAT(22)

      TYPE 63
63    FORMAT(/,' Print out session info + stats ? Y or N : ',$)
      ACCEPT 65,YESNO
65    FORMAT(A1)
      IF(YESNO .NE. 'Y') GOTO 145

      PRINT 70,(INSTAT(I),I=1,4)
70    FORMAT(/,' Monkey #',I5,5X,'Date:',I3,'/',I3,'/',I3)
      PRINT 75,(INSTAT(J),J=5,7)
75    FORMAT(/,' Condition #',I2,' ; Day #',I3,' ; % WS trials=',I3)
      PRINT 80,(INSTAT(K),K=8,10)
80    FORMAT(/,' Limited hold(ms)=',I5,/,' Inter-stimulus interval(ms)=',
     9I5,/,' IS duration(ms)=',I6)
      PRINT 85,(INSTAT(L),L=11,(INSTAT(12)+12))
85    FORMAT(/,' Artifact limit= +/-',I6,/,/,' Sampled the following',I2,
     9' channels:',8(1X,I2))
      PRINT 90,INSTAT(21),INSTAT(22)
90    FORMAT(/,' Sample size for WS average=',I3,' ; for DS average=',I3)
      PRINT 95,INSTAT(23),INSTAT(24)
95    FORMAT(/,' Total # trials=',I3,/,' # of WS trials=',I3)
      PRINT 100,(INSTAT(M),M=25,28)
100   FORMAT(/,' # aborts due to slow RT=',I3,/,' # aborts due to premature
     9 bar-pressing=',I3,/,' # aborts due to E opting to abort=',I3,/,
     9' # rejects due to artifacts=',I3)
      PRINT 105,INSTAT(29),INSTAT(30)
105   FORMAT(/,' Total # bar-presses=',I5,/,' All bar-presses during
     9 ITIs=',I5)
      PRINT 110,RLSTAT(1),RLSTAT(2)
110   FORMAT(/,' % WS trials aborted=',F4.0,/,' % of WS trials rejected
     9 due to artifacts=',F4.0)
      PRINT 120,RLSTAT(3),RLSTAT(4)
120   FORMAT(/,' Mean RT(ms) for "ok" WS trials=',F7.1,/,
     9' Standard deviation for these RTs=',F10.4)
      PRINT 125,RLSTAT(5),RLSTAT(6)
125   FORMAT(/,' For ok WS trials,mean # reinforcements=',F6.3,/,
     9' For ok DS trials,mean # bar-presses(in phases 6+7)=',F6.3)
      PRINT 130,(RLSTAT(K),K=7,14)
130   FORMAT(/,' For artifact-rejected WS trials,mean # deviant points:',
     9/,2X,'Chan 1',2X,'Chan 2',2X,'Chan 3',2X,'Chan 4',2X,'Chan 5',
     92X,'Chan 6',2X,'Chan 7',2X,'Chan 8',/,8(2X,F6.3))
```

```
      PRINT 140
140   FORMAT(5(/))
145   TYPE 150
150   FORMAT(' Display US or DS ? Channel # ? (e.g. U4 or U8 or D1) ',$)
      ACCEPT 160,TYPE,NUMCH
160   FORMAT(A1,I1)
      IF(TYPE.NE.'U' .AND. TYPE.NE.'D') GOTO 145
      IF(NUMCH.LT.1 .OR. NUMCH.GT.8) GOTO 145
      IF(TYPE .EQ. 'D') GOTO 175

      DO 170 K=1,400
      YVAL(K)=USAVG(NUMCH,K)
      XVAL(K)=K
170   CONTINUE
      GO TO 185

175   DO 180 K=1,400
      YVAL(K)=DSAVG(NUMCH,K)
      XVAL(K)=K
180   CONTINUE

185   TYPE 190,(PARAM(L),L=1,6)
190   FORMAT(/,' Display parameters are:',/,5X,'1)XMAX= ',F9.2,/,5X,
     7'2)XMIN= ',F9.2,/,5X,'3)YGRDLO= ',F9.2,/,5X,'4)YMAX= ',F9.2,/,5X,
     7'5)YMIN= ',F9.2,/,5X,'6)XGRDLO= ',F9.2)
200   TYPE 202
202   FORMAT(/,' Change display parameters ? Y or N : ',$)
      ACCEPT 203,YESNO
203   FORMAT(A1)
      IF(YESNO .NE. 'Y') GOTO 210
      TYPE 207
207   FORMAT(/,' Enter parameter # and new value, e.g. "6,5385.7": ',$)
      ACCEPT 209,NPAR,REVALU
209   FORMAT(I2,F9.2)
      PARAM(NPAR)=REVALU
      GO TO 185

210   DO 213 L=1,10
      XTABL(L)=0
      YTABL(L)=0
213   CONTINUE
      XMAX=PARAM(1)
      XMIN=PARAM(2)
      YGRDLO=PARAM(3)
      YMAX=PARAM(4)
      YMIN=PARAM(5)
      XGRDLO=PARAM(6)
      YZERO=0.

      TYPE 214
214   FORMAT(/,' "Z" to zero baseline, #s to score points, "Q" to quit')
      PAUSE   'HIT RETURN'
      TYPE 215
215   FORMAT(25(/))
```

```
      CALL BELL(1)
      CALL ERASE
      CALL GRID(LABELX,XMAX,XMIN,YGRDLO,LABELY,YMAX,YMIN,XGRDLO,MMFLG)
      CALL POINT(400,XVAL,YVAL)
      CALL HTEXT('X data',405.,YMAX)
      CALL HTEXT('Y data',405.,-10.)
220   CALL BELL(1)
      CALL VCURSR(ICHAR,XCOOR,YCOOR)
      IF(ICHAR .EQ. 'Q') GOTO 270
      IF(ICHAR .EQ. 'E') GOTO 260
      IF(ICHAR .NE. 'Z') GOTO 225
      YZERO=YCOOR
      GO TO 220
225   DECODE (1,227,ICHAR) NDATUM
227   FORMAT(I1)
      IF(NDATUM .EQ. 0) NDATUM=10
230   XCOOR=AINT(XCOOR+0.5)           ! Reconstruct original x value
      NPOS=IFIX(XCOOR)
      CALL POINT(1,XVAL(NPOS),YVAL(NPOS))      ! Intensify scored point
      XTABL(NDATUM)=XCOOR             ! Enter x value into table
      XPOS=XCOOR-3.                   ! Where to affix tag
      CALL PLTSYM(1,XPOS,150.,ICHAR)  ! Mark tag up top
      VERT1=150.-10.*FLOAT(NDATUM)
      VERT2=-20.-10.*FLOAT(NDATUM)
      CALL HTEXT(ICHAR,405.,VERT1)
      CALL FLTXT(XTABL(NDATUM),425.,VERT1)     ! Display X table entry
      YTABL(NDATUM)=YVAL(NPOS)-YZERO  ! Non-interpolated y value
      CALL HTEXT(ICHAR,405.,VERT2)
      YDISP=AINT(YTABL(NDATUM)*100.)/100.
      CALL FLTXT(YDISP,415.,VERT2)    ! Display Y table entry
      GO TO 220
260   CALL VCURSR(JCHAR,XNEW,YNEW)
      DECODE (1,265,JCHAR) NDATUM
265   FORMAT(I1)
      IF(NDATUM .EQ. 0) NDATUM=10
      CALL MVCUR(XTABL(NDATUM),YTABL(NDATUM))
      XPOS=XTABL(NDATUM)-3.
      YDISP=AINT(YTABL(NDATUM)*100.)/100.
      VERT1=150.-10.*FLOAT(NDATUM)
      VERT2=-20.-10.*FLOAT(NDATUM)
      CALL PUTSTR(7,STROFF,' ')                ! Data level = 1
      CALL PLTSYM(1,XPOS,150.,JCHAR)
      CALL FLTXT(XTABL(NDATUM),425.,VERT1)
      CALL FLTXT(YDISP,415.,VERT2)
      CALL PUTSTR(7,STRON,' ')                 ! Data level = 0
      ICHAR=JCHAR
      XCOOR=XNEW
      YCOOR=YNEW
      GO TO 230              ! Go enter new values
270   CALL ERASE
275   IF(ITTOUR("030) .NE. 0) GO TO 275        ! Enter transparent mode

      TYPE 280
280   FORMAT(/,12X,'Datum #',8X,'X-coordinate',8X,'Y-coordinate')
      DO 290 M=1,10             ! REPLACE NDATUM
      TYPE 285,M,XTABL(M),YTABL(M)
285   FORMAT(12X,I3,10X,F10.3,10X,F10.3)
290   CONTINUE
```

```
        TYPE 295
295     FORMAT(/,' Now plot data ? : ',$)
        ACCEPT 299,YESNO
299     FORMAT(A1)
        IF(YESNO .NE. 'Y') GOTO 399
300     TYPE 305
305     FORMAT(/,' ENTER GAIN AND OFFSET INTEGERS : ',$)
        ACCEPT 310,IGAIN,ILEVEL
310     FORMAT(I5,I5)
        JOLD=0
        JDATUM=0
        INIVAL=(YVAL(1)*IGAIN)-(ILEVEL*IGAIN)+2047
        CALL DAOUTP(1,INIVAL,"170440)
        PAUSE  'SET PLOTTER; HIT RTN'
        IPEN=1
        CALL DEVICE(-1,IPEN,"164000)
        CALL CLOCKW(1,3,-500,,WATCH,"170420,"440)
315     IF(JDATUM .LE. JOLD) GOTO 315
        JOLD=JDATUM
        IF(JDATUM .NE. 2) GOTO 317
        IPEN=0
        CALL DEVICE(-1,IPEN,"164000)
317     IF(JDATUM .GT. 400) GOTO 320
        IVAL=(YVAL(JDATUM)*IGAIN)-(ILEVEL*IGAIN)+2047
        CALL DAOUTP(1,IVAL,"170440)
        GOTO 315
320     CALL IPOKE("170420,"0)          ! Turn off clock
        TYPE 325
325     FORMAT(/,' REPLOT DATA ? : ',$)
        ACCEPT 330,YESNO
330     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 300

399     TYPE 400
400     FORMAT(/,' View more average data (Y or N) ? ',$)
        ACCEPT 410,YESNO
410     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 145

        CLOSE(UNIT=2,DISPOSE='SAVE')
        TYPE 430
430     FORMAT(/,' OPEN NEW DATAFILE ? : ',$)
        ACCEPT 435,YESNO
435     FORMAT(A1)
        IF(YESNO .EQ. 'Y') GOTO 1

        CALL EXIT
        END

        SUBROUTINE WATCH
        COMMON /BLOCK1/JDATUM
        JDATUM=JDATUM+1
        CALL IPOKE("170420,"133)
        RETURN
        END
```

END

FILMED

1-84

DTIC