A GUI Software Suite for Data Acquisition and Analysis of Evoked Field Potentials: Applications in Biomedical and Electrophysiological Research

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***Abstract* – A PC-based system to control the stimulation, data acquisition, and analysis of evoked field potentials from the dentate subfield of the hippocampal formation in the behaving adult rat is presented. The system consists of a commercially available stimulation generator, multifunction I/O board (16 bit), graphical programming language (LabVIEW), and customized virtual instruments (VI's). System operation consists of user interfaced on-screen front-end panels designed to imitate hardware controls.**

I. Introduction

In today's growing software market, choosing the right software package for a particular application is providing to be a difficult challenge. To be efficient, software tools must provide a quick and easy way to perform routine tasks and enable the user to make customized alterations (i.e., subroutines and macros) to the original program in order to satisfy evolving experimental designs and unforeseen problems. Therefore, a high-level programming system would be better adept in creating solutions to many problems than low-level languages. For these reasons, we have designed and implemented a graphical user interface (GUI)-driven software suite for acquiring and analyzing specific evoked field potentials from the dentate gyrus of the hippocampus formation in the behaving adult rat. The system we have developed was written in the graphical programming language of LabVIEW 6i (National Instruments, Austin, TX) and consists of software virtual instrument (VI) modules that mimic physical laboratory instruments [1],[2]. Besides being useful in creating commercially available programs for electrophysiology, LabVIEW is well suited to create customized application that can be continuously modified to meet the researcher's needs [3],[4].

The goal of developing a LabVIEW-based program was to be able to acquire accurate data and perform consistent analysis in a user-friendly platform. Other positive features of this programming platform include its ability to create stand-alone program executables (i.e., VI's) that can be reused and combined with other programs to form more complex VI's.

II. Materials And Methods

Male Sprague-Dawley VAF^{+} rats 70–90 days of age were stereotaxically implanted with recording and stimulating electrodes in the dentate gyrus and medial perforant pathway, while under pentobarbital anesthesia (50mg/kg, IP). Ground and indifferent electrodes were fixed to the contralateral parietal bone. Confirming the positioning of both stimulating and recording electrodes was done by visual inspection of the dentate granule cell field potential evoked by single pulse stimulation (< 0.1HZ) of the perforant path. When a maximal dentate response was obtained, the electrodes were fixed to the skull with dental acrylate. Following surgery, animals were given 48–72 hours for recovery. Twenty-four hours prior to testing, the animals were introduced into a recording chamber and allowed to habituate to the new environment. Animals were then connected to a counterbalanced electrical commutator (Plastics One, Roanoke, VA, USA) to allow for 360º of rotational freedom and minimal stress to the animal.

Activation of the dentate granule cells by stimulation of the medial perforant path was performed by a Grass S-88 stimulation generator, which was triggered through a sub routine created in LabVIEW. The resultant stimulation produced a triphasic extracellular field potential from the granule cell perikarya [5],[6],[7]. The signal was then amplified, bandpass filtered (1Hz – 3kHz) and fed to a 16-bit data acquisition board (National Instruments, Austin, TX, USA) sampling at 70 kHz.

The user was able to instantly view the captured signal with a virtual oscilloscope on the front panel of the LabVIEW program "Fig 1." To locate and identify the response, the stimulus artifact preceding the desired response was isolated and discarded. The incoming data was next sectioned into a 2-dimensional array representing response amplitude versus time and saved for archival reasons.

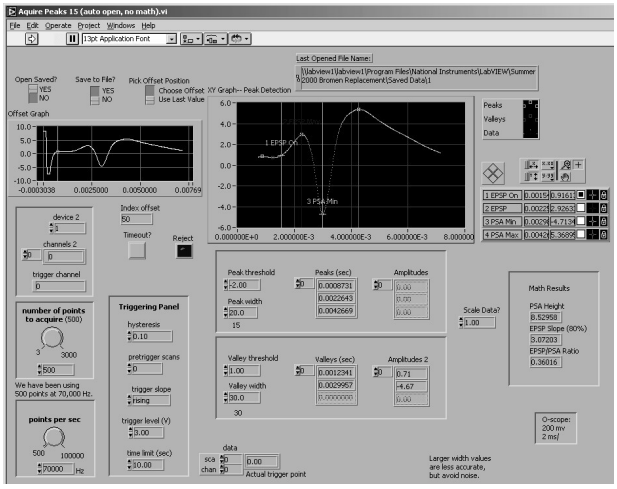

Fig. 1. Screenshot of the front-end panel of the software suite showing artifact truncation and peak isolation.

From this pre-conditioned waveform, four component points were automatically identified and analyzed through a peak detection subroutine. These points include: (1) EPSP onset (a measure of conduction velocity), (2) population spike onset (latency to cellular discharge), (3) population spike minimum (for a percentage of granule cell population discharge), and (4) population spike offset. To allow for greatest reliability, the user was prompted between bursts to make any necessary adjustments to the cursors, and had the option to discard any given signal before triggering the next pulse. The X-axis (time) and Y-axis (mV) coordinates for each component measure were stored as reduced features along with the calculated EPSP slope and population spike amplitude (PSA) in text format for further analysis. File and folder names were automatically labeled with the animal number, user, date, and time in order to facilitate the archiving of large volumes of data across multiple experiments and users.

III. Results And Discussion

The initial design of the program was to acquire and analyze a single evoked response to a single stimulus input. When this study successfully came to an end, it became of interest to the researchers to view the effects of paired-pulse stimulation [8]. This required acquiring and analyzing the response to a pair of stimulus pulses separated by a varying interpulse interval (IPI). Therefore, the program was modified to allow the user to see two windows that clearly showed the traces of the two responses "Fig.2."; this was done without sacrificing resolution or reliability. After the first artifact and its associated response were found and displayed, the second artifact could be isolated and used to trigger the selection of the second response. Further improvements on the reliability of the automatic peak selection routines increased user throughput of valid data and facilitated the progress of research. A marked improvement was evident in this system's speed, reliability, and ease of use over the previous DOS-based system. The LabVIEW-based system was so accessible to researchers that over the course of eight weeks, a group of three high school interns were trained and became proficient in the basics of graphical programming. These students were able to modify existing VI's and implement their own data logging subVI, which was successful in recording and saving analog signals and is now a part of the overall biomedical suit used in the laboratory.

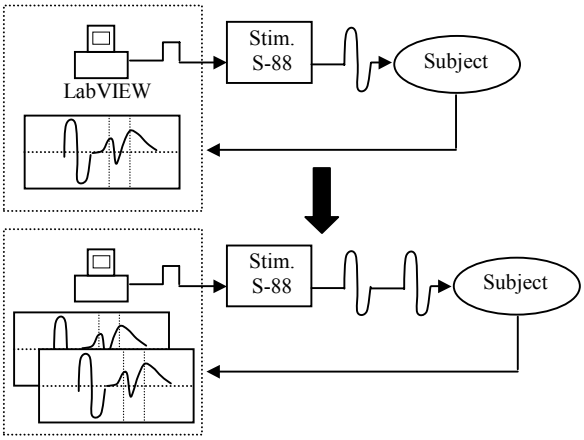

Fig. 2. Diagram showing LabVIEW's evolving role from the single, to the paired-pulse study.

As a result of the above application, the acquisition and analysis of evoked field potentials from the dentate gyrus can be performed in a user-friendly and continually evolving laboratory setting. Furthermore, once the user is comfortable with this programming environment, it becomes very easy to modify and/or create subVI's to satisfy the changing needs of the research effort.

Acknowledgments

This work was supported by NSF Grants #0074530 and 9618935.

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