A Portable System for Measuring the Tactile Temporal Discrimination Threshold in Cervical Dystonia

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Background

This multidisciplinary study combined both bioelectronics and neuroscience, with the aim of developing a tool to probe the underlying neuropathology of the movement disorder Dystonia.

Dystonia is the third most common neurological movement disorder - after Parkinson's disease and Essential Tremor [1] *Fahn*. It is characterized by sustained or intermittent muscle contractions causing abnormal, often repetitive, movements or postures. The hypothesis of the pathomechanisms of dystonia is based on disordered inhibition affecting brainstem mechanisms of covert attentional orienting. Temporal discrimination is the shortest time interval at which an observer can discriminate two sequential stimuli as being asynchronous. Temporal discrimination provides a mechanism for probing covert attentional orienting [2]. Visually assessed temporal discrimination thresholds (V-TDT) have demonstrated that covert attention is abnormal in cervical dystonia patients [3]. A portable system for V-TDT testing has been previously developed [4] , [5].

In this study, we developed a portable biosensor platform for measuring digit based tactile based temporal discrimination threshold (T-TDT). By combining tactile with visual temporal discrimination thresholds, it is hypothesised that one can increase the discrimination ability to probe covert attentional orienting in dystonia. The new portable instrument for T-TDT testing was validated against the gold standard methods described in the literature.

Methods

A hardware and software system were developed to produce two vibro-tactile stimuli of 5msec duration with precise inter-stimulus intervals (ISI). In the 'staircase' mode of the TDT experiment the ISI is varied from 0msec in increasing steps of 5ms. At each ISI the participant is asked to state if the they perceive a single stimulus, i.e. synchronous, or two stimuli separated in time as asynchronous. The test ends when the participant responds "asynchronous" for three consecutive increasing ISIs. The experiment is then ended by the Experimenter pressing a stop button. The TDT is then reported as the first of these ISIs.

In another mode of the experiment a random method of ISI presentation can be selected. Here the ISI is randomized between 0 to 100 ms. The experiment ends after a set duration with the Experimenter pressing a stop button.

The system realised has small dimension. The device was designed and built in-house at the Trinity Centre for Bioengineering, Trinity College Dublin.

The system is divided into three main blocks: the control unit, the vibrotactile stimulation unit and the Experimenter's user interface. See Figure 1.

The control unit is based on an Arduino ATmega328 microcontroller and includes a USB port to provide power and data communications. The microcontroller controls the vibrotactile stimulation unit that produces square pulses that generates the stimuli presented to the participant's fingers.

To generate the tactile stimuli, two vibration motors were employed. Vibrotactile stimulation generation is more power efficient than electrotactile stimulation systems [6]. Microcontrollers can only provide a small amount of current from their output as these are intended to send control signals, not to act as power sources. In order to control a high-current DC load, such as a DC motor it is necessary to use a motor driver. In this device a Metal-oxide-semiconductor Field-effect transistor (MOSFET) was employed as a switch for high-current loads.

The microcontroller also controls the user interface consisting of a 2.4" touch Thin Film Transistor-Liquid Crystal Display (TFT-LCD) screen. This screen provides the experimenter with a means for entering data relevant to the TDT experiment (experimental mode). The interface also allows data (experimental mode, ISI interval when stimulus asynchrony detected etc.) to be sent and saved to a computer via serial port avoiding errors in data collection.

Results

To validate the system, two TDT test were performed to two healthy control participants (2 females of 22 and 26 years old) with a mean TDT raw score of 30 msec and 32.5 msec respectively.

These values compare to the those in the literature [7], [8].

Discussion

The portable platform developed is a reliable and accurate method for tactile temporal discrimination testing in outpatient clinic environments. Furthermore, as it is a portable and easy-to-use system it increases the opportunity to gather more TDT data in the target population. Further development will focus on integrating both visual and tactile temporal discrimination threshold testing in one multimodal portable system.

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Figures

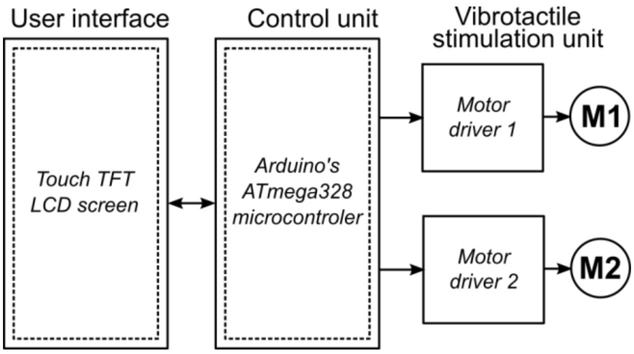

Figure 1. Block diagram of the system.

Figure 2. Picture of the device.

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