A low-cost experimental set-up for Functional Magnetic Resonance Imaging

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Introduction:

Functional Magnetic Resonance Imaging (fMRI) is a technique that uses MRI to detect localized changes in blood flow and oxygenation that occur in the brain due to neural stimuli (e.g. visual, auditory, motor, etc.) [3]. As it is necessary to synchronize stimuli presentation with the MR data acquisition and to record the patients' response to each stimulus, an fMRI experimental setup should include: a coupling circuit to connect the trigger signal available from the scanner to the computer that presents the stimuli (scanner trigger detector, STD); and a Response-Detection Pad (RDP) which needs to be placed inside the scanner and, thus, can not contain any ferromagnetic materials. Currently, there are several RDP and STD commercially available, but their cost is significantly high (~3,000 USD + shipment). Here, we propose a cheap (~155 USD + shipment) fMRI experimental setup that includes a fiber optic-based RDP inspired on [1, 2] and a photo coupler-based STD. This system is compatible with Philips MR scanners and commercially available fMRI software (Presentation, E-prime, etc).

Methods

Scanner Trigger Detector (STD): Our STD consists of a photo-coupler that permits the transmission of the TTL output of the MR scanner to the serial port of the computer (using a MAX232 device), assuring complete electrical isolation (Fig.1, left). The materials needed to build this circuit were: 1 4N32 (photo coupler), a 5V power supply (e.g. 4 AA batteries), 2 Resistors (220 Ω, 1 k Ω), 5 polarized capacitors (1 µF), 1 MAX-232, a BNC connector and 1 Double DB9 cable (Total cost: ~19 USD +PCB+shipment).

Response Detection Pad (RDP): The operating mechanism of our proposed device is very simple: an optical fiber transmitter is continuously emitting light and when the patient pushes the button, light transmission is interrupted [1, 2]. Following materials were used for its construction: 1 HFBR1522Z (Avago Tech. optical fiber transmitter), 1 HFBR2522Z (Avago Tech. optical fiber receiver), 2 optical fiber cables (10 m length each), 2 optical fiber connectors, 1 Resistor (51 Ω), 5 polarized capacitors (1 µF), 2 decoupling capacitors (0.01 µF and 4.7 µF), 1 MAX-232, a 5V power supplies (e.g. 4 AA batteries), 1 double DB9 cable, wood and plastic springs (Total cost: ~136 USD +shipment). The resistor connected to pin 1 of the transmitter (51 Ω) was chosen in order to meet both receiver and transmitter optical power specifications [4]. (Fig.1, right)

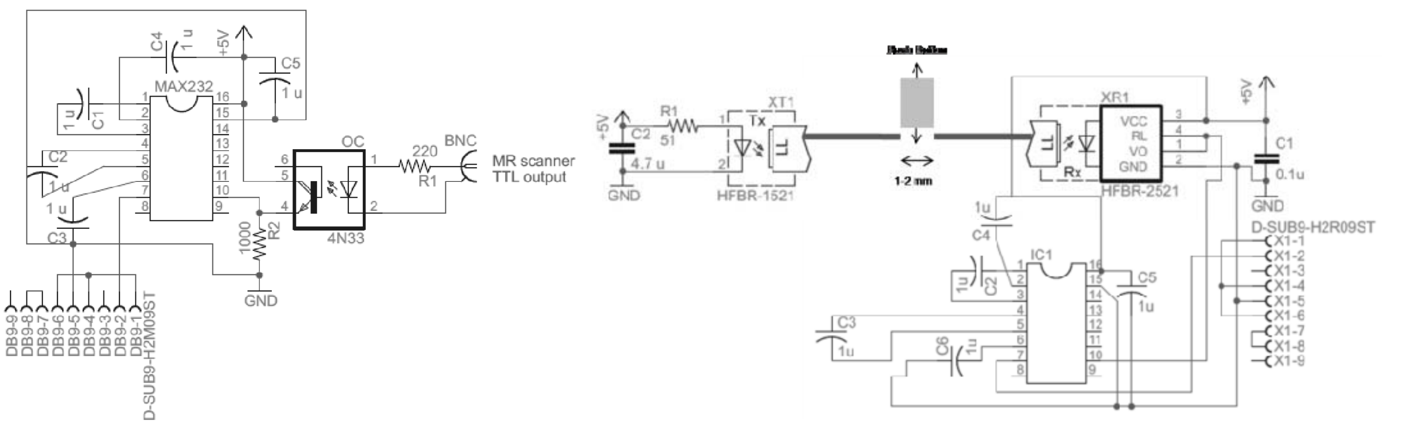

Fig.1. Left: STD circuitry. Right: RDP schematic.

Tests: RDP and STD prototypes were tested on a Philips Intera 1.5 T scanner, using a traditional go/no go paradigm (subject had to press the button in response to a go stimulus) carried out with one adult healthy volunteer. The software *Presentation* and SPM8 were used, respectively, to present the stimuli and to process fMRI data.

Results:

Our prototypes were successfully synchronized with the MR scanner. Results of the go/no go experiment are depicted in Fig. 2.

Discussion:

Obtained results, which are consistent with previous go/no go-based studies [5], validate the efficiency and good performance of our proposed setup. Optical fiber sensitivity to light alignment was the main issue during the building process of our proposed RDP. It is necessary to assure that both extremes of the optical fiber cable (at push button) are perfectly aligned to make sure light will jump over the 1-2 mm gap. When transmitter and receiver are connected with a no-gapped cable, receiver's digital output is either 0 V (when light is detected) or 5 V (when no light is detected). If there is a gap, and the optical fibers are not perfectly aligned, the receiver's digital output will not be exactly 0V in the presence of light. If voltage difference produced by light is too small to be detected as a different state by the MAX-232 device (and, thus, by the computer), we suggest to connect receiver's output signal to a voltage comparator, to get a perfect detection.

Conclusion: a low-cost and effective fMRI experimental setup was successfully built. This kind of setups makes fMRI experiments affordable for a greater scientific community.

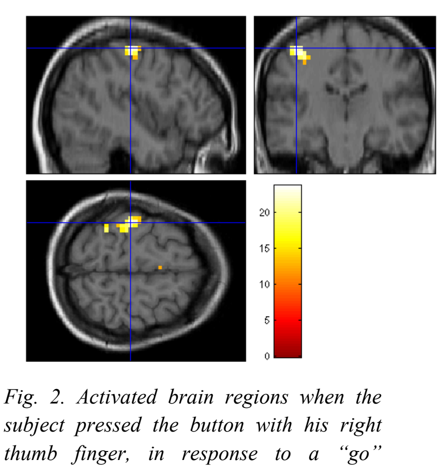

Fig. 2. Activated brain regions when the subject pressed the button with his right thumb finger, in response to a "go" stimulus.

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