The Nintendo Wii Remote as an MR-Compatible Interface to Cognitive Studies Using fMRI

J. M. Rasmussen[1,2], and K. A. Rasmussen[3]

[1]Pediatric Neuroimaging Research Consortium, Cincinnati Children's Hospital, Cincinnati, OH, United States, [2]Dept. of Neurology, Cincinnati Children's Hospital, Cinicinnati, OH, United States, [3]Long Beach Memorial Medical Center

Introduction

Nintendo's Wii remote control represents a more immersive and intuitive interface than traditional push button and joystick devices. In addition to being cost effective compared to traditional fMRI interfaces, the use of Infrared (IR) sensing and accelerometers would enable investigators to probe human cognition in novel ways. This study outlines the methods necessary for modifying the Wii remote and evaluates the fMRI compatibility of the modified device.

Materials & Methods

Hardware/Software: The primary concern when modifying components for MR compatibility is safety. The speaker magnet and rumbling motor were removed and the 2-AA steel encased batteries were replaced with a low magnetic signature battery available from Saft. The system consisted of the Wii remote communicating the IR and button press information to the display console via Bluetooth® and a USB dongle, while the feedback from the console was presented with Avotec goggles and headphones. In order for the console to interpret the signals coming from the Wii remote, the freely available software Wiinremote was used to translate the Wii information into mouse events. Adobe's Flash was used to create the paradigm used for testing the ability to perform fMRI, although the task related results are beyond the scope of this abstract.

Imaging: The imaging protocols and analysis used to evaluate the ability to produce artifact free imaging was based on those used in a similar study[1] quantifying effects of two different MR-compatible computer keyboards inside an MR scanner. Time-variant and time-invariant statistics were calculated using T2*-weighted Echo Planar Imaging (TR/TE = 2000/38 ms, FOV = 25.6 x 25.6 cm, matrix = 64 x 64, slice thickness = 5 mm, 180 TRs).

Analysis: The time-invariant analysis was done by comparing a Mean Phantom Image (MPI) with and without the controller present one meter from the magnet's isocenter. The controller-present condition simulated button presses by taping down a button making repeated key presses. The same conditions were used in the time-variant analysis by calculating the Temporal Signal to Noise Ratio[2] (TSNR).

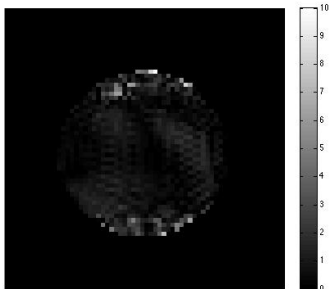

Figure 1. MPI difference map. ($|MPI_{without} - MPI_{with}|/MPI_{without}$)

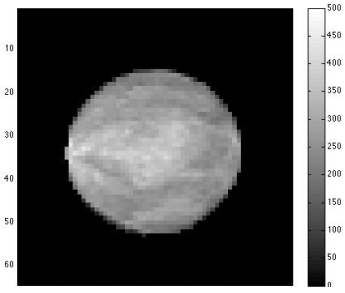

Figure 2. TSNR image with the Wii remote.

Results

Wii remote Usability: The magnetic forces acting on the Wii remote were calculated to be 15% weaker than the gravitational forces due to the weight of the controller. In addition, a wrist strap allows the device to be attached to the wrist ensuring maximum safety. During scanning, the controller maintained an open communication portal for the entire duration of all scans on all patients and no problems were observed or reported by any of the four subjects.

B1, MPI, TSNR: The MPI results (figure 1) demonstrate that only 3% of the Wii remote-present pixels had a signal deviation of more than 4% when compared to the remote-not-present condition. The TSNR was calculated to be 286 without the controller present and 274 with the remote and is shown for both conditions in figure 2. These results compare favorably with past studies of peripheral tools being used for fMRI[1].

Discussion

The Wii remote has been shown to be cost effective (less than US$80), MR-safe and fMRI-compatible, all while maintaining core functionality. The modified device shows promise in exploring the cognitive nature of poorly understood mechanisms such as benign essential tremor and the neural plasticity of brain trauma rehabilitation.

References

1. James G.A., He G., Liu Y. 2004. A full-size MRI-compatible keyboard response system. NeuroImage. 25, 328-331.
2. Weisskoff R.M. 1996. Simple measurement of scanner stability for functional NMR Imaging of activation in the brain. MRM. 36, 643-645.
3. Nintendo Company Ltd. Additional information is available at Nintendo.com .
4. Saft. Additional information is available at saftbatteries.com.
5. Wiinremote. Additional information is available at onakasuita.org.