Immersive technology for functional neuroimaging

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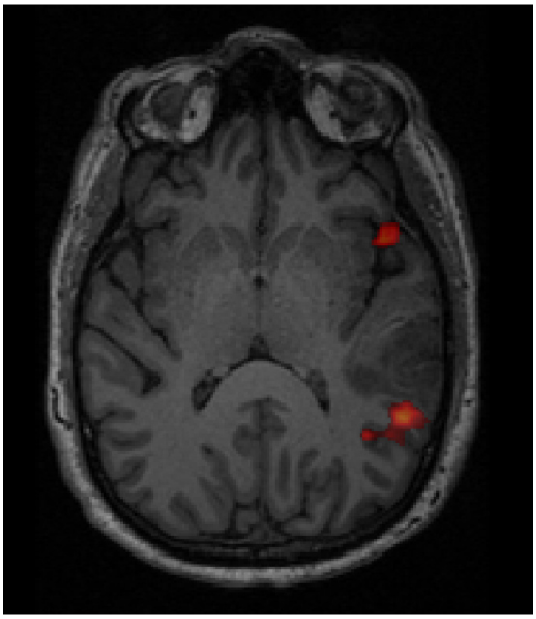

Broca and Wernicke brain regions are activated (red) when a subject performs a language task during an MRI exam.

The Challenge

Are you a neuroscientist interested in studying how memories are created and how we use memory to navigate in space? Or a neurologist who would like to develop noninvasive methods for early detection of neurological disorders such as Parkinson's disease, Alzheimer's disease and other forms of dementia?

Perhaps you are a neuropsychologist who would like to understand the neurophysiological manifestations of phobias and PTSS and design better treatment strategies? Or maybe a neuromarketing researcher who would like to study how our mind responds to certain stimuli on the neurophysiological and neurofunctional level to apply this knowledge to marketing applications?

Looking inside the brain

These and similar questions are being studied with a range of experimental techniques, most notably neuroimaging using fMRI, CT, PET, EEG, MEG, and NIRS. Many of these techniques, such as fMRI, are minimally invasive and give us insight into the inner workings of our brain.

For example, fMRI can help localize not only parts of the brain that are engaged during language processing and speech production, but also brain areas that are employed when we perceive danger, or when we try to orient ourselves in space. Although all imaging techniques have their limitations, they nevertheless aid neuroscientists in understanding the brain and physicians in diagnosing functional abnormalities, often long before the occurrence of visible symptoms or structural changes.

The eyes are the window to the soul

Another powerful tool to study the brain is eye tracking. Using eye-tracking cameras, combined with powerful software, one can determine the subject's involvement in a given task, as well as monitoring eye movements and gaze in relation to a visual stimulus.

For example, when studying responses of the war veteran to a war scenario, or the creation of spatial memory maps, one can determine which environmental elements captured the subject's attention and for how long.

In neuromarketing, eye-tracking is an indispensable tool that enables the researcher to understand the subject's marketing decisions, and in neuropsychology, distinctive eye movements and gaze behavior can help diagnose psychological disorders such as Schizophrenia, ADHD/ADD and autism (Bittencourt et al. 2013; O'Driscoll et al. 2008; Ytter et al. 2013).

Eye tracking provides important data about a subject's gaze patterns when presented with a scene, for example.

> *The combination of fMRI and eye-tracking is a very powerful tool in neuroscience*

fMRI & Eye-Tracking

The combination of fMRI and eye-tracking is a very powerful tool in neuroscience and has led to many advances in neuropsychology, neuropsychiatry, neurophysiology and basic science (Bonhage et al. 2015; Tylen et al. 2012; Hausler et al. 2016; Kalpouzos et al. 2010; Kim et al. 2020).

However, one disadvantage of MRI is that due to the inherent nature of the technology the subjects are forced to lie still inside a very confined and extremely loud environment.

Can you imagine trying to study how a person with PTSS responds to a dangerous and stressful war scenario when the main stress factor during fMRI is confinement in a narrow magnet bore? Or to study how a person with early manifestations of dementia is able to navigate in a 3D maze when they are required to lie as still as possible (Vlcek et al. 2014)?


Virtual Reality
fMRI
Eye-Tracking

Creating virtual environments

One solution is virtual reality (VR). This is now becoming feasible for researchers due to advances in audio-visual technology (Bohil et al. 2011). VR lenses or goggles are becoming affordable consumer goods that can help immerse the subject into an ecologically valid situation.

The major obstacle in combining modern VR and eye-tracking technology with MR imaging is the interference such devices cause when placed inside a strong magnetic field. The electronics inside the VR goggles and eye-tracking cameras can significantly degrade MR image quality, or worse, make such equipment unsafe for use.

Many past studies that have explored VR scenarios in combination with fMRI (Voermans et al. 2004; Kim & Maguire 2019; Speirs & Maguire 2006) have made use of projectors and 2D screens to present the visual stimuli.

The use of VR for creating 3D immersive environments is proven in itself to be an advantage over 2D representations, in a number of applications (Gaebler et al. 2014; Wiederhold et al. 2008).

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NordicNeuroLab Visual Systems for MR environment

The NordicNeuroLab VisualSystem HD (VSHD) solves these problems. Shielded electronics and MR-safe materials make the VSHD **MR-conditional** for use at field strengths up to 3T.

The NordicNeuroLab Visual System HD (VSHD)

The Visual System HD mounted on a head coil enables the patient to be totally immersed in a new environment.

The VSHD goggles mount on top of the most commonly used fMRI head coils via a coil-specific adapter and are height adjustable such that the rubber eye-caps completely enclose the subject's eyes. This prevents spurious light sources from entering the subject's visual field.

Built-in **diopter correction (-8 to +5)** and **fine-tuning of pupil distance** are easy to regulate and customize to each patient, both children as well as adults.

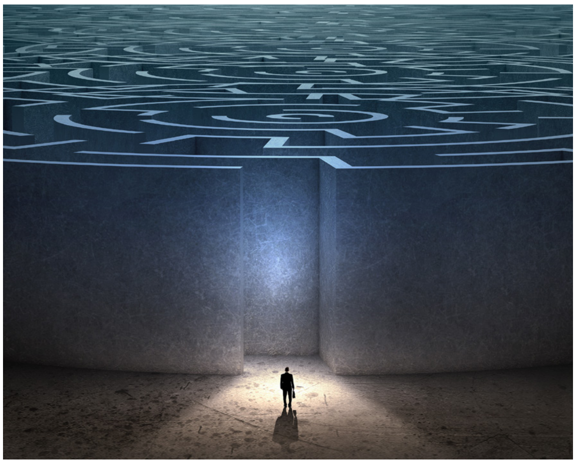
All these features enable the subject to be completely immersed in the experience.

The NordicNeuroLab VSHD goggles come with a **wide field-of-view** (51.2 degrees horizontal) allowing for presentation of stimuli within a larger area of the subject's visual field.

In addition to aiding the feeling of immersion, the large field-of-view could provide a useful tool for functional imaging studies which map the visual field and examine visual field deficits (Urbanski et al. 2014). Furthermore, **HD (1920x1200 @ 60Hz)** display resolution results in crystal clear images.

Imagine, there are as many pixels on these tiny displays as there are on a HD TV screen or the state-of-the-art smart phone!

All these features enable the subject to be completely immersed in the experience.



Having 3D paradigms makes it possible to create more realistic and complex environments in the MR scanner.

The VSHD can display a stereoscopic (3D) view with high visual fidelity, making the subject's experience more compelling and immersive

Using **dual-display OLED technology**, the NordicNeuroLab VSHD can display a **stereoscopic (3D) view** with high visual fidelity (without compromising the picture refresh rate), making the subject's experience more compelling and immersive.

Each display is driven separately via a standard HDMI port, providing a simple and intuitive setup for integration with third party paradigm presentation software.

This unique technology allows you to experiment with paradigm designs that are dynamic and interactive, creating a more engaging experience for the subjects, with a high degree of ecological validity (Parsons et al., 2017).

Additionally, the VSHD immersion experience offers a solution that can complement VR technology when used in the context of cognitive behavioral therapy (CBT) for psychiatric or emotional disorders. Simulating realistic environmental situations while in the MR scanner enables the researcher to investigate the brain's response to stimuli that can be designed to be either therapeutic, or to simply measure an emotional response.

The NordicNeuroLab VSHD are the only MR-compatible goggles with **integrated binocular eye-tracking**. The video-based PCCR eye-tracking technology uses two active glint points and an adjustable camera focus for precise and reliable tracking of each eye.

The integration of the eye-tracking cameras into the goggles themselves reduces the amount of cables and equipment in the MR bore, simplifying the setup and reducing possible compatibility issues. With HDMI video outputs for each eye camera it is easy to interface the eye-tracking video signal with third party eye-tracking post-processing software.

By combining the VSHD with the NordicNeuroLab ResponseGrips one can additionally create interactive scenarios inside the MR scanner that allow applications spanning from clinical research to patient entertainment to neuromarketing, and many more.

Virtual Reality in fMRI with the advanced VisualSystem from NordicNeuroLab

Our VSHD could be the solution that meets your needs. With our support, you could be well on your way to producing high quality research using the most sophisticated equipment on the market.

If you would like to receive additional information about the NordicNeuroLab VSHD or see a live demo, please contact using the button below or email us at sales@nordicneurolab.com

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