Literature Review of the Role of fMRI in Patients with Multifocal IOLs

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BY MARIA S. ROMERO ET AL.

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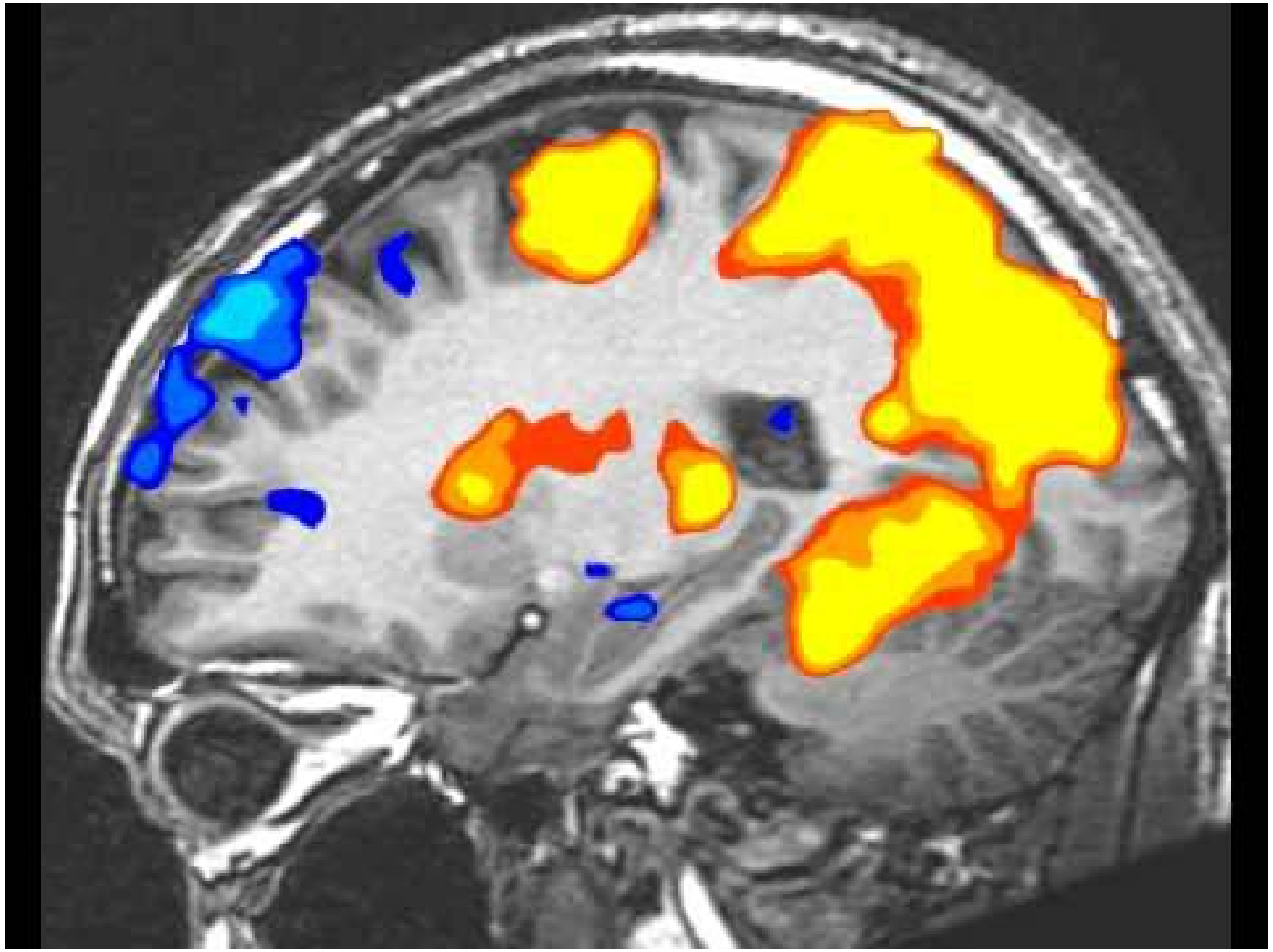
fMRI

- Localizes **neural activity** in the brain in rest and task activation
- Detects **changes** in **oxygen saturation** level in blood (BOLD)
- Non-invasive imaging with high spatial resolution are **advantages**
- Disadvantages - low signal to noise ratio and **complex statistical analysis**



Rosa et al., 2017.

Purpose

- To evaluate the use of fMRI in assessing neuroadaptation with multifocal intraocular lenses (IOLs).

Methods

- Observational fixed cohort study
- 30 pat bilateral diffractive IOL had fMRI imaging at 3 & 6 months post op. 15 pat control group
- Stimulus:
  - Sinusoidal gratings
  - Light source for glare
- Vision quality and reading performance were assessed including wavefront analysis.

Miranda et al., 2018.

Purpose

Investigate relation between:

- Optical properties
- Population receptive fields (pRFs)
- Visual function
- Perceived post-op vision quality after bilateral cataract surgery

Methods

- Cross -sectional study
- 30 pat with bilateral diffractive IOL underwent fMRI imaging and pRF modeling based on fMRI imaging. 15 pat control group
- The pRF modeling focused on the V1-V3 areas of the cortex.
- fMRI visual stimulus consisted of 2 perpendicular bars that crossed the display in different phases and orthogonal directions.
- Vision quality and reading performance were assessed including wavefront analysis

Zhang et al., 2021.

Purpose

Investigate visual neuroadaptation after implantation of both Monofocal and Multifocal IOLs

Methods

- Prospective controlled clinical trial
- 11 pat diffractive IOL & 11 pat monofocal IOL were studied using resting-state fMRI analysis.
- fALFF analysis (fractional amplitude of low-frequency fluctuations) was used for the fMRI data.
- fALFF allows the detection of spontaneous neural activity across the whole brain.
- Brodman's areas 17-19
- VA, retinal straylight, contrast sensitivity , PVEP

Rose et al., 2017.

Statistical Testing

•Brain Voyager QX software was used for fMRI analysis and statistical testing.

•Software allowed for detection of image voxel-based clusters of the induced BOLD signal.

•Monte Carlo simulations were used to test cluster spatial extent.

•Simulations generated surrogate activation maps with similar spatial correlations to estimate false positive rate for cluster size.

Miranda et al., 2018.

Statistical Testing

•Brain Voyager QX software was used for BOLD signal cluster size and spatial extent.

•pRF models by Dumoulin and Wandell were estimated from these BOLD responses.

•Models that best predicted the BOLD signal and minimized signal variance were plotted.

Zhang et al., 2021.

Statistical Testing

•Data Processing Assistant for Resting-State fMRI was used for cluster detection and extent.

•Two sample *t*-tests were used to investigate differences in fALFF values between the 2 implant types.

•Repeated use of ANOVA was used to study preoperative and post-operative fALFF values.

Rose et al., 2017.

Results

•Glare decreased the fMRI signal for sinusoidal gratings at 3 weeks, but not at 6 months (p=0.04).

•This was also verified with contrast detection under glare improvement (p=0.002).

- Over the 6 months monitoring period, there was an increase in fMRI signal for cortical areas important for visual attention, procedural learning, and cognitive control. This normalized at 6 months. The control group remained unchanged

Miranda et al., 2018.

Results

- Patients with worse optical testing had larger pRF sizes (implying worse spatial resolution).
- pRF sizes were also larger for subjects with worse contrast sensitivity (p=0.038).
- Subjects scoring high on the subjective visual “bothersome” dimension induced by glare had lower pRF sizes (p=0.012)

Zhang et al., 2021.

Results

•fALFF values in the visual cortex decreased in the Mu-IOL group at 1 week postoperatively, and then recovered to baseline at 3 months, with improvement at 6 months, compared with the preoperative value.

•On the other hand, for the monofocal IOL group, fALFF values increased one week after surgery, and then decreased to baseline at 3 and 6 months.

•The fALFF values recorded in the lingual gyrus were negatively correlated with visual disturbance.

Conclusions

- Rosa et al : evidence of **neuroadaptation** to multifocal IOLs was demonstrated with **fMRI** in higher level visual cortex.
- Miranda et al : investigated **pRF** as model through fMRI and demonstrated a **disconnect** between negative subjective response and improved **perception** of visual **disturbances**.
- Zhang et al : utilized fALFF in the fMRI **signal** which demonstrated distinct neuroadaptation **patterns** for Monofocal and Multifocal IOLs.

Recommendations

- New and exciting field; As these **studies** become more validated, fMRI could become a **useful** tool to investigate the visual response to multifocal **IOLs** and different types of IOLs.
- fMRI is not without its challenges and a **multimodal** approach can be implemented to **overcome** some of the limitations due to the low signal to noise ratio **combining** EEG, transcranial magnetic stimulation, or direct cortical recordings.

References

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