

Noninvasive measurement of cerebral blood flow with visual stimulus before and after cataract surgery using optical topography

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Summary Sentence: Increased blood flow of the whole cerebral cortex was observed in 85% of patients 3 months after cataract surgery.

Key Words: optical topography, cerebral blood flow, cataract surgery, quality of vision

Financial Disclosure

Yuichi Kaji, Genichiro Kishino, Senichiro Kikuchi, Hidetoshi Kawashima: none

Tetsuro Oshika Johnson & Johnson Vision, Santen Pharmaceutical, Topcon: C) Consultant/Advisor, L) Lecture Fees and R) Research/Grant Support

Logic & Design: C) Consultant/Advisor and L) Lecture Fees

Senju Pharmaceutical, HOYA, Kowa, Otuka: L) Lecture Fees and R) Research/Grant Support

Futaba: R) Research/Grant Support

Glaukos, Tomey, Inami, Luminis, Japan Focus: L) Lecture Fees

Novartis, Chugai Pharmaceutical: L) Lecture Fees and R) Research/Grant Support

Purpose

Cataract surgery improves both visual acuity and quality of life.

Previous papers indicate that cataract surgery improves memory function¹⁻⁴ and depressive mental status^{5,6} of the elderly people. However, these papers have analyzed subjective data of the patients using various questionnaires.

Brain function and blood flow of the cerebral cortex are closely related. We aimed to **noninvasively observe changes in cerebral blood flow using optical topography with visual stimulation before and after cataract surgery.**

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Noninvasive Measurement of Cerebral Blood Flow

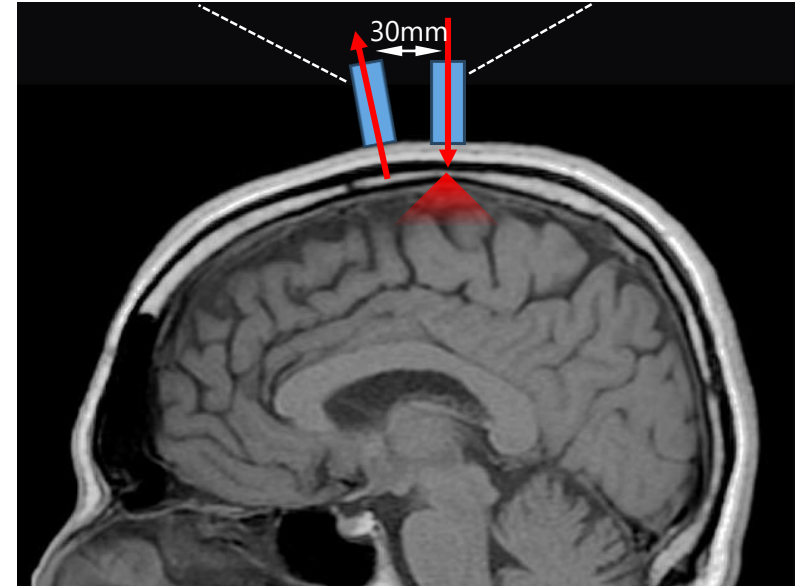
Fig 1



Fig 2

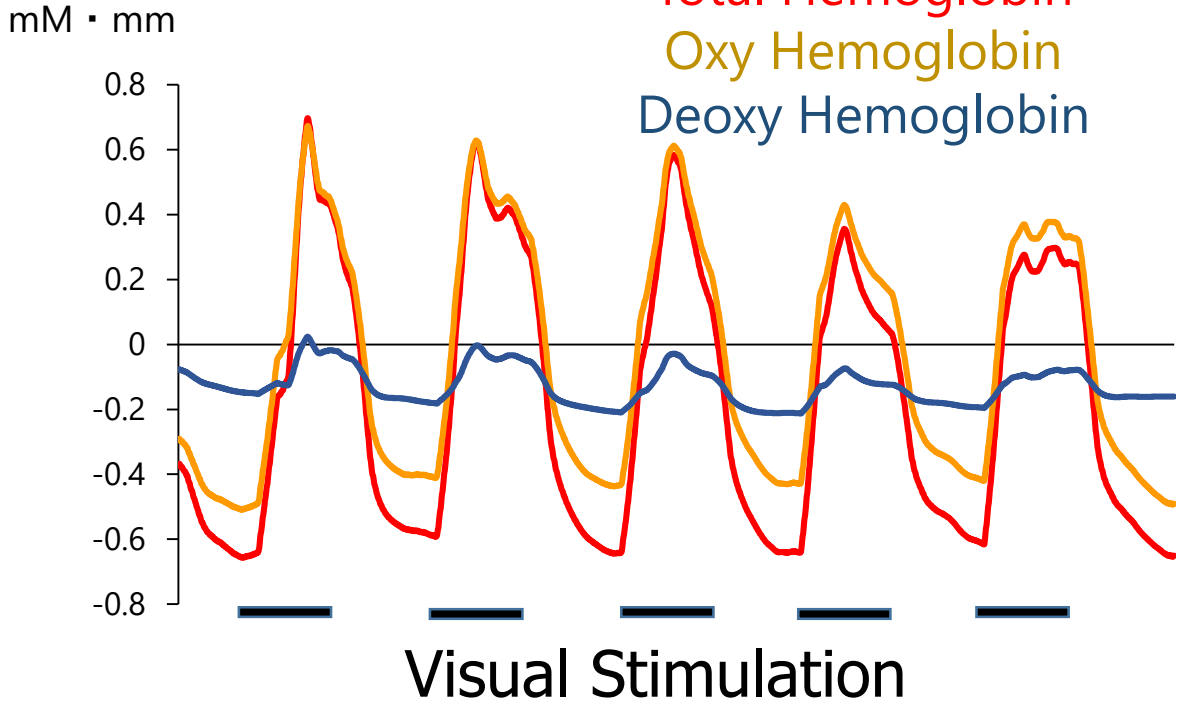
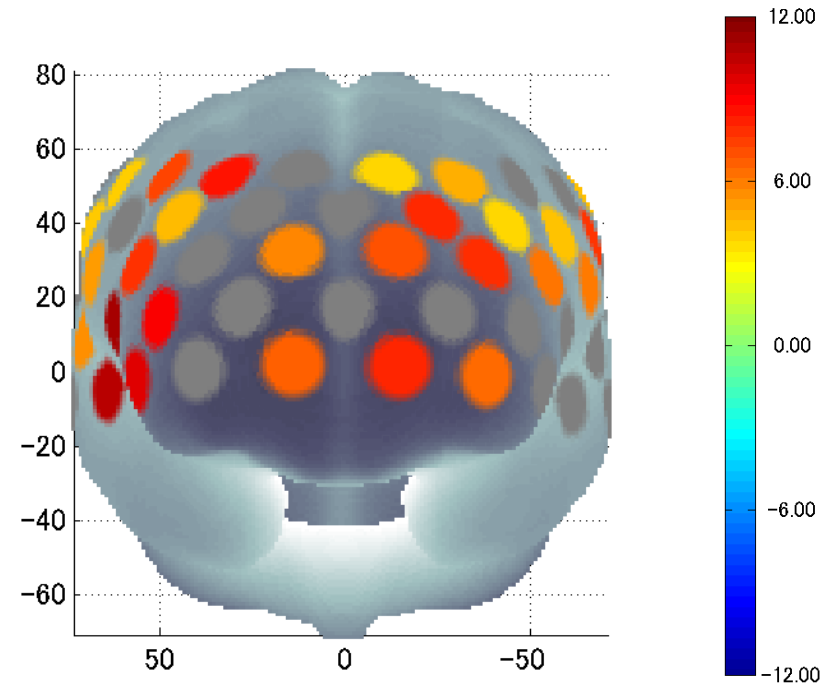
Real-time measurement of reflected infra-red ray

Emission of infra-red ray (780/830nm)



For measurement of cerebral blood flow using optical topography, probes are mounted on the surface of the patients (Fig 1). Near infra-red rays (780/830 nm) are emitted to the surface of the cerebral cortex. Near infra-red rays with longer wavelength than visible light has relatively high transmissivity through skin of the scalp (Fig 2).

By real-time measurement of reflected infra-red ray, we can calculate the changes in concentration of hemoglobin that indicates the blood flow of the cerebral cortex.

Fig 3**Fig 4**

Oxy-hemoglobin and deoxy-hemoglobin have different absorption coefficients. We can measure the fluctuation of oxy-hemoglobin and deoxy-hemoglobin with/without visual stimulation (Fig 3). The concentration of total hemoglobin are monitored on entire surface of the cerebral cortex. Using the data, we can create a 2-dimensional map of the cerebral blood flow (Fig 4).

Comparison with Conventional Modalities

	PET	fMRI	Optical Topography
Resolution	~15mm	~2mm	~15mm
Deep-brain measurement	Yes	Yes	No
Measurable Object	Metabolic Material	Deoxy-hemoglobin	Oxy-hemoglobin Deoxy-hemoglobin
Restriction	Exposure to X-ray Use of Radioisotope	Closed Space Difficult to do Visual Stimulation	Nothing

Without using X-ray or radioisotopes, we can measure blood flow of brain in a natural posture.

Methods

We examined 13 patients with corrected visual acuity of 0.5 or less, making a total of 26 eyes (4 men and 9 women, age 76.2 ± 6.3 years), which had undergone cataract surgery. NEI VFQ-25 was used to examine vision quality.

The patients were directed to see natural objects projected onto an LCD monitor. The protocol of visual stimulation is shown in Fig 4. Before and 3 months after cataract surgery, oxy- and deoxy-hemoglobin of the cerebral cortex was measured with 52 far-infrared ray sensors connected to optical topography (ETG-4000, FUJIFILM Healthcare Laboratory) and attached on the head of the patients (Fig 5). This study was approved by the Ethics Committee of Jichi Medical University, and the data were obtained prospectively.

Fig 4

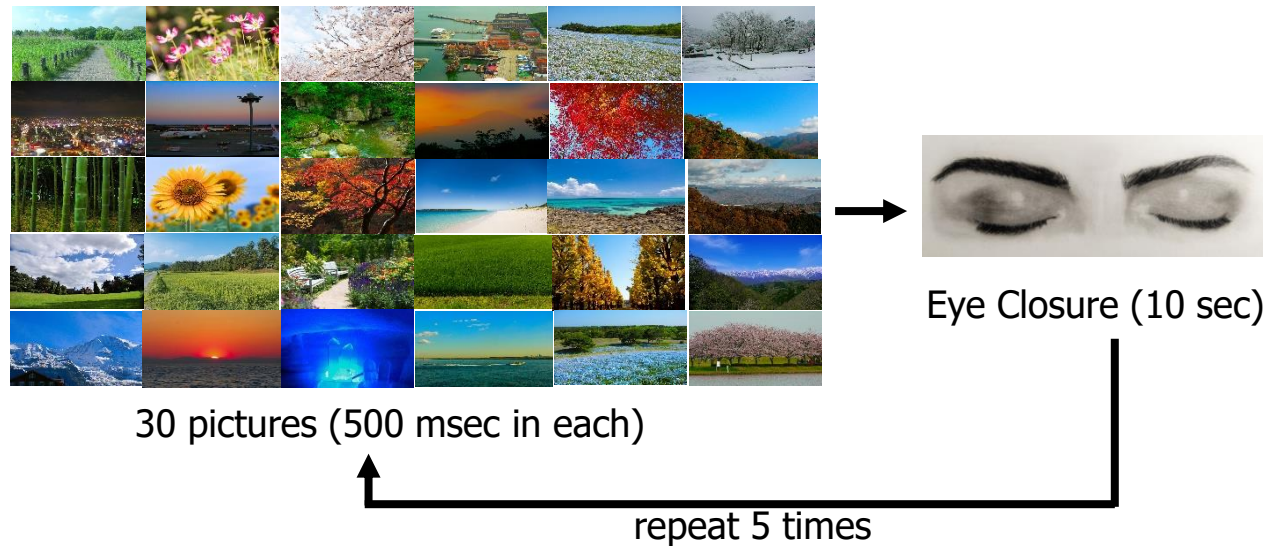
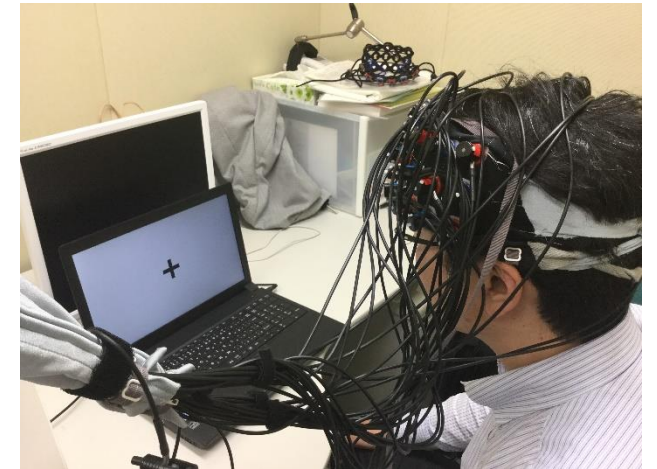
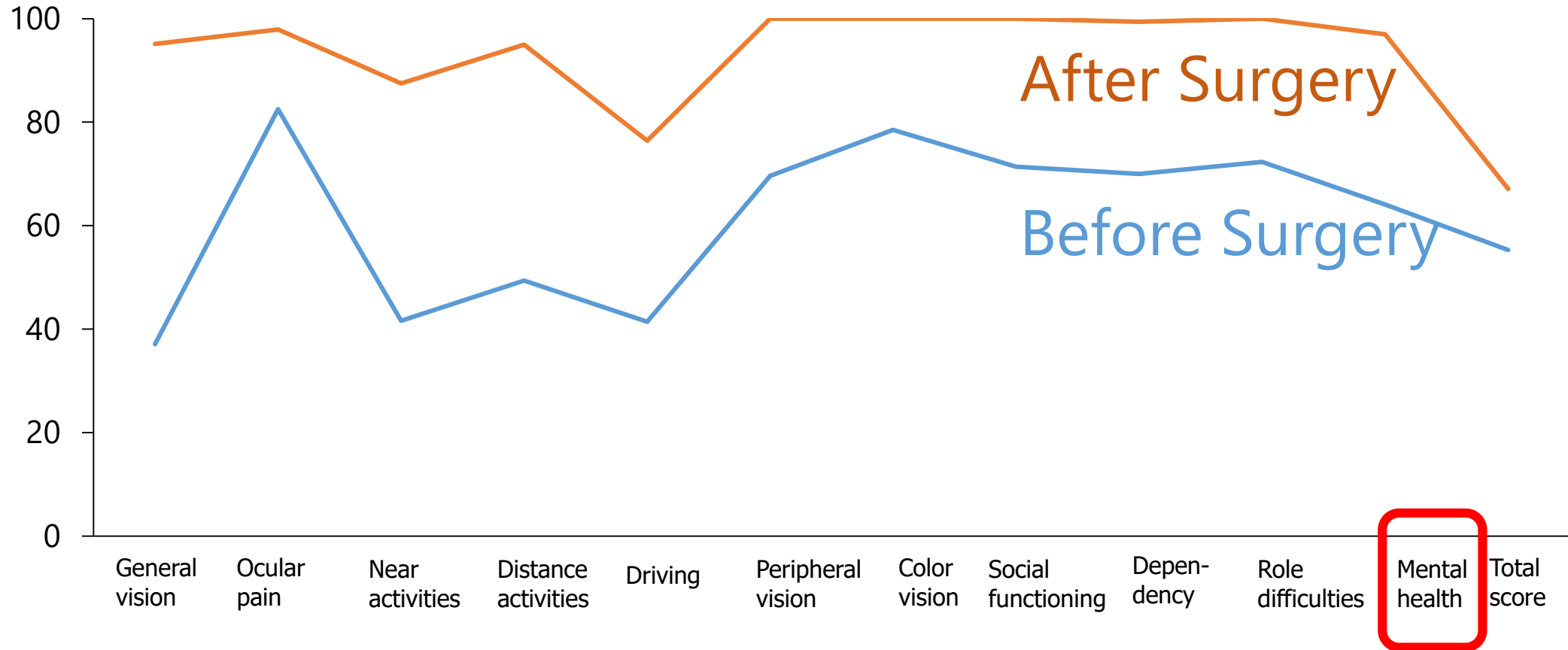


Fig 5



Result 1: NEI VFQ-25



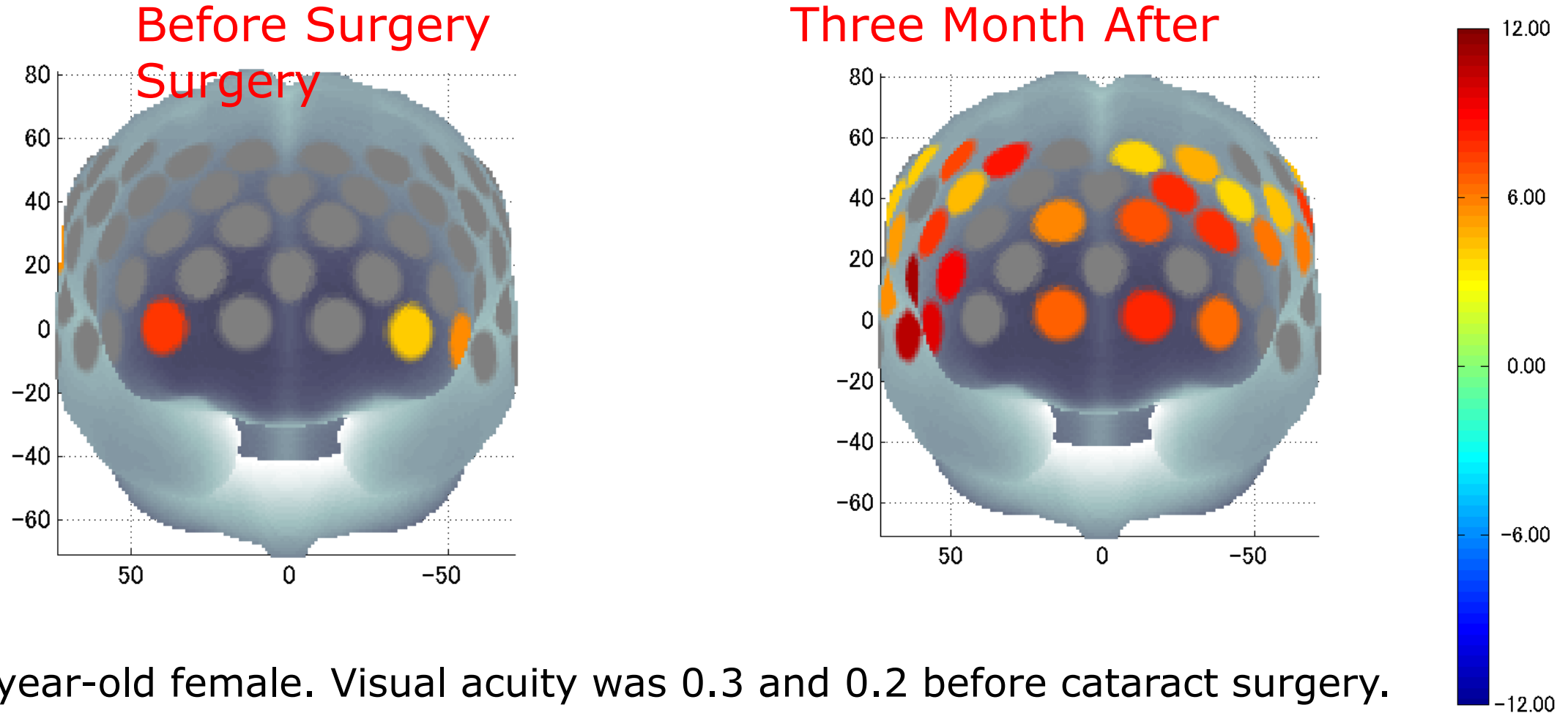
Cataract surgery increased vision-related activities. In addition, it increased the score of mental health, indicating that the cataract surgery has a benefit on brain function.

Result 2

Optical topography showed that **the blood flow of the cerebral cortex significantly increased in 11 of 13 (85%) patients** at 3 months after cataract surgery (paired T test, $P < 0.05$).

The two patients who did not show increased blood flow of the cerebral cortex had preoperative cerebral hemorrhage or cerebral infarction.

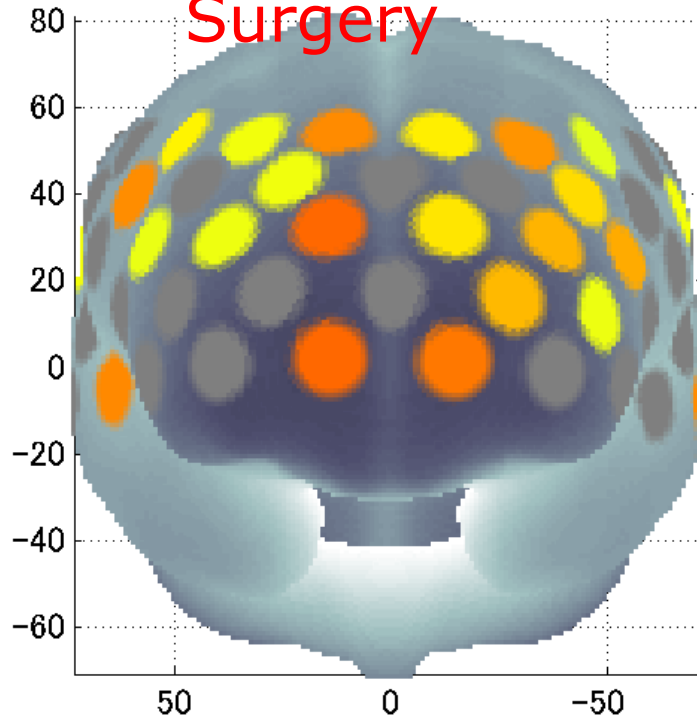
Case 1: Increased Blood Flow of Cerebral Cortex



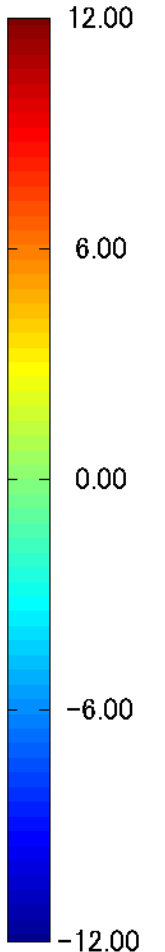
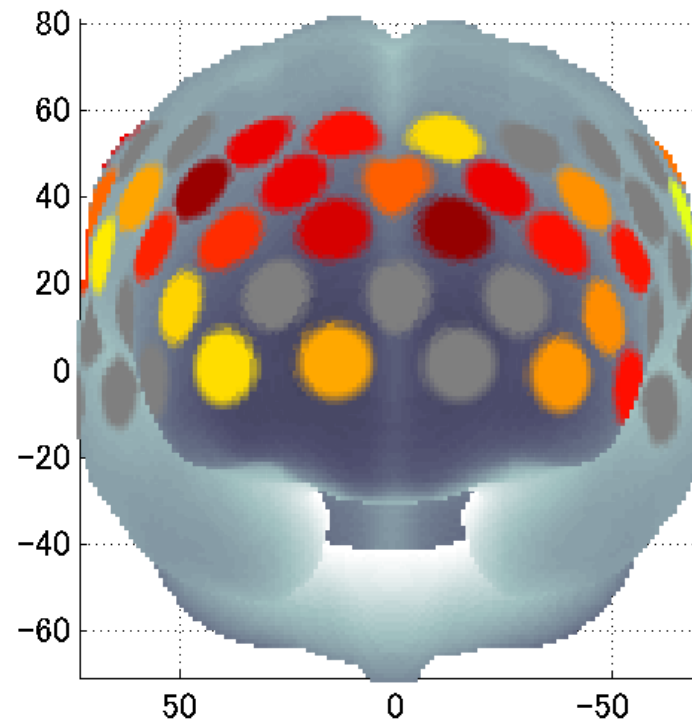
A 75-year-old female. Visual acuity was 0.3 and 0.2 before cataract surgery. After surgery, visual acuity was 1.0 and 1.0. She increased the time on her hobbies and became easier to fall asleep.

Case 2: Increased Blood Flow of Cerebral Cortex

Before Surgery
Surgery



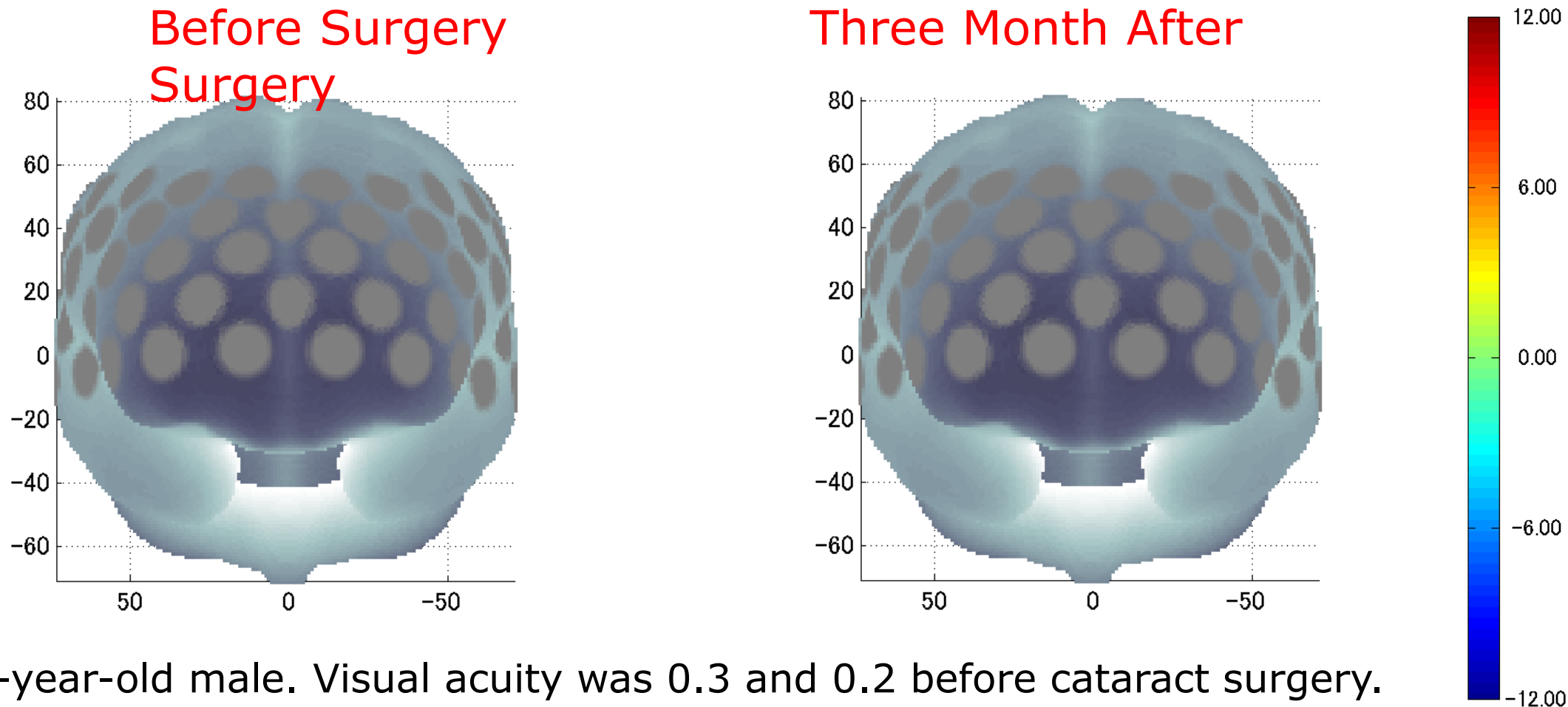
Three Month After



An 80-year-old male. Visual acuity was 0.4 and 0.5 before cataract surgery. After surgery, visual acuity was 1.0 and 1.2.

He became easier to drive and started a lot of activities with his families and friends.

Case 3: No Increase in Blood Flow after Cataract Surgery



A 74-year-old male. Visual acuity was 0.3 and 0.2 before cataract surgery. After surgery, visual acuity was 1.0 and 0.5. He has a medical history of old brain infarction and central serous chorioretinopathy on his left eye.

Conclusion

Cataract surgery increased the blood flow of the cerebral cortex including temporal, parietal, and frontal lobes. The result indicates that cataract surgery may improve the function of whole brain. This may be an objective explanation why cataract surgery improves quality of life and mental health of the patients.

