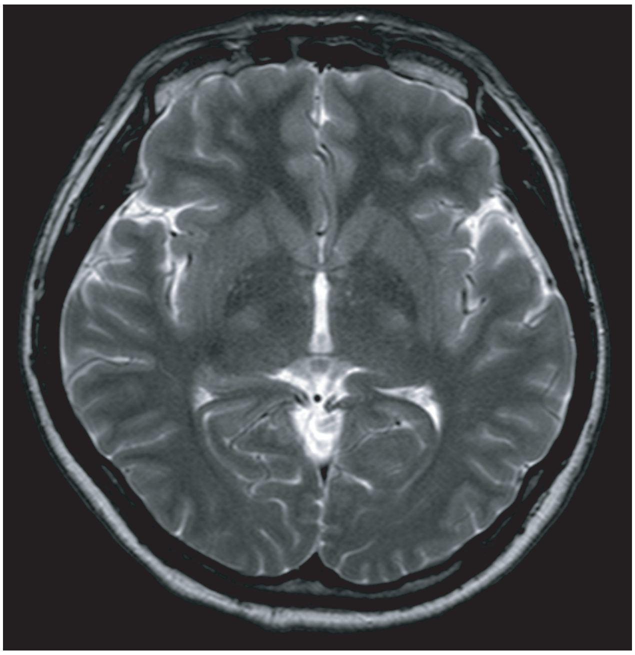

Fig. 4. A cross-section view of the brain by using MRI.

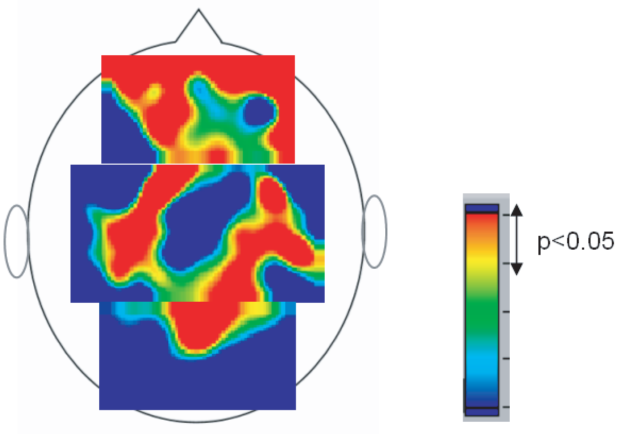

Fig. 5. The cerebral blood flow changes as shown in the brain mapping of the significant difference obtained by the post-hoc test.

the central sulcus (Appendix) and the field on which the cerebral blood flow increases. The experiment was fully explained to the subjects beforehand, and written consent was obtained. The experiment was approved by the Ethics Committee of Nagoya University Graduate School of Information Science.

The temporal muscle EMG was recorded using a multichannel telemeter system, WEB-7000 (Nihon Kohden), at a sampling frequency of 1 KHz. The measurement sites of the temporal muscle were set by assigning 1 ch each to the bilateral temples (2-ch measurement) (Fig. 1).

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Changes in the blood oxygenized hemoglobin level in the brain were measured using a near infrared light brain function imaging system, FOIRE-3000 (Shimadzu Corporation), at a sampling frequency of 7.7 Hz. A head holder was attached to the subject's head, and light transmission/receiver probes were attached as shown in Fig. 2. Cerebral blood flow on the frontal lobe, occipital lobe, and parietal lobe can be measured at 22-ch, 22-ch, and 45-ch, respectively (Fig. 2).

The experiment was performed in a sitting position. After resting for 5 minutes, regarding a 20-second pre-rest, 30-second chewing, and 40-second post-rest as one set, the subject held 2 pieces of xylitol gum in their mouth in the pre-rest of the first set and repeated 3 sets, and removed the gum in the post-rest of the 3rd set. This 3-set test was repeated 3 times, and the subjects finally rested for 3 minutes (Fig. 3). The brain activity was measured using NIRS while confirming the chewing motion in the EMG.

Paying attention to changes in Oxy-Hb, we compared changes in Oxy-Hb between those at rest and during the task at each channel employing two-way analysis of variance (ANOVA). States (rest and task) and channels are set as factors in this statistical analysis. When Oxy-Hb significantly changed during the task ($p < 0.05$), it was regarded as a significant change during the task at the channel. In accordance with the Bonferroni's method, the post-hoc test was held at each channel.

On 2 way ANOVA of the hemoglobin levels at rest and during the task, a main effect was noted in each factor ($p < 0.05$). Therefore, the cerebral blood flow did not uniformly change but locally increased or decreased. Difference between Oxy-Hb averaged during the rest and the task is calculated at each channel and is interpolated by the spline method. Fig. 4 shows a cross-section view of the brain by using MRI to confirm the field on which the cerebral blood flow changes. As shown in the brain mapping (Fig. 5), the significant difference between the rest and the task was obtained by the post-hoc test ($p < 0.05$). As a result, the cerebral blood flow on the frontal lobe increased during the gum chewing. In addition, the cerebral blood flow on the primary motor cortex and parietal association area of the parietal lobe increased during the gum chewing. The symptoms of mental illness often involve weakened regulation of thought, emotion, and behavior by the prefrontal cortex (PFC) (Appendix). Therefore, it was also suggested that chewing is effective for reducing stress and enhancing high performance in the athletes.

To clarify the influence of masticatory movement on the brain, young males chewed gum and electromyography of the masticatory muscles and NIRS were simultaneously performed to investigate the relationship between chewing and local cerebral blood flow.

Cerebral blood flow increased with the gum chewing but decreased after chewing and returned to the level before chewing. The increased cerebral blood flow indicated that the gum chewing activated the whole prefrontal area. It was suggested that chewing activates the brain, which may be effective for improving memory and reducing stress.

Effects of the difference in chewing rhythm on the brain activity will be examined in the next step.