fMRI

Playing an Active Role in the Most Advanced Brain Research

Advanced ICT Research Center

An Important Tool for Promising Brain Research

The 3.0-T high magnetic field MRI (Magnetic Resonance Imaging) equipment is installed in the MRI room of No. 3 Research Building at the Advanced ICT Research Center (Fig. 1).

MRI, which is widely used in the medical facilities, is based on nuclear magnetic resonance. In this process, a hydrogenic atom is used to acquire tomographic images of the human head and body. Although fMRI (functional Magnetic Resonance Imaging) and MRI equipments are manufactured using the same hardware, fMRI equipment can detect the brain's activities by measuring the increase of blood flow in the brain. For example, when we look at something or touch an object, neurons in the corresponding areas of the brain get excited, and the brain's blood flow increases. Therefore, by using fMRI, we can determine the area of the brain where such activities occur.

Brain research is being carried out by NICT in order to apply the human brain's advanced information processing functions to information and communication technologies. fMRI plays a very important role in the non-invasive measurement of the brain's activities and the visualization of brain information.

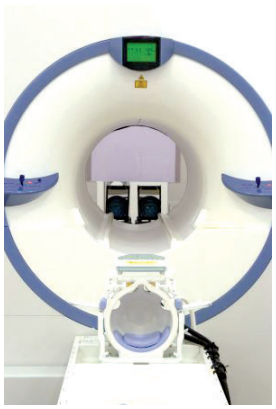

Fig.1:
3.0-T High Magnetic Field MRI Equipment

Observing the brain activities through fMRI

The 3.0-T high magnetic field MRI equipment has a better S/N (Signal-to-Noise) ratio than the 1.5-T MRI equipment. The former can also measure the brain's active area with high surface imagery. A strong magnetic field is generated by superconducting electromagnets cooled by liquid helium. An 8-channel phased array coil is eguipped for the component that receives the magnetic resonance signals from an examinee.

The magnetic field produced by the superconducting electromagnets is so strong that if a credit card is placed in its vicinity, the magnetic information stored on the card will be erased. Hence, it is prohibited to bring metals or magnetic cards into the room where the superconducting electromagnets are installed.

NICT started brain research using fMRI in Koganei City in 1993 and moved it to Kobe City in 1998. The new research building was resourcefully created, based on a well-considered design, to minimize the influences of minute vibrations and electromagnetic noises so as to build a research building optimal for non-invasive measurement through fMRI and magnetoencephalography.

The brain information project team of the Biological ICT Group and the NICT-CREST brain function imaging team are currently engaged in studies using fMRI.

Measurement of brain's activities during dreaming

The NICT-CREST brain function imaging team under Satoru Miyauchi, Research Manager is now addressing to measure the brain's activities during sleep. REM (Rapid Eye Movement) sleep and non-REM sleep occur alternatively during sleep. During REM sleep, which appears at intervals of approximately 90 minutes, our eyes frequently move and we see dreams. It was hypothesized in the 1950s that eyes move during dreaming because they trace the images appearing in the

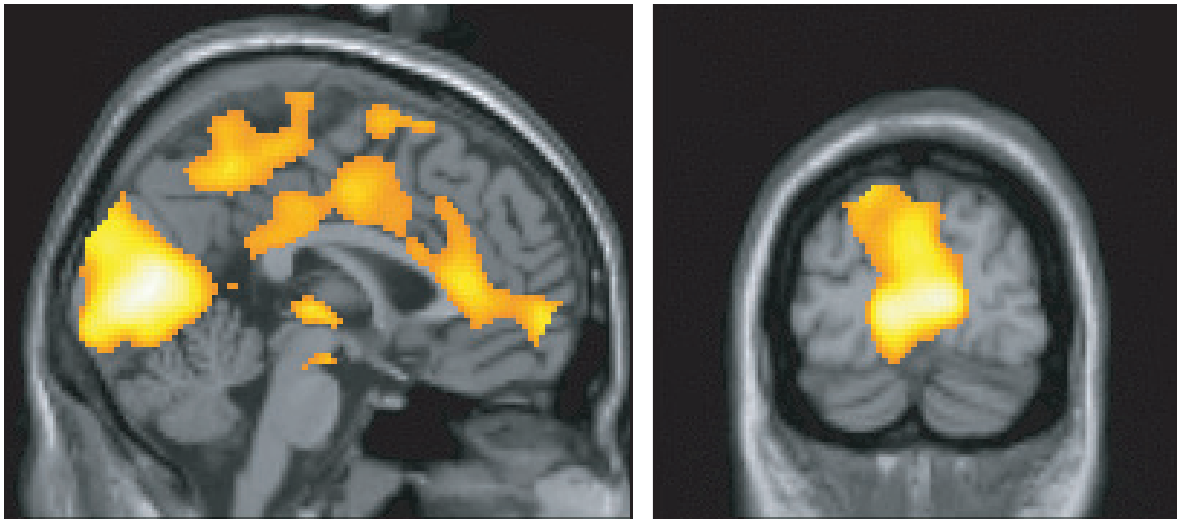

Fig.2: Brain Activities in Accordance with Rapid Eye Movements during REM Sleeps

dream; however, there has been no evidence to support this hypothesis.

Results of a study on brain activation time-locked to rapid eye movements during REM sleep using simultaneous EEG (ElectroEncephaloGraphy) recording with fMRI that began around 2002 have been recently published (Experimental Brain Research, DOI10.1007/s00221-008-1579-2). They indicate the occurrence of clear activities in the primary visual area corresponding to rapid eye movements during REM sleep. This result shows that we experience clear visual images in the form of dreams even when our eyes are closed during sleep. Furthermore, the study identified the activities of amygdalas and gyrus parahippocampalis, which have a bearing on emotion and memory but are normally inactive even during eye movement in the waking state (Fig. 2). More specifically, it seems that rapid eye movements during REM sleep are not random but playing an important role in generation of realistic dreams.

Measuring brain waves in strong magnetic field

It is difficult to measure the brain's activities during REM sleep using fMRI. "fMRI can identify the activated areas of the brain but it cannot determine whether an examinee is asleep or in an active state. To know whether the examinee is in REM sleep, it is necessary to measure the examinee's brain waves simultaneously," says Miyauchi. Measurement of brain waves with the MRI equipment which generates strong magnetic fields has been assumed to be difficult for a long time. However, breakthrough technologies and ingenuities have enabled coinstantaneous measurement of brain waves and activities during REM sleep using fMRI.

Dream is the ultimate virtual reality

People are reluctant to volunteer as examinees because they have to remain inside the MRI scanner for a long time until REM sleep occurs. However, NICT has the largest volume of data in the world, with regard to concurrent measurement of brain waves and measurement of the brain's activities using fMRI during REM sleep.

Miyauchi says, "Dream is the ultimate virtual reality which our brain spontaneously generates." Our brains create virtual reality almost indistinctive from the reality with no outer information given when we see dreams. Current technologies are incapable of artificially inducing such virtual reality. Novel technologies that support future information and telecommunication systems may be developed from the studies on physiological mechanisms for generating dreams.

Dr. Miyauchi and MRI Equipment

Profile

Satoru Miyauchi

Research Manager, Project Promotion Office, Kobe Advanced ICT Research Center

After completing his graduate course, studied at Brown University in the U.S. and the National Institute for Physiological Sciences (NIPS) of the National Institutes of Natural Sciences (NINS) in Japan; Joined the Communications Research Laboratory (current NICT) in 1993. At present, involved mainly in research and development of non-invasive brain function measurement systems such as fMRI / Magnetoencephalography / Electroencephalography; Doctor of Medical Sciences