Final Lecture by Professor Shoogo Ueno at the Main Auditorium, Faculty of Medicine, the University of Tokyo, Tokyo, Japan, at 14:00-16:00, March 9, 2006

Studies on Magnetism for 40 Years

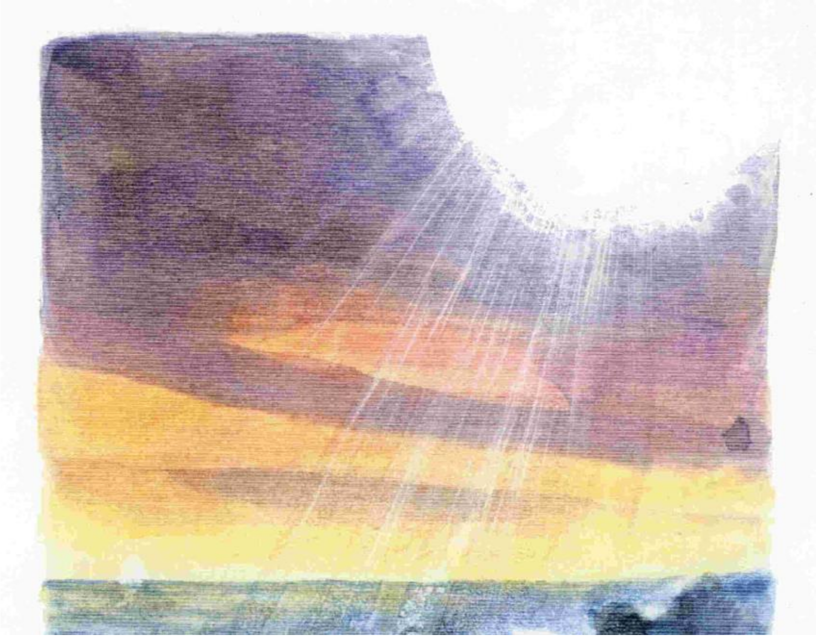
Wonder of Biomagnetism, and Human Brain Stimulation and Imaging

Shoogo Ueno

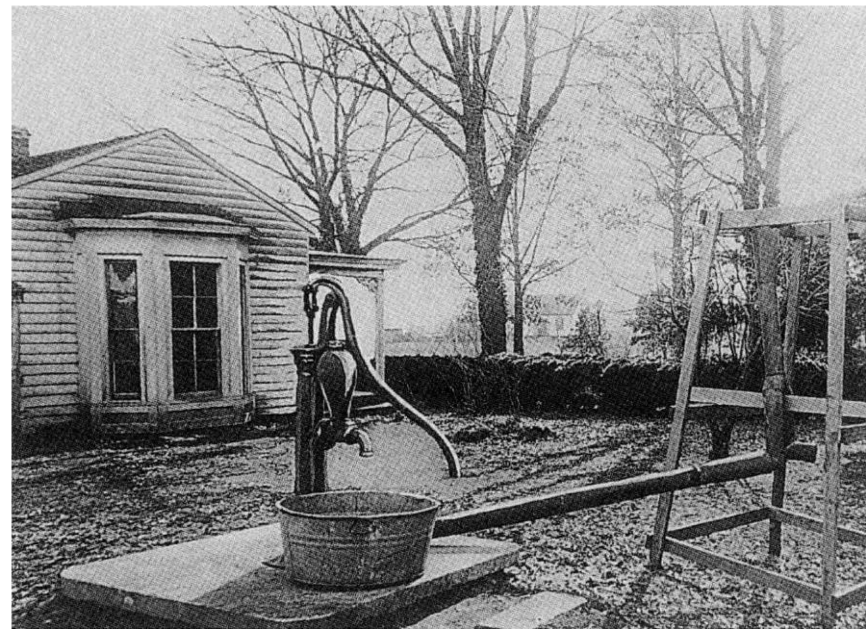
Professor, the University of Tokyo

The unfolding of your words gives light :
it gives understandings to the simple.

The Psalms 119 : 130



Helen Keller and Miss Sullivan



Well in Tuscumbia

Everything has its name.

Professor Koosuke Harada

Hysteresis Model of Partial Flux Reversal in Ferrite Cores

SHOOGO UENO AND KOOSUKE HARADA, SENIOR MEMBER, IEEE

Abstract—**A hysteresis model of partial flux reversal in a ferrite core under voltage pulsed excitations is proposed in order to explain the relation between partial flux sets and the memory characteristics of magnetic analog memories. The model is based on the assumption that the slope of the irreversible region declines in proportion to the reversed flux level. The recurrence equations for flux levels derived from the model explain the hysteresis phenomenon in the meomory characteristics.**

Introduction

SINCE THE introduction of the transfluxor [1], square-loop ferrite cores have been studied for accurate analog memories from a standpoint of partial flux switching [2]–[8]. However, the relation between the magnetizing characteristic of the core and the memory characteristic has not been successfully explained. When the polarity of the write-in pulses is reversed at a memorized level, a hysteresis effect appears in the memory characteristics, which depends upon the history of the excitation required to achieve the reversed level.

A new hysteresis model discussed here explains this history effect. The partial flux state in the core due to a train of voltage pulses is described by recurrence equations of flux levels. These results were confirmed by experiments on a Mn–Cu ferrite core.

Hysteresis Model

The basic circuit to be discussed here is shown in Fig. 1. We consider the partial flux switching due to a train of voltage pulses. That is, the input resistance R_1 is so small that the waveform of the MMF in the core does not rise

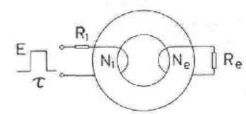


Fig. 1. Basic circuit.

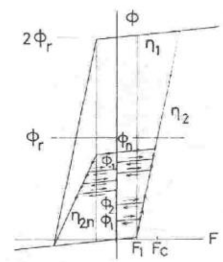


Fig. 2. Hysteresis model.

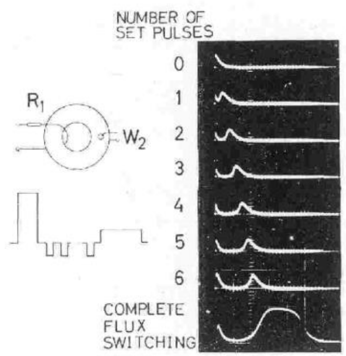
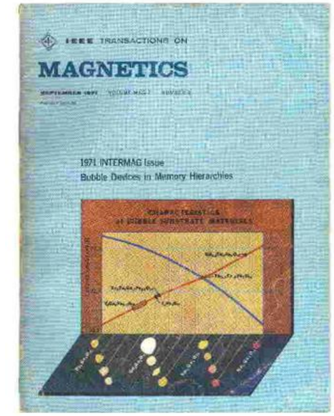
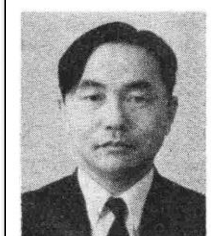


Fig. 3. Pulse responses to verify model. Core is Mn–Cu ferrite with 10-mm OD, 4-mm ID, 1-mm hole D; horizontal scale is 2 μs/div; vertical scale is 1 V/div.

pulses with 10-V height and 1-μs width were applied through the primary winding with resistance $R_1 = 50\ \Omega$. Finally, induced voltage was observed [11] in the winding





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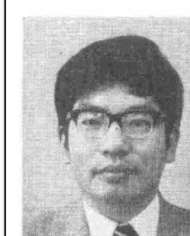

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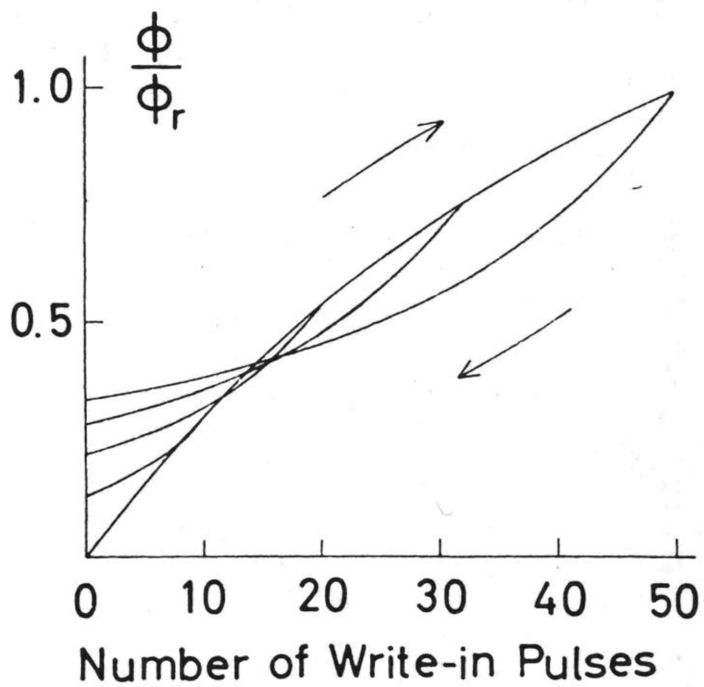
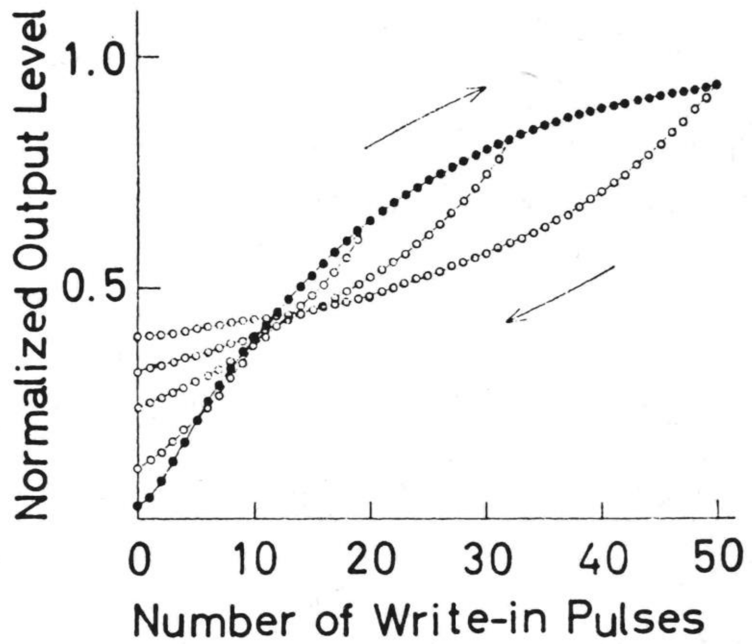


Calculated results



Experimental results

S. Ueno and K. Harada: IEEE Trans. Magn. (1971)

Visit to the Medical Campus

S. Ueno "I want to study brain at medical campus. Lecture by Dr. Motohiro Kato was so attractive."

Prof Harada "Which Department Dr. Kato works at?"

S. Ueno "Dr. Kato works at Department of Neurology"

Prof Harada "Chairman of the Department of Neurology is Prof Yoshigoro Kuroiwa?"

Searching the telephone number,
Prof Harada calls Prof Kuroiwa.

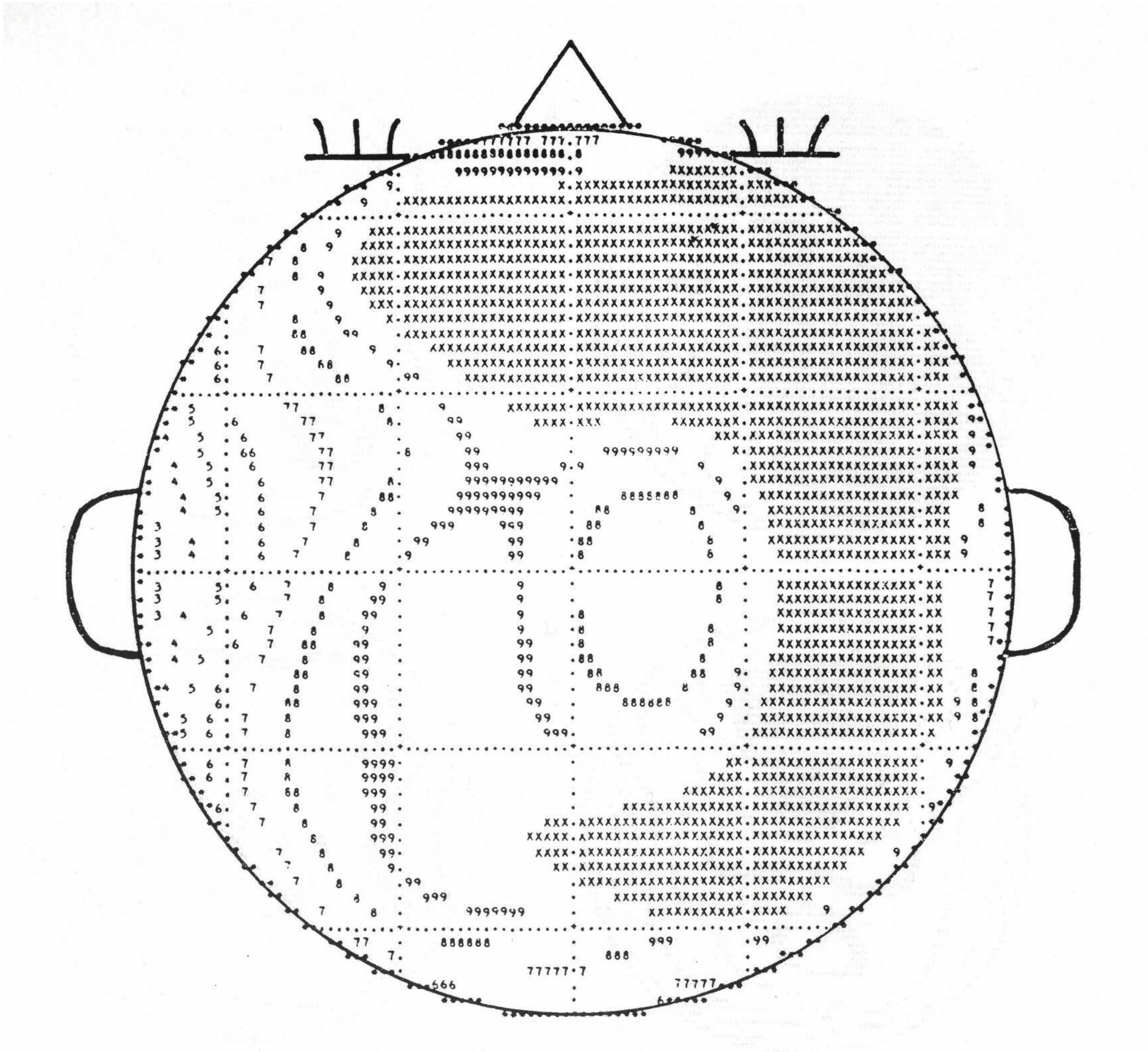
Prof Harada "Dr. Ueno in my lab wants to study brain research at your Department. Could you accept him?"

Prof Kuroiwa "OK. Come to my office on 4th January."

Direction of my life was decided in 3 min.

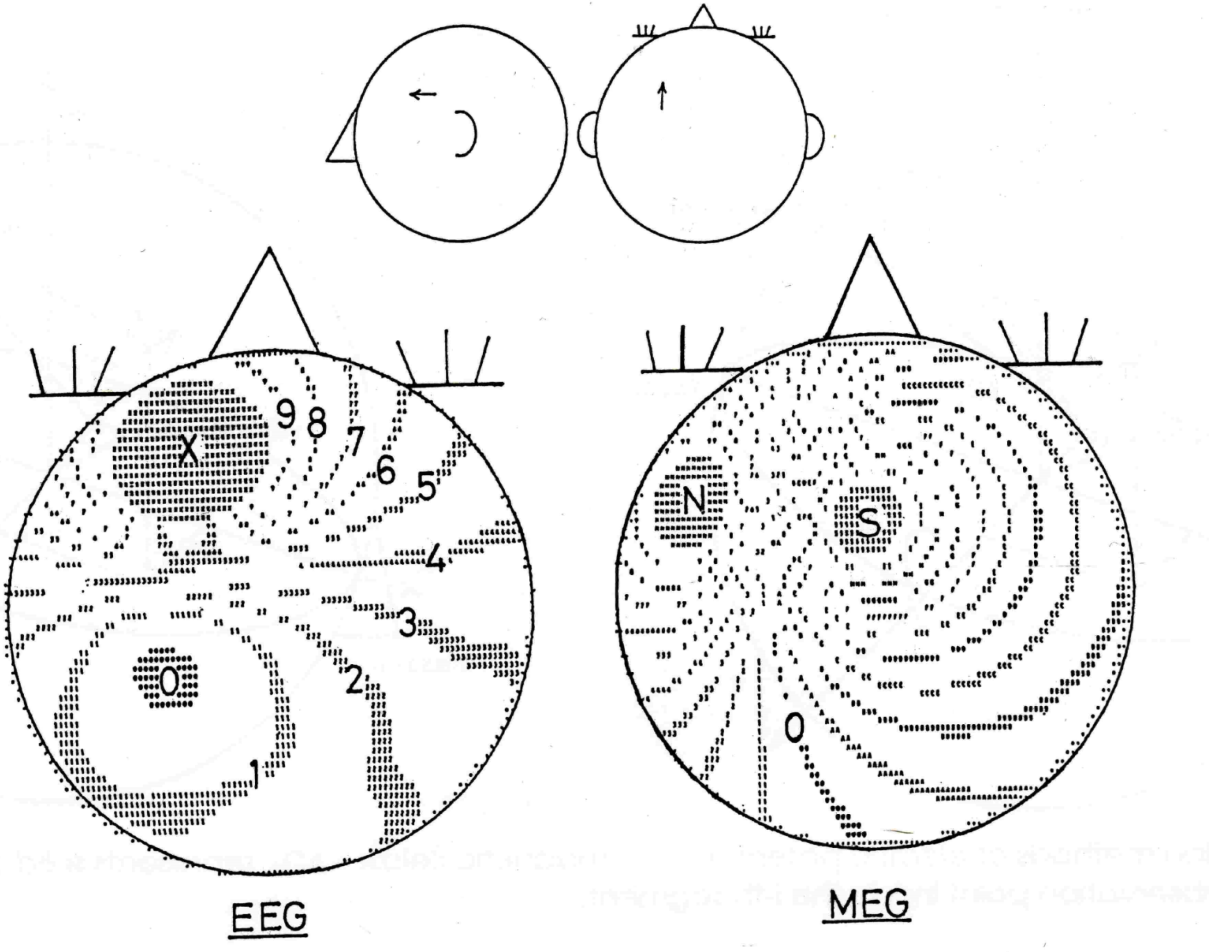
Professor Yoshigoro Kuroiwa

Professor Shigeaki Matsuoka



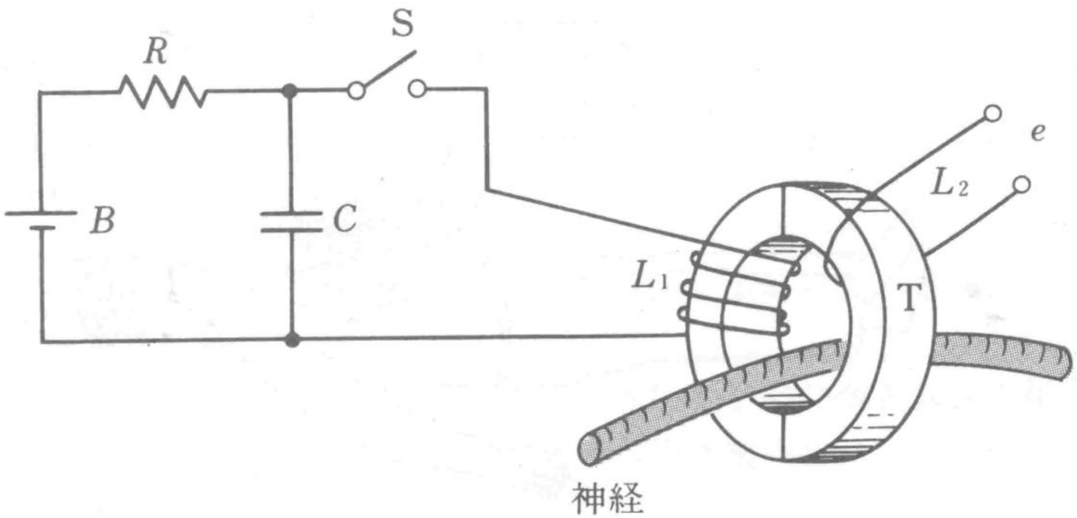
EEG topography

S. Ueno, S. Matsuoka, T. Mizoguchi M. Nagashima, and C. L. Cheng (1975)

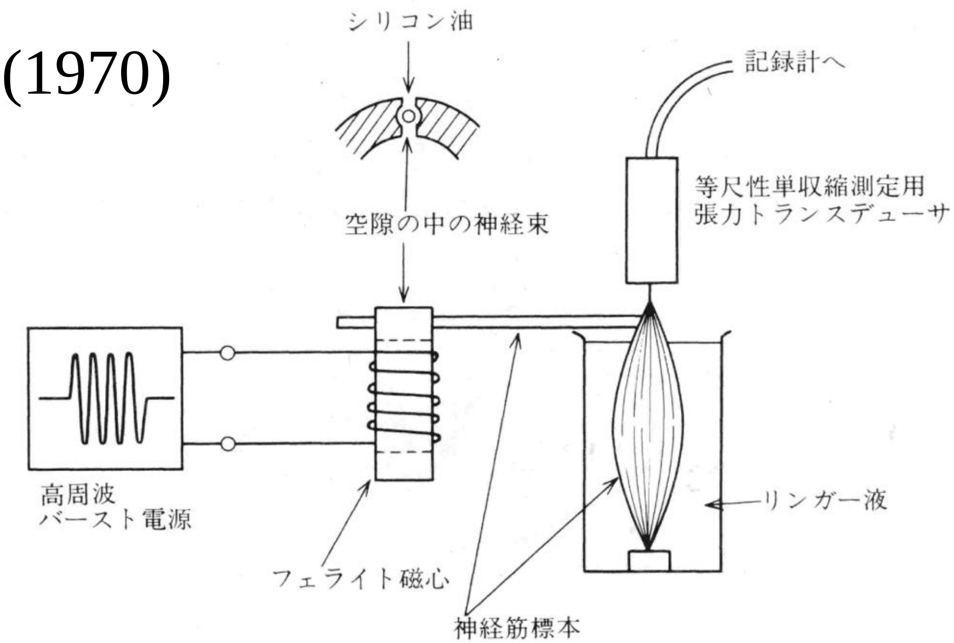


S. Ueno and Y. Fukui (1978)

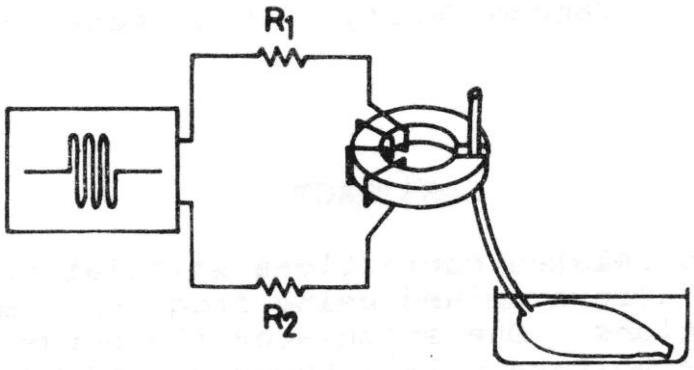
Professor Yutaka Oomura



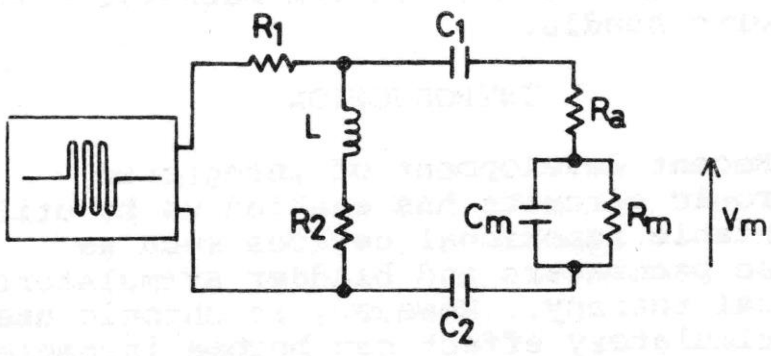
J.A. Maass and M.M. Asa (1970)



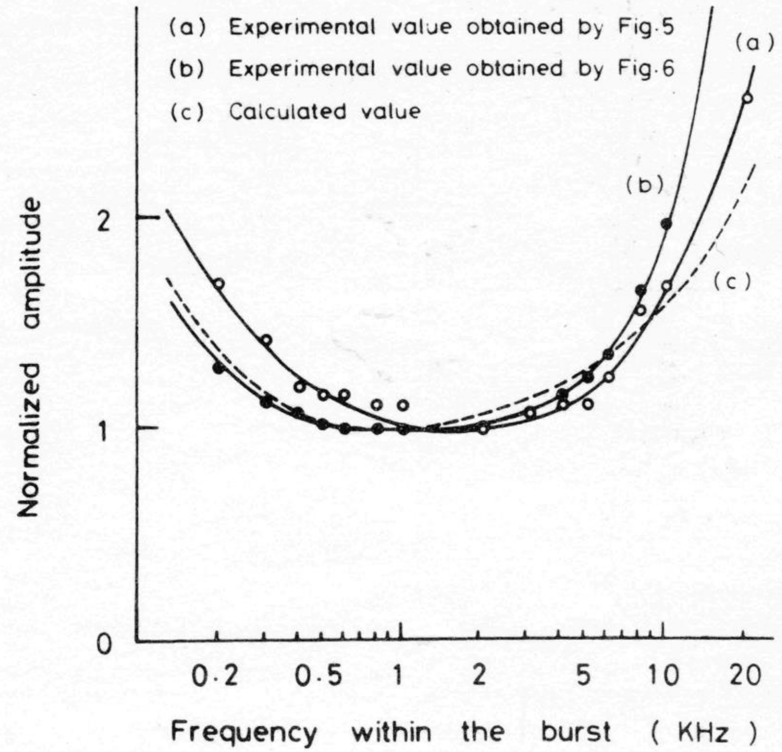
P.A. Oberg (1973)



Experimental set up



Equevalent circuit



Frequency characteristics

S. Ueno, S. Matsumoto, K. Harada, and Y. Oomura: IEEE Trans. Magn. (1978)

IFMBE Conference at Ottawa, Canada, August 1976

Discussion at the Conference

Myself : “Your method of nerve stimulation is not magnetic stimulation but instead might be capacitive stimulation, I think.”

Ake Oberg: “Why don’t you come to my lab to work together?”

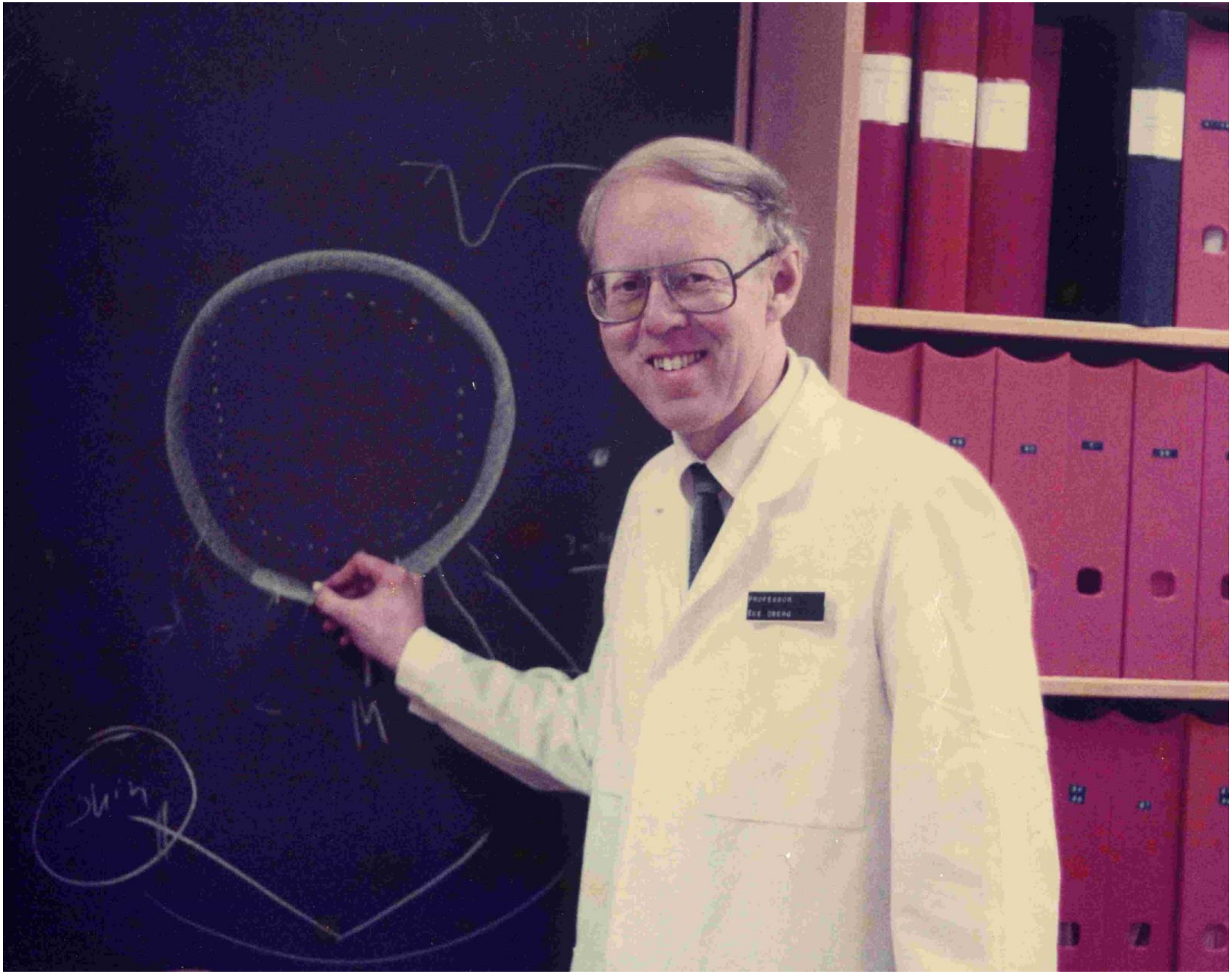
Application for Japan-Sweden Foundation

Interview at Swedish Embassy in Tokyo

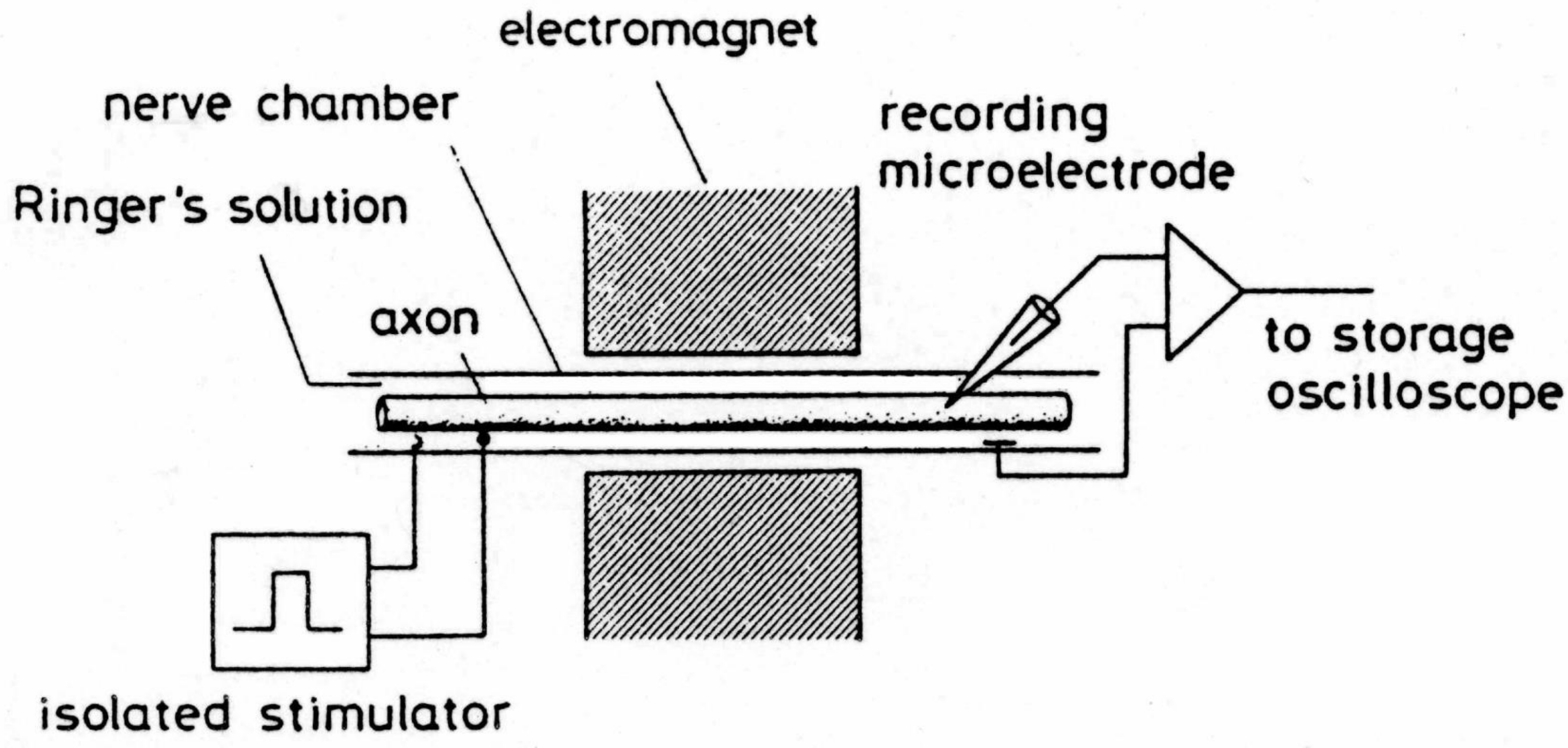
1 Year　　Not succeeded
2 Year　　Succeeded（Prof Kazuhiko Atsumi, Examiner）

I studied magnetic nerve stimulation using lobster giant axons at Linkoping University, Linkoping, Sweden, for 20 months from August 1979 to March 1981.

Former guest researchers supported by Japan-Sweden Foundation
Dr. Kenji Ikeda, Dr. Nozomu Hoshimiya, and Dr. Akira Kamiya

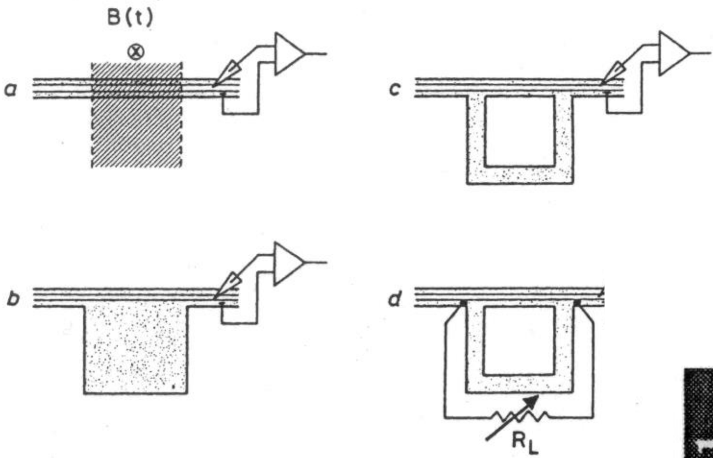


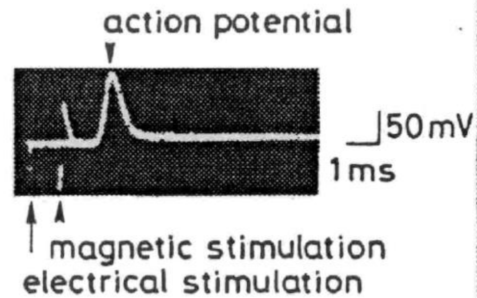
Professor Ake Oberg

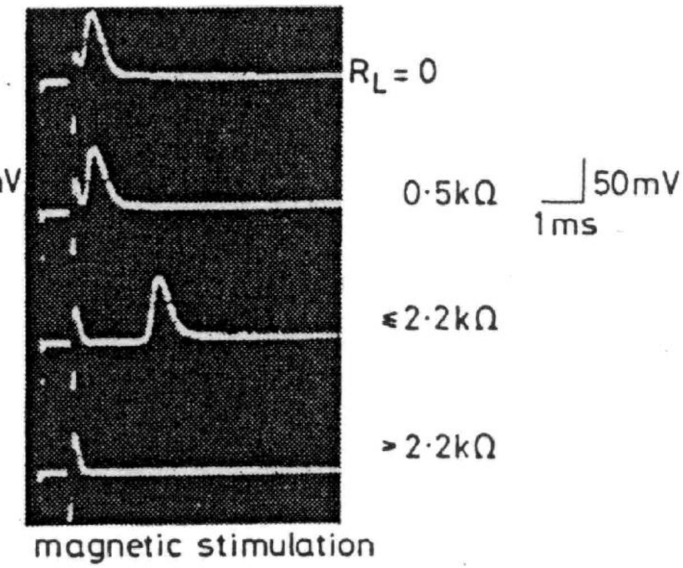


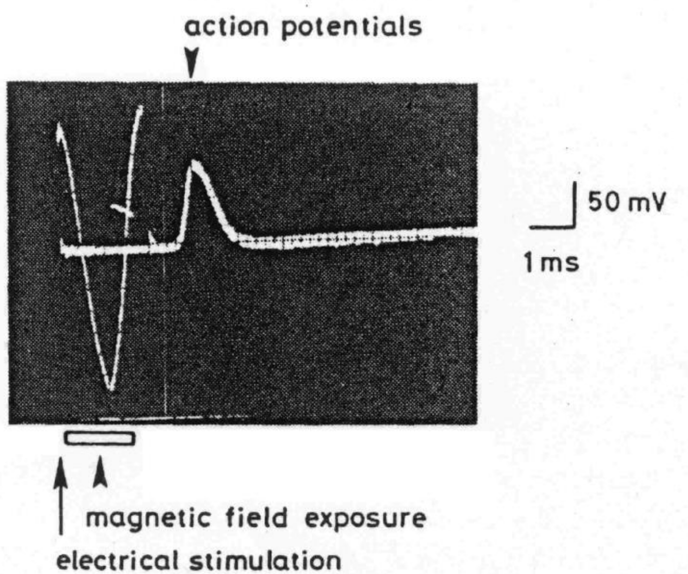
Experimental set up to measure action potentials intracellularly from lobster giant axon during magnetic field exposures

Linkoping, Sweden, January 1980



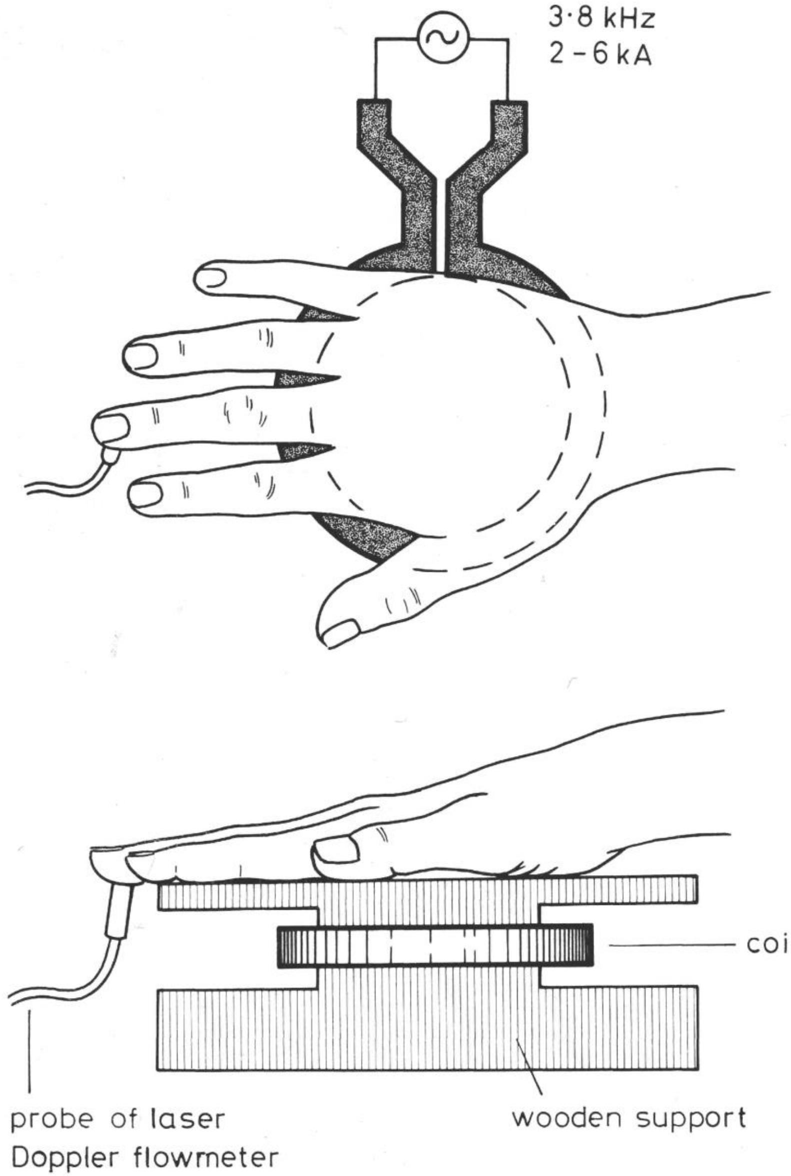






S. Ueno, P. Luvsund, and P. A. Oberg : Nordic Meeting (1981)

S. Ueno, P. Luvsund, and P. A. Oberg : Med. & Biol. Eng. & Comput. (1986)

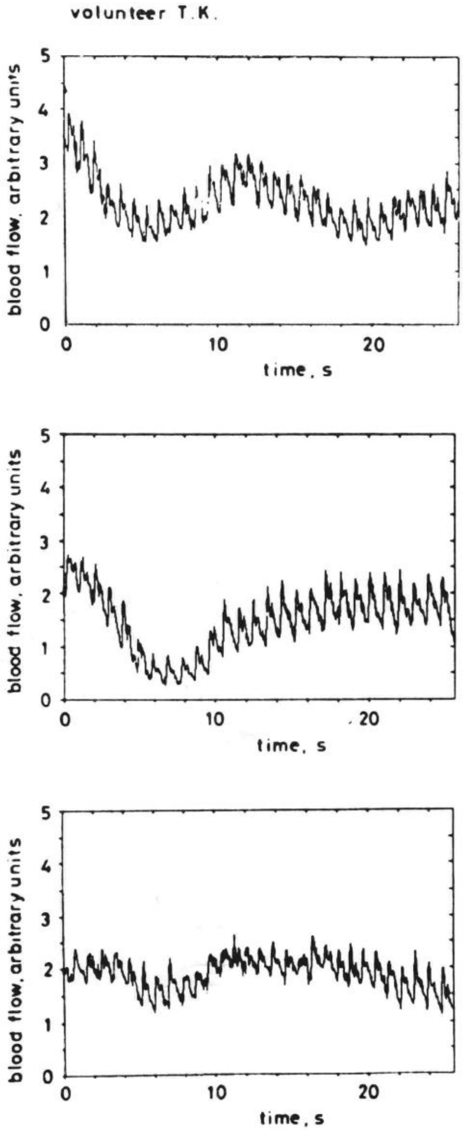


Hand is positioned on an induction coil

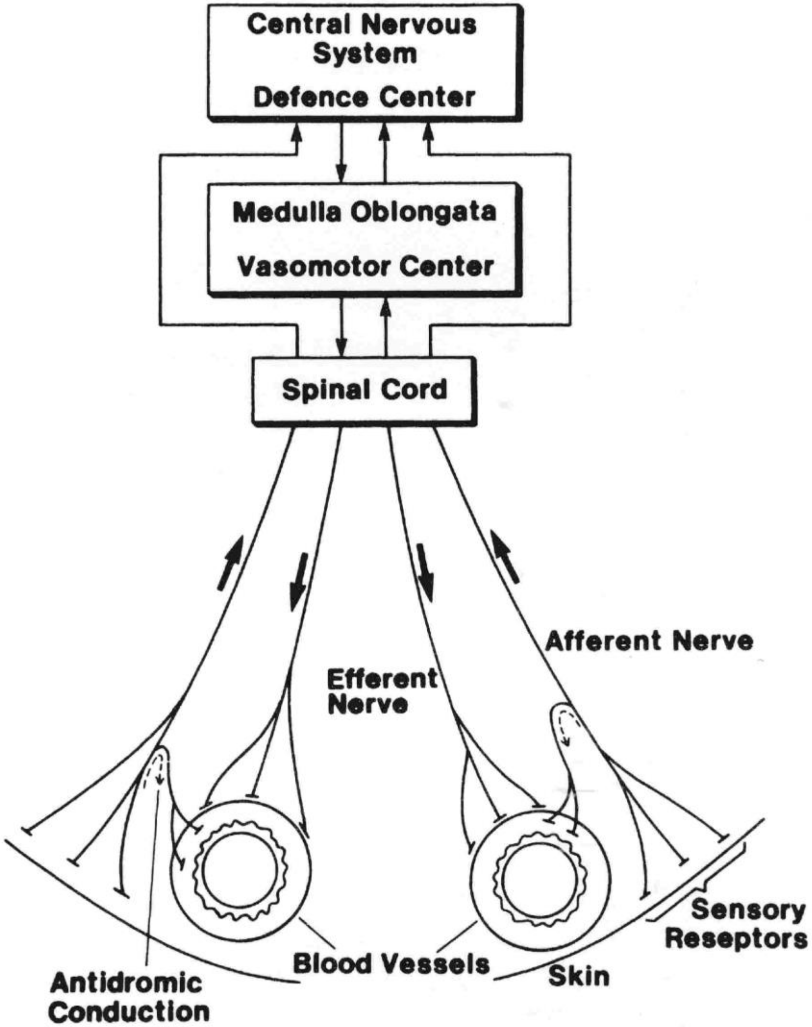
6kA
48mT

4kA
32mT

2kA
16mT



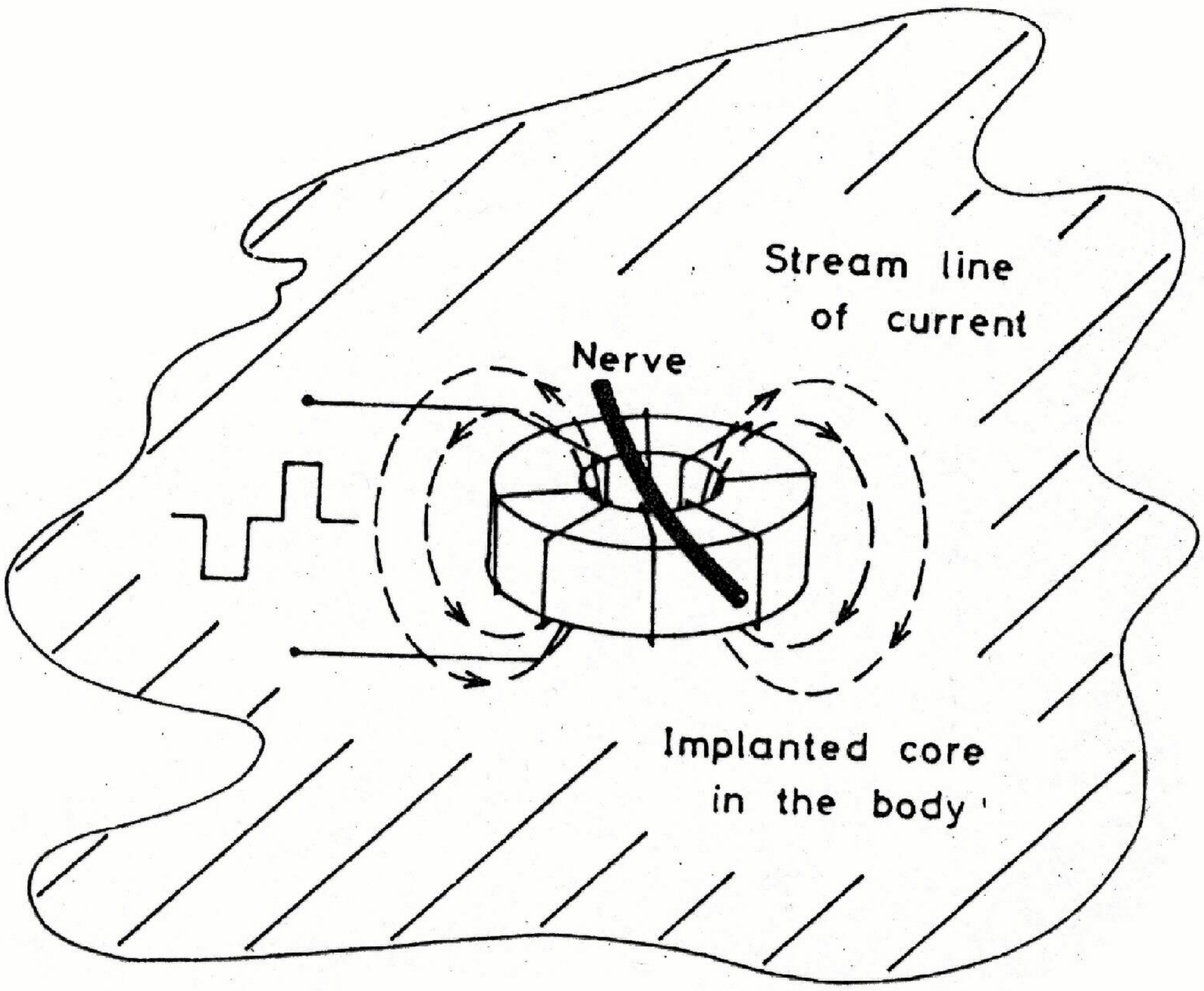
Changes in blood flow



Mechanism of blood flow change

S. Ueno, P. Luvsund, and P. A. Oberg : Nordic Meeting (1981)

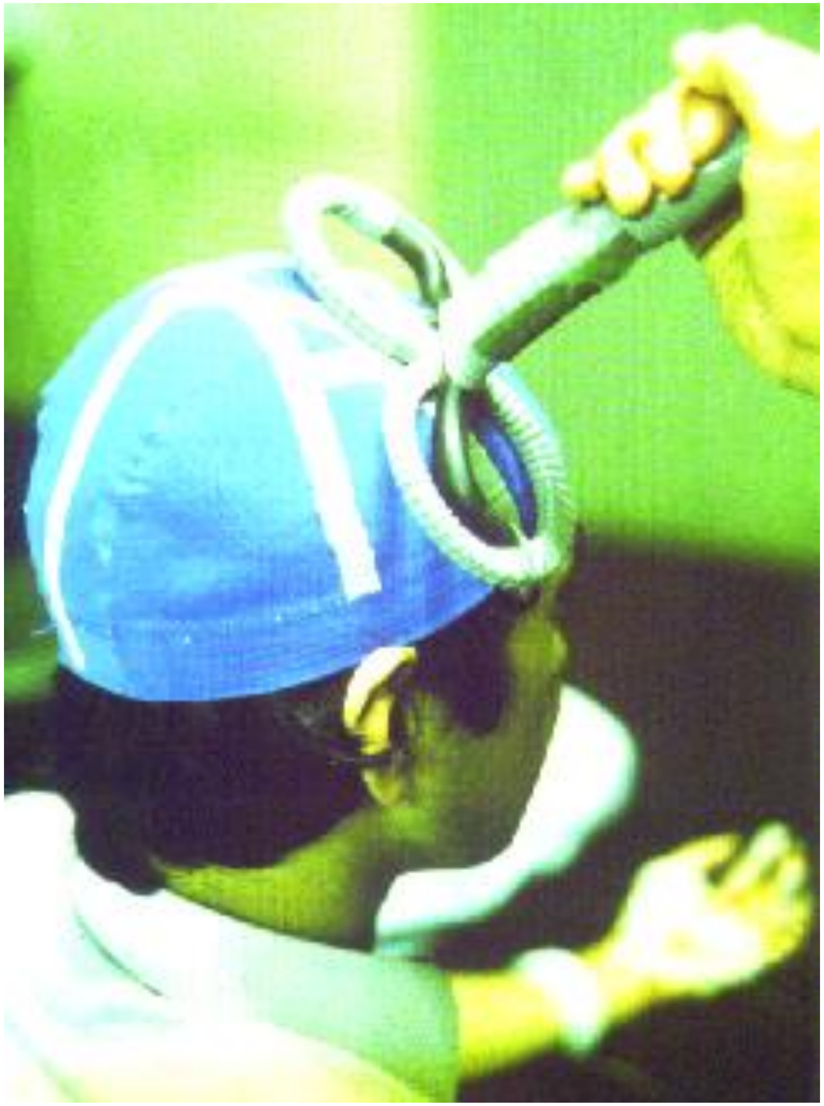
S. Ueno, P. Luvsund, and P. A. Oberg: Med. & Biol. Eng. & Comput. (1986)



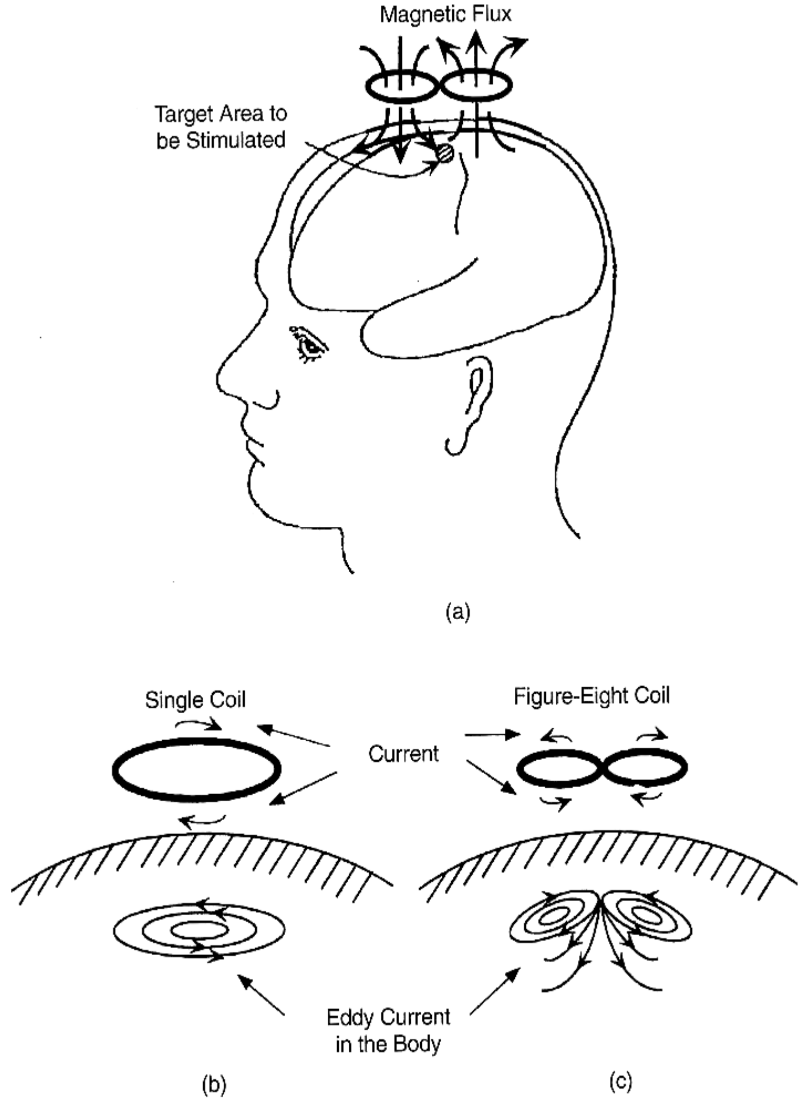
Magnetic nerve stimulation without interlikage between nerve and magnetic flux

S. Ueno, K. Harada, C. Ji, and Y. Oomura : IEEE Trans. Magn. (1984)

Transcranial Magnetic Stimulation (TMS) with a Figure-Eight Coil

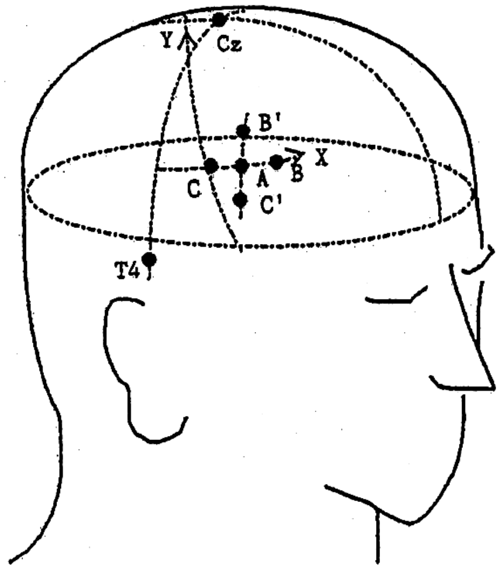


Motor evoked potentials (MEPs) responded to magnetic brain stimulation are measured.

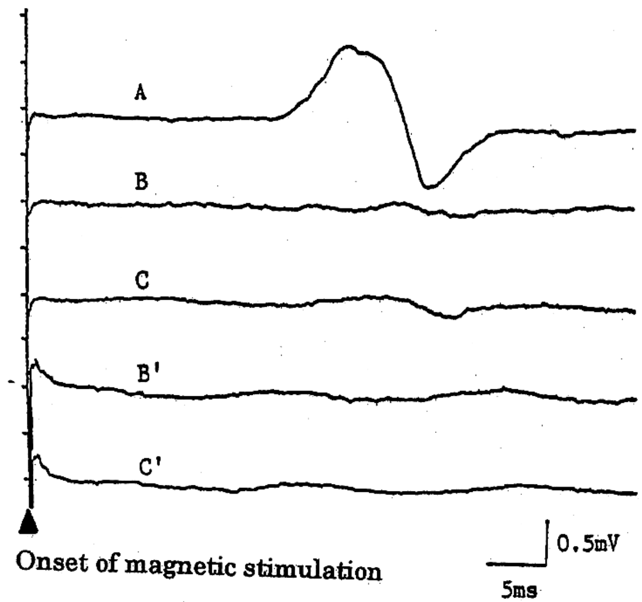


S. Ueno (1987)

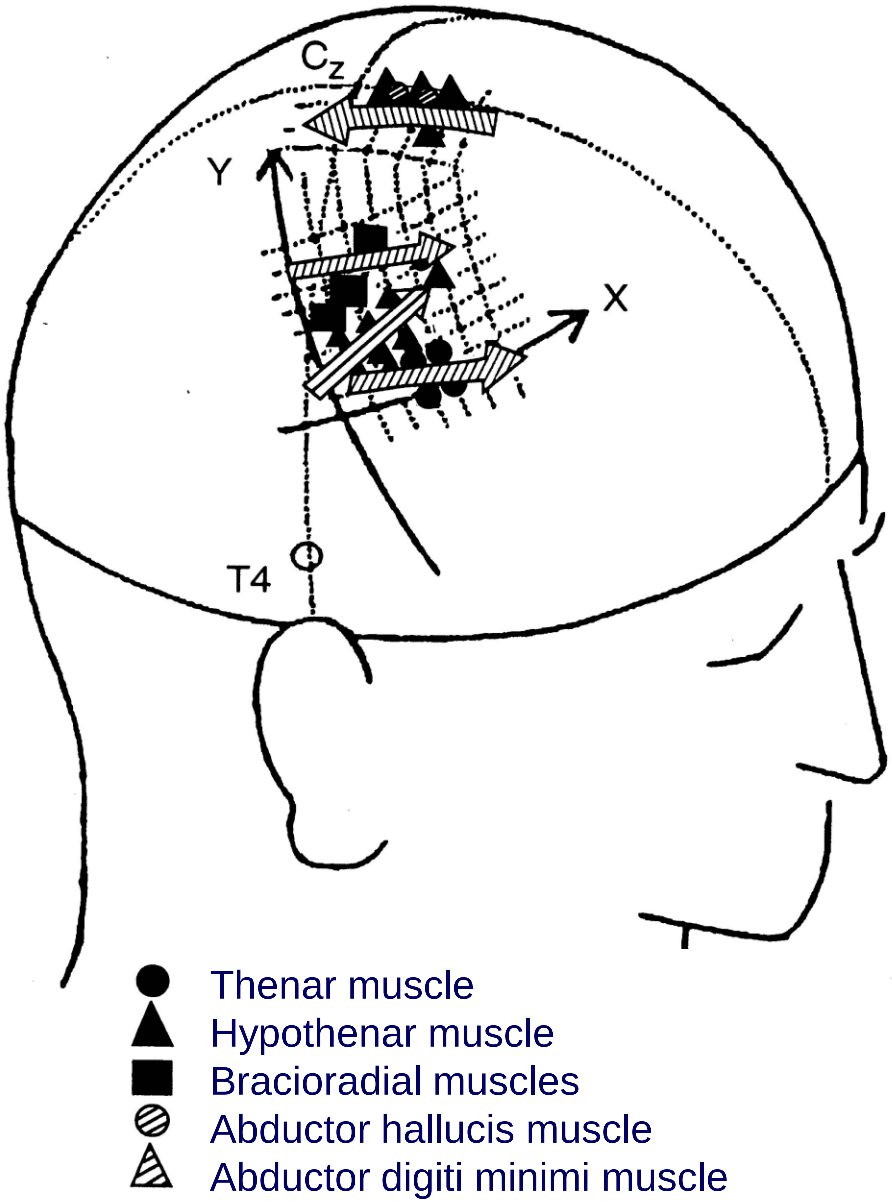
S. Ueno, T. Tashiro, and K. Harada, J. Appl. Phys. (1988)



Motor cortex is transcranially stimulated within a 5 mm resolution



S. Ueno, T. Matsuda, and M. Fujiki: Biomag. New York (1989)
S. Ueno, T. Matsuda, and M. Fujiki: IEEE Trans. Magn. (1990)



TMS controls finger movements

The arrows show optimal directions of induced currents for brain stimulation.

Comment from the floor

"Play Chopin's piano !!!"

IEEE International Magnetics Conference
(Washington, D.C. March 1989)

Ueno S, Matsuda T, and Fujiki M*: IEEE Trans. Magn.*, **MAG-26** (1990)

Transcranial Magnetic Stimulation (TMS): From Measurements to Treatments

- Functional brain mapping
- Creation of virtual brain lesions

- Neuronal plasticity and modulation of neuronal networks
- Modulation of neuro-transmitting processes
- Parkinson’s disease
- Depression, epilepsy, Alzheimer’s disease, and etc.
- Motivation and creativity

- Deep brain stimulation
- Safety aspects of TMS and repetitive TMS (rTMS)

Activities for 24 hours at Ueno's laboratory

Hiroshi Esaki
Keiji Iramina
Tsuruo Matsuda
Osamu Hiwaki
Masakazu Iwasaka
Hideki Yoshida

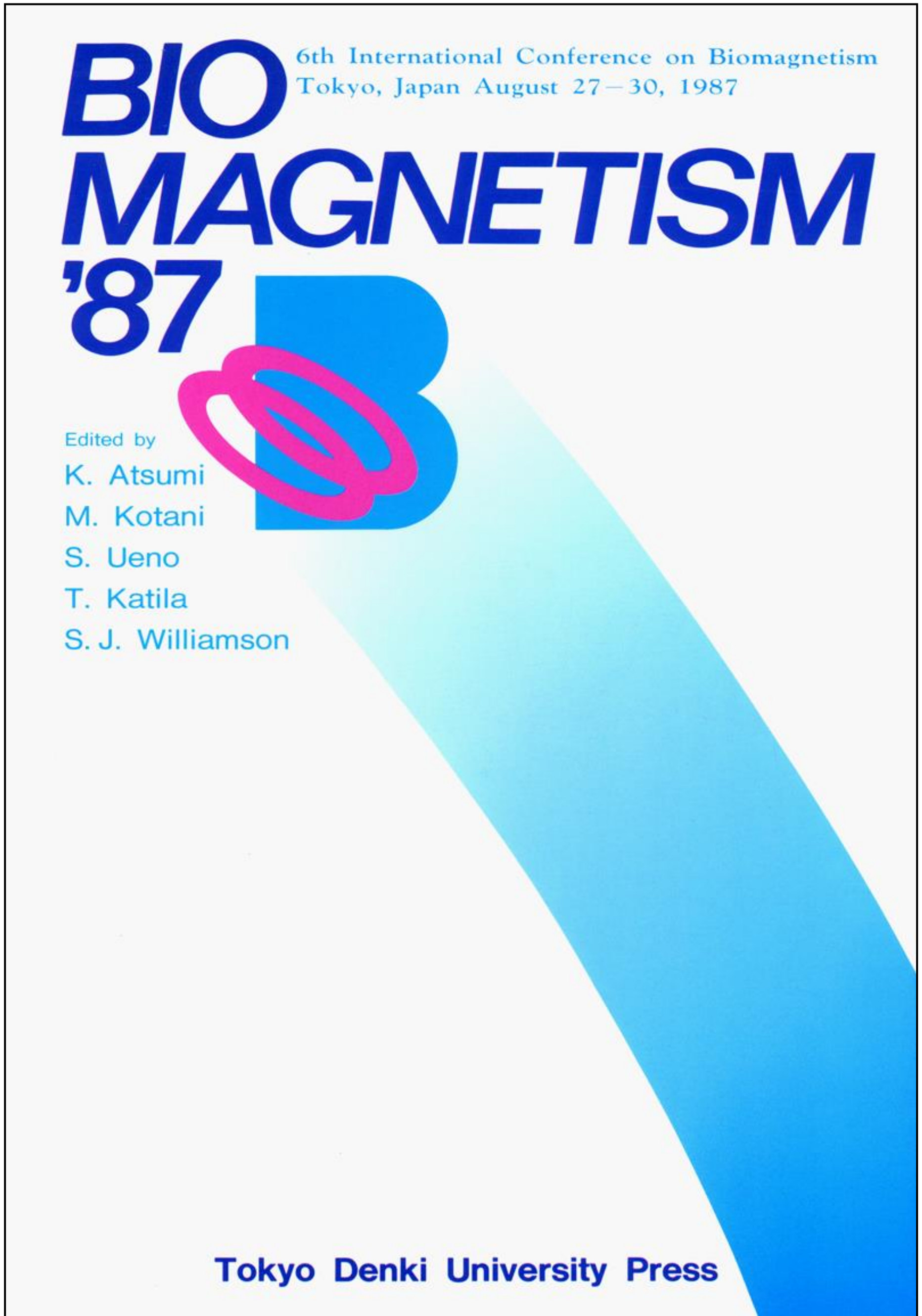
RyouichiTsuda
Masakuni Iwahashi
Takao Suda
Seiya Uchida

Minoru Fujiki
（Neurosurgery）
Takashi Yoshiura
（Radiology）

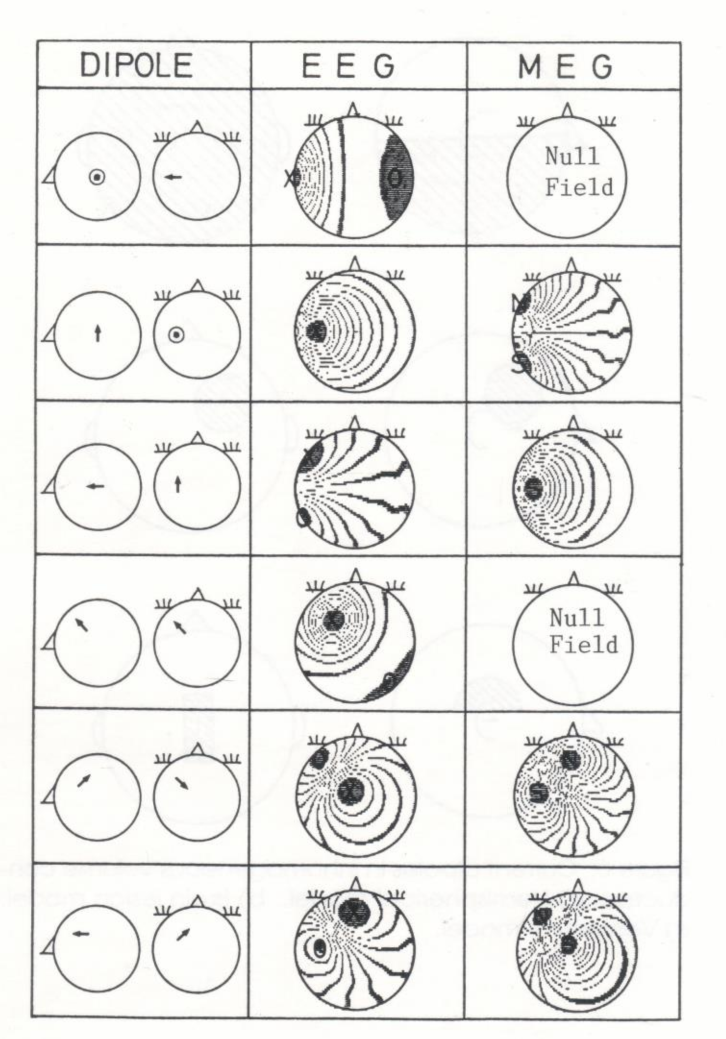
Graduate and Undergraduate Students

Ueno Convenient Store
Ueno Zoo (Smelling of animals)

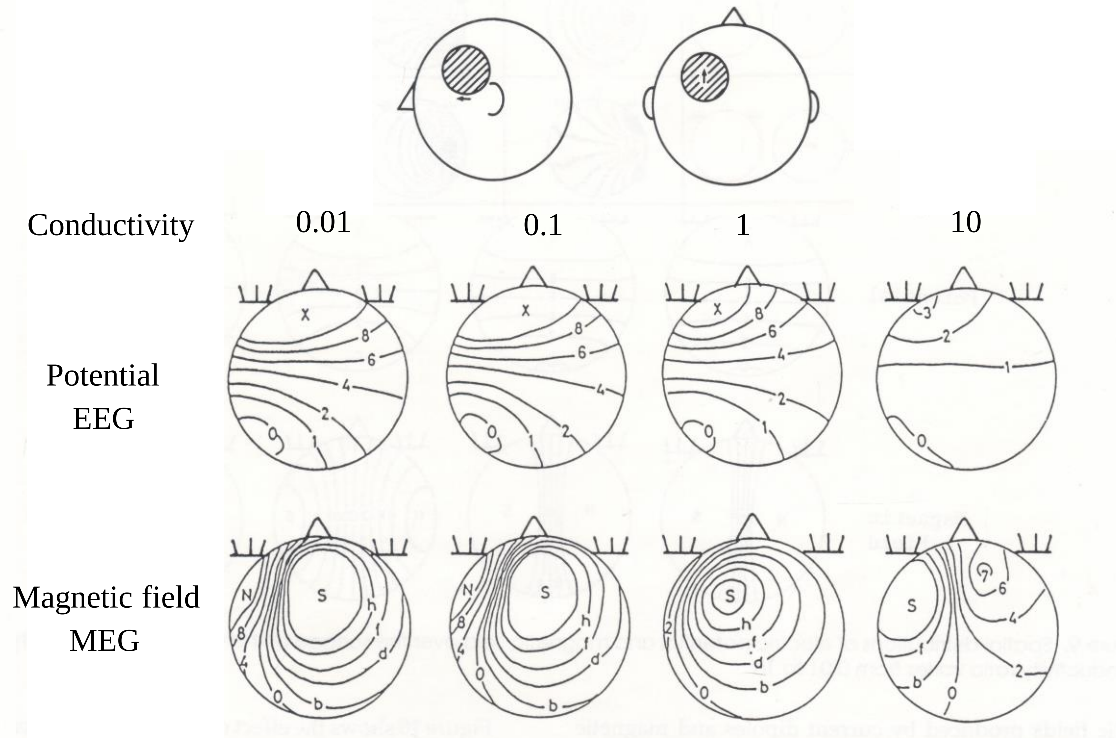
Thanks to
Professor Yutaka Omura (Neurophysiology)
Professor Yoshigoro Kuroiwa (Neurology)
Professor Katsutoshi Kitamura (Neurosurgery)
Professor Shigeaki Matsuoka（Neurosurgery)
Professor Motohiro Kato（Clinical Neurophysiology）
Professor Hitoshi Fukui（Neurosurgery）
Professor Koji Masuda（Radiology）
Professor Hitoo Nakano（Gynecology）
Professor Yoshiaki Nose（Medical Informatics）



6th International Conference on Biomagnetism Tokyo, Japan August 27-30,1987



Forward Problems in EEG and MEG



Effects of Conductivities on the EEG and MEG

S. Ueno, and Y. Fukui (1978)
S. Ueno, H. Wakisako, and S. Matsuoka (1983)
S. Ueno, K. Iramina, and K. Harada (1987)
K. Iramina, and S. Ueno (1987)
S. Ueno, K. Iramina, (1990)

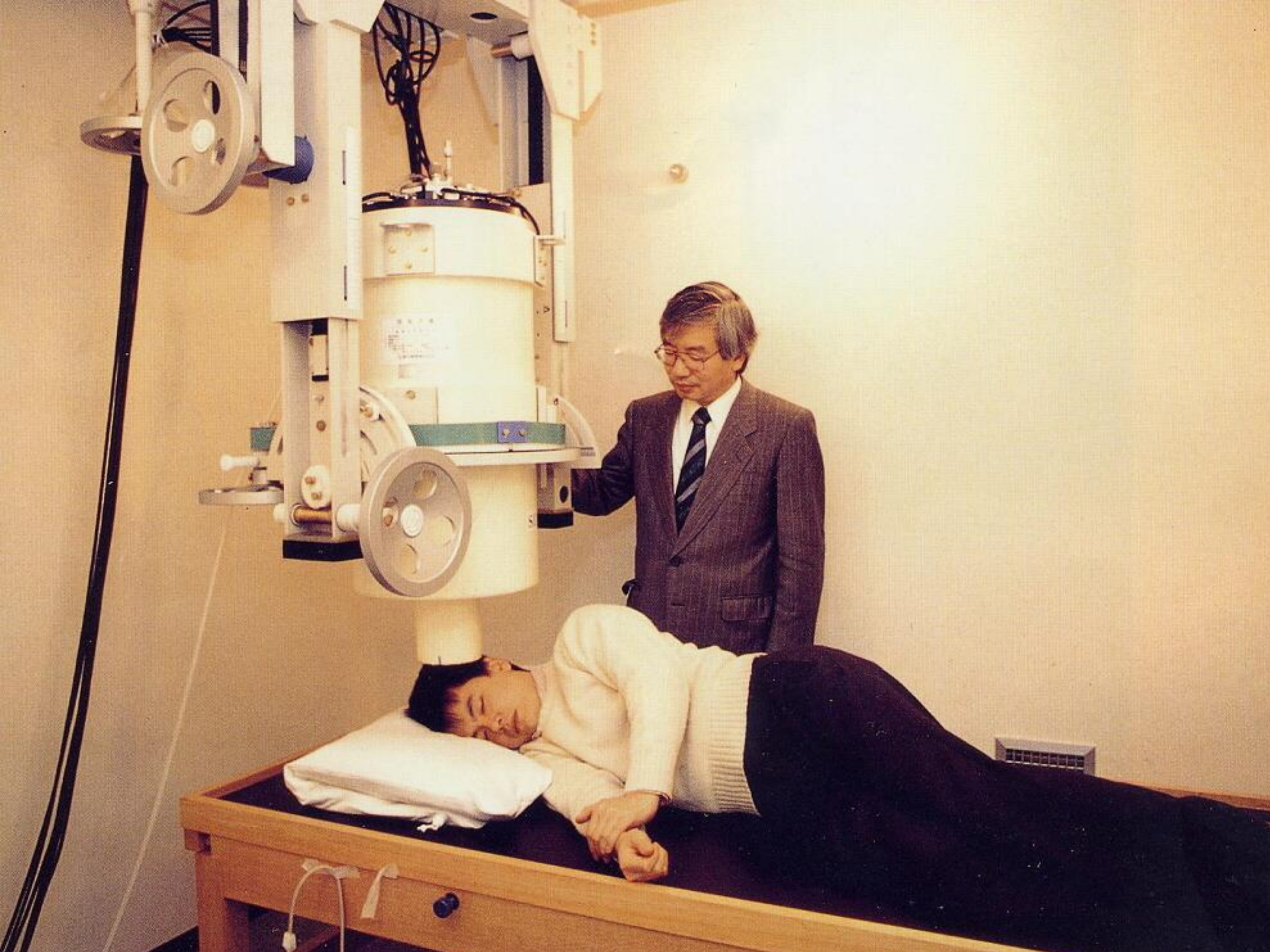
Fabrication of MEG system

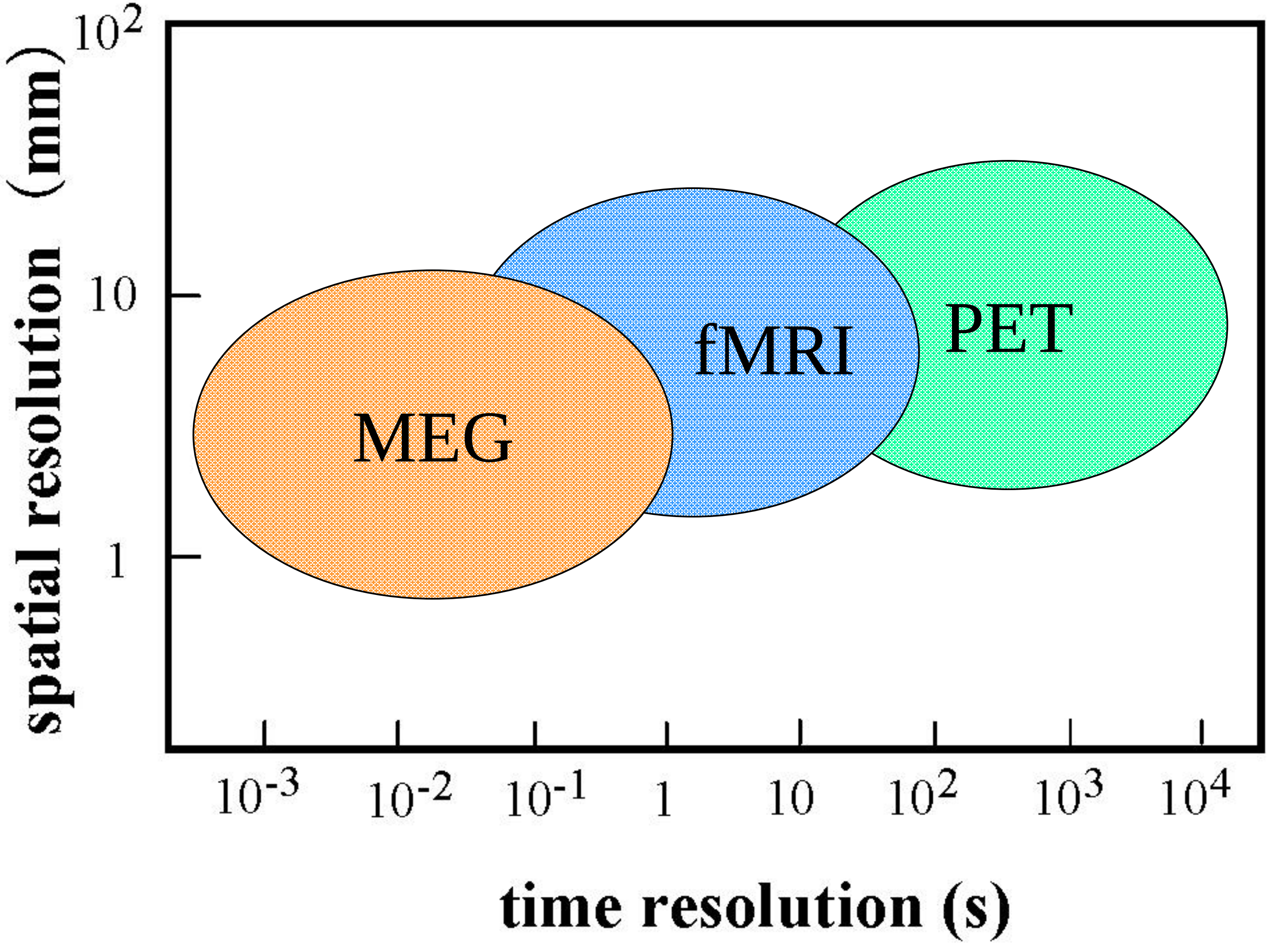
Project on Fabrication of MEG System for Functional Brain Research

Project Research（A）（1） granted by Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan
1991~1993 fiscal years
Research Number： 03505002

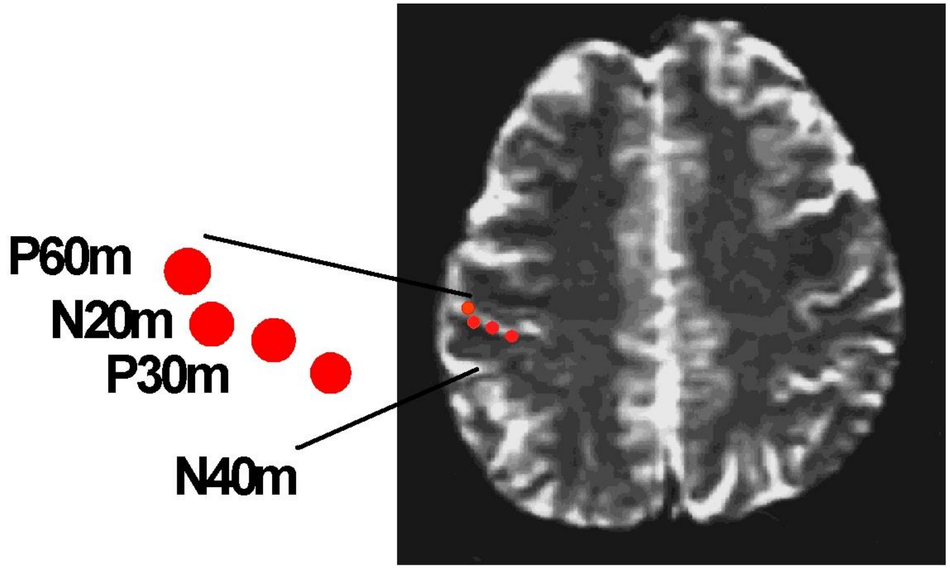
Dr. Naoko Kasai, National Institute of Advanced Industrial Science and Technology (AIST), Japan
Dr. Kazuo Chinone, Seiko Instruments Technology Ltd.
Dr. Keita Yamazaki, Takenaka Corporation Ltd.
and other coworkers contributed to the project.

We developed a useful and reliable MEG system for brain research.

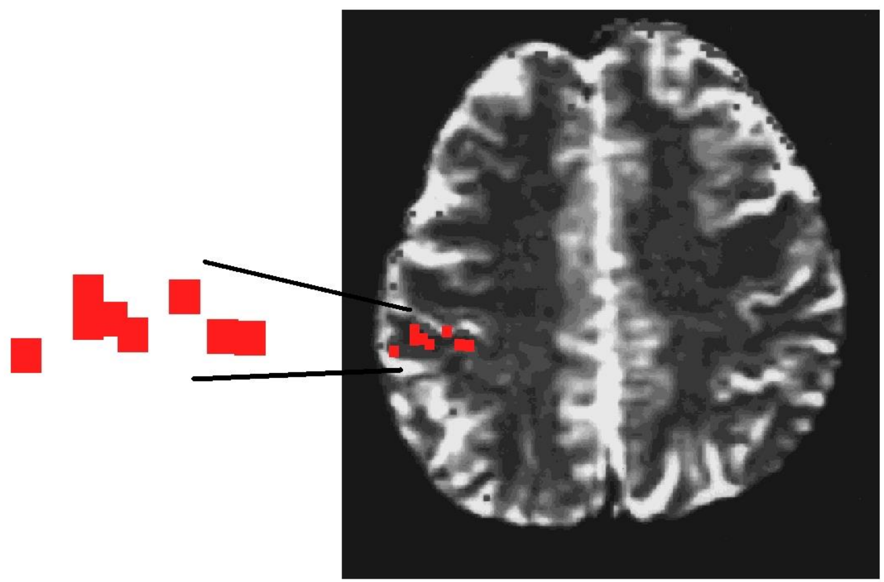




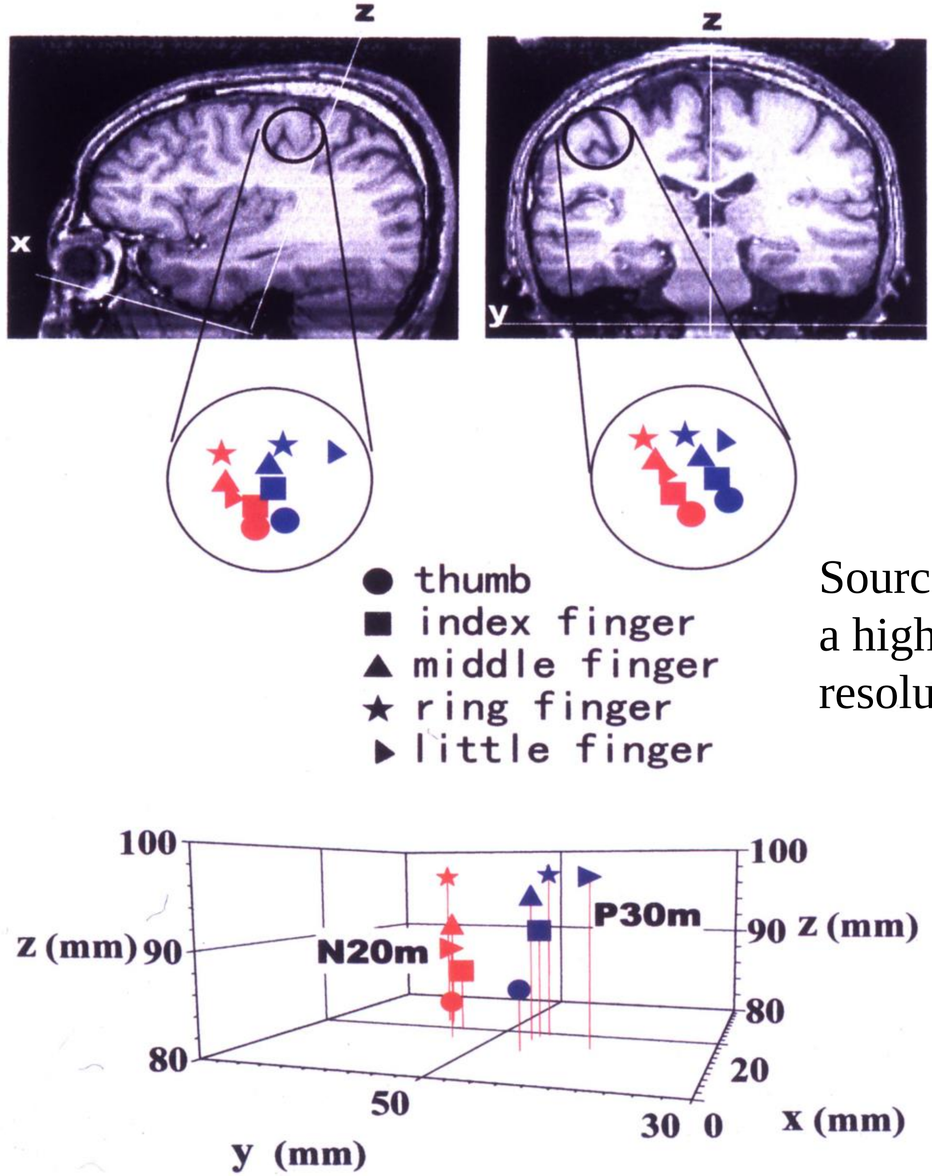
Spatial and Temporal Resolution for Brain Imaging



(a) MEG



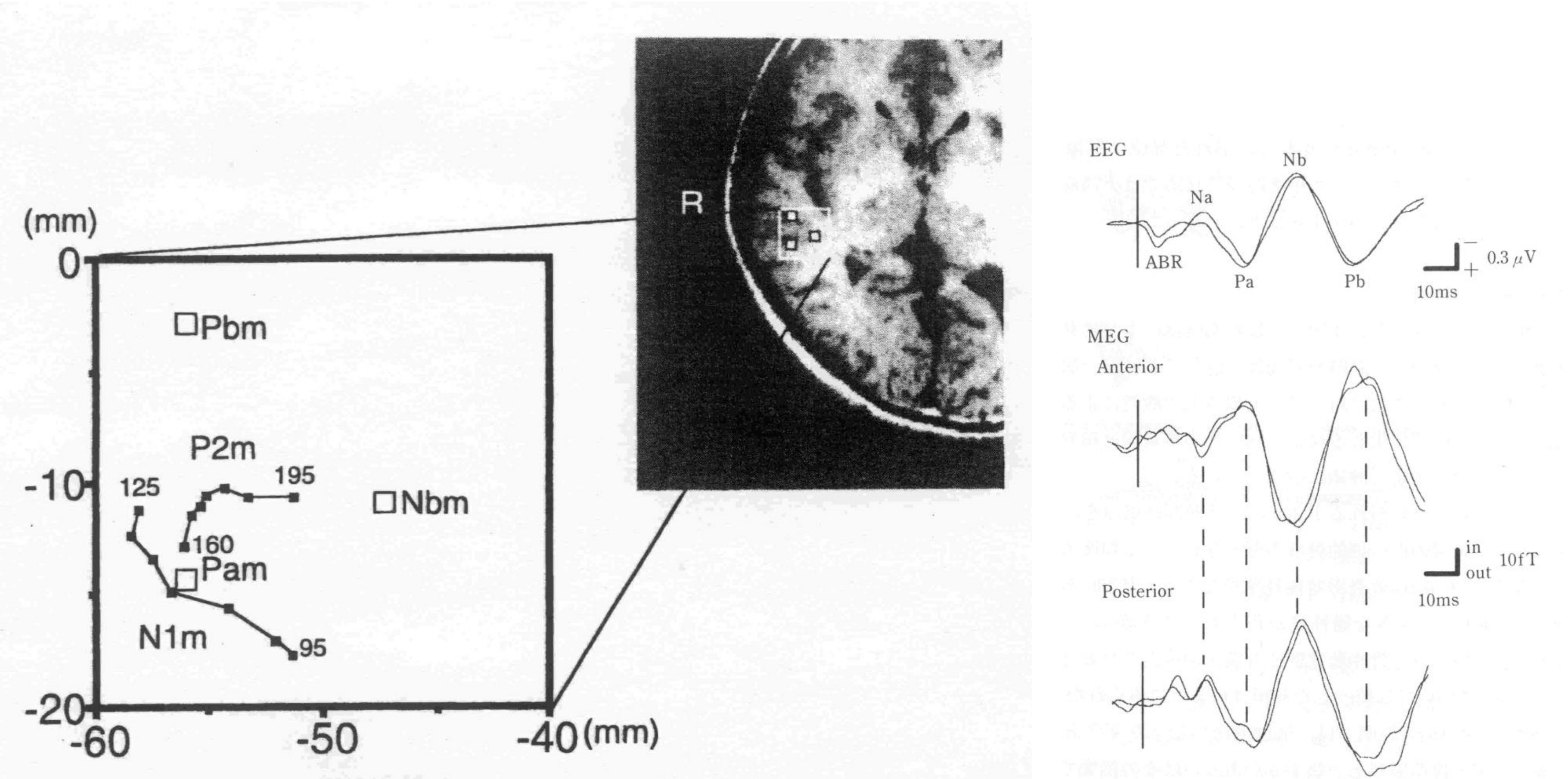
(b) fMRI



Sources are estimated with a high temporal and spatial resolution in m-sec and mm.

Sources of activation in the somatosensory area responded to electrical stimulation of each finger.

Auditory evoked magnetic fields and source estimation



Source estimation of long latency and middle latency auditory evoked magnetic fields. Long latency evoked fields N1m and P2m show travelling sources in ms. The middle latency evoked fields Pam, Nbm, and Pbm show sources ☐ in the auditory cortex.

T. Yoshiura, S. Ueno, K. Iramina, and K. Masuda: Neuroscience Letters (1994)

Effects of Static Magnetic Fields ?

Oxygen and Combustion
Dissolved Oxygen under Magnetic Fields
Combustion and Magnetic Curtain
Chemical Reaction and Radicals
Cystotome C in Hem Proteins

▪

▪

Focused on paramagnetic properties

Effects of magnetic fields on combustion of alcohol catalyzed by platinum catalysis

Professor Taku Matsuo “Use well known and well specified fuel.”

Slowly processing combustion of alcohol catalyzed by platinum catalysis is carried out under magnetic fields, changing the number of carbons (C1~C4).

Combustion velocity is reduced by magnetic fields.

Methanol	(CH_3OH)	-5%	0.9T
Ethanol	(C_2H_5OH)	-3%	0.6T
Propanol	(C_3H_7OH)	-18%	0.6T
Normal-butanol	(C_4H_9OH)	-80%	0.7T
Iso-butanol	(C_4H_9OH)	-19%	0.5T

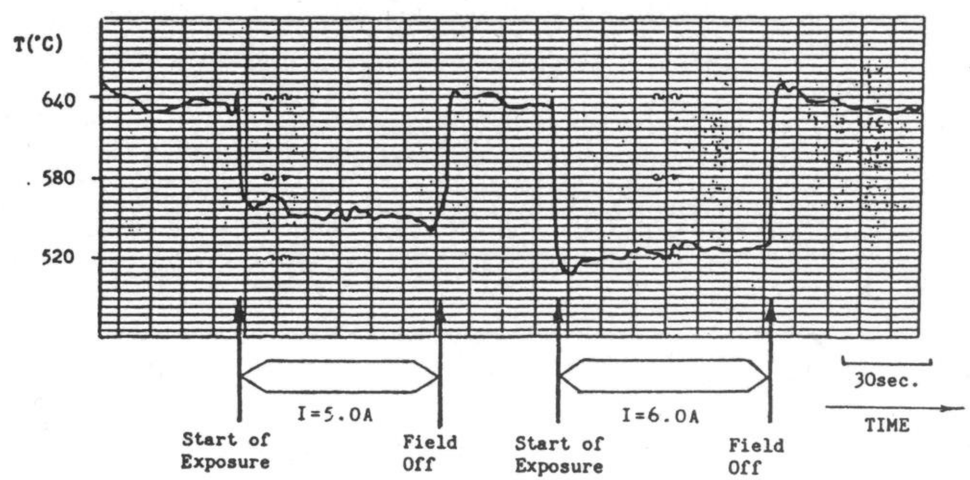
Successive experiments have been done over nights for two weeks.

Hiroshi Esaki worked heard for this experiment.

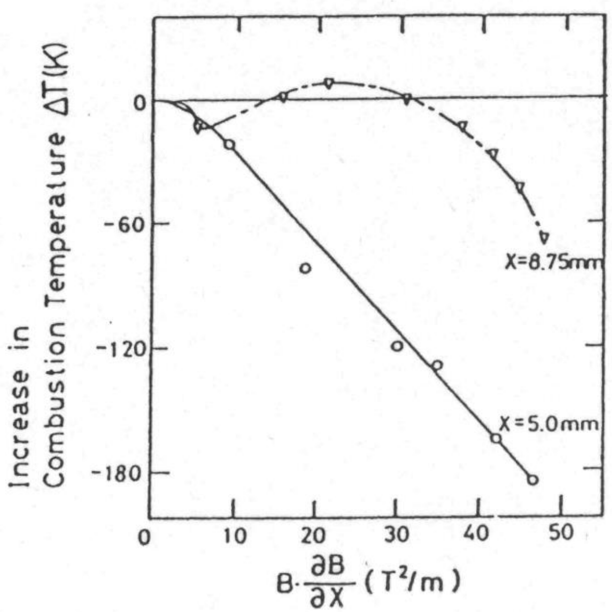
S. Ueno, H. Esaki, and K. Harada; IEEE Trans. Magn. (1985)

Unexpected Results

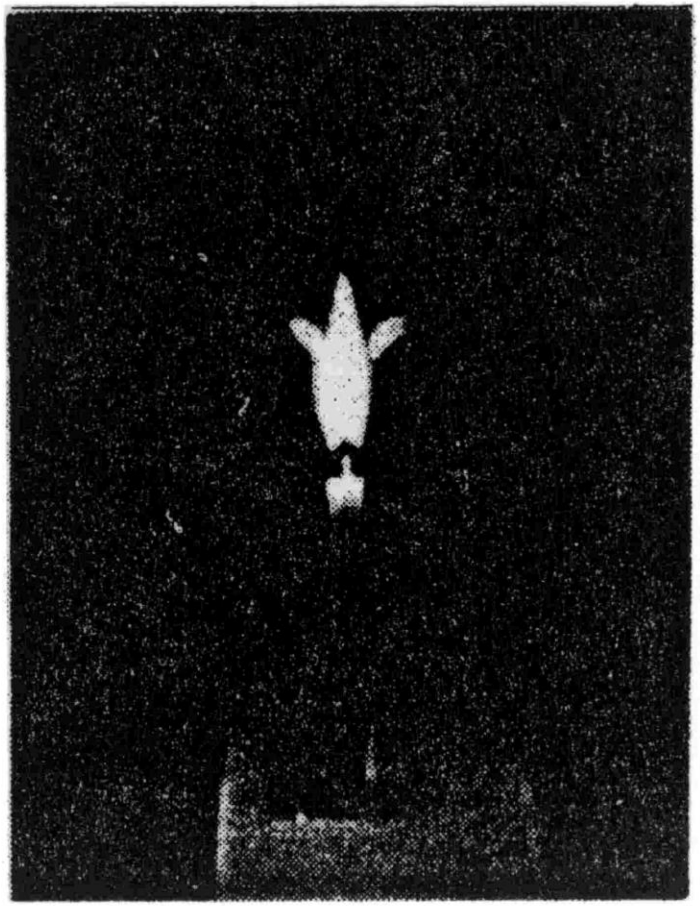
We expected that combustion temperature might increase in rich oxygen atmosphere.
Adversely, combustion temperature decreased during magnetic field exposures.



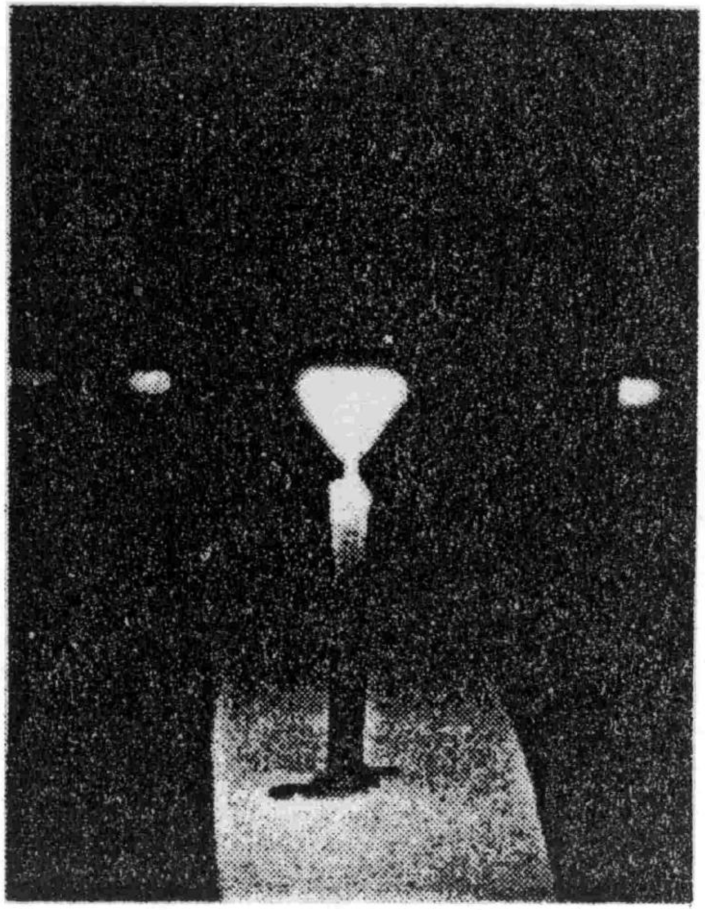
Changes in combustion temperature by magnetic field exposures



Combustion temperature
vs magnetic force.



Before magnetic field exposure



During magnetic field exposure

（5） 昭和63年(1988年)1月26日 火曜日 西日本新聞（夕刊） （第3種郵便物認可）

炎のダンス磁気とデュエット

炎が踊り、炎が変わる。右に傾き、左に寝る。姿、形も逆三角形をしているかと思えば、ハート形からキノコ形にと変転極まりない。――九州大学工学部電子工学科の研究室で、ロウソクの炎が繰り広げる光と形の芸術だ。

炎を自在に操ってみせるのは上野照剛教授で、その秘密は磁場だという。クサビの形をした磁極同士が向き合うすき間に、炎を下から近づける。磁場がかかった途端、炎は穂先が押しつぶされたように逆三角形に変わり、さらに押し上げてすき間にさし込むとキノコ形に変形する。磁極の一方をねじると、炎は横に倒れるといった具合なのだ。

フィーバーが続く超電導。開発レースが激しい核融合発電。生体診断の"新兵器"磁気共鳴装置。――さまざまな分野で技術革新のカギを握る磁気だが、上野教授はまだまだナゾ多い。生体への影響に注目した。

生体内で、食べた栄養を酸素でエネルギーに変換する反応も、炎の上がる燃焼も、いずれも同じ酸化現象。そこでロウソクの実験を通して、どの程度の磁気を、どのように当てれば生体内反応にどのような影響が出るか、など基礎データを得よう、という狙いだ。

そこで演じられる炎の華麗なパフォーマンス。――それは磁気に感じやすい酸素がエアカーテンを作り、炎を変形させる現象だ、と上野教授がタネ明かししてくれた。

（文・古賀透記者、写真・安本照夫記者）

とんがり帽子　炎の上方、左右にあるのはクサビ型の磁極。これを微妙に動かすと炎の形は七変化

ワイングラス　"磁気ナイフ"で炎の穂先が切られると、スマートな形に…

光と形の芸術の演出家たち。中央の磁極の間に炎をさし込んで、磁気のナゾを探る上野教授（右）ら

新型ＵＦＯ　あのＳＦ映画監督のスピルバーグも気づかなかった宇宙船の出現!?　これも磁場のいたずらなのだ

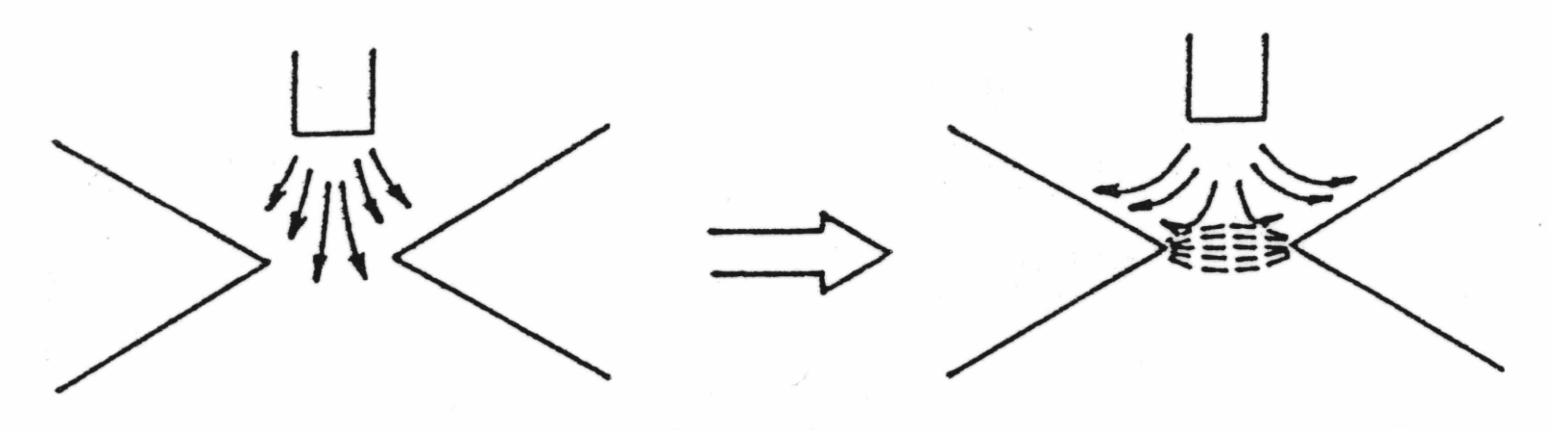
ぶんぶんゴマ　回転音が聞こえてきそうな形だが、あくまでも静かで優雅なパフォーマンスだ

神秘的なマジック
最先端の研究です

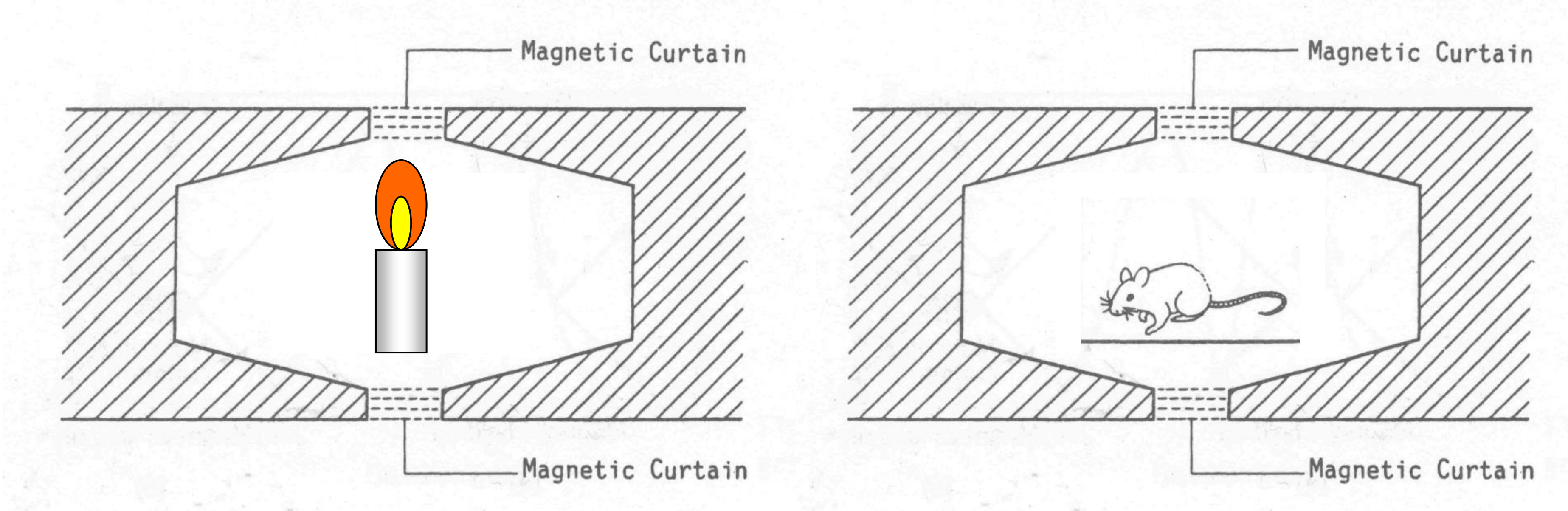
しっぽ　"磁気の風"に吹かれて右、左。ねじれた磁場が炎を押し倒す

Wonder of magnetism: Flame dance and duet with magnetic fields

from Nishinippon Shinbun (Newspaper in Kyushu) issued on January 26, 1988



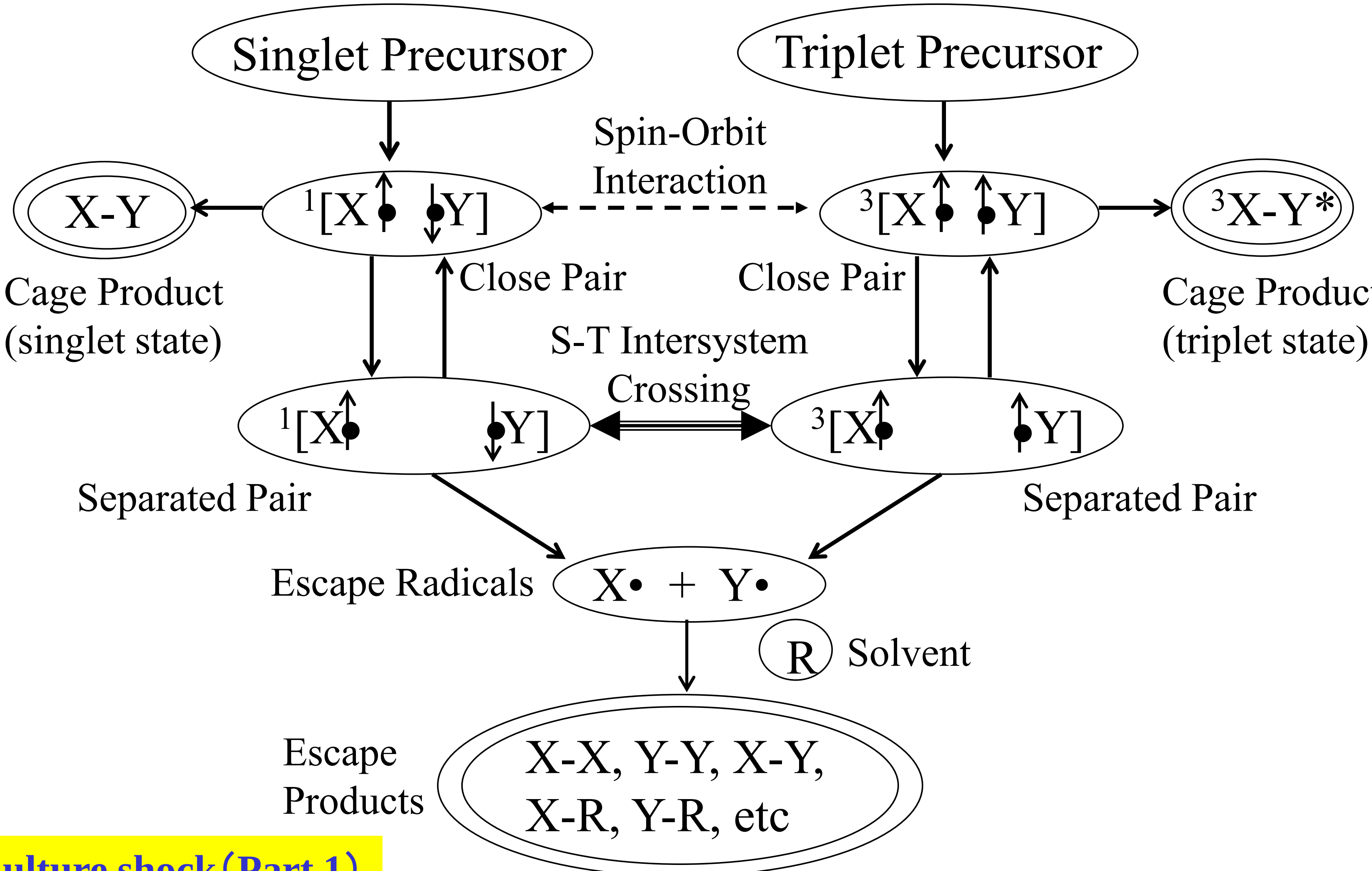
Bocking of gas flow by magnetic curtain



Candle flame is quenched by magnetic curtain!

S. Ueno, et al. (1986, 1987)
S. Ueno: J. Appl. Phys. (1989)

Professor Saburo Nagakura, Founder of spin chemistry



Culture shock（Part 1）

Magnetic field effects of chemical reaction via radical pairs

Reaction scheme of radical pairs generated from singlet and triplet precursors.
(Modified from Hisaharu Hayashi (2004))

$$\text{xanthine} + O_2 + H_2O \xrightarrow{\text{xanthine oxidase}} \text{uric acid} + 2H^+ + O_2^{\cdot -}$$

$$O_2^{\cdot -} + \text{cytochrome c } (Fe^{3+}) \longrightarrow O_2 + \text{cytochrome c } (Fe^{2+})$$

$$2O_2^{\cdot -} + 2H^+ \xrightarrow{\text{superoxide dismutase}} O_2 + H_2O_2$$

$$H_2O_2 \xrightarrow{\text{catalase}} H_2O + 1/2\ O_2$$

Possible effects of magnetic fields on biochemical reactions catalyzed by xanthine oxidase and by catalase are examined.

Dr. Michio Nakamura worked for us, teaching us biochemical experiments.

(1985-1986)

Culture shock (Part 2)

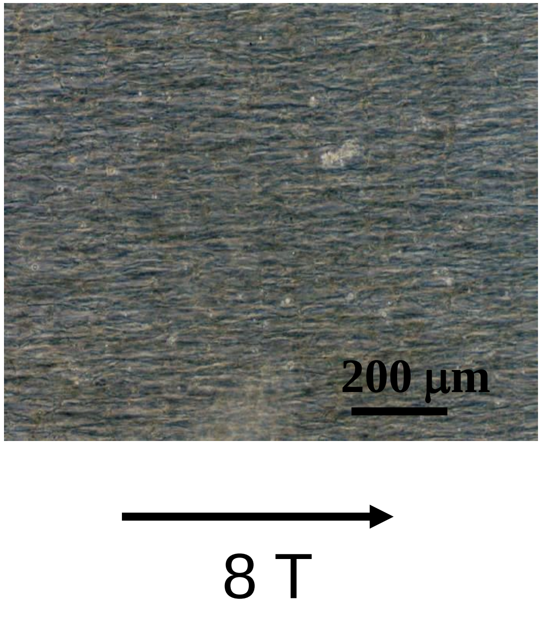
Important roll of Diamagnetism

- J. Torbet et al. Nature (1981)

Magnetic orientation of fibrin

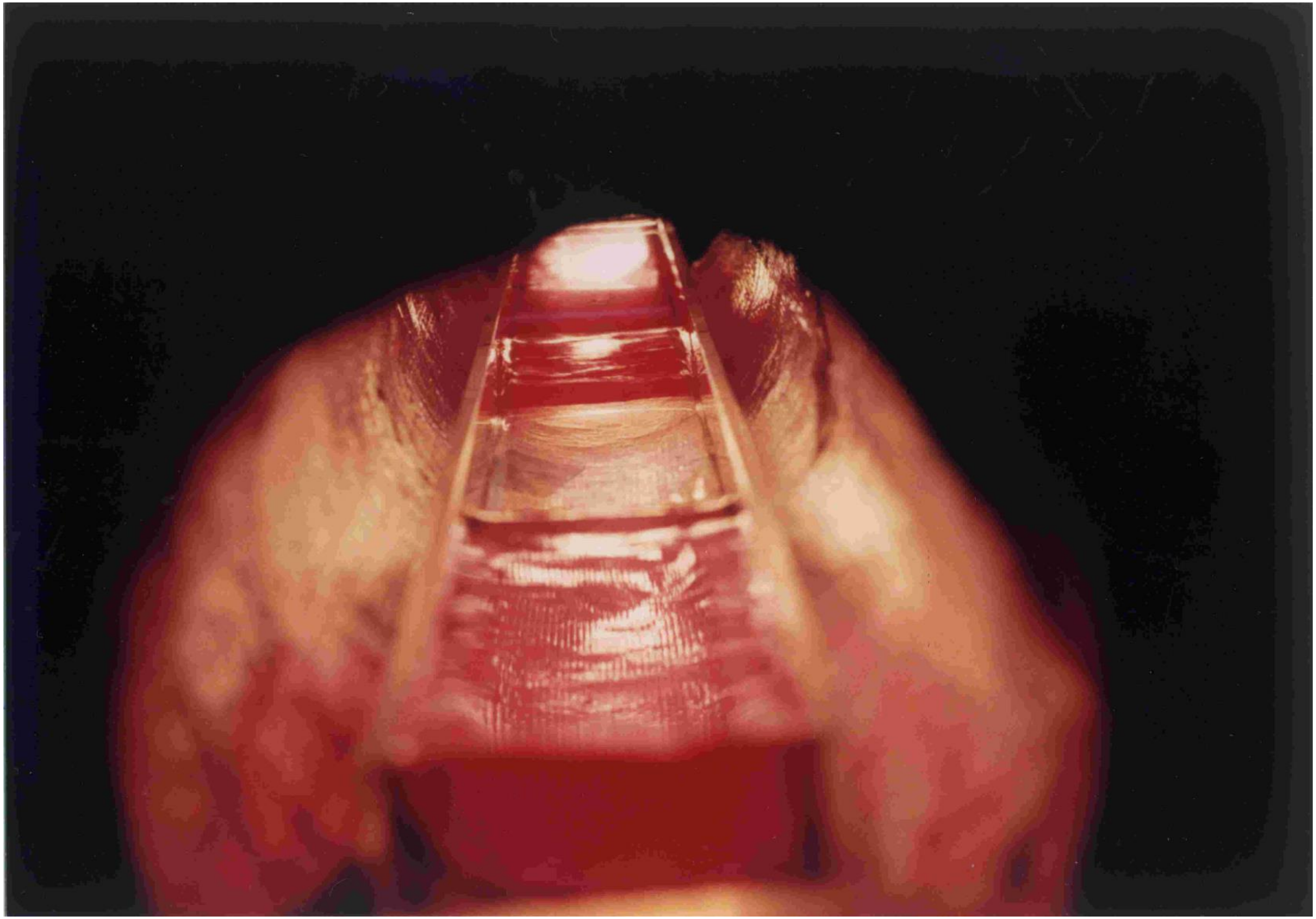
When polymerization process from fibrinogen to fibrin is exposed to strong magnetic fields, fibrin fibers orient in parallel to magnetic fields.

We learned blood coagulation and resolution processes by Prof Hiroko Tsuda.



Parting of water by magnetic fields

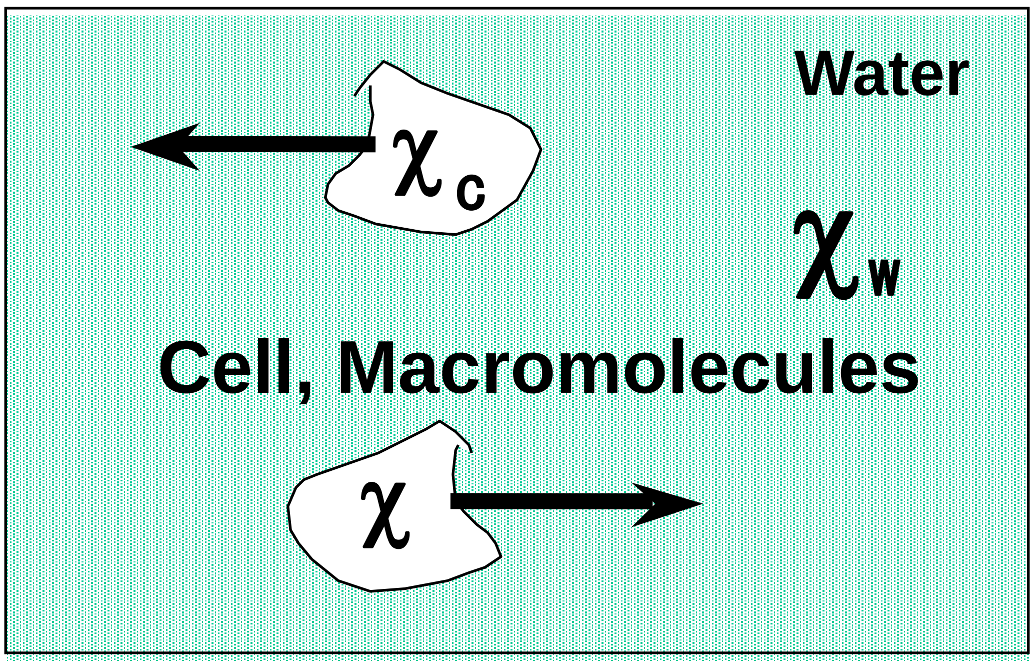
S. Ueno and M. Iwasaka (1993, 1994)



Dried bottom appeared in water chamber.
Magnetic force = 0.3 N（1/3 of the earth gravity）

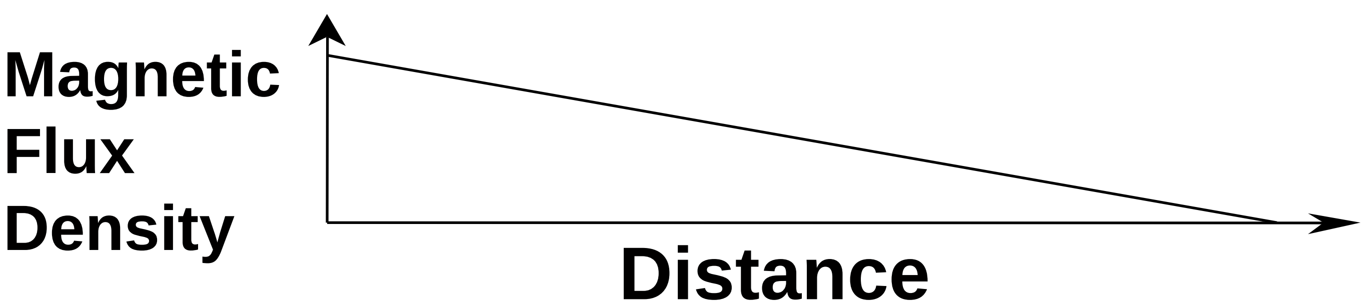
Moses parted the Red Sea.

Magnetic Cell Manipulation



$$\chi_c > \chi_w$$

$$\chi_d < \chi_w$$

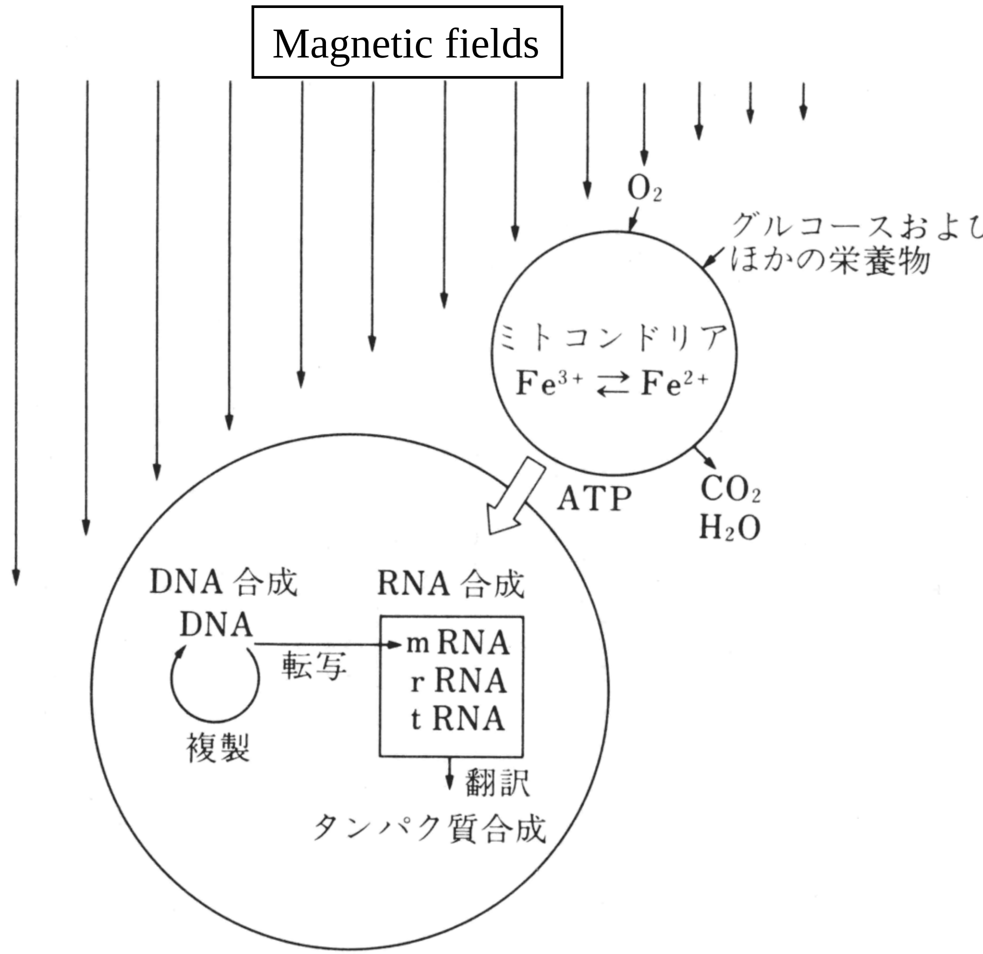


Developmental Biology and Magnetic Fields

Early development of *Xenopus laevis*

Professor Koichiro Shiokawa

1.2	T	No effects
4.0	T	No effects
6.34	T	No effects
8.0	T	No effects
14.0	T	No effects



The University of Tokyo: Fusion of different fields

Prof Shoogo Ueno started his work at the University of Tokyo on 1st April 1994.

Your Own Research: 60 %
For the Nation: 40 % ?

Prof Masao Saito "This chair is not for an ordinary professor's position, but for humble professor's position to serve people and nation. You should look at not only US and Europe but also other countries, in particular, Asian countries."

Professor Masao Saito

Biological and biomedical engineering, Circuit theory, Biomaterials, etc.
President, International Federation for Medical and Biological Engineering
President, Japanese Society for Medical and Biological Engineering

Encounter and Fusion of Different Fields

Research activities in Graduate School of Medicine, the University of Tokyo, are leading the world.

Re-modelling of blood endothelial cells by shear stresses
Artificial heart in living goat; world record in survival days
Leg lengthening; extension of leg 1 mm a day.
Colon cancer and surgical oncology
Radiology, diagnosis and treatments, MRI, PET
Auditory evoked brainstem response, cochlear implant
Tolerance against cerebral ischemia, apoptosis
Treatments of incontinence, prostate cancer, etc.
Motor proteins and molecular cell biology
Cell informatics
Cell cycles
Memory and cognition
Plasticity in synapses
Immunology

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Supported by many people at the Faculty of Medicine

Institute of Medical Electronics

Prof Akira Kamiya, Director of the Institute
Prof Ko Imachi
Prof Joji Ando

Coworkers and Graduate Students

Prof Takahide Kurokawa, Dean of the Faculty
Prof Kozo Nakamura

Prof Tetsuichiro Muto, Director of the Hospital
Prof Hirokazu Nagawa

Prof Kimitaka Kaga
Prof Fumio Eto
Prof Kazuki Kawabe
Prof Tadaichi Kitamura
Prof Kanjiro Masuda
Prof Makoto Araie
Prof Nobumasa Kato
Dr. Shigeru Ichioka

MEG

Prof Akiyuki Ohkubo
Prof Kazuhiko Nakahara
Dr. Masato Yumoto

Administration

Thanks to Stuffs in Administration office.

Graduate students

Dr. Makoto Kobayashi

Dr. Giichiro Tsurita
Dr. Hironori Yamaguchi Dr. Keisuke Hata

Dr. Takako Saotome Dr. Yutaka Maeno
Dr. Hellen Ahamedo
Dr. Tetsuyuki Fujishiro
Dr. Keiichi Goto

Dr. Kiyoto Kasai

Lecture for Graduate Students at Department of Electronic Engineering, Graduate School of Engineering

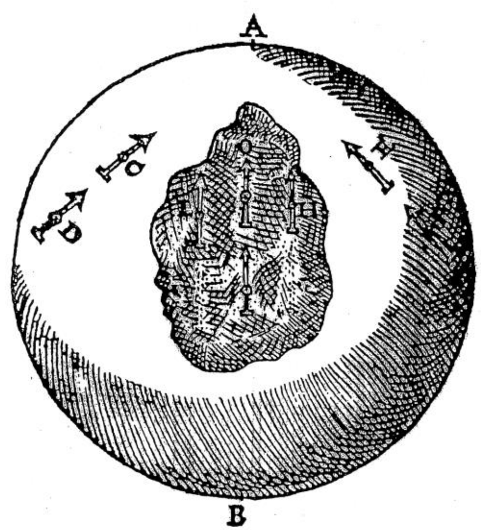
Prof Hiroshi Harashima " Good morning. I introduce to you Prof Ueno who will give a lecture on Biological Engineering for you."

Building No. 3, Faculty of Engineering

I started lecture on 11th April 1994.

I luckily received the graduate students from Department of Electronic Engineering to work with them in the next years.

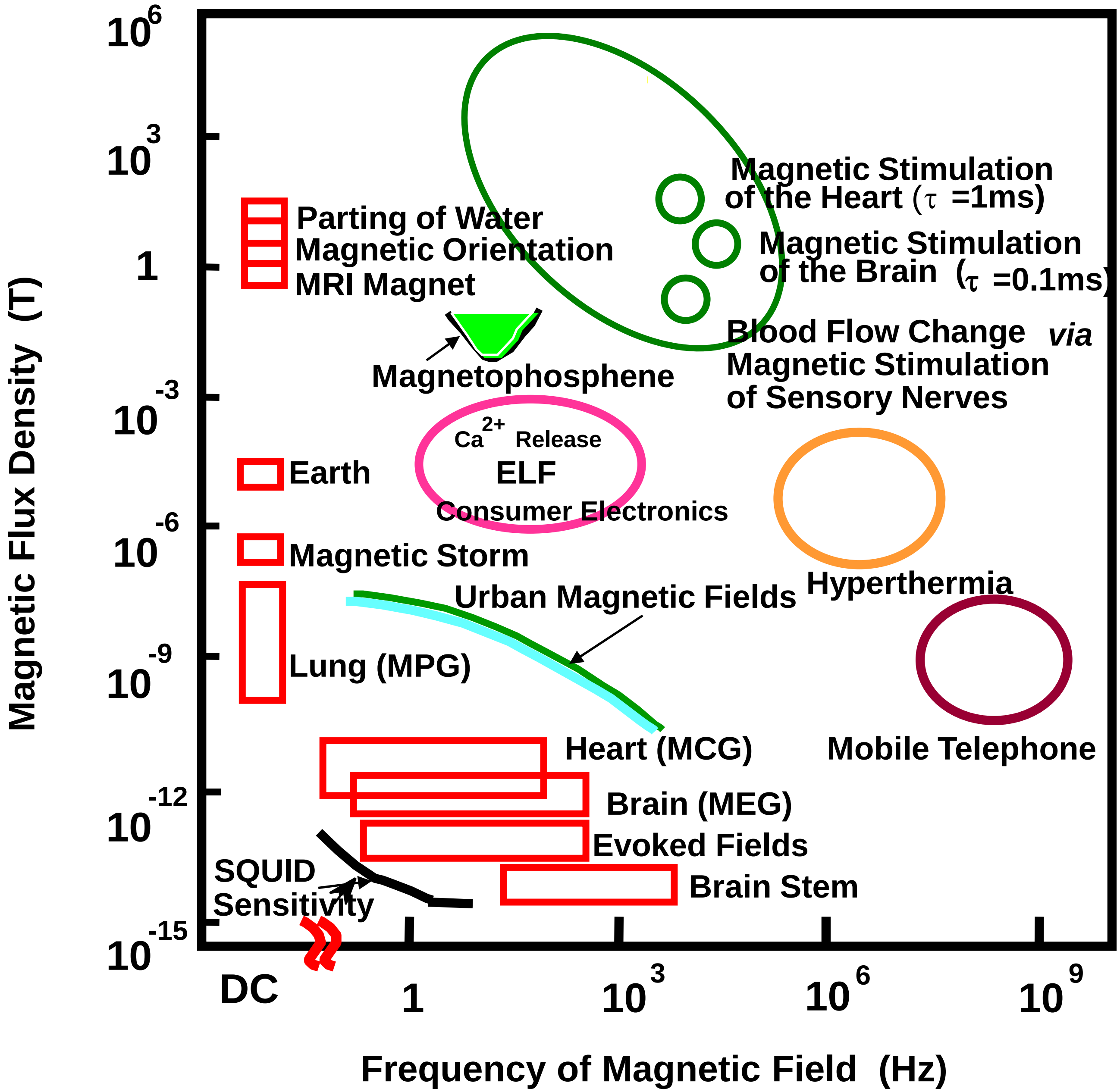
William Gilbert, Father of Magnetism
"The Earth is itself a huge magnet."



De Magnete, William Gilbert (1600)

"Magnetic force is animate or imitates life; and in many things surpasses human life, while this is bound up in the organic body."

William Gilbert, 1600



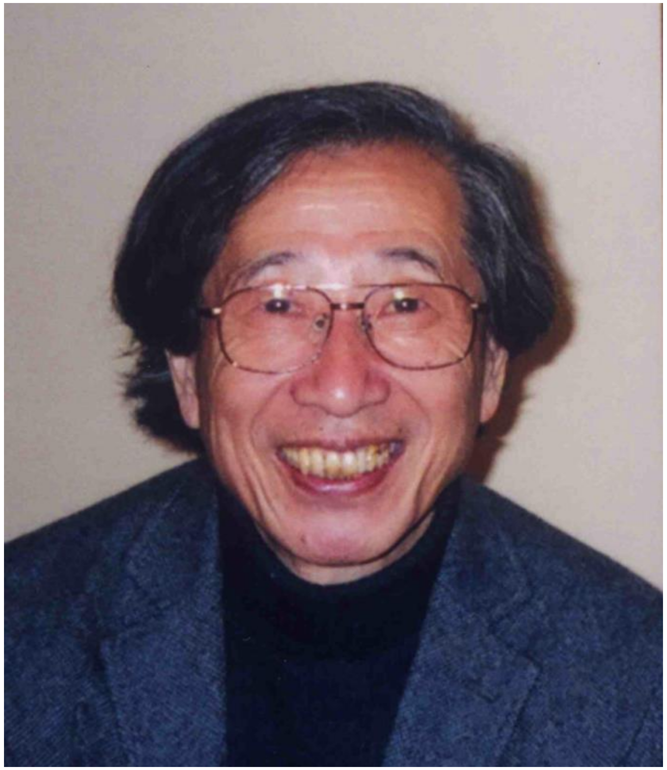
Magnetic Flux Density (T)
10^6
10^3
1
10^{-3}
10^{-6}
10^{-9}
10^{-12}
10^{-15}
Parting of Water
Magnetic Orientation
MRI Magnet
Magnetic Stimulation of the Heart (τ =1ms)
Magnetic Stimulation of the Brain (τ =0.1ms)
Blood Flow Change *via* Magnetic Stimulation of Sensory Nerves
Magnetophosphene
Ca^{2+} Release
ELF
Consumer Electronics
Earth
Hyperthermia
Magnetic Storm
Urban Magnetic Fields
Lung (MPG)
Mobile Telephone
Heart (MCG)
Brain (MEG)
Evoked Fields
Brain Stem
SQUID Sensitivity
DC
1
10^3
10^6
10^9
Frequency of Magnetic Field (Hz)

Specially Promoted Research granted by the Government

Study on Functional Brain Dynamics by Magnetic Brain Stimulation and Imaging
Grant-in-Aid for Specially Promoted Research, Ministry of Education, Science, Sports, Culture and Technology, Japan (No. 12002002)

1993	Failed	
1994	Failed	
1995	Failed	
1996	Passed at 1 step	Failed at interview
1997	Passed at 1 step	Failed at interview
1998	Failed	
1999	Passed at 1 step	Failed at interview
2000	Passed at 1 step	Succeeded at interview, Promoted
2001	Promoted	
2002	Promoted	
2003	Promoted	
2004	Promoted	
2005	Promoted	(until March 31, 2005)

Succeeded in getting a big grant after 7 trials !

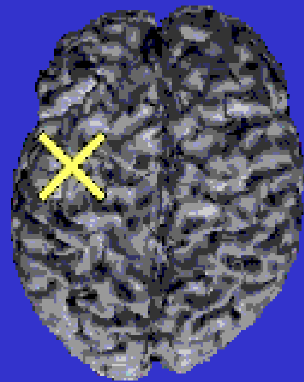


Professor Shun-ichi Amari

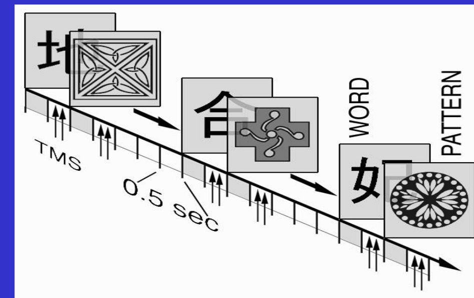
Pioneer of information geometry and mathematical neuroscience
Director, RIKEN Center for Brain Science
Professor Emeritus, the University of Tokyo

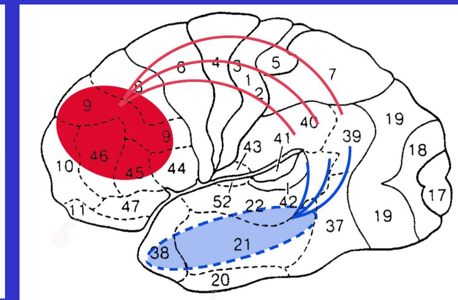
TMS and Brain Dynamics

TMS

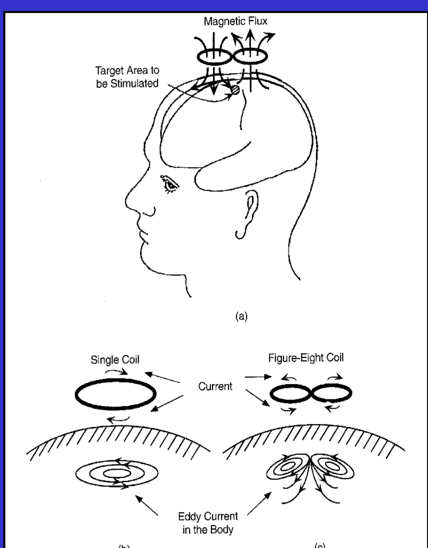


Brain Dynamics

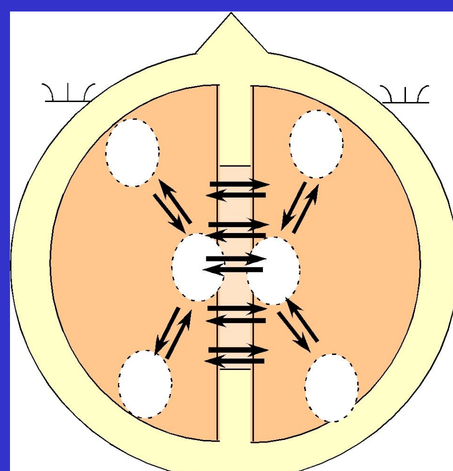




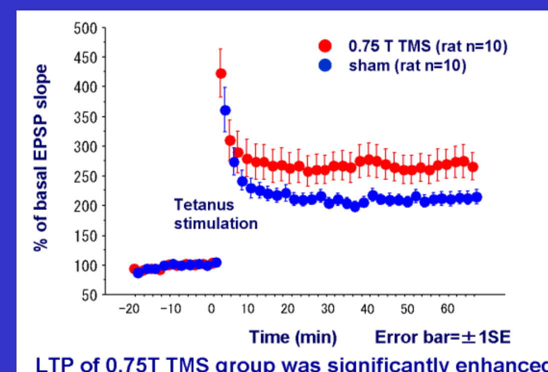
Working Memory Task



Principle of TMS



Neuronal Connectivity



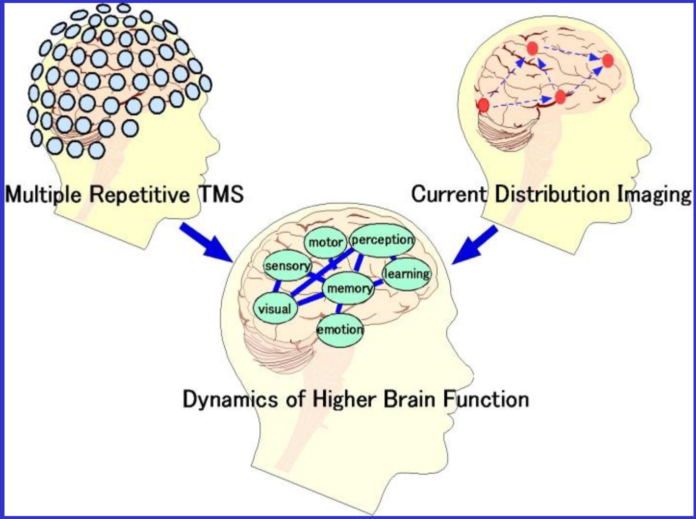
Long-Term Potentiation

Therapeutic Application of TMS

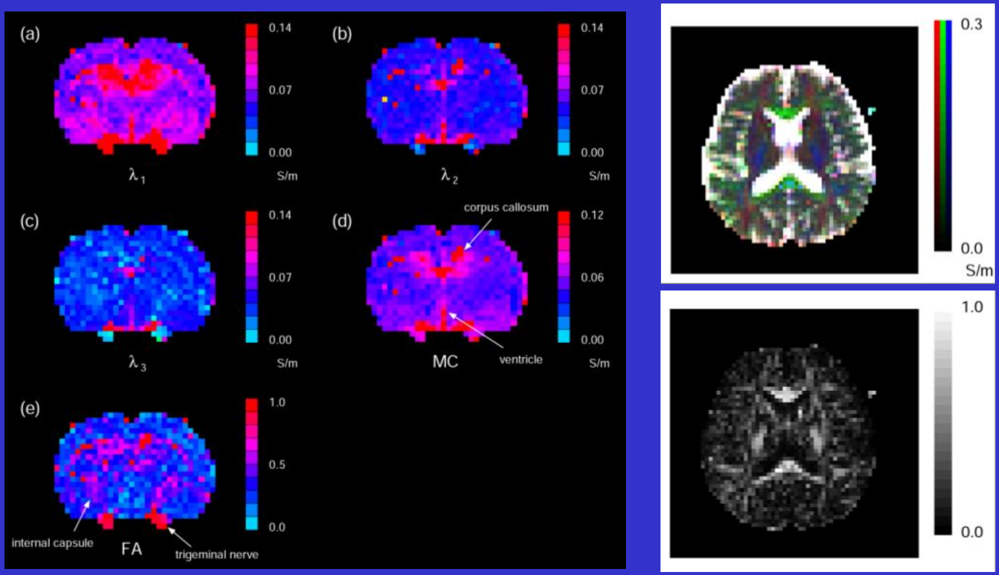
Control of Neuronal Plasticity

Treatment of Depression

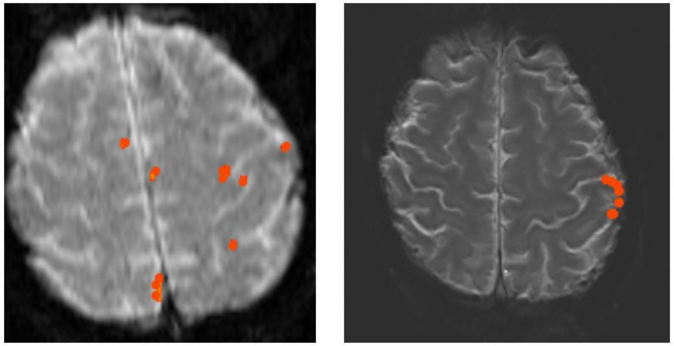
Biomagnetic Imaging and Brain Dynamics



Study of Brain Dynamics by TMS, MRI, and EEG



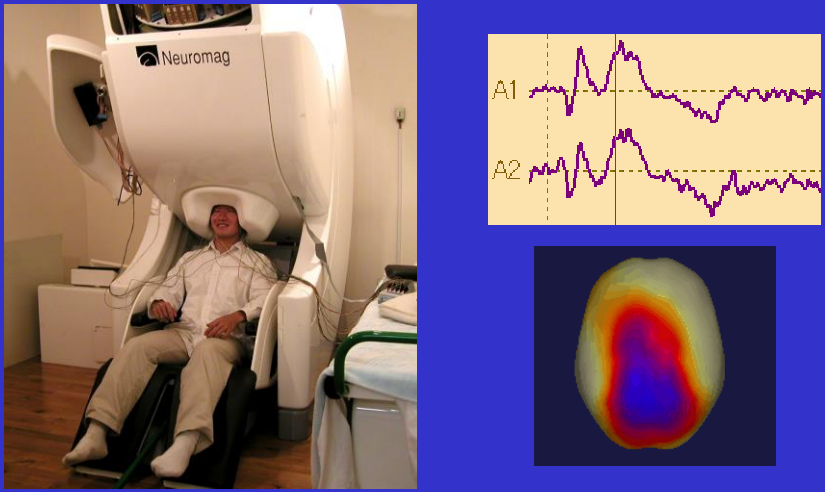
Conductivity Tensor MR Imaging



(a) fMRI (b) current MRI

(a)fMRI and (b) current MRI mapping of the neuronal currents in the brain during middle finger and thumb tapping.

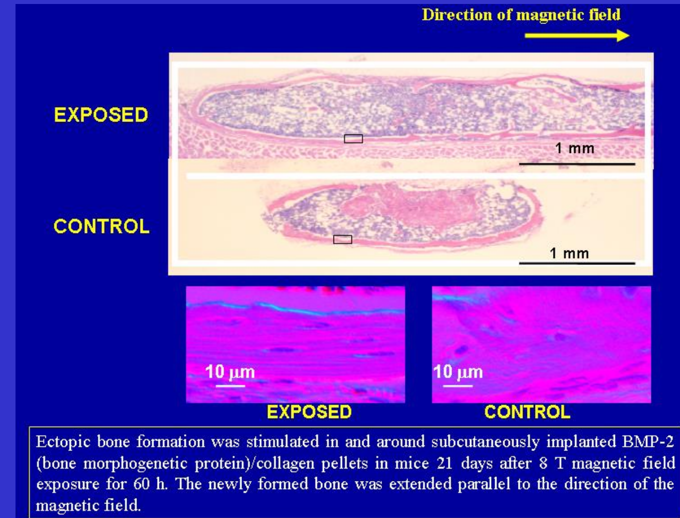
Current MR Imaging



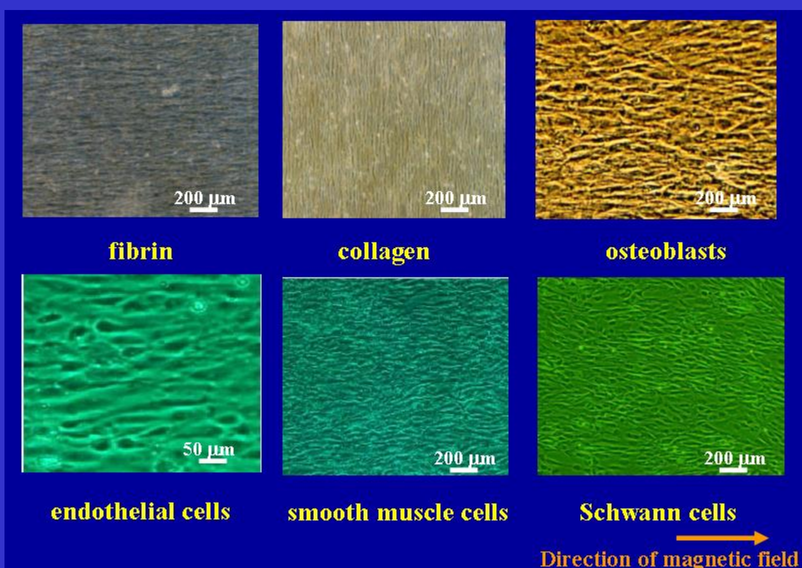
MEG and EEG

Parting of Water and Cell Orientation by Magnetic Fields

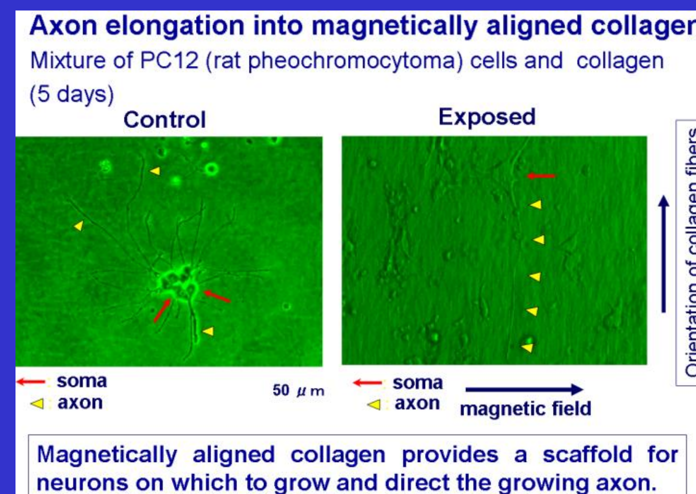
Parting of Water



Bone Growth by Magnetic Field

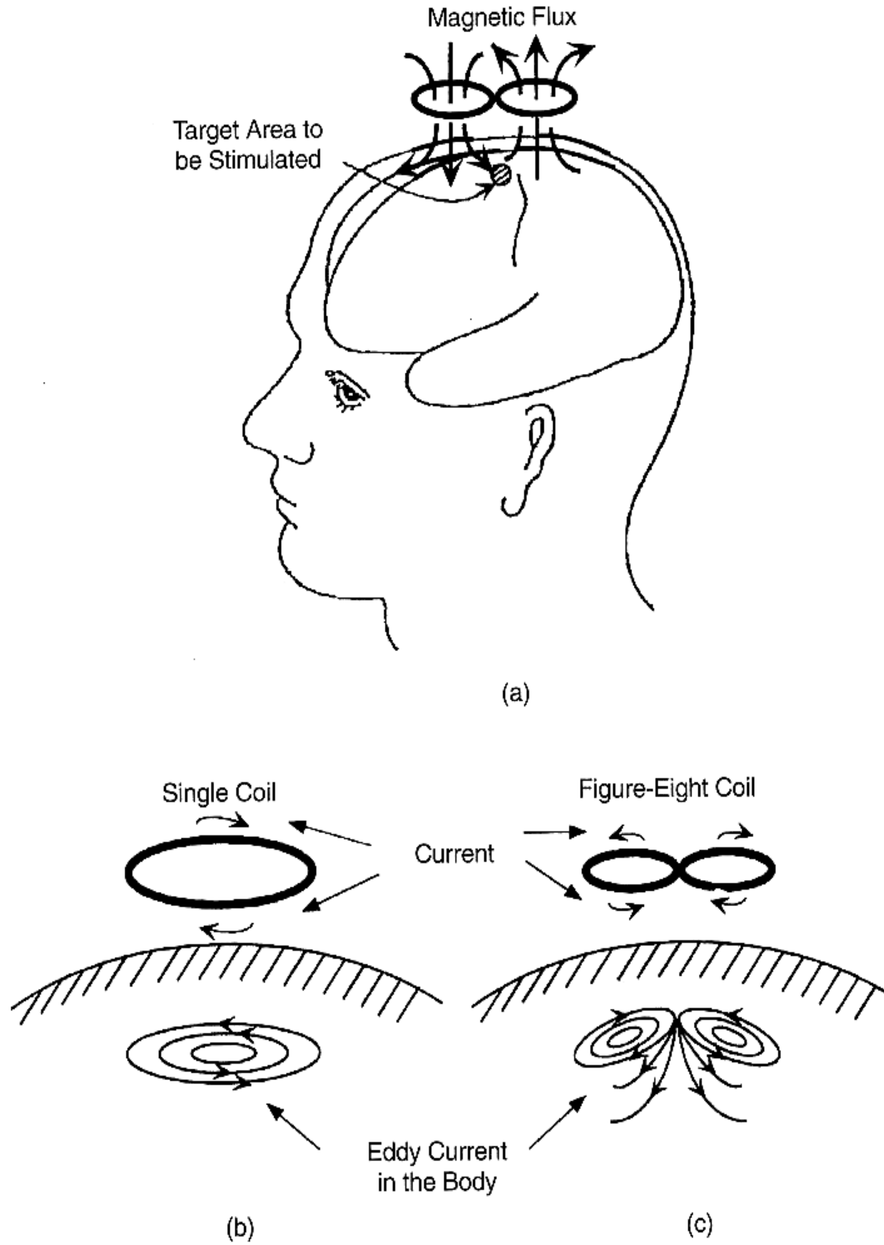


Magnetic Orientation of Adherent Cells

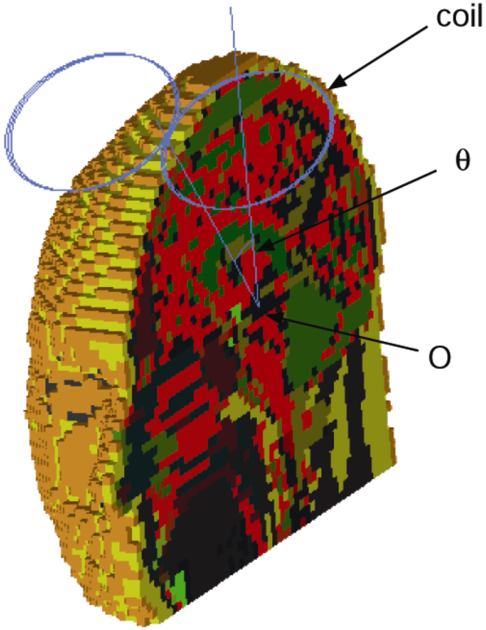


Axonal Growth by Magnetic Field

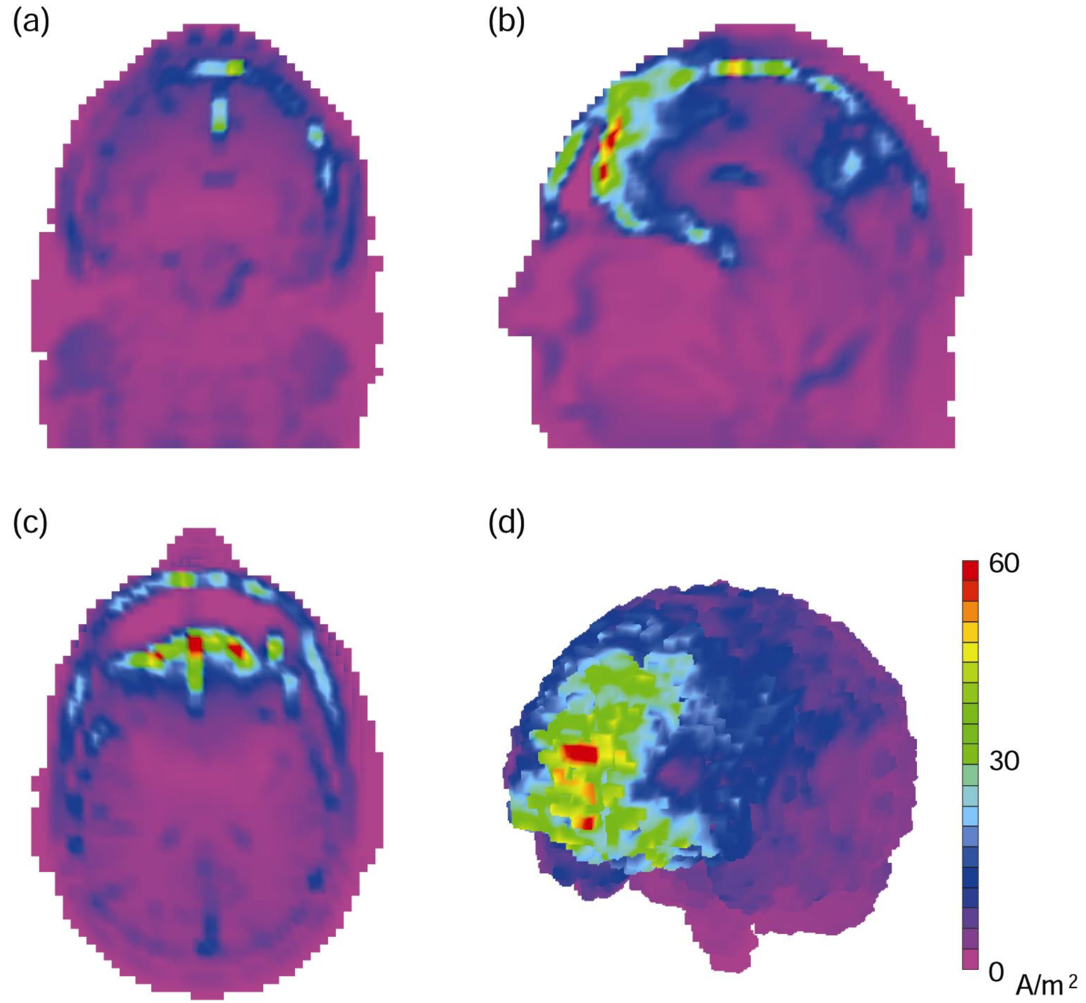
TMS（Transcranial Magnetic Stimulation)



Current Distributions in TMS



Numerical model of the human head

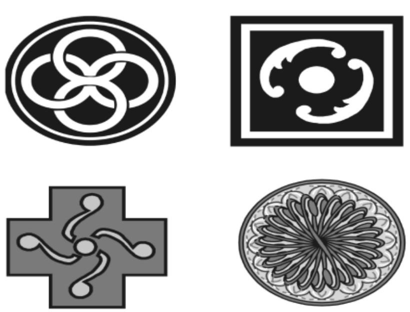


Current distributions in TMS represented in (a) coronal, (b) sagittal, and (c) transversal slices, and (d) the brain surface.

Medical Applications of Transcranial Magnetic Stimulation

1. Estimation of localized brain function
2. Creating virtual lesions to disturb dynamic neuronal connectivities
3. Damage prevention and regeneration of neurons
4. Modulation of neuronal plasticity
5. Therapeutic and diagnostic applications for the treatment of CNS diseases and mental illnesses

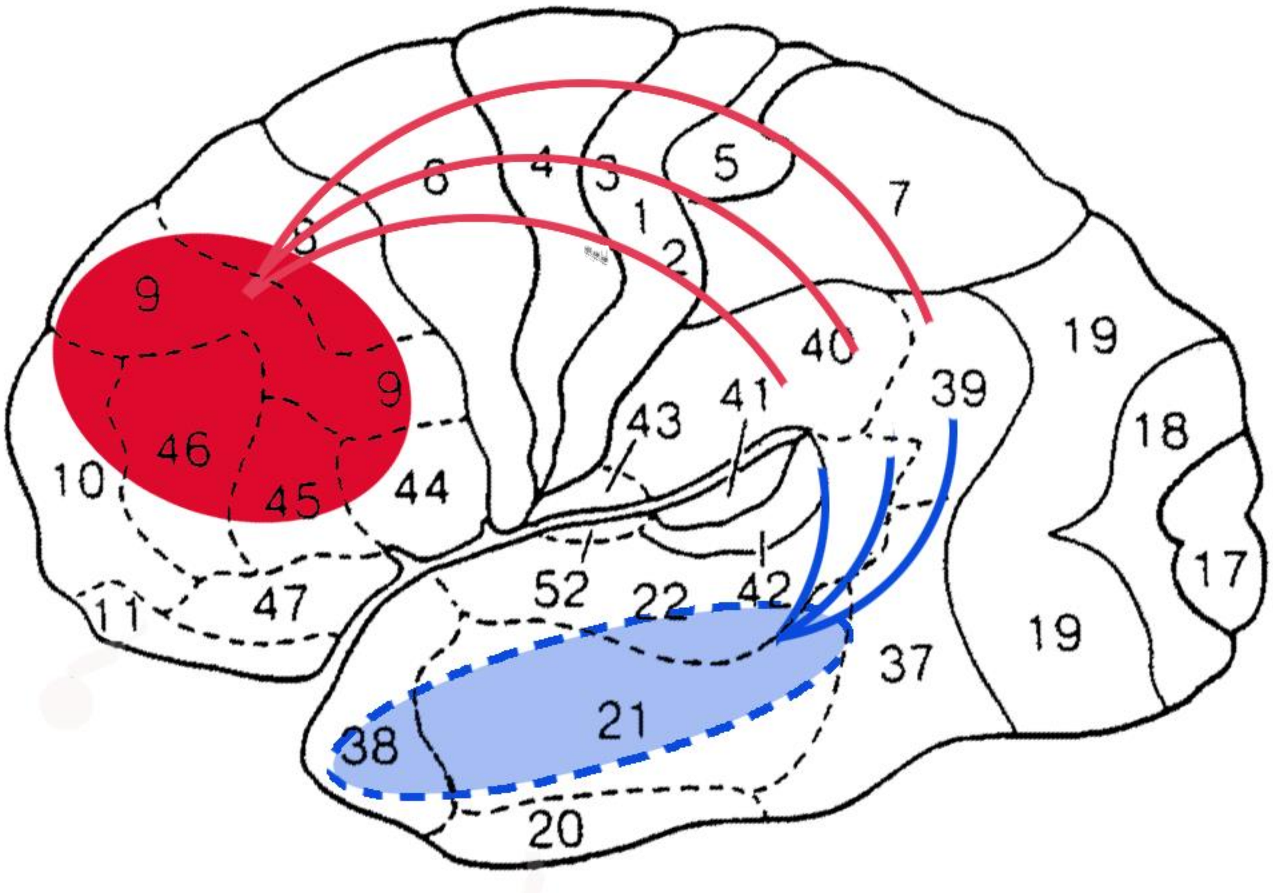
Effect of TMS on associative learning for visual patterns

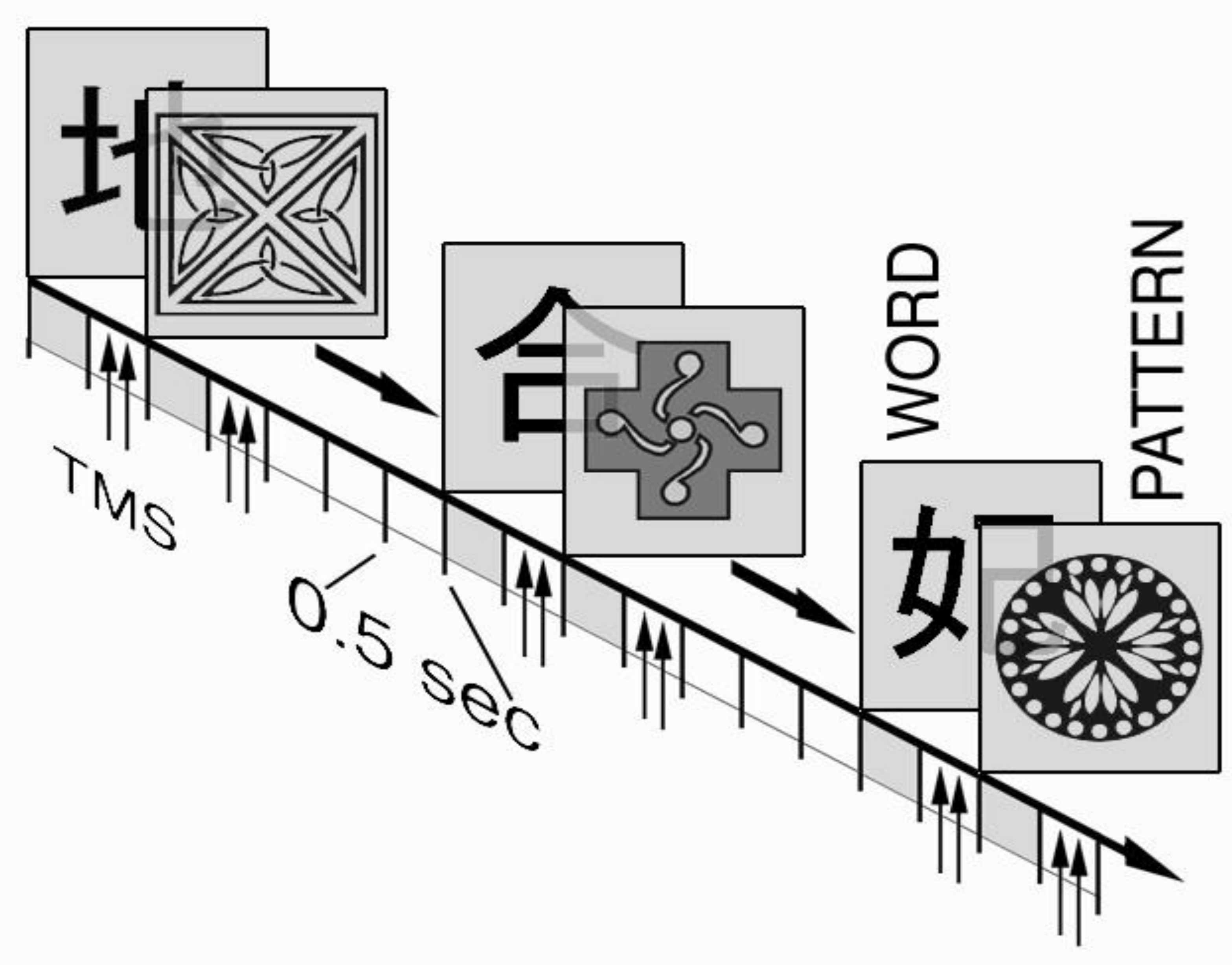


地　妃

客　辺

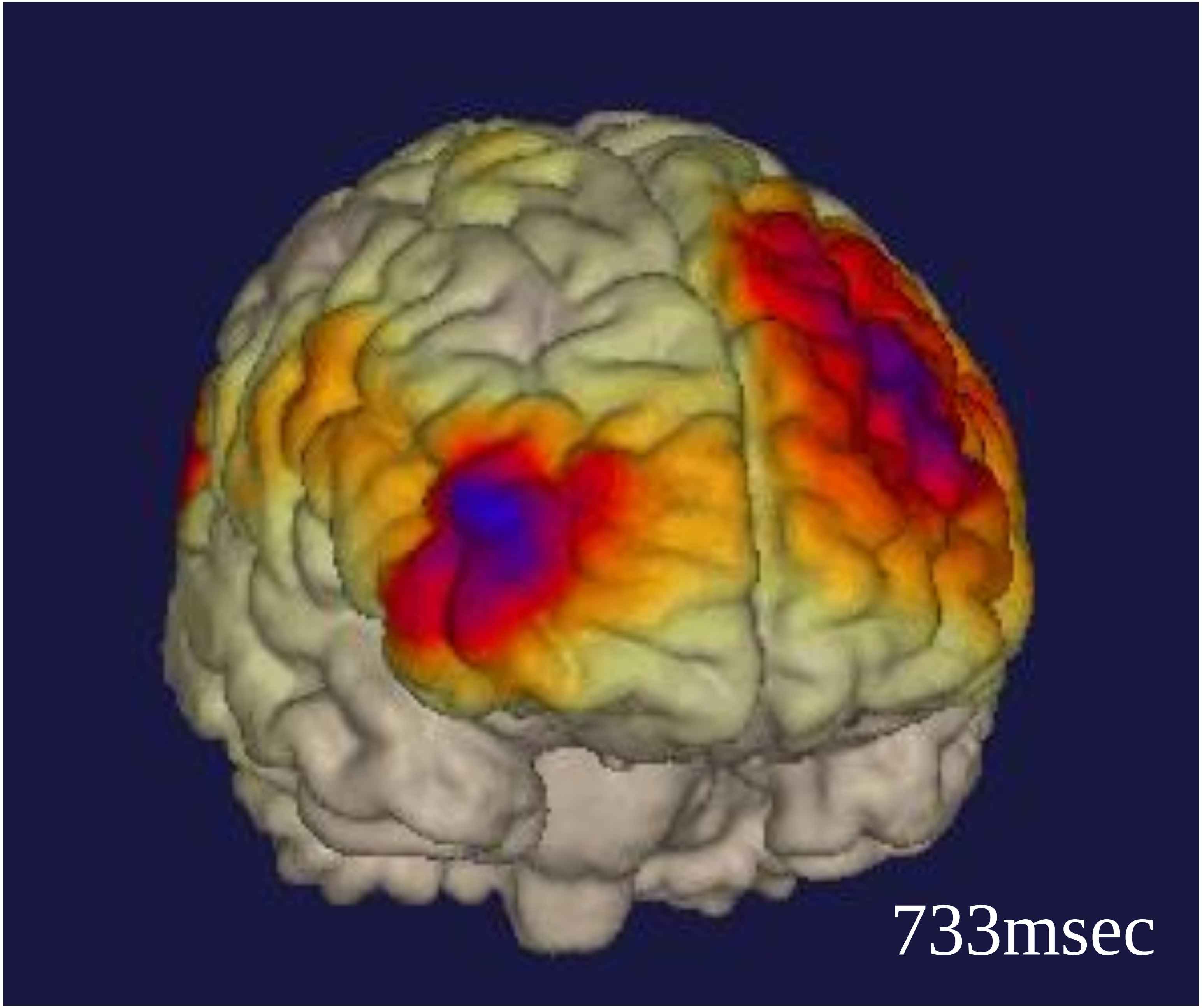
- Working memory is dependent on prefrontal granular cortex.
- Associative memory is dependent on the hippocampus and temporal lobe.

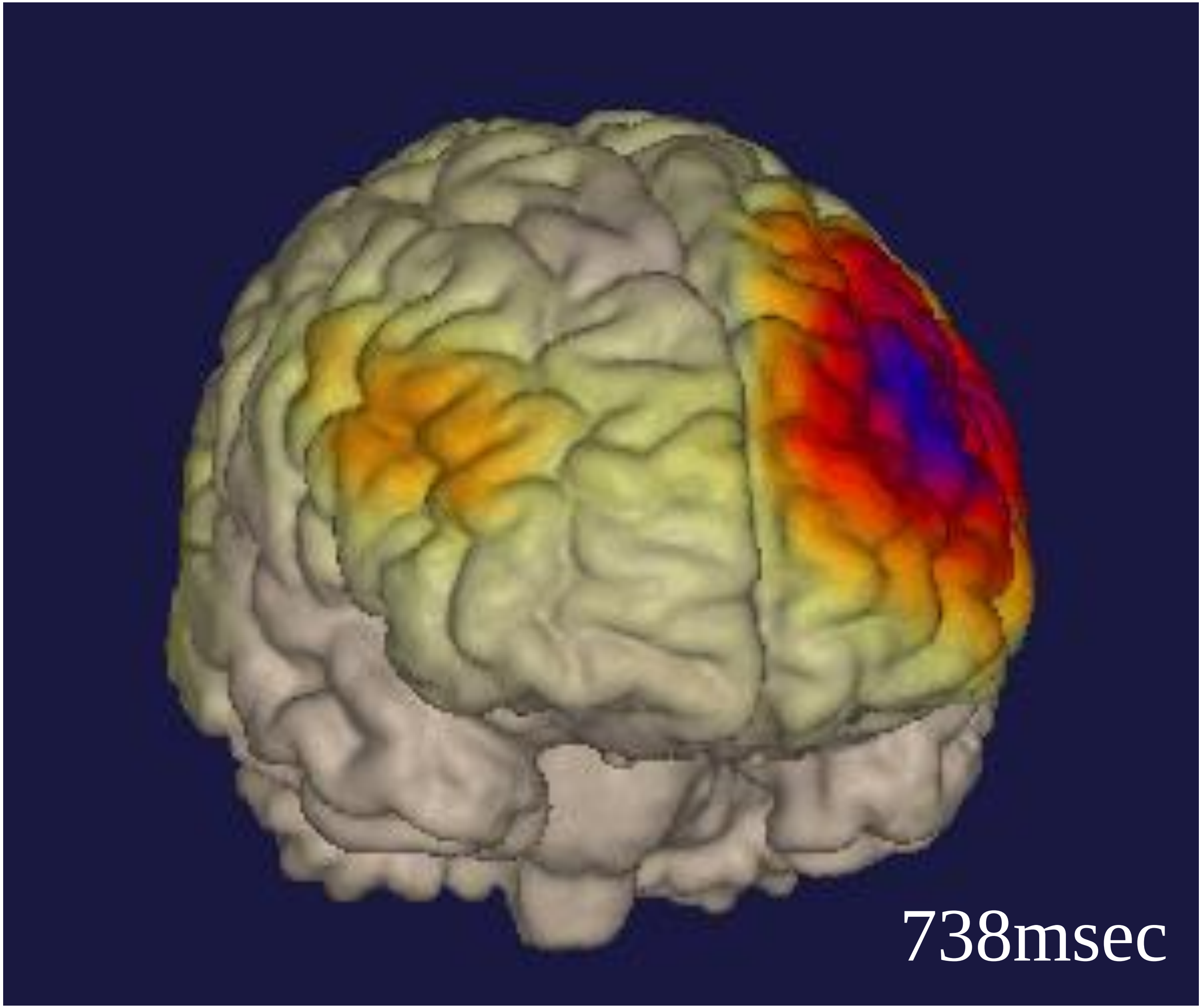


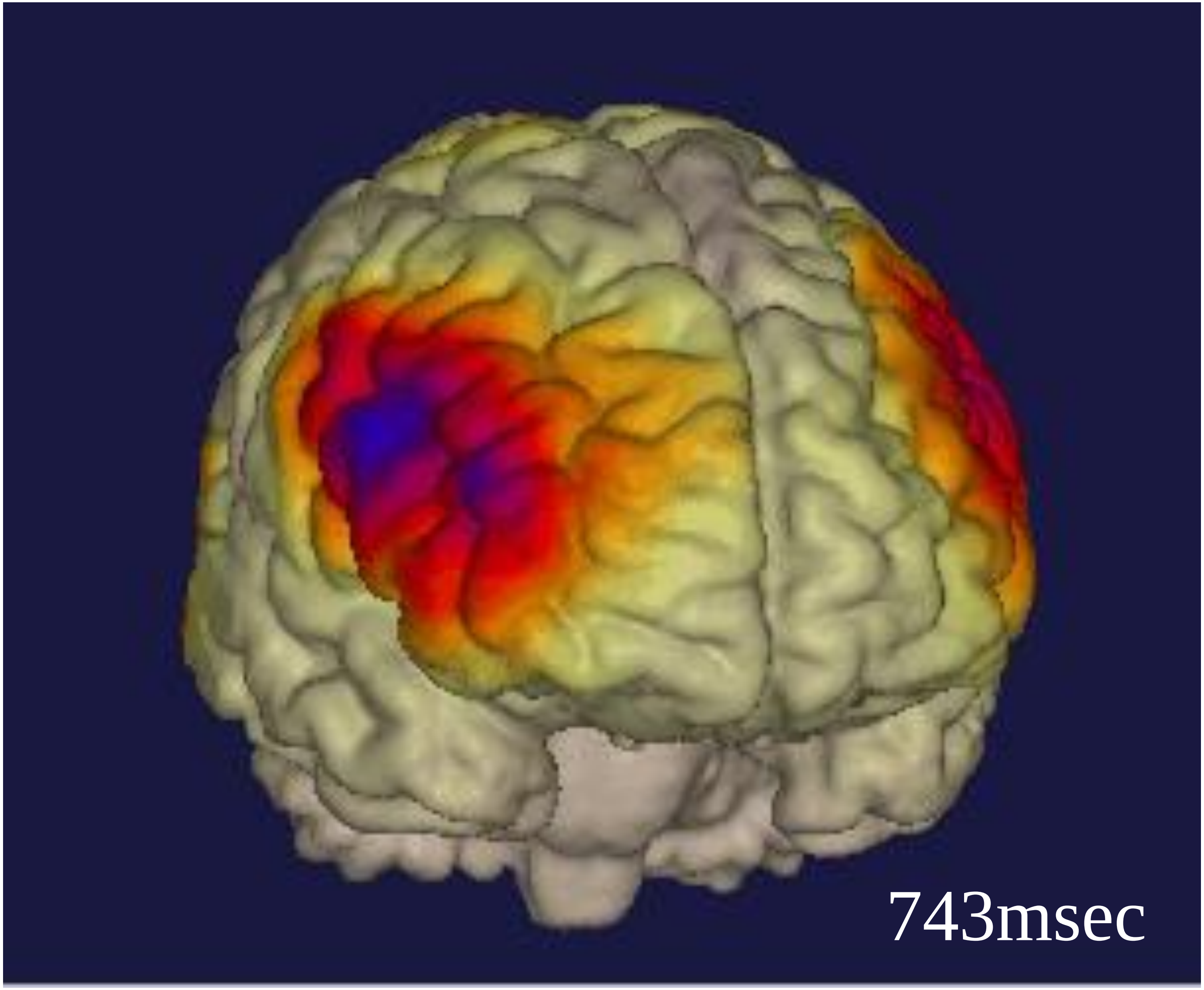


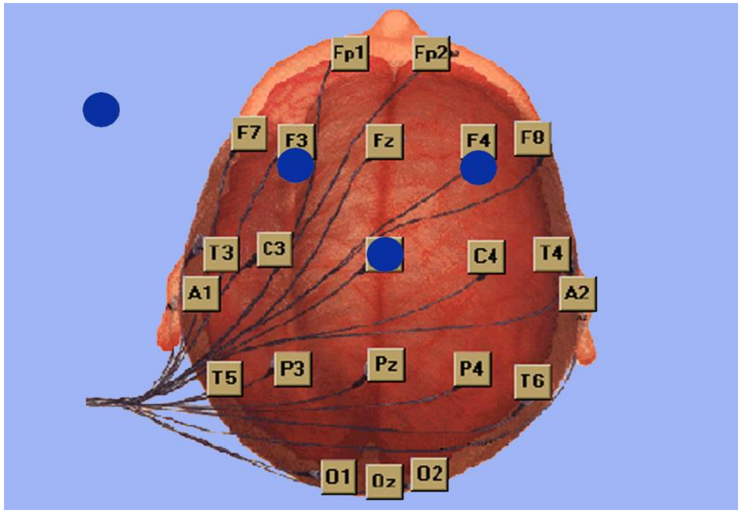
地
合
如
TMS
0.5 sec
WORD
PATTERN

725~745msec


733msec

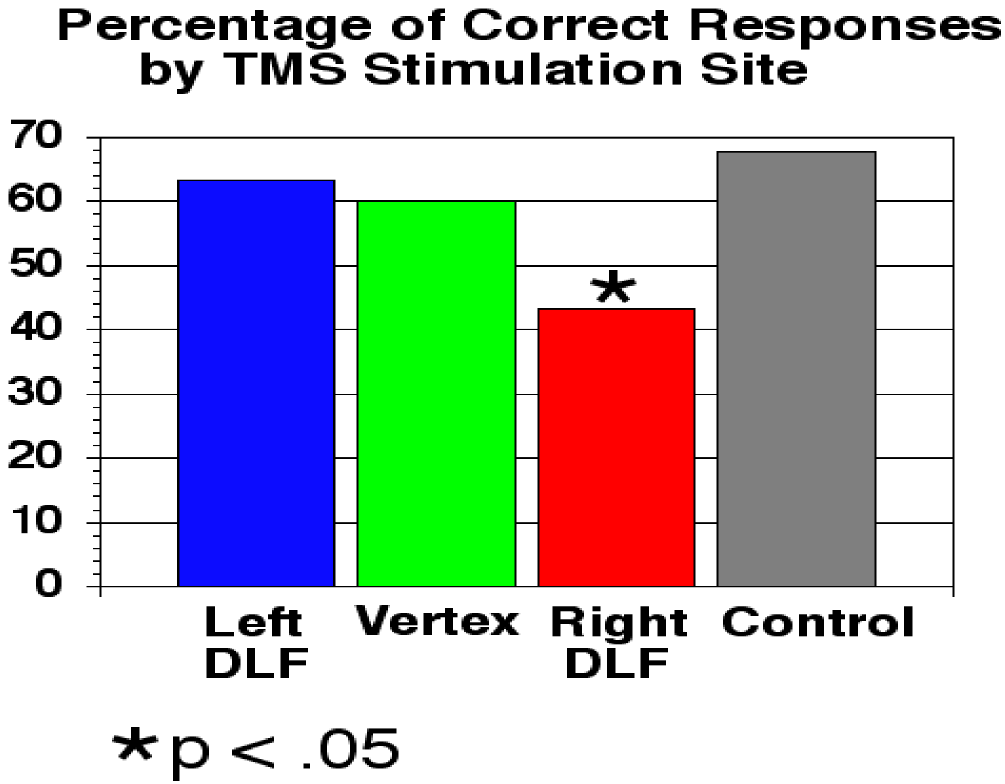

738msec


743msec



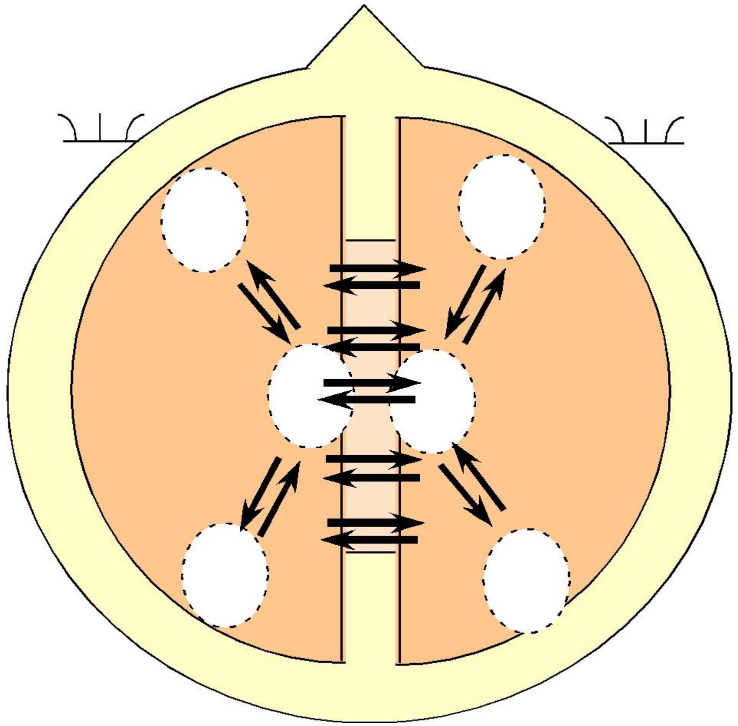
Brain function revealed by TMS

Right dorsolateral prefrontal (DLF) cortex has an important roll in retrieval of information related to short-term and associative memory task.



C. M. Epstein, et al., S. Ueno: Neuroscience Letters (2002)

Intra- and Interhemispheric Connectivity

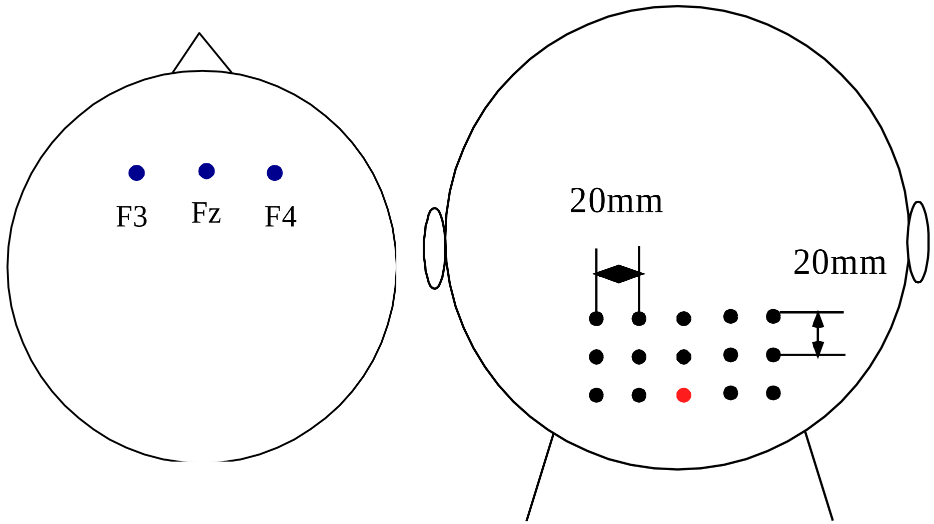


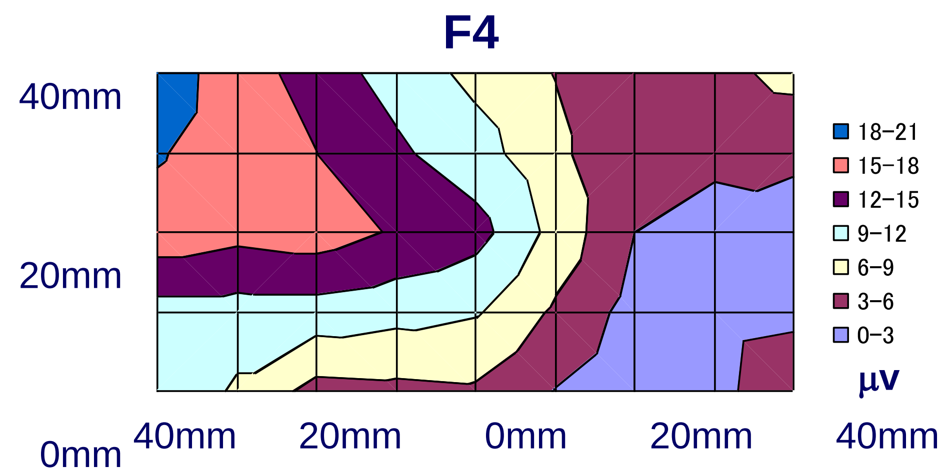
Interhemispheric connectivity

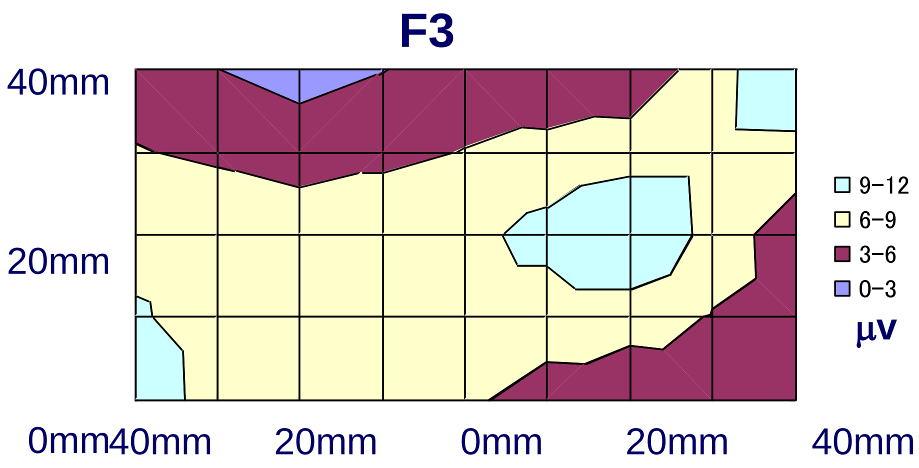
Commissural fibers

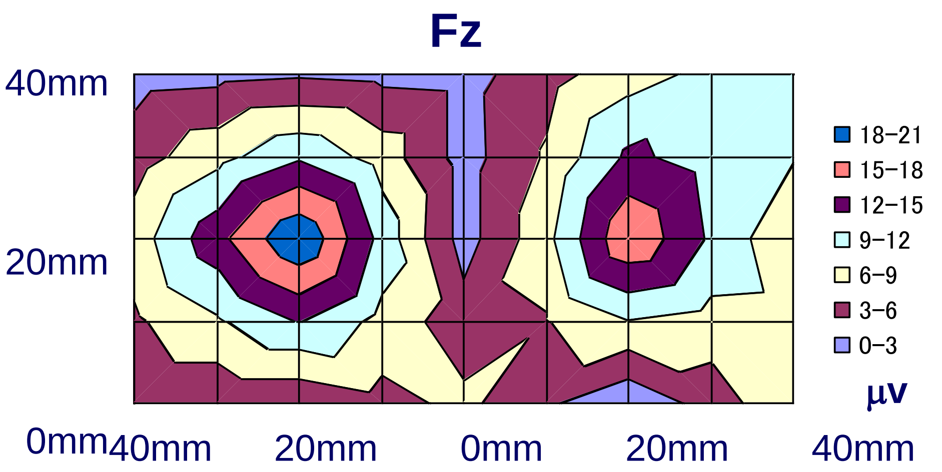
- **corpus callosum**
- **anterior/posterior commissure**
- **hippocampal commissure**

Topography of the amplitude of the 9 ms EEG component

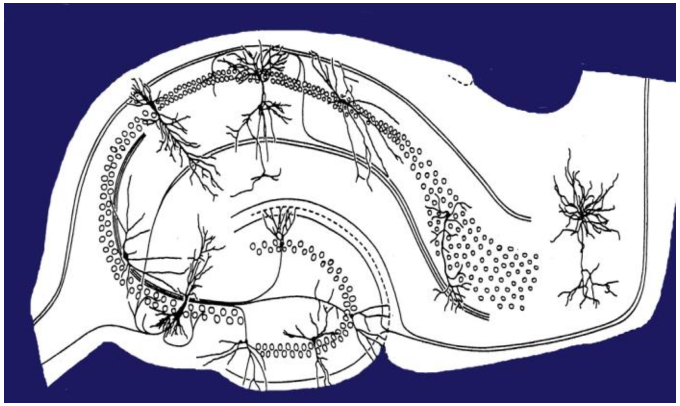








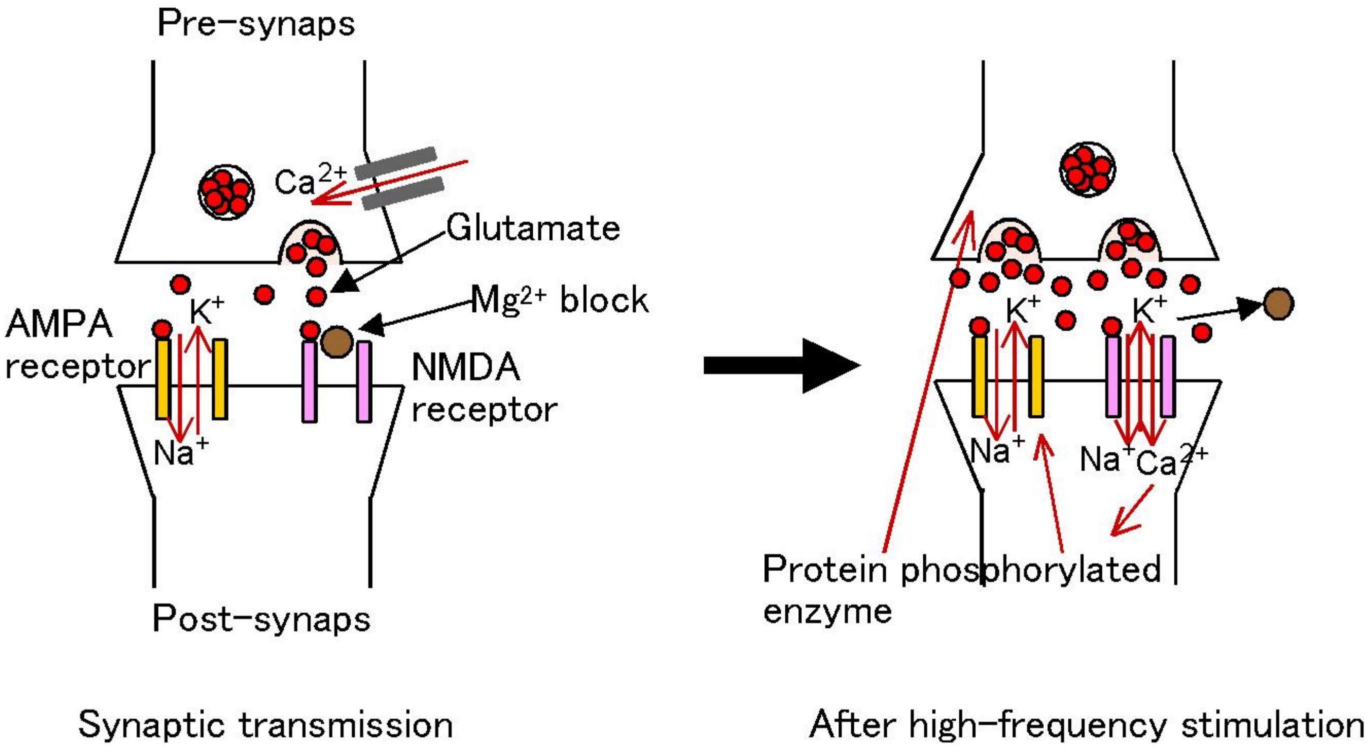
Effect of pulsed magnetic fields on rat hippocampus



Long-term potentiation, LTP

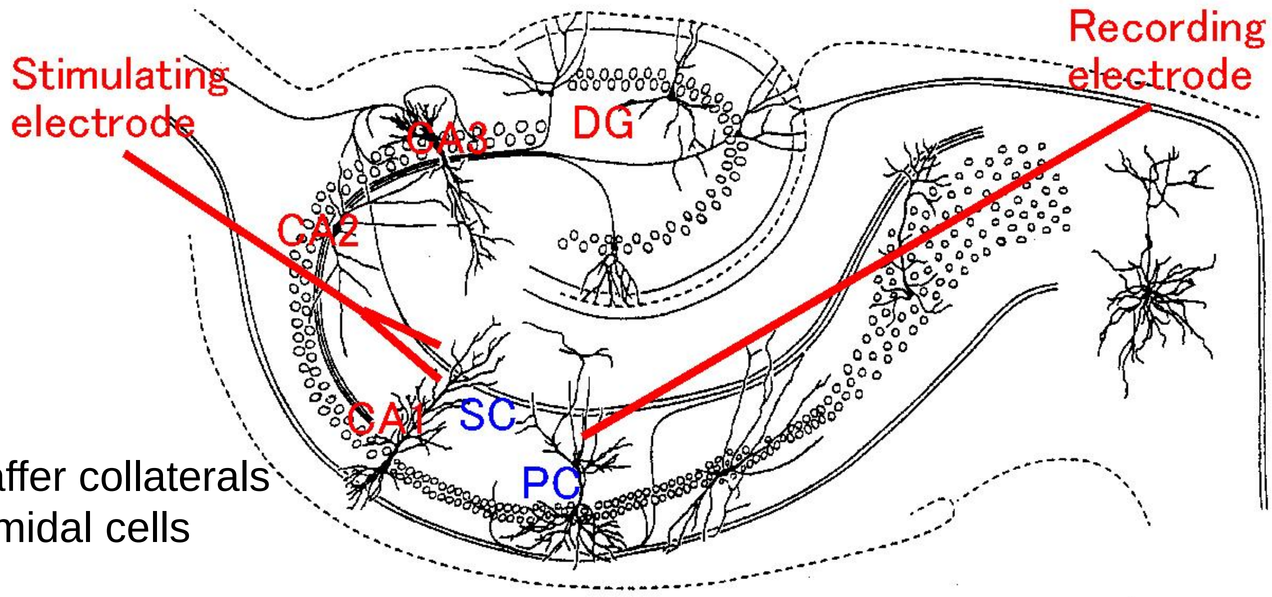
Long-lasting increase in synaptic efficacy resulting from high-frequency stimulation of afferent fibers.

LTP in the hippocampus = typical morel of synaptic plasticity related to learning and memory.



- Enhancement of transmitter release
- Activation of AMPA and NMDA receptors

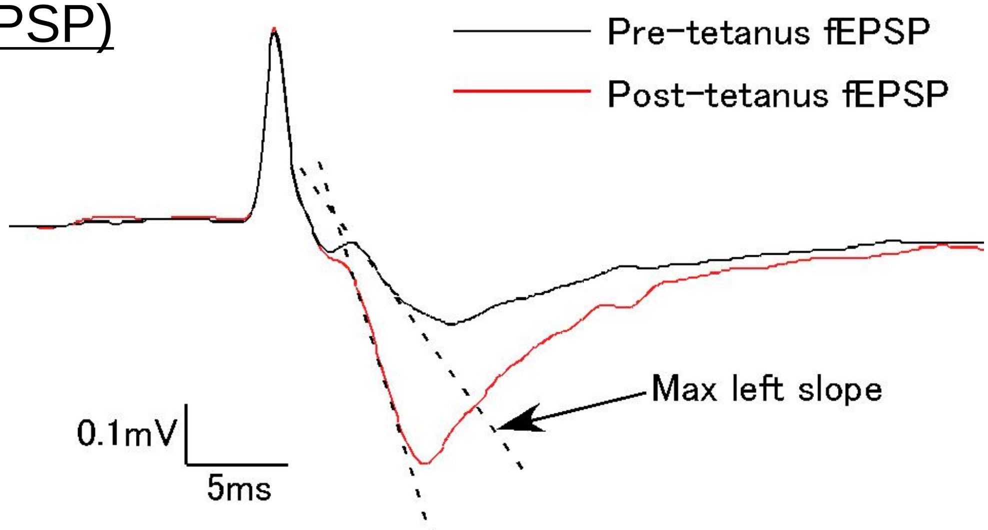
Measurement of fEPSP and LTP



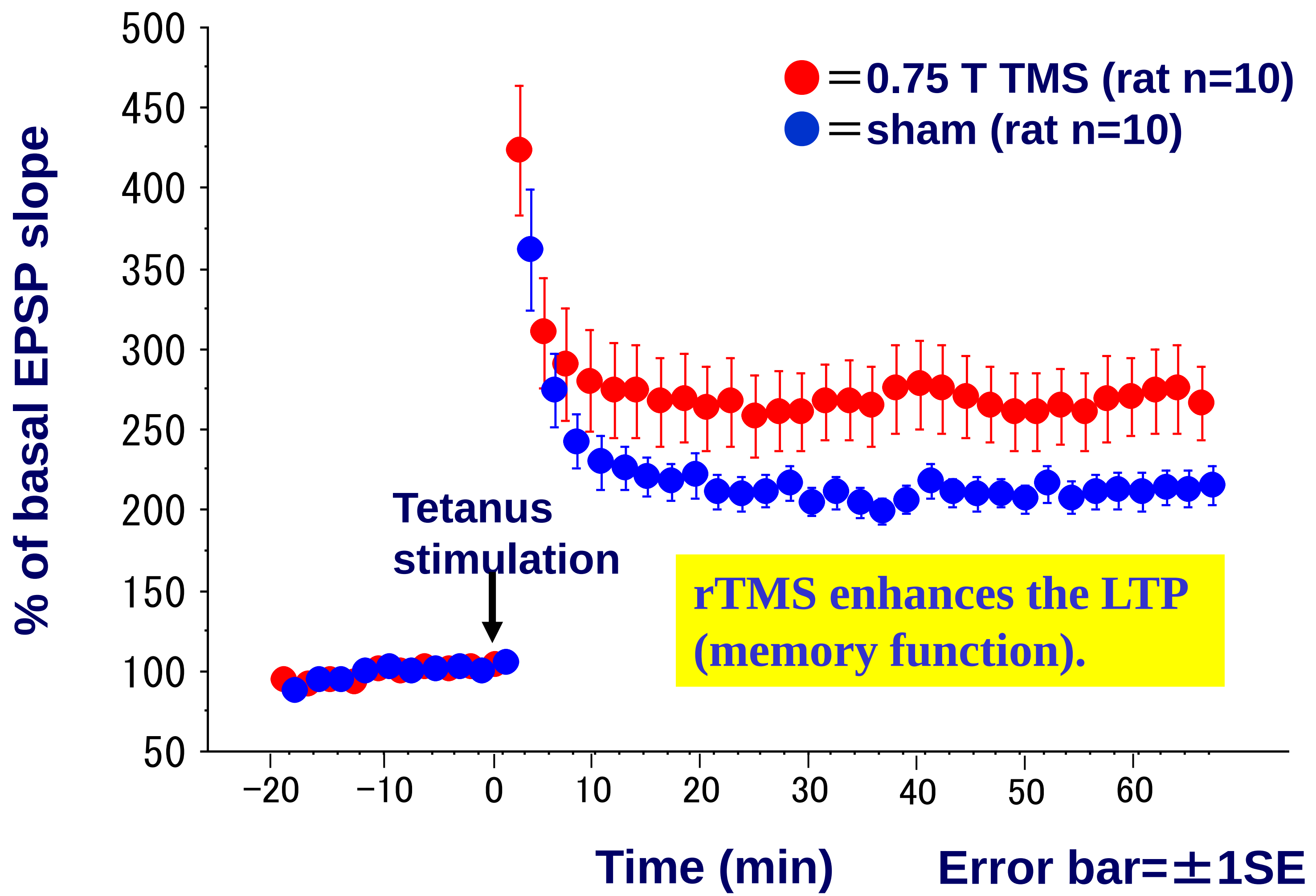
SC: Schaffer collaterals
PC: pyramidal cells

Excitatory postsynaptic potential (EPSP)

Tetanus stimulation (100 Hz for 1 sec)
→Enhancement of EPSP
= Long-term potentiation (LTP)



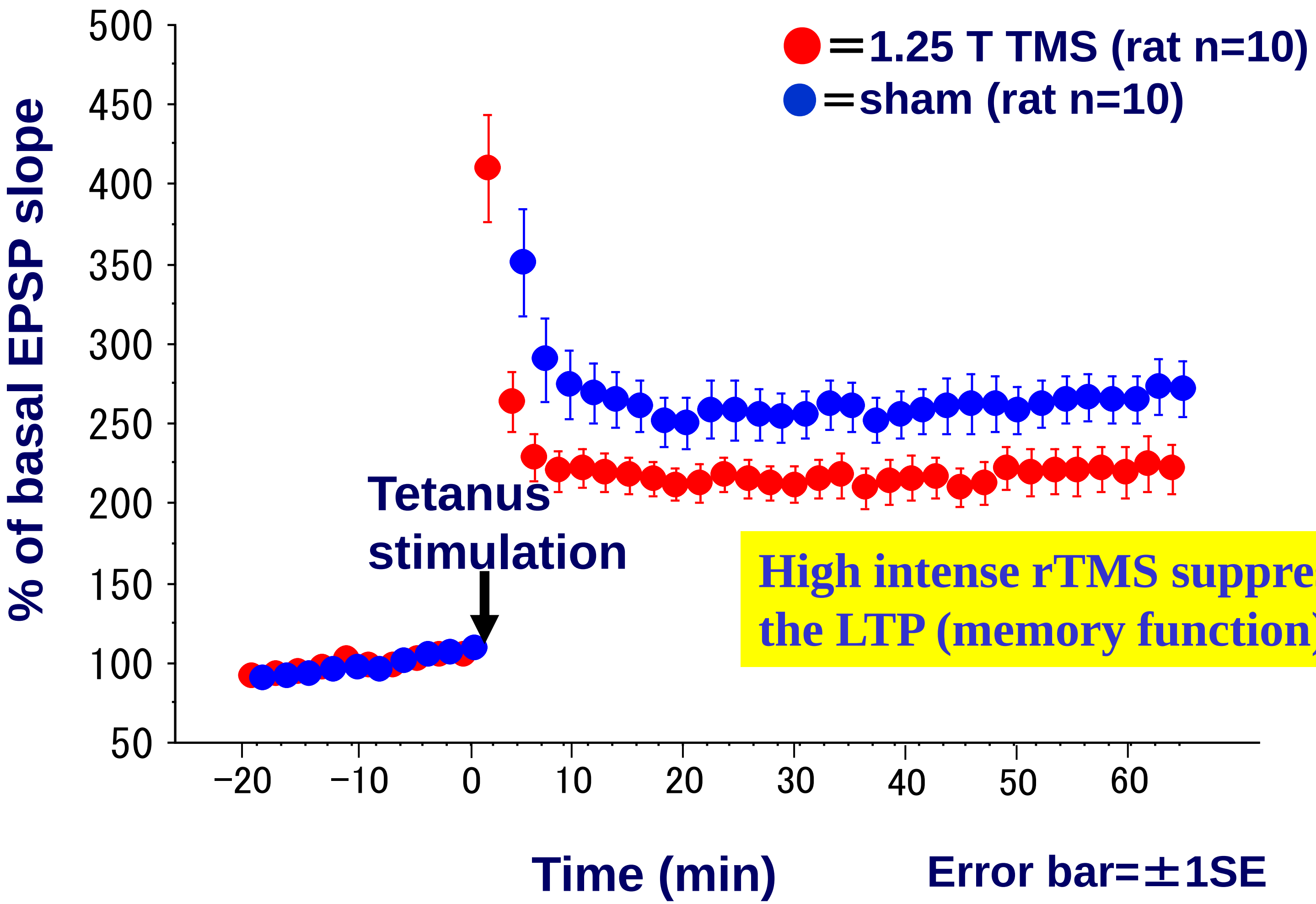
LTPs of 0.75 T rTMS



LTP of 0.75T rTMS group was significantly enhanced (p=0.0408).

Ogiue-Ikeda M, Kawato S, and Ueno S: Brain Research (2003)

LTPs of 1.25 T rTMS



Error bar=±1SE

High intense rTMS suppresses the LTP (memory function).

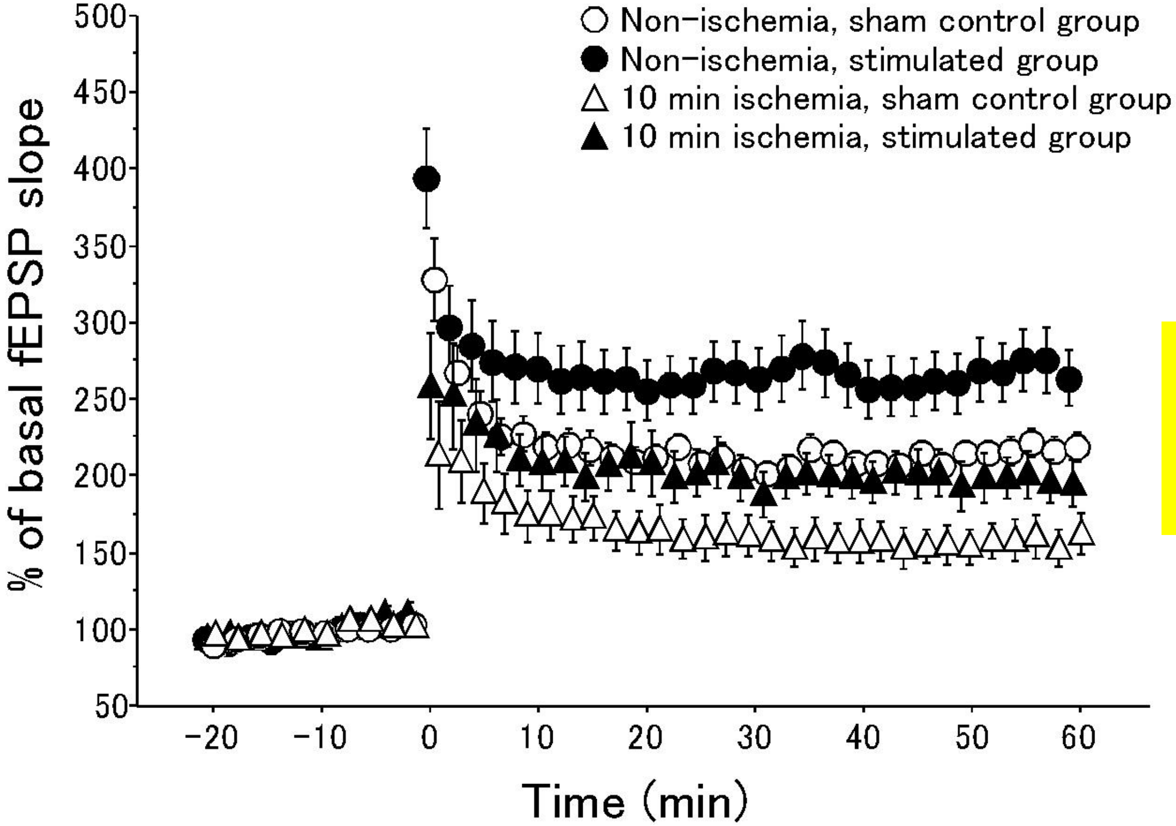
LTP of 1.25 T rTMS group was significantly suppressed (p=0.0289).

Ogiue-Ikeda M, Kawato S, and Ueno S: Brain Research (2003)

Acquisition of ischemic tolerance by 0.75 T rTMS

Ischemic condition: 10 min, ischemic ACSF (without glucose, oxygen).

LTP after ischemia

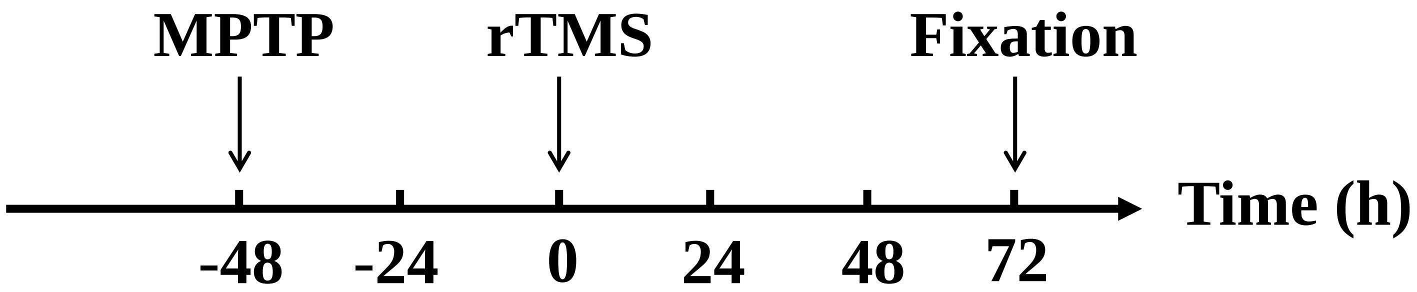


rTMS enhances tolerance against cerebral ischemia.

0.75T rTMS has potential to protect hippocampal function from ischemic injury.

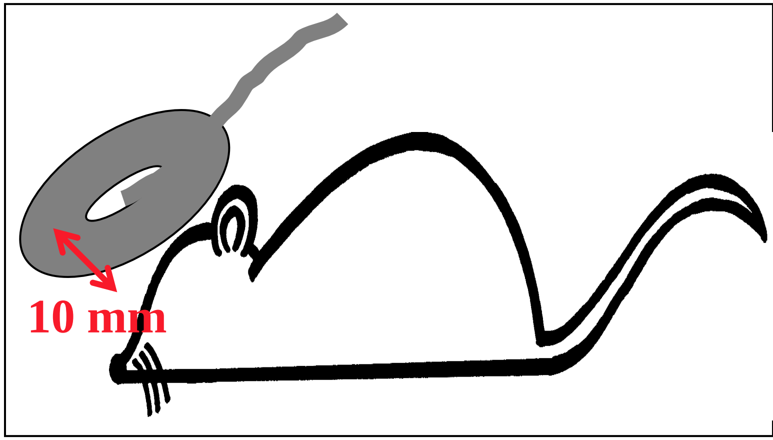
Ogiue-Ikeda M, Kawato S, and Ueno S: *Brain Research*, **1037** (2005)

Effect of rTMS on injured neurons



Subjects: Wistar rats (♂)
5 weeks old

Neurotoxin: MPTP
(1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine) (20 mg/kg)



Injections: 4 subcutaneous injections per day, 2 hour interval between injections

Magnetic field: 1.25 T at the center of coil

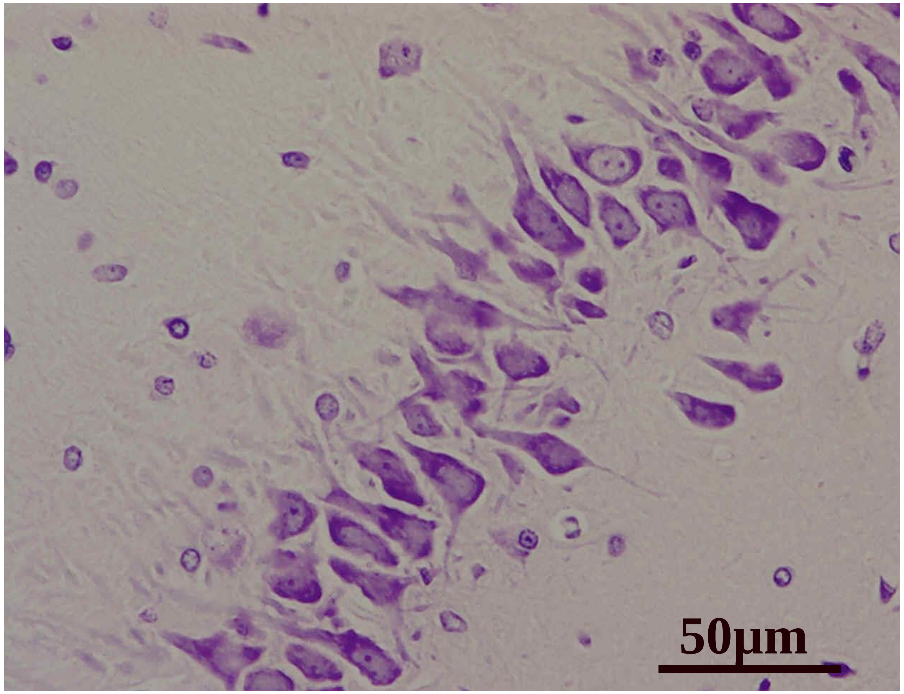
25 pulses/sec ×8 sec ×10 trains (= 2000 pulses) per day

Interval between trains = 10～15 min

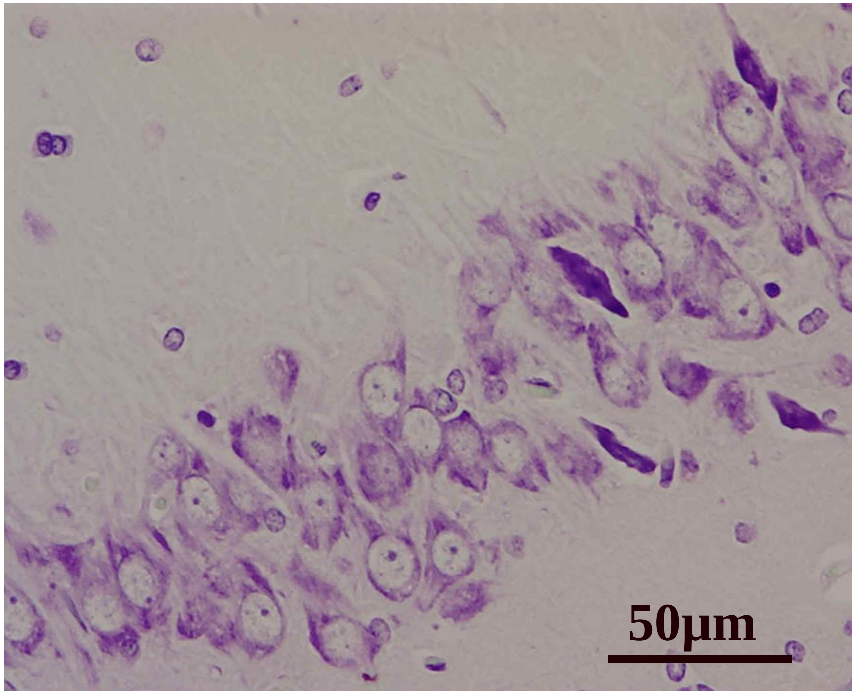
Funamizu H, Ogiue-Ikeda M, Mukai H, Kawato S, and Ueno S: Neuroscience Letters (2005)

Effect of rTMS on the injured neurons in the hippocampal CA3

nissl stain



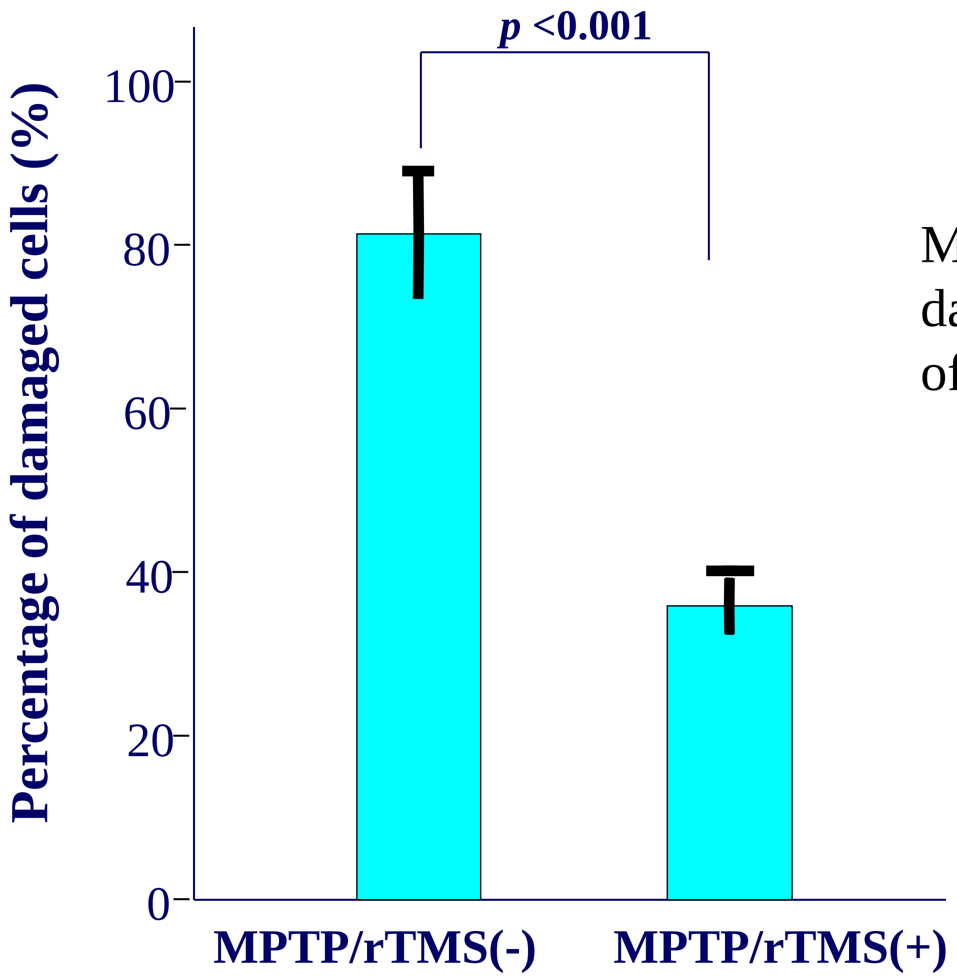
MPTP/rTMS(-)



MPTP/rTMS(+)

rTMS prevents damage to hippocampal CA3 pyramidal neurons.

Percentage of damaged cells in hippocampal CA3



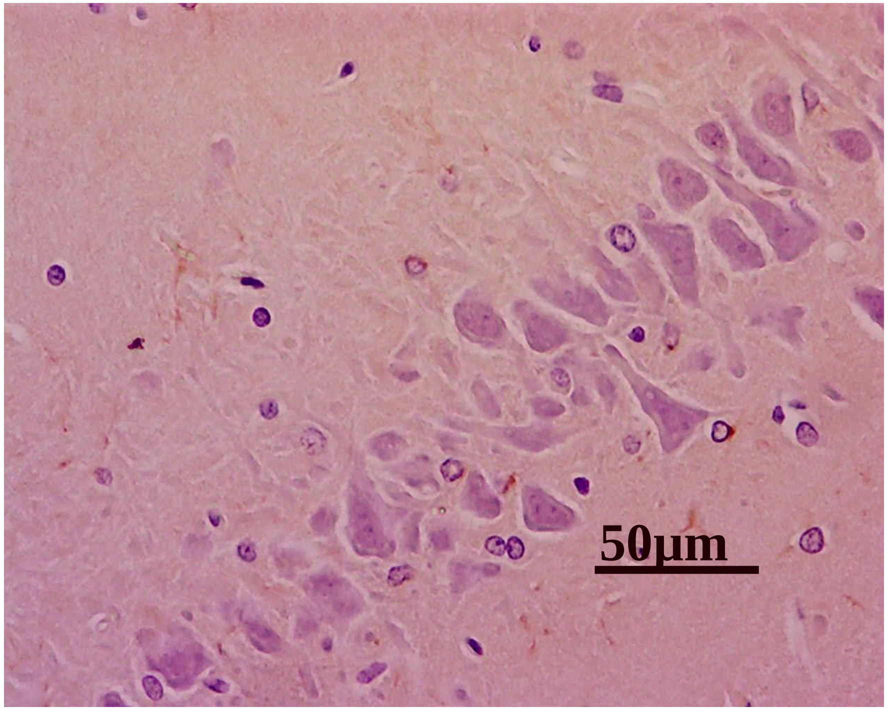
Moderate rTMS contributes to damage prevention and recovery of injured neurons.

Rat n = 6, Sample n = 24 for each group.

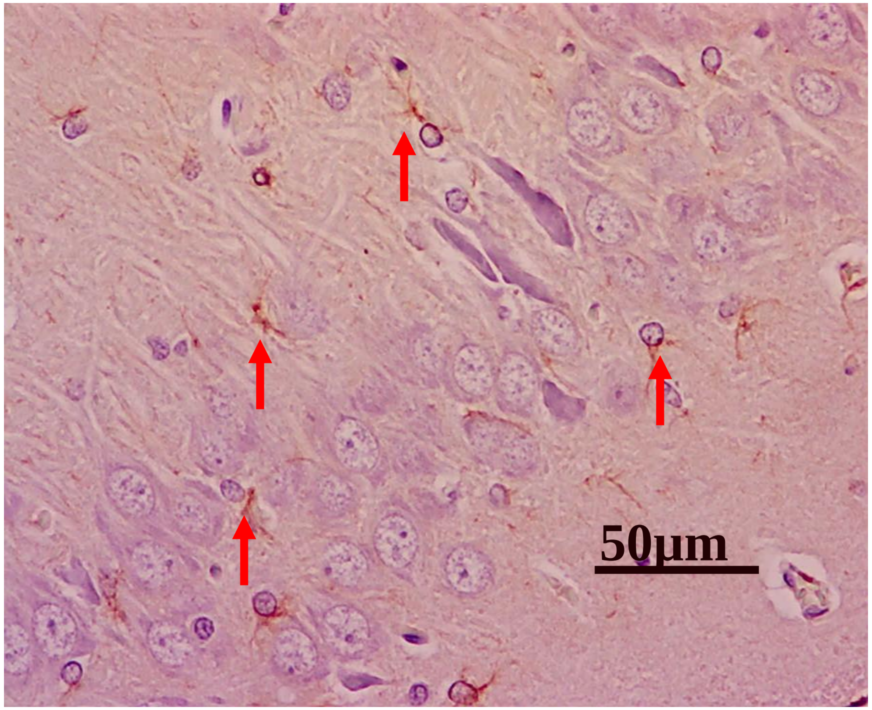
The percentage of damaged cells of the MPTP/rTMS(+) group was significantly lower than that of the MPTP/rTMS(-) group.

Activation of astrocytes in the hippocampal CA3

immunocytochemistry



MPTP/rTMS(-)



MPTP/rTMS(+)

Arrows indicate GFAP (glial fibrillary acidic protein) positive astrocytes. GFAP is a cell specific marker in astrocytes.

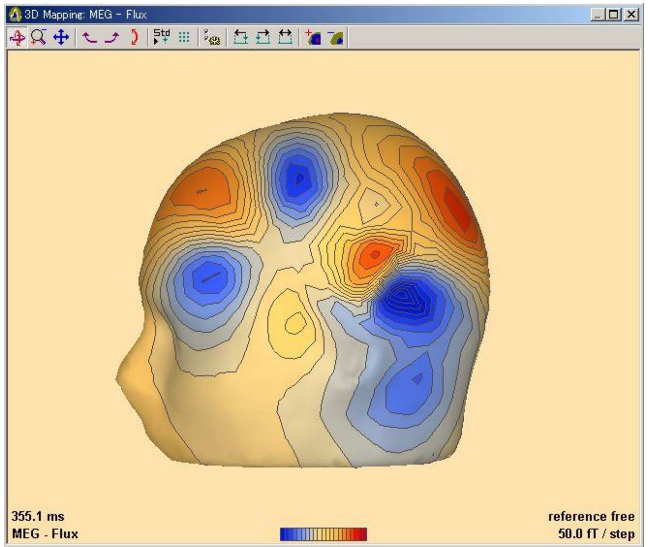
• rTMS **increases** the **GFAP immunoreactivity** in the hippocampal CA3.

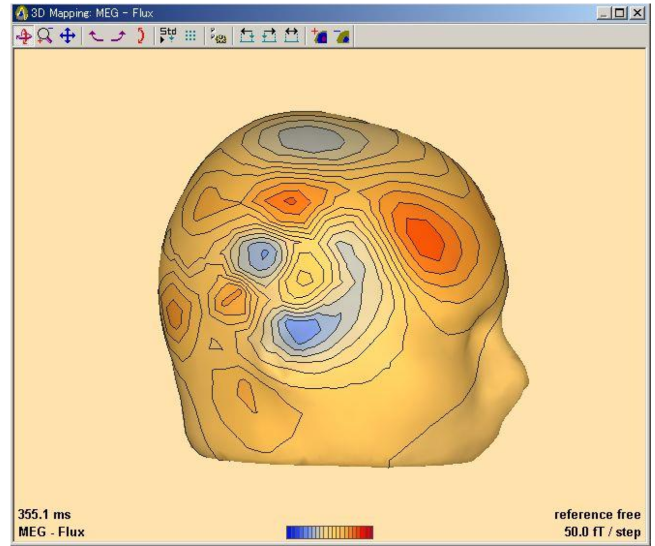
Potential Treatments by rTMS

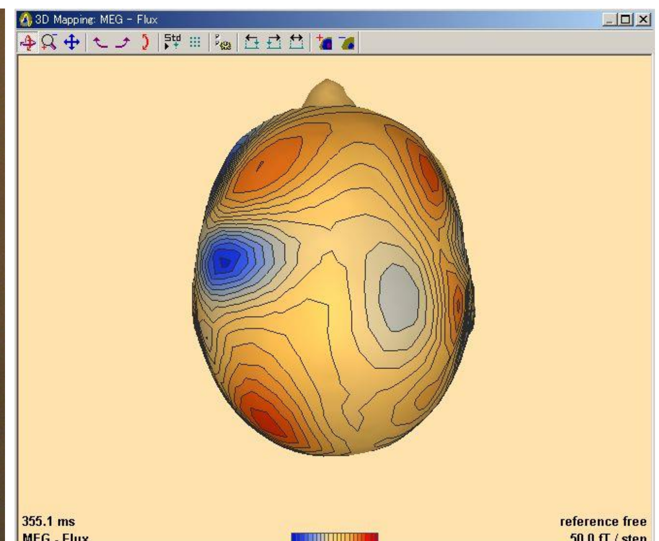
rTMS (repetitive TMS) modulates or contributes to

- memory function
- learning and memory processes
- neuronal plasticity
- prevention of neurons against injury
- recovery of injured neurons
- acquisition of tolerance against cerebral ischemia

Whole cortex type of MEG system







Inverse Problem

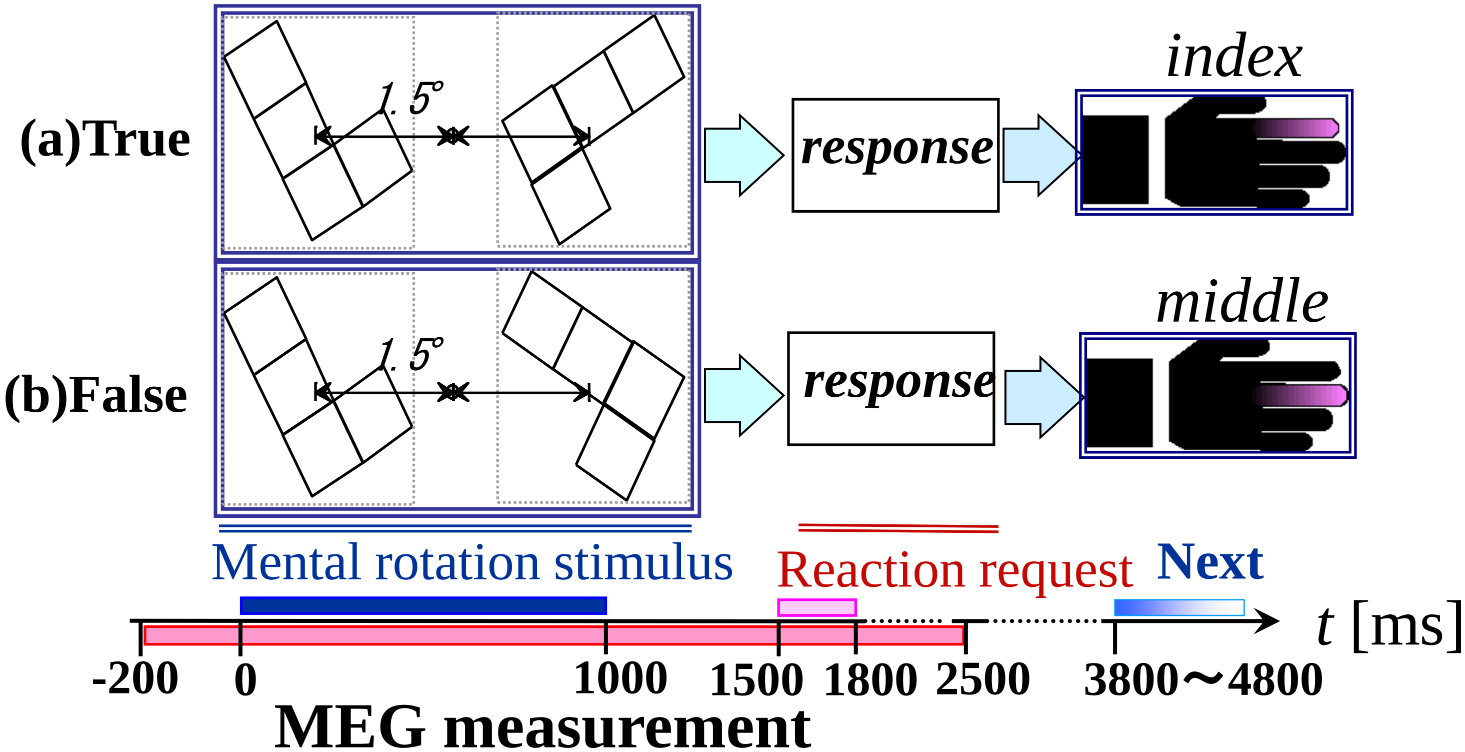
I. Estimation of Current Dipoles

* Newton Iteration Method
* Marquardt's Method
* Simulated Anneling Method
* Genetic Algorithm

II. Estimation of Current Distribution

* Fourier's Transformation Method
* Pattern Matching Method
* Minimum Norm Estimation
* MUSIC (Multiple Signal Classification) Algorithm
* Sub-Optimal Least-Squares Subspace Scanning Method
* Spatial Filtering Method
* LORETA (Low Resolution Brain Electromagnetic Tomography)

Mental rotation task



A mental rotation process requires rotation and matching of a pair of mental images.

Estimated source distributions (mental rotation)

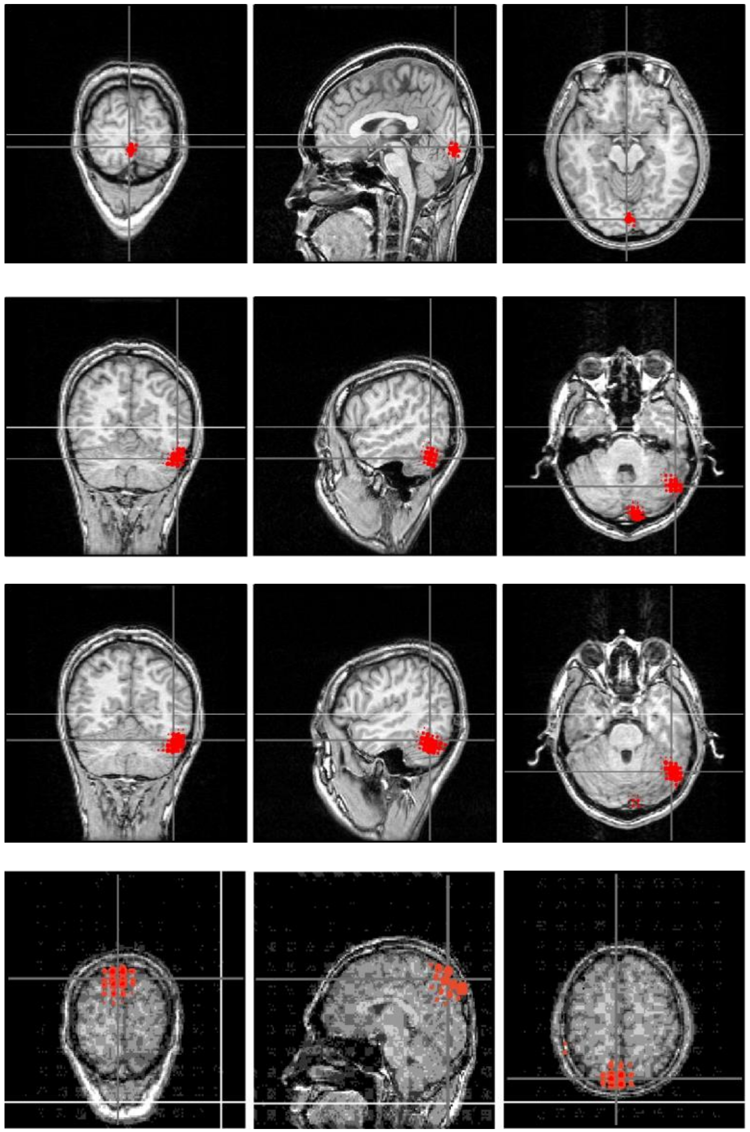
Mental rotation task

180 ms

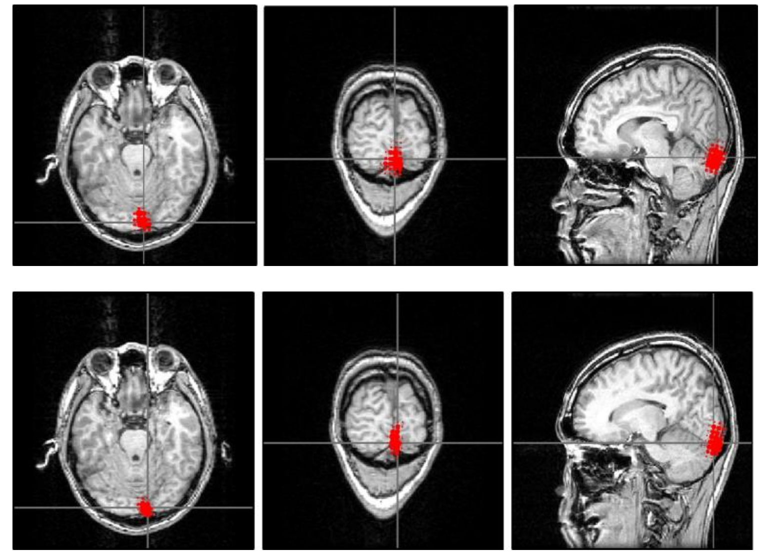
190 ms

210 ms

240 ms

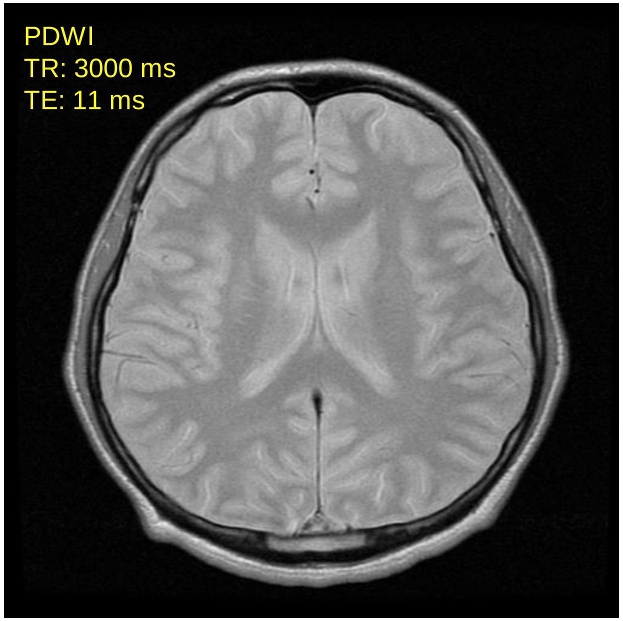


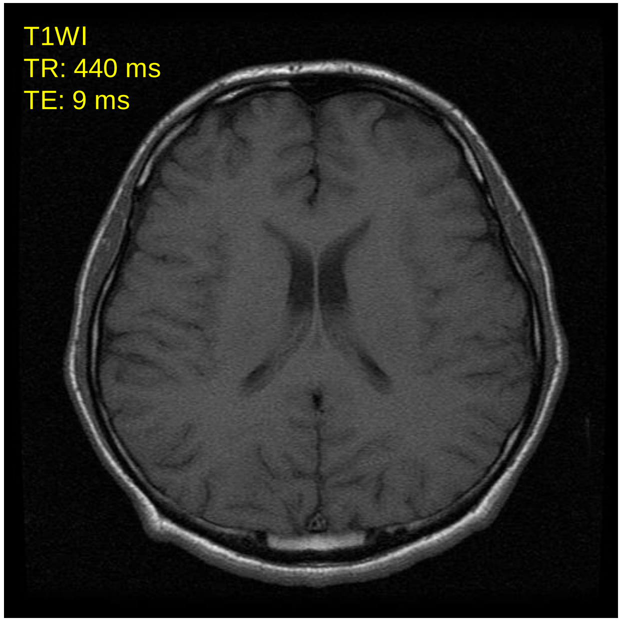
Control task

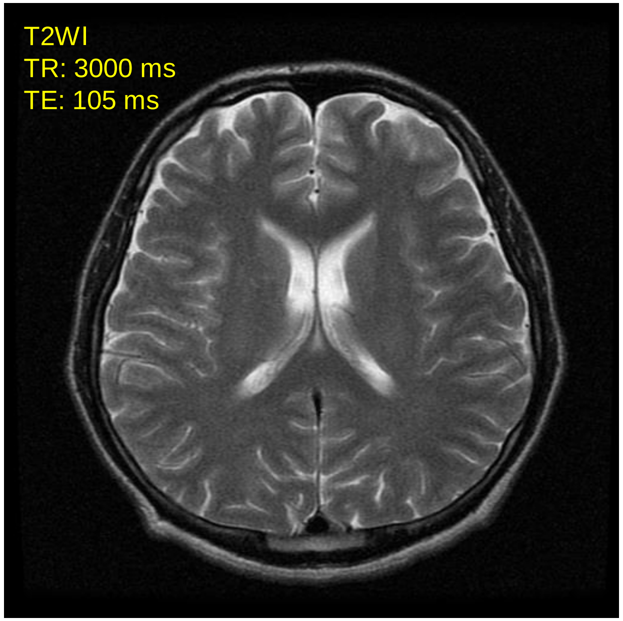


Iwaki S, Ueno S, Imada T, and Tonoike M: NeuroReport (1999)

Conductivity imaging of the brain







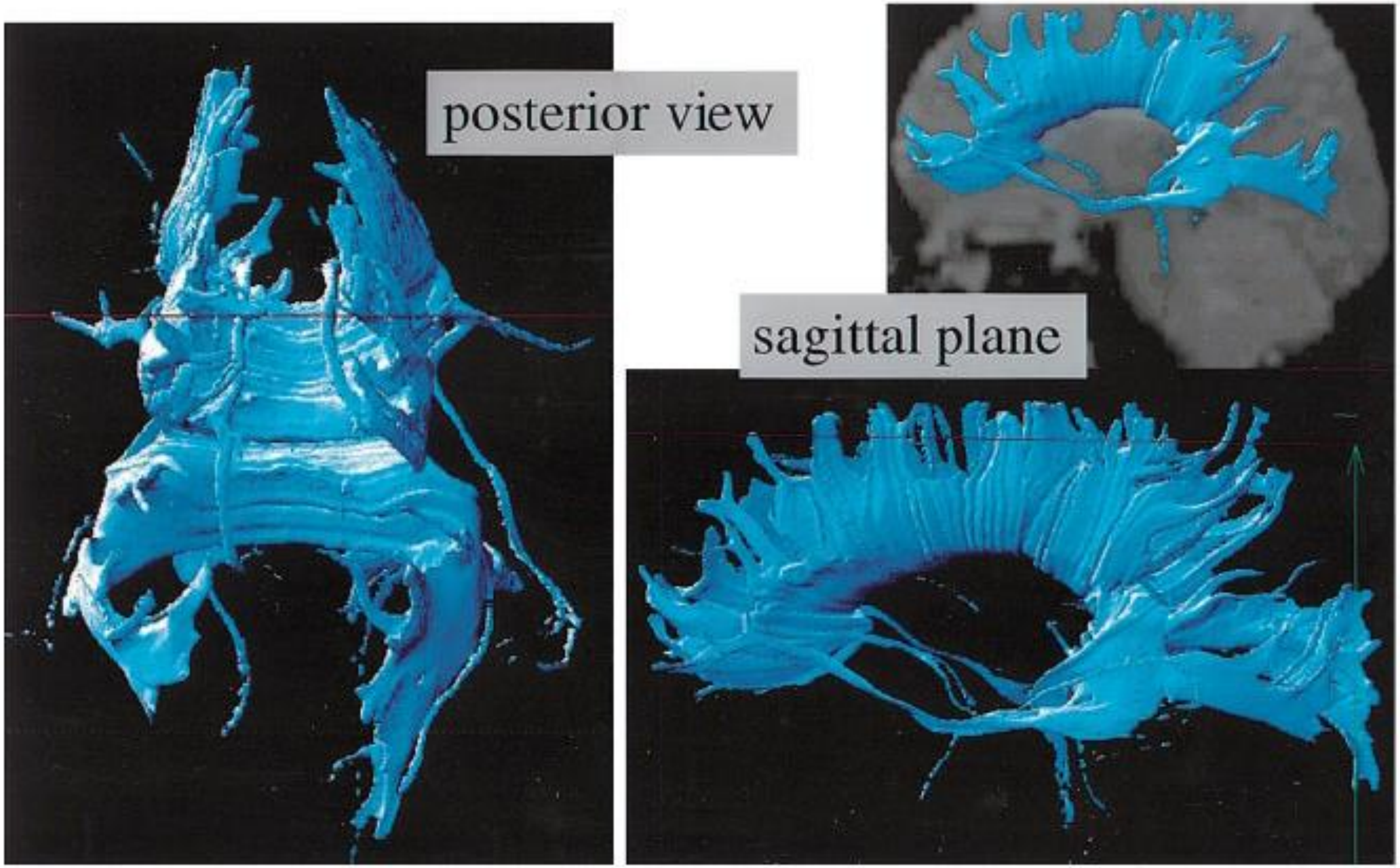
Images were obtained using a GE 1.5 T MRI system.
Maximum magnetic field gradient: 33 mT/m, Maximum rate of rise: 150 mT/m/ms
Maximum b value: 10000 s/m^2

Dr. Seiji Ogawa

Functional MRI (fMRI) based on Blood Oxygenation Level Dependent (BOLD) effects was invented by Dr. Seiji Ogawa.

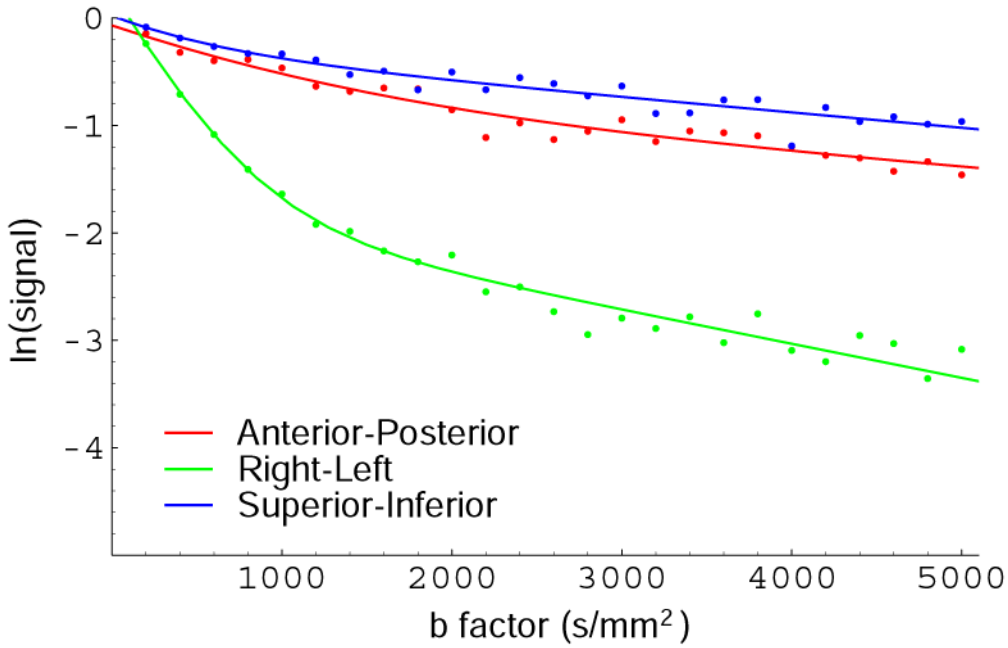
Dr. Seiji Ogawa was awarded Japan Prize in 2003, and Canada Gairdner International Award in 2003.

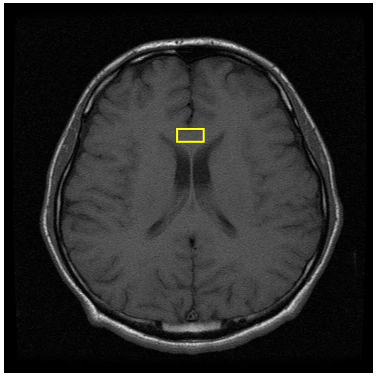
Fiber-Tract Trajectories of the Corpus Callosum



Basser PJ, Pajevic S, Pierpaoli C, Duda J, Aldroubi A. Magn Reson Med 2000;44:625-632.

Relationships between the b-factor and the logarithm of the signal intensity in the corpus callosum

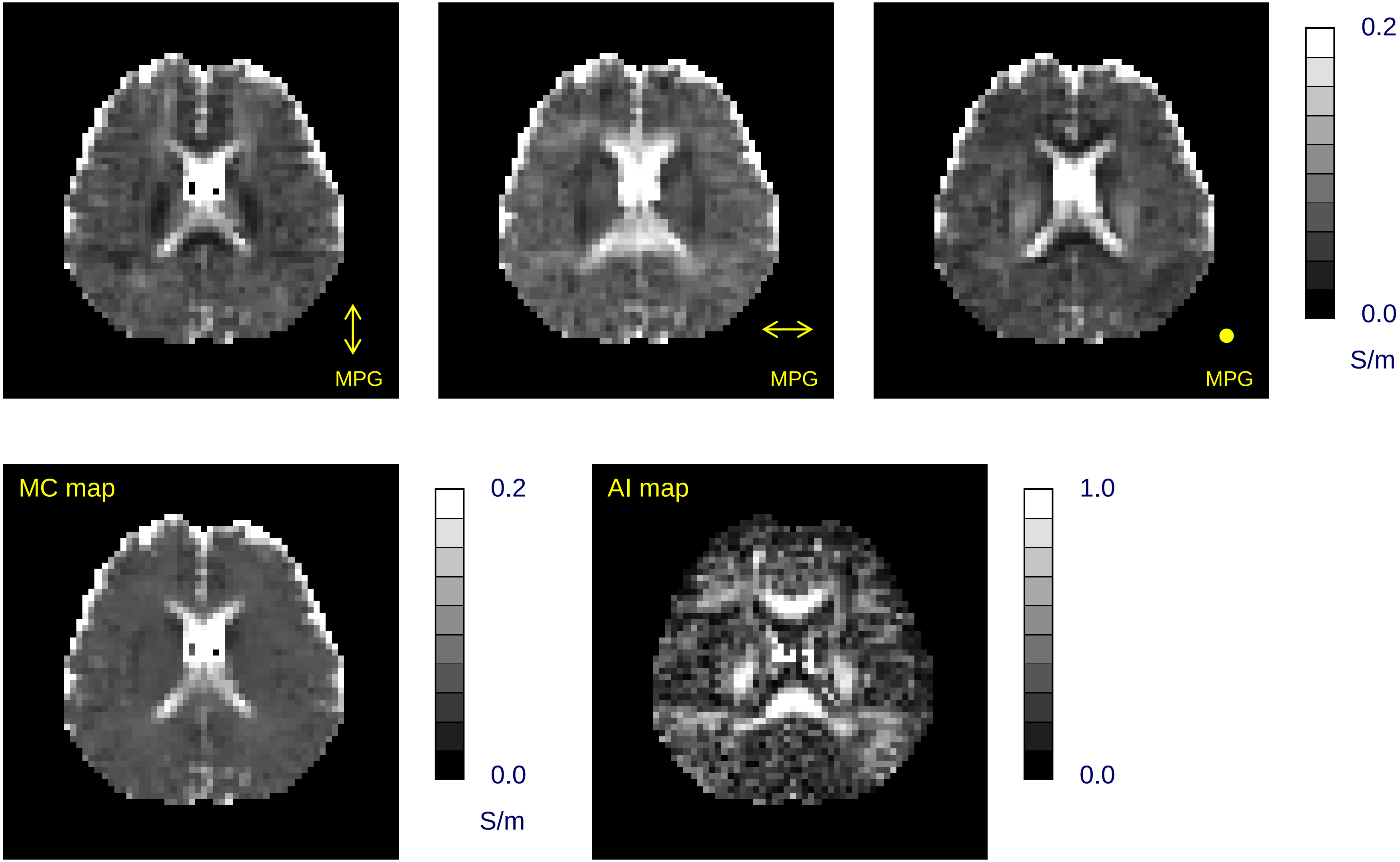




	Annerior-Posterior	Right-Left	Superior-Inferior
D_{fast} ($\times 10^{-3}$ mm^2/s)	2.09 ± 0.45	2.46 ± 0.55	2.32 ± 0.71
f_{fast}	0.58 ± 0.04	0.54 ± 0.07	0.56 ± 0.05
D_{slow} ($\times 10^{-3}$ mm^2/s)	0.50 ± 0.11	0.42 ± 0.07	0.44 ± 0.09
f_{slow}	0.42 ± 0.04	0.46 ± 0.07	0.44 ± 0.05

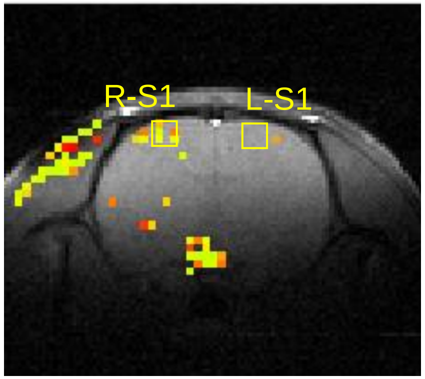
An application of the MPG in the right-left direction caused the most rapid signal attenuation.

Conductivity images

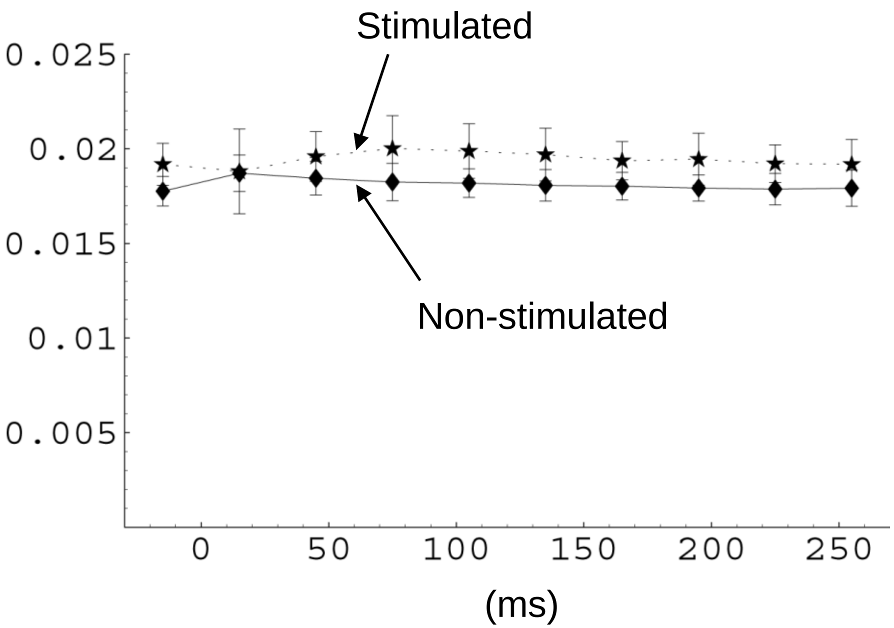


M. Sekino, Y. Inoue, and S. Ueno (2005)

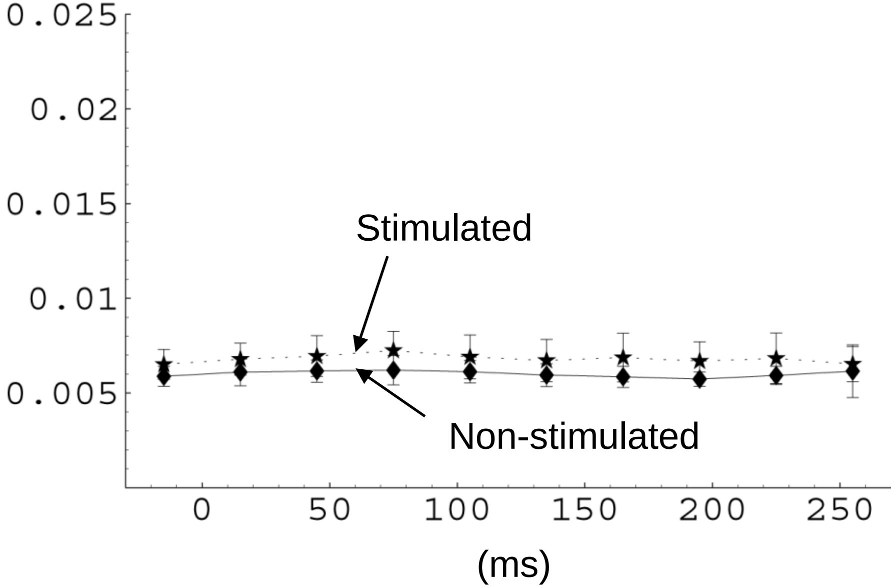
Detection of change of magnetic fields related to neuronal electrical currents by MRI



BOLD-fMRI of the somatosensory area activated by electrical stimulation of the left hindpaw of a rat.

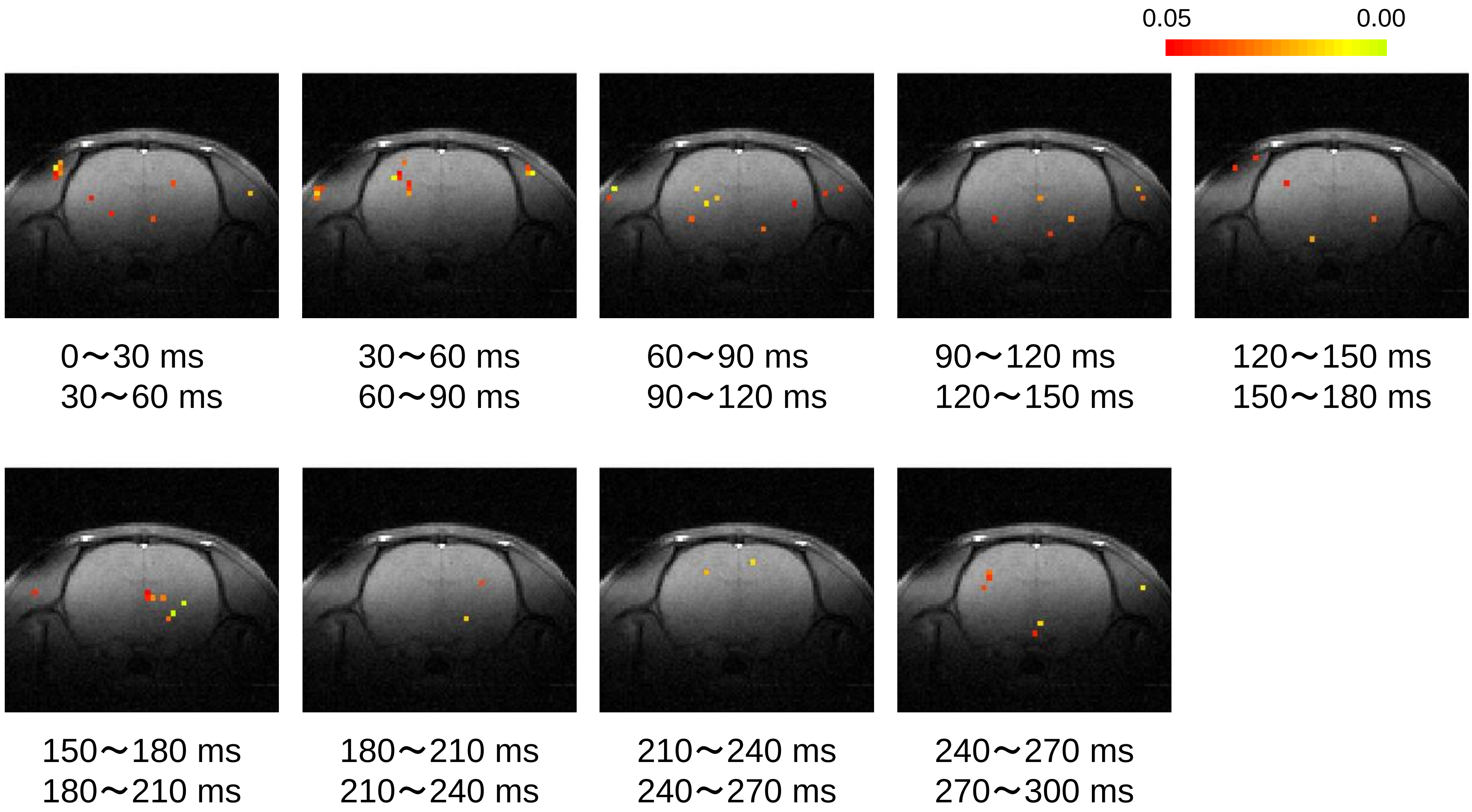


Right somatosensory area

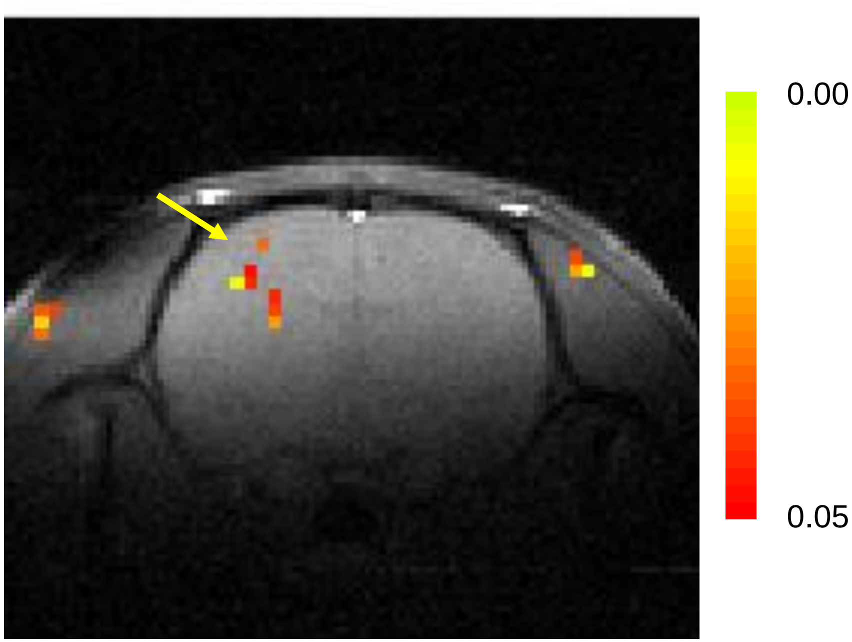


Left somatosensory area

Comparison of the signal intensity between the images obtained at adjacent time points after electric stimulation



Current MR Imaging: Imaging of magnetic fields caused by neuronal electrical activities in the brain



Subtraction image of signals at 30 – 60 ms from signals at 60 – 90 ms.

Pulse Sequence : gradient echo
Spatial Resolution : 500 μm
Slice Thickness: 2 mm

Color scales show p-values.

M. Sekino and S. Ueno (2005)

Theoretical limit of the detection of magnetic field by MRI

Magnetic field generated by neuronal electrical current

5 pT = 5.0×10^{-12} T on the surface of the human head (30 mm away from the source)

4.5×10^{-9} T at the vicinity of neurons 1 mm away from the neurons

Limit of sensitivity after a times averaged.

$$\sigma_B = \frac{N}{S\gamma T_E \sqrt{a}}$$

$$R_s = 1.17(\Omega)$$

$$N = n\sqrt{4kT_S \Delta f R_S} = 1.11\times10^{-5}(\text{V})$$

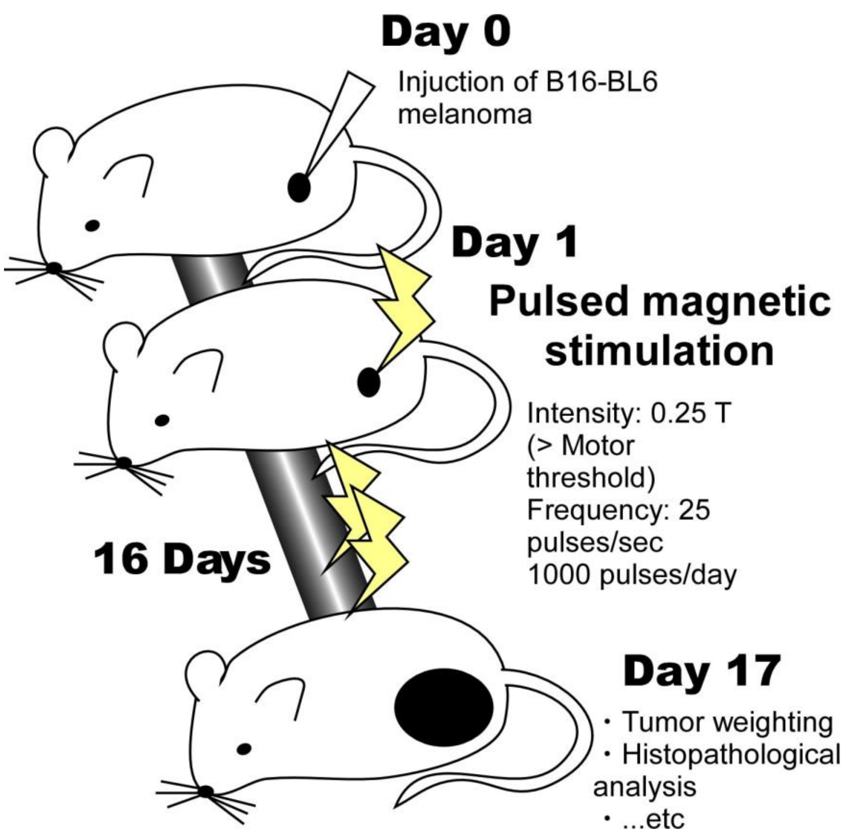
Limit of sensitivity at the gray matter

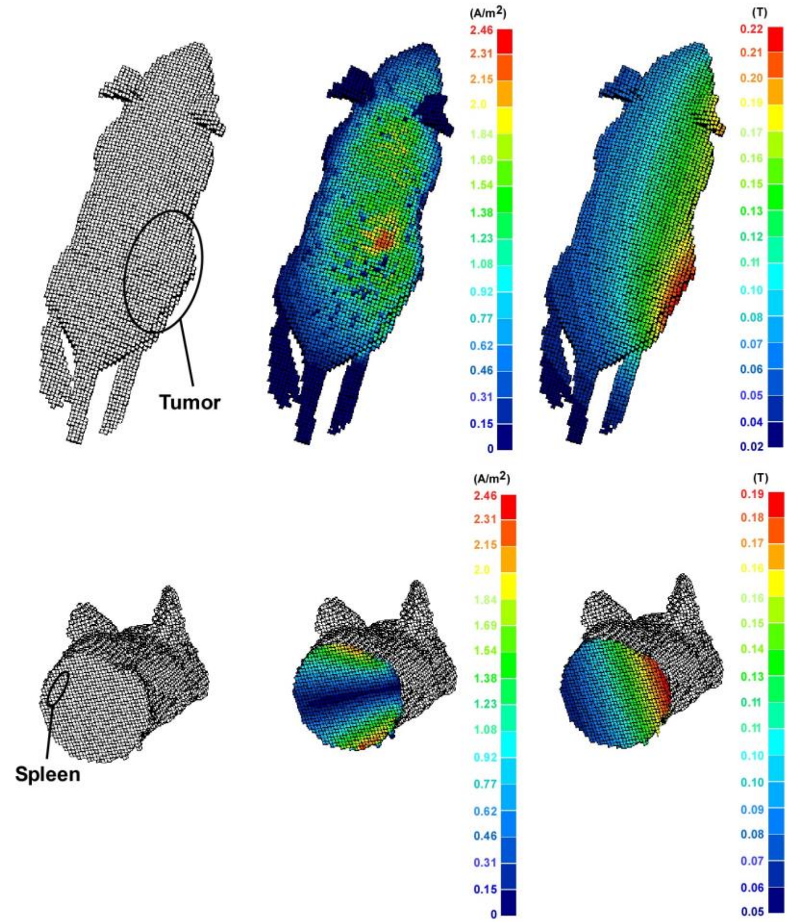
σ_B = 2.61×10^{-8} T

a = 20 → 5.8×10^{-9} T

	Human	Rat
Repetition time (T_R)	400 ms	333 ms
Echo time (T_E)	5 ms	30 ms
Static field (B_0)	1.5 T	4.7 T
RF field (B_1)	2×10^{-6} T	3.5×10^{-5} T
Field of view (L)	220 mm	32 mm
Slice thickness (h)	6 mm	2 mm
Flip angle (θ)	90º	20º
Number of pixels (n)	256	64
Resistance (R)	1.17 Ω	0.08 Ω
Number of averages (a)	20	20
Limit of sensitivity (σ_B)	5.8×10^{-9} T	4.3×10^{-11} T

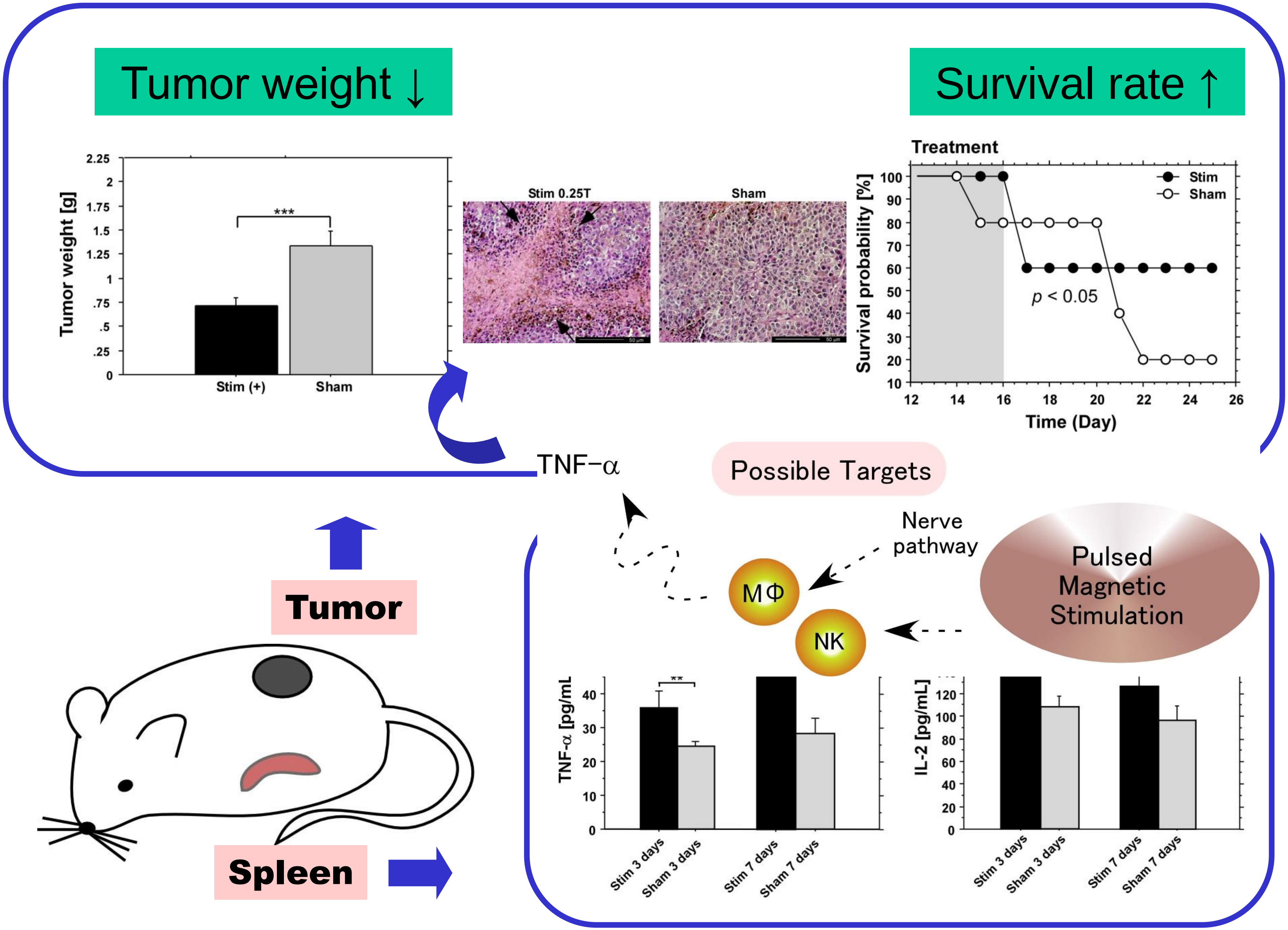
Effects of Pulsed Magnetic Stimulation on the Tumor Development Processes





Stimulus intensity	At the center of the coil	Tumor area	Spleen area	Min - Max
Magnetic flux (T)	0.25	0.13 - 0.22	0.06 - 0.1	0.023 - 0.22
Eddy current (A/m^2)	0	0.79 - 1.54	0.15 - 0.92	0 - 2.46

S. Yamaguchi, M. Ogiue-Ikeda, M. Sekino and S. Ueno, Bioelectromagnetics (2006)



S. Yamaguchi, M. Ogiue-Ikeda, M. Sekino and S. Ueno, Bioelectromagnetics (2006)

Cell Destruction by Pulsed Magnetic Force and Magnetizable Beads

Materials and Methods

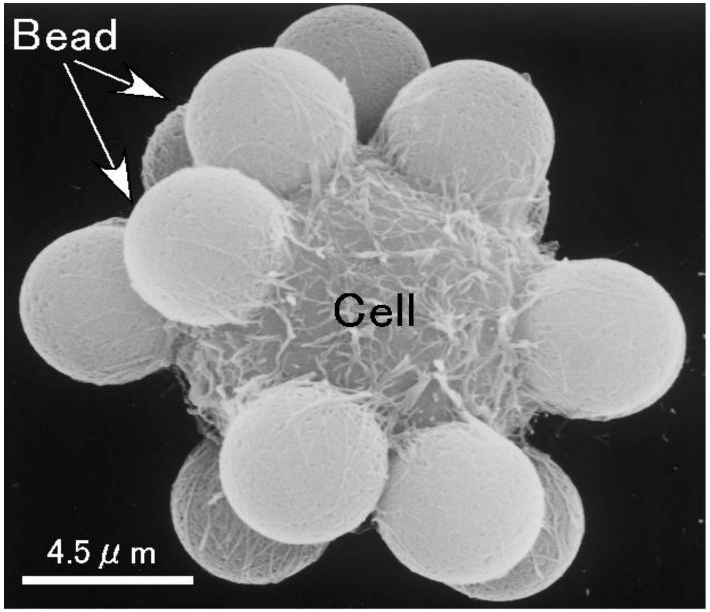
Cells: TCC-S (Leukemic cells) expressing
CD33 antigen

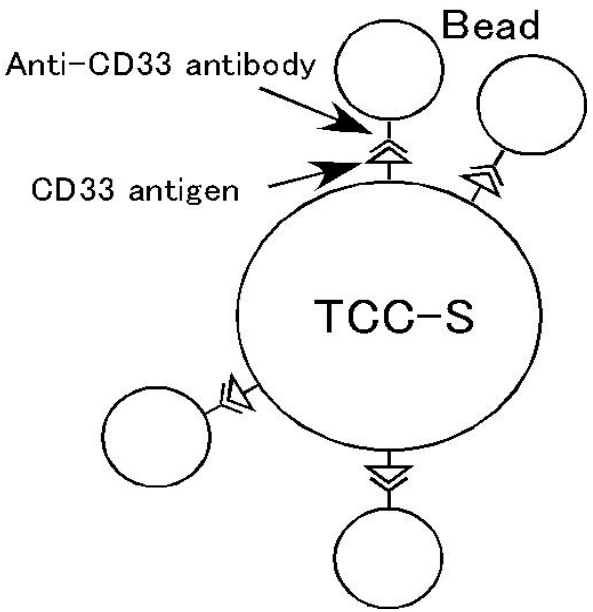
Beads: Dynabeads Pan Mouse IgG (Dynal),
diameter = 4.5 ± 0.2 μm,
magnetic mass susceptibility
$= (16 \pm 3) \times 10^{-5}\ m^3/kg$

Dynabeads:

mono-sized, superparamagnetic, macroporous particles with narrow pores, in which magnetizable materials are distributed in the pores throughout the whole volume of the particles.

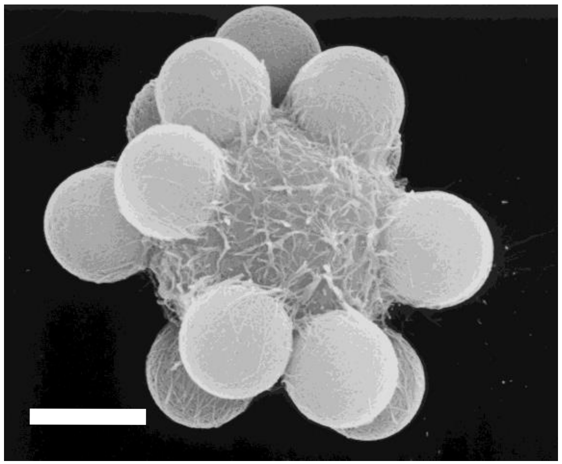
TCC-S cells and beads were bound together by an antigen-antibody reaction →cell/bead/antibody complex



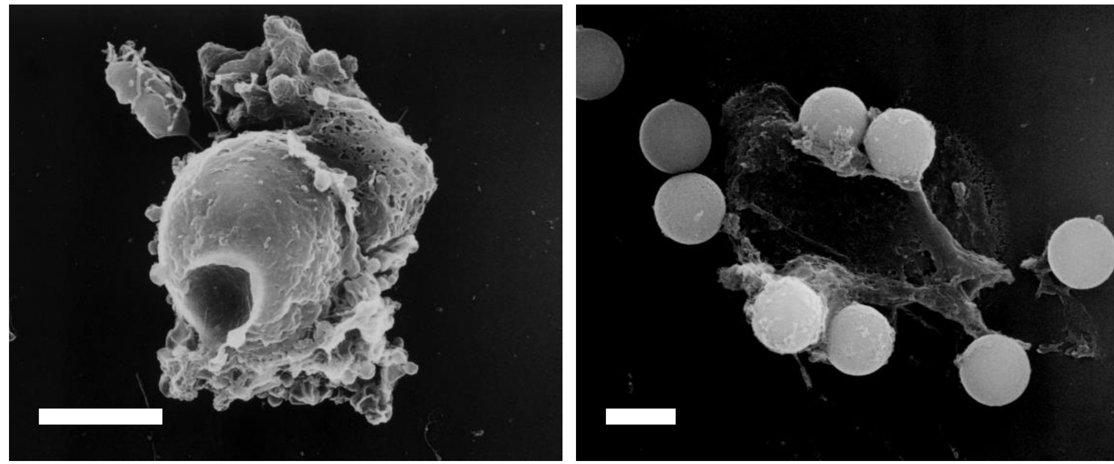


Electron scanning micrograph of the stimulates and nonstimulated cell/bead/antibody complex

Nonstimulated



Stimulated



Scale bars = 4.5 μm

The cells were damaged by penetration of the beads or rupturing by the beads.
The instantaneous pulsed magnetic forces cause the beads to forcefully penetrate or rupture the targeted cells.

M. Ogiue-Ikeda, Y. Sato, and S. Ueno: IEEE Trans. NanoBiosci. (2003)

Electromagnetic wave: heat

Ultrasonic wave: heat, microbubbles

Magnetic forces: no heat, no microbubbles

↓

The absence of heat and microbubbles makes this a potentially viable treatment modality for solid tumor type cancers as well as leukemia in which cells are distributed throughout the whole body.

Mechanisms of biological effects of electromagnetic fields

1) Time-varying magnetic field

eddy currents $$J = -\sigma \frac{\partial B}{\partial t}$$

nerve stimulation

heat $$SAR = \sigma \frac{E^2}{\rho}$$

thermal effects

2) Static magnetic fields

i) homogenous magnetic field

magnetic torque

$$T = -\frac{1}{2\mu_0} B^2 \Delta\chi \sin 2\theta$$

magnetic orientation of biological cells

ii) inhomogeneous magnetic field

magnetic force

$$F = \frac{\chi}{\mu_0} (\mathrm{grad}\, B)\, B$$

parting of water by magnetic fields (Moses effect)

3) Multiplication of magnetic fields and other energy

photochemical reactions with radical pairs

singlet-triplet intersystem crossing

yield effect of cage -product and escape -product

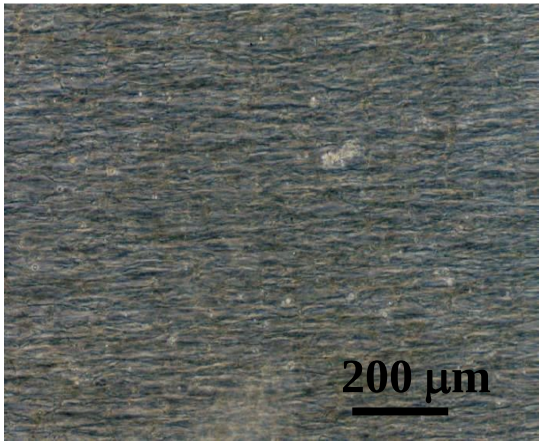
- **Diamagnetic Materials**
  - **Water**
  - **Fibrin, Collagen**
  - **Erythrocytes**
  - **Oxyhemoglobin**
- **Paramagnetic Materials**
  - **Oxygen**
  - **Deoxyhemoglobin**
- **Ferro- and Ferrimagnetic Materials**
  - **Magnetites – Fe_3O_4**
  - **Magnetic Particles**
  - **Magnetic Fluids**

Parting water by magnetic fields: The Moses effect

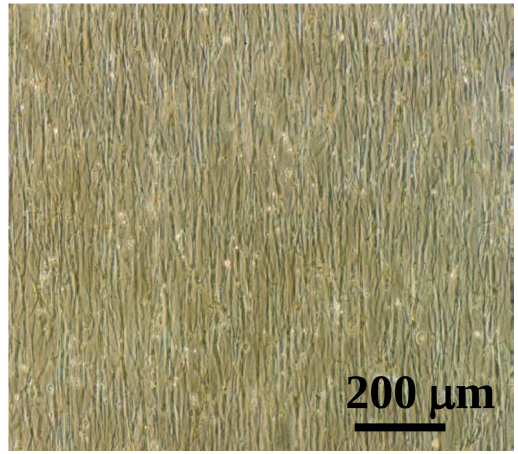
S. Ueno, M. Iwasaka (2003, 2004)

Magnetic orientation of adherent cells

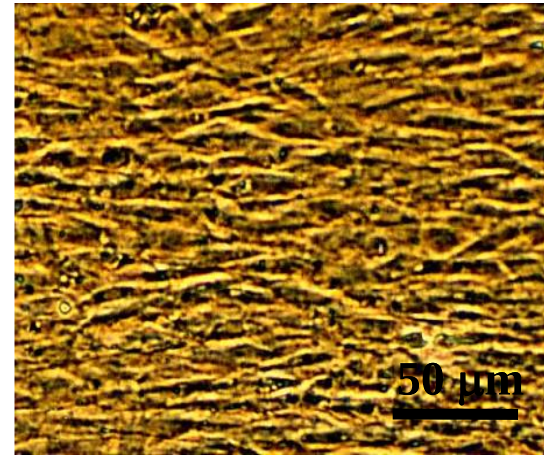
Direction of magnetic field



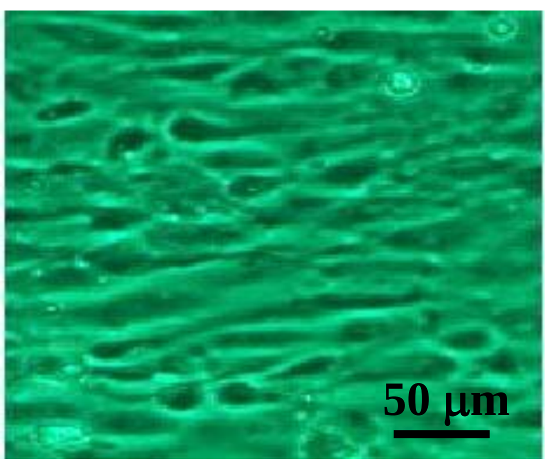
fibrin



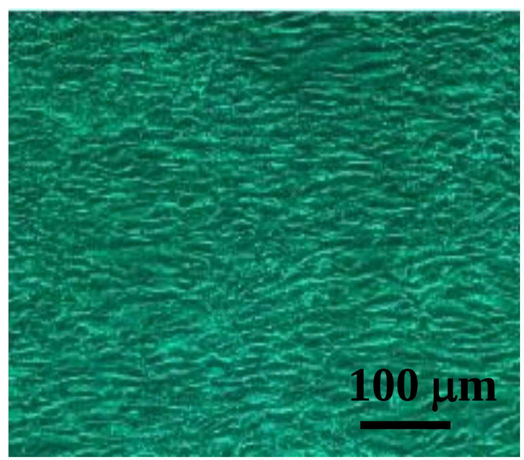
collagen



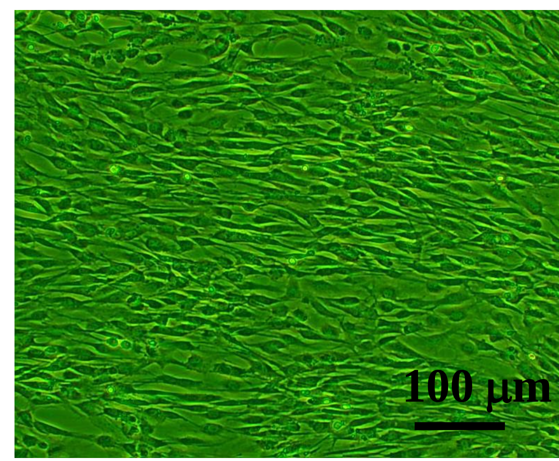
osteoblasts



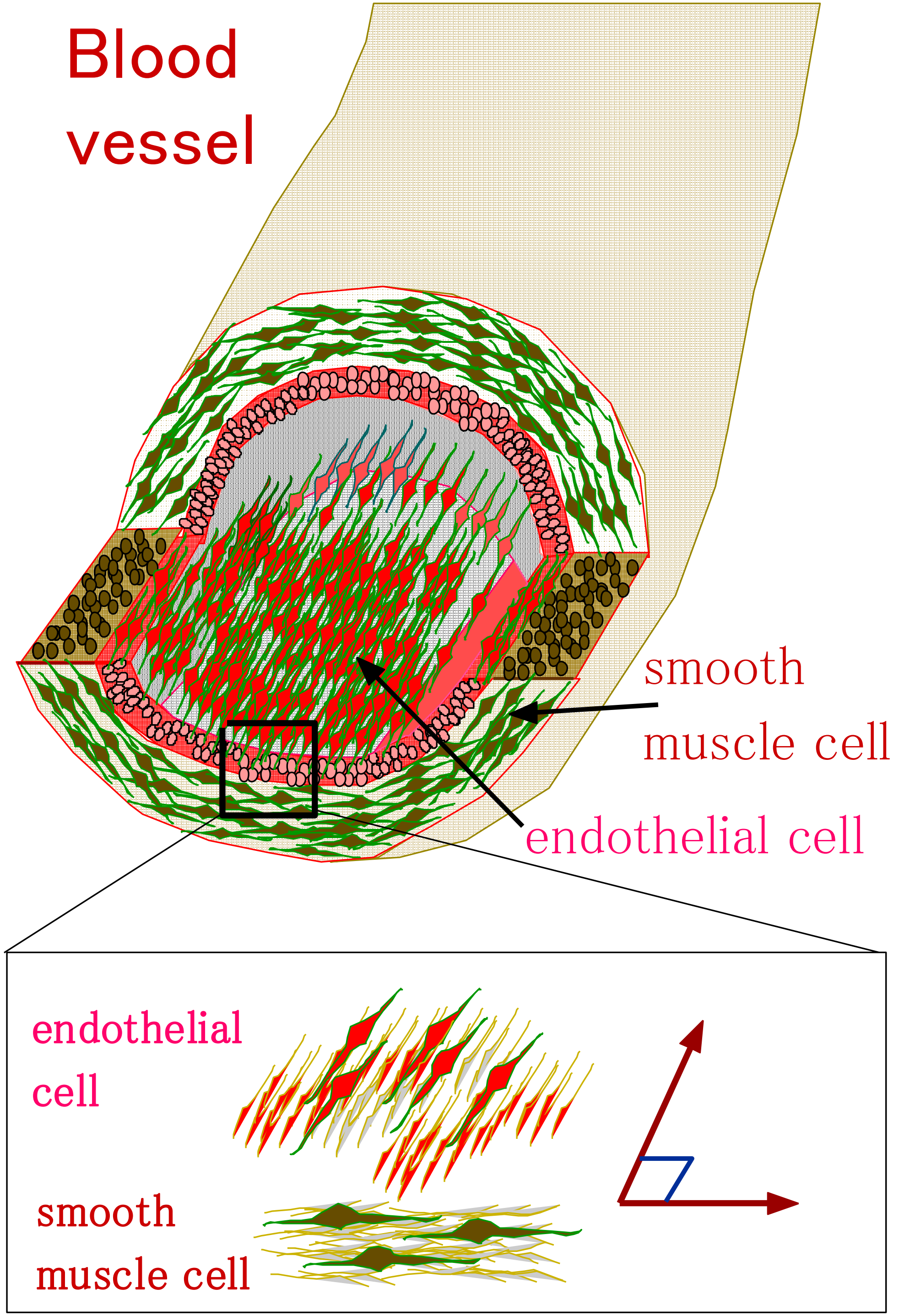
endothelial cells



smooth muscle cells



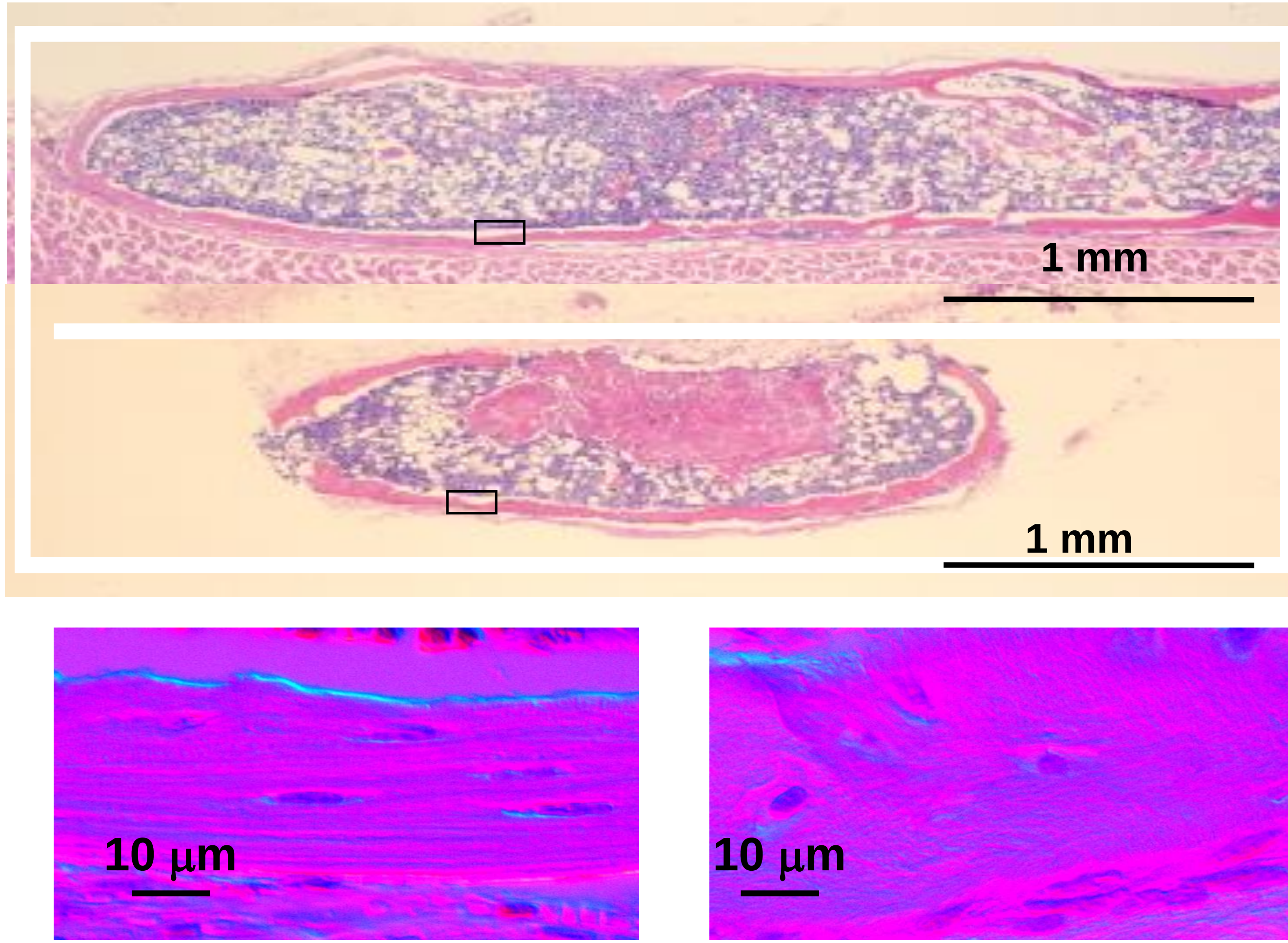
Schwann cells


Blood
vessel
smooth
muscle cell
endothelial cell
endothelial
cell
smooth
muscle cell

Direction of magnetic field

EXPOSED

CONTROL

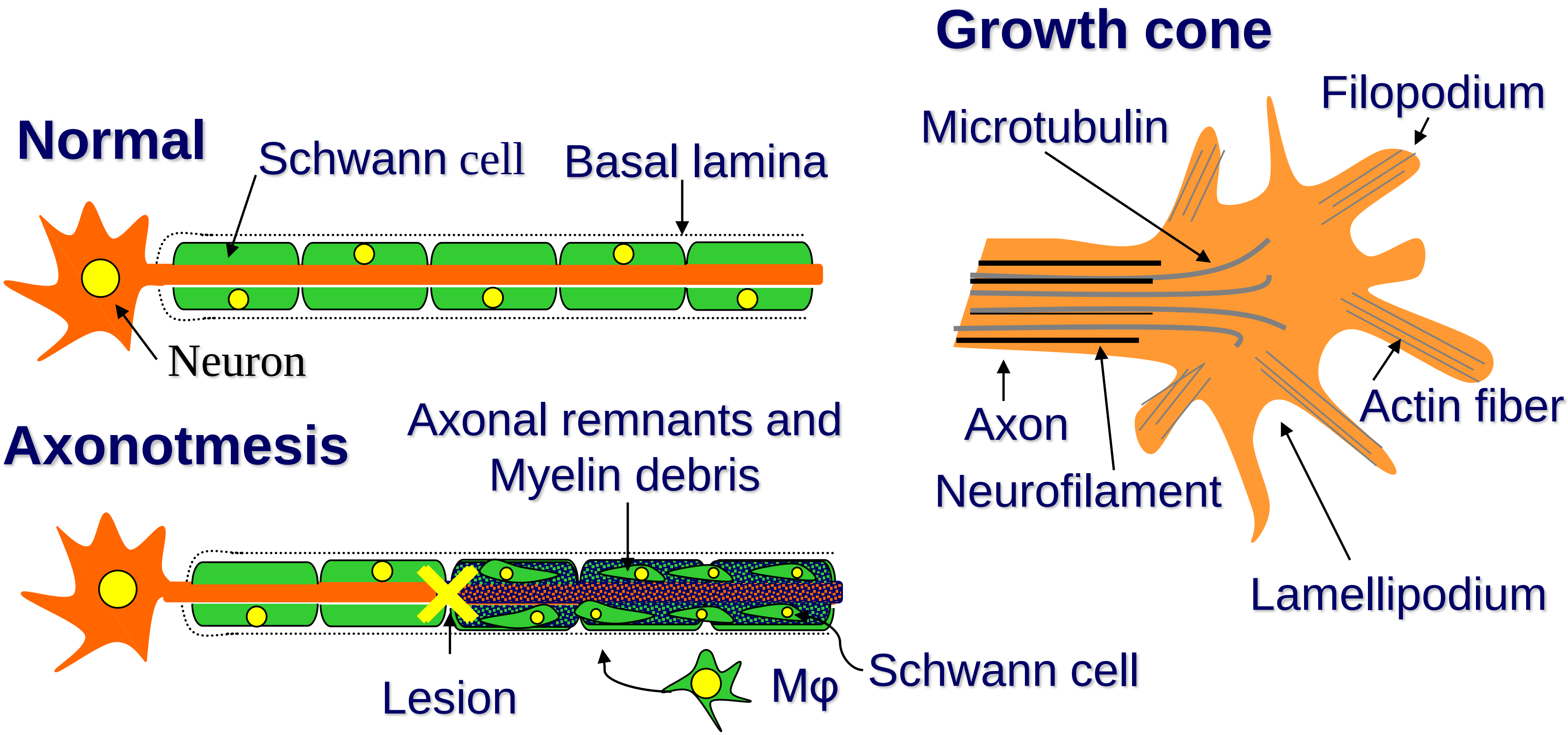


EXPOSED CONTROL

Ectopic bone formation was stimulated in and around subcutaneously implanted BMP-2 (bone morphogenetic protein)/collagen pellets in mice 21 days after 8 T magnetic field exposure for 60 h. The newly formed bone was extended parallel to the direction of the magnetic field.

H. Kotani, S. Ueno, et al. (2002)

Walerian degeneration & sprouting

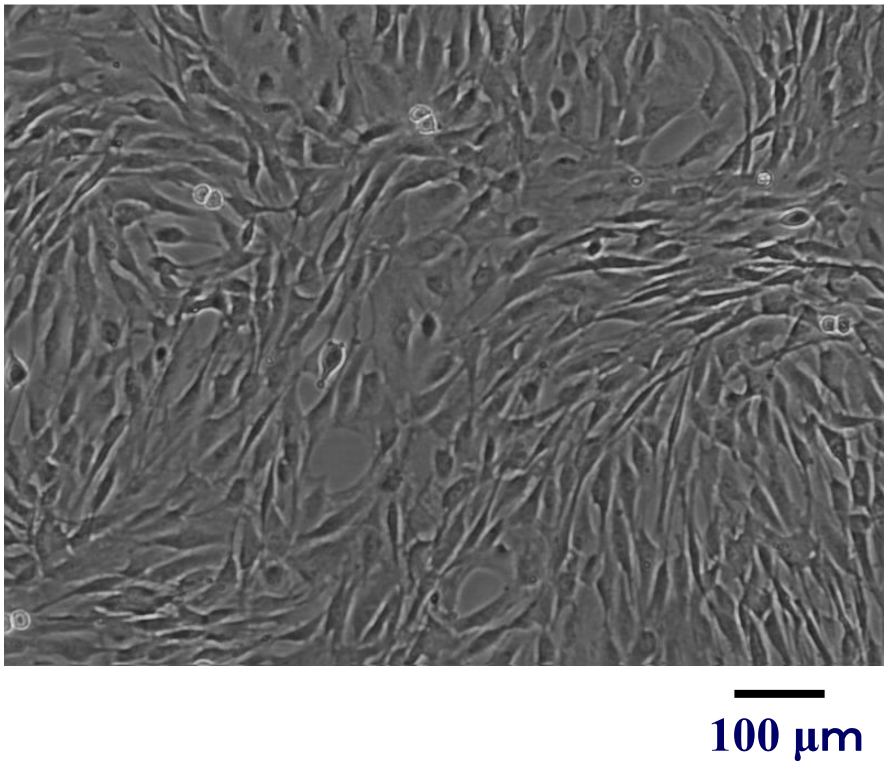


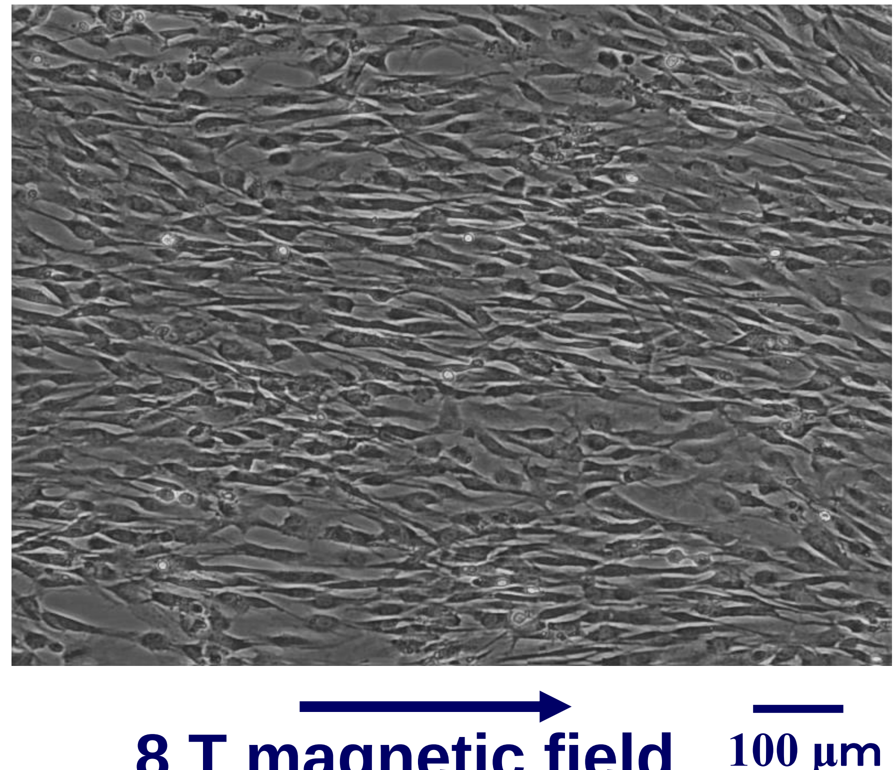
Schwann cell column
(Bungner band)

II

Guidance of regenerating axons

Magnetic orientation of Schwann cells

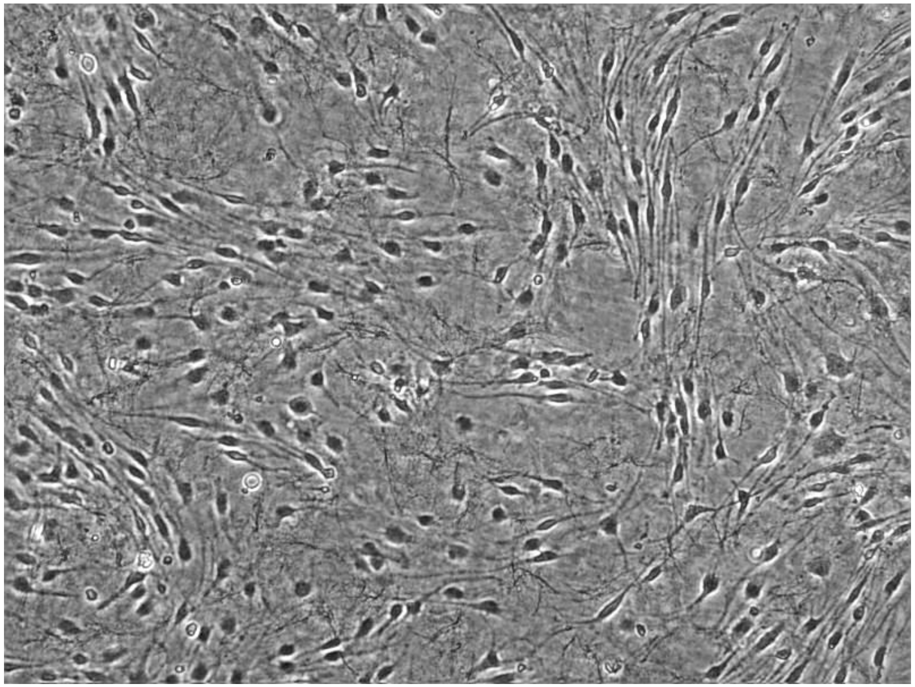




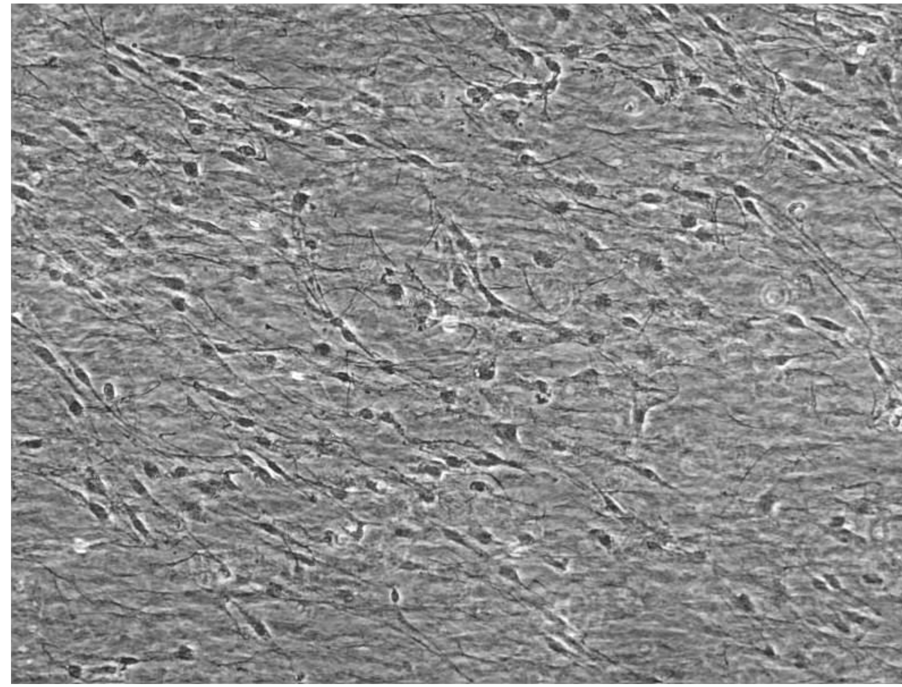
Schwann cells oriented parallel to the direction of the magnetic field after 8 T exposure for 60 h in the confluent condition.

Magnetic orientation of a mixture of Schwann cells and collagen

Control | **Exposed**



100 µm



Orientation of collagen fibers

100 µm

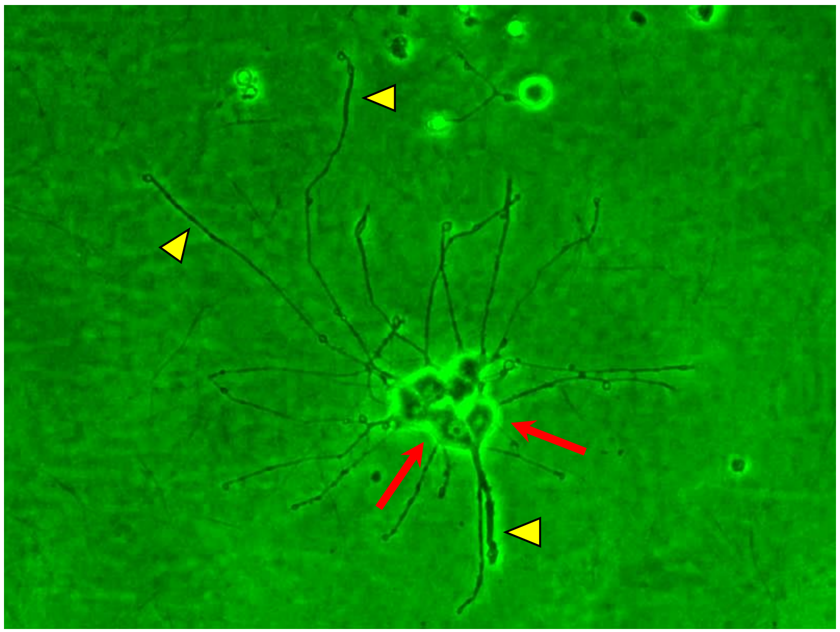
Schwann cell alignment along the magnetically oriented collagen fibers was observed on the 6th day in culture after 8 T magnetic field exposure for 2 h.

.

Axon elongation into magnetically aligned collagen

Mixture of PC12 (rat pheochromocytoma) cells and collagen (5 days)

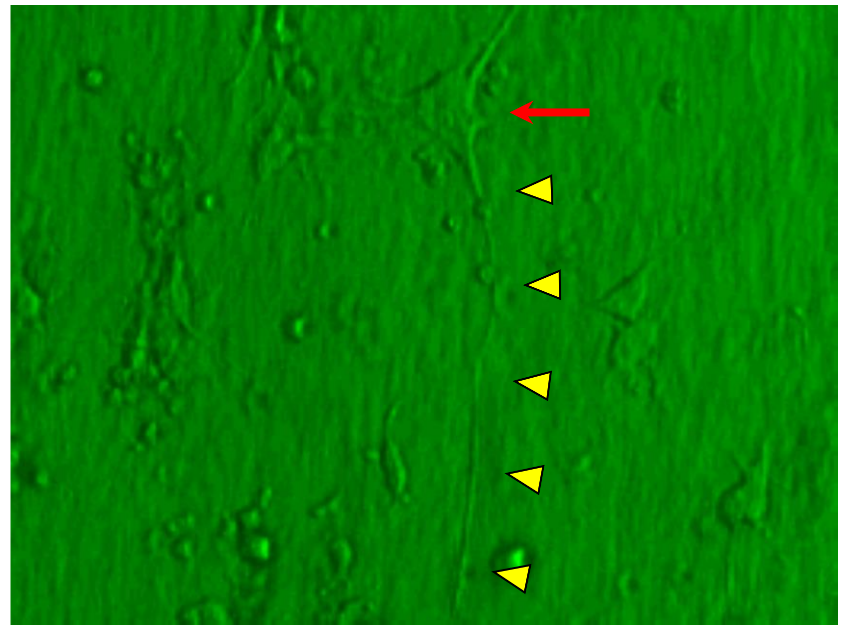
Control



←: soma
◀: axon

50 μm

Exposed



←: soma
◀: axon

→ magnetic field

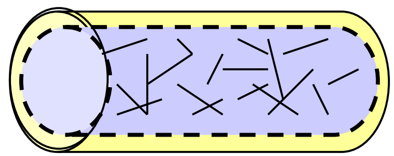
50 μm

↑ Orientation of collagen fibers

Magnetically aligned collagen provides a scaffold for neurons on which to grow and direct the growing axon.

Medical application for artificial nerve graft

Silicone tube
(length : 15.0 mm
inter diameter : 1.5mm)



Type Icollagen solution

〈 Control 〉

Incubation for 2 h

(37 ℃)

〈 Exposure 〉

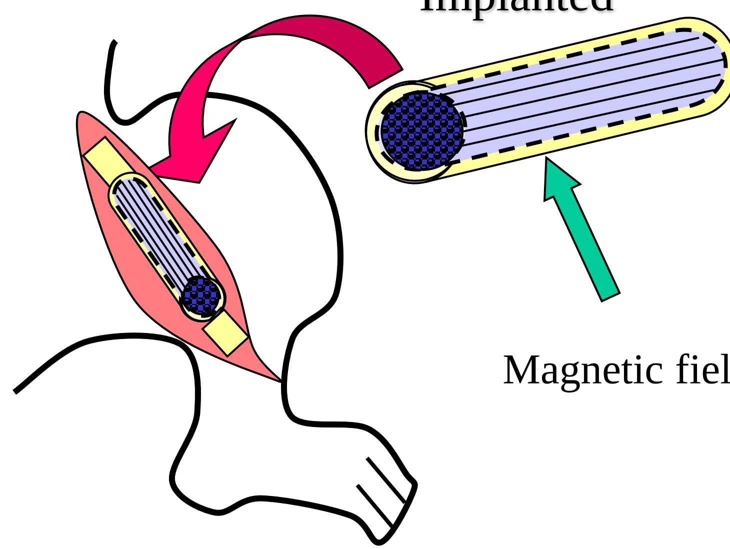
8-T exposure for 2 h (37 ℃)

Experimental groups

1) **Control (0T)**
2) **Exposed (8T)**

Examinations (po.12W)

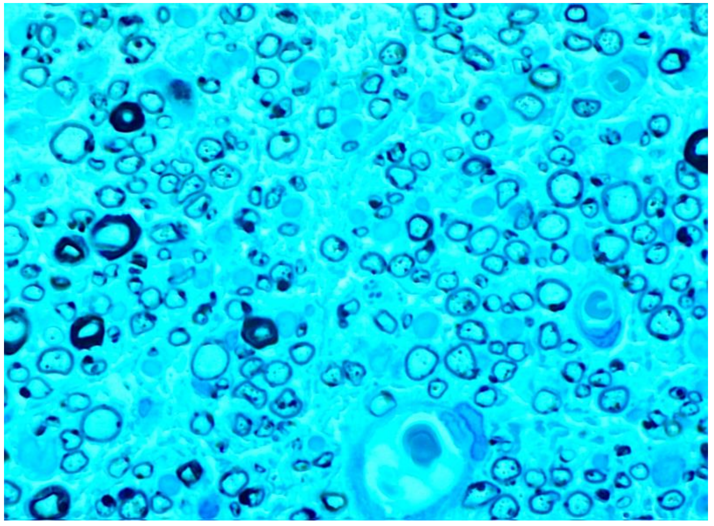
1) **% occupied neural tissue**
2) **Morphological examination**
3) **Nerve functional examination**



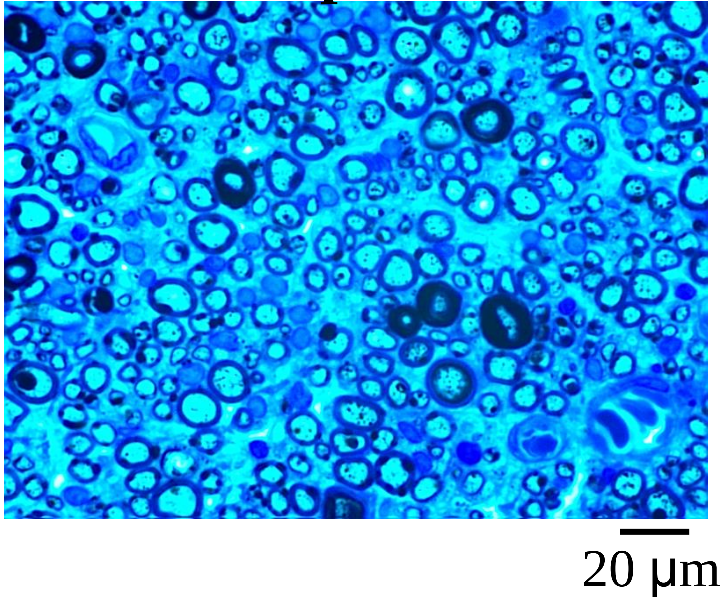
Wistar rat
Sciatic nerve defect

Morphological examination（12 w)

Control



Exposed



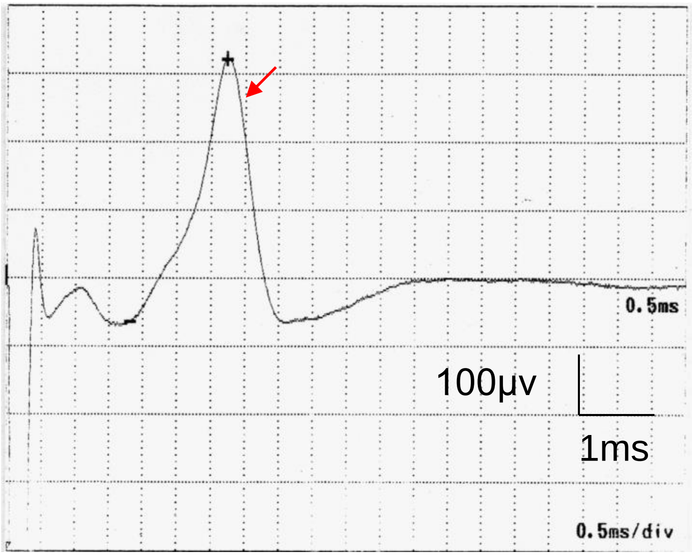
Numbers and diameters of myelinated fibers (po.12W)

	Control	**Exposed**
Numbers	274.0±11.7	373.4±27.6**
Diameters (μm)	5.53±0.064	5.81±0.087*

*p<0.05, **p<0.01

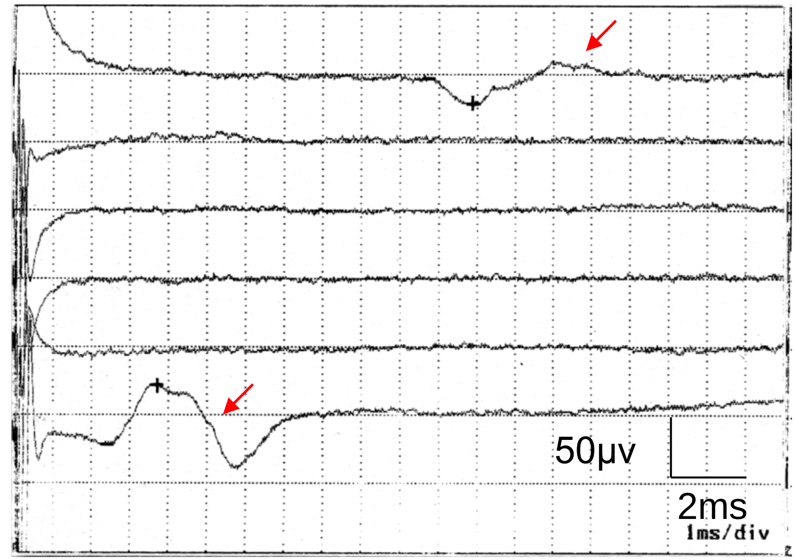
Nerve function（12 w)

Intact nerve



Amp.; 380μv
Lat.; 3.2 ms

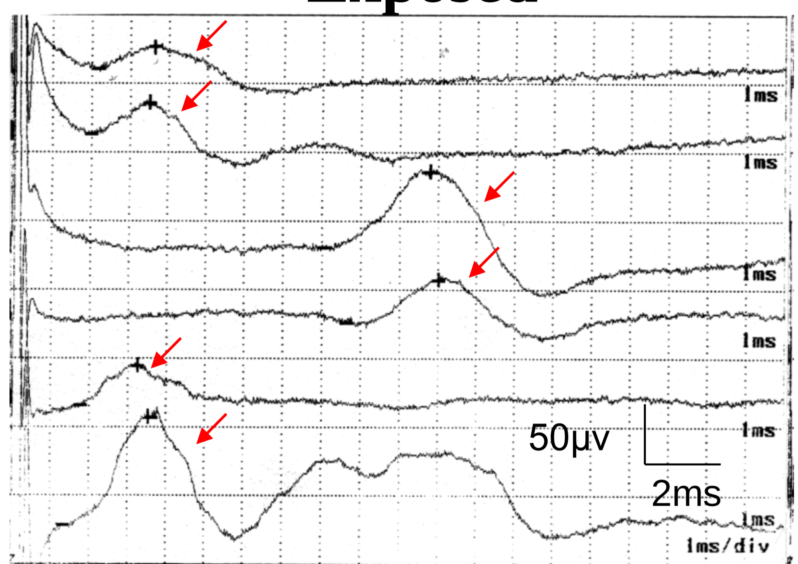
Control



N=2 / N=6

Amp.; 30μv
Lat.; 7.8 ms

Exposed

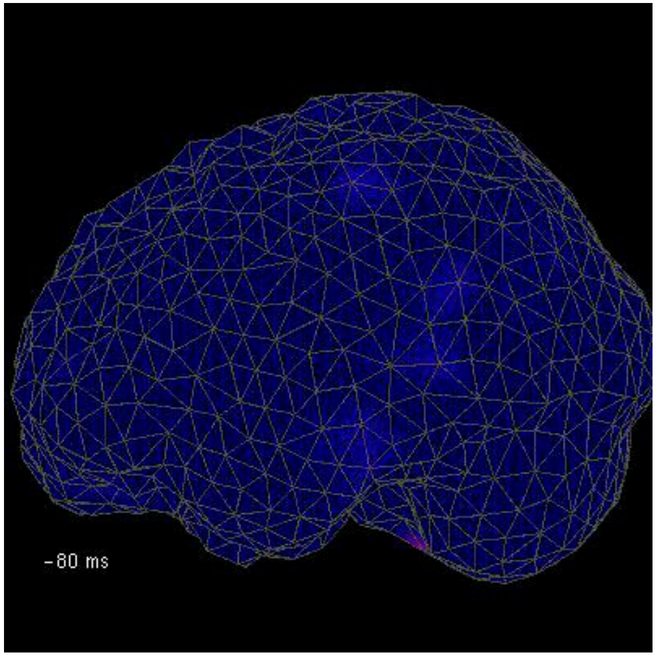


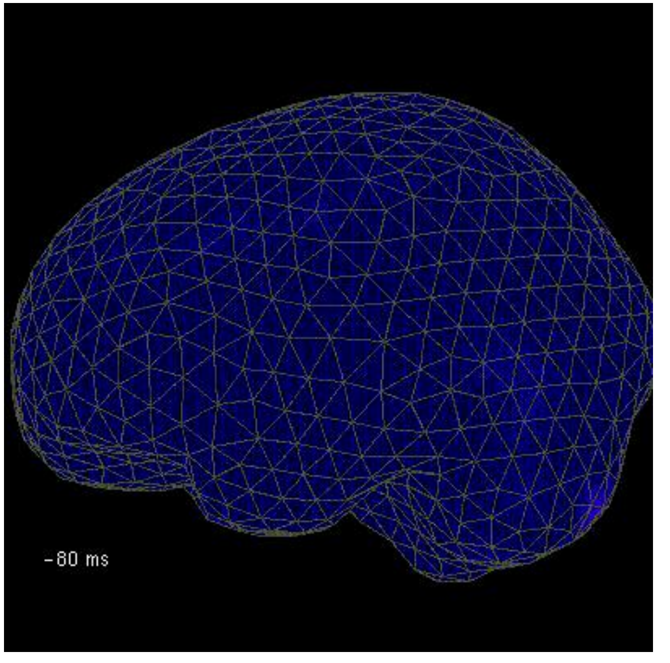
N=6 / N=6

Amp.; 40μv
Lat.; 5.9 ms

Action potentials were observed in all nerves in six exposed groups, but in only two nerves in six control groups

Reading of Kanji and Kana words: A comparative study between native and non-native speakers



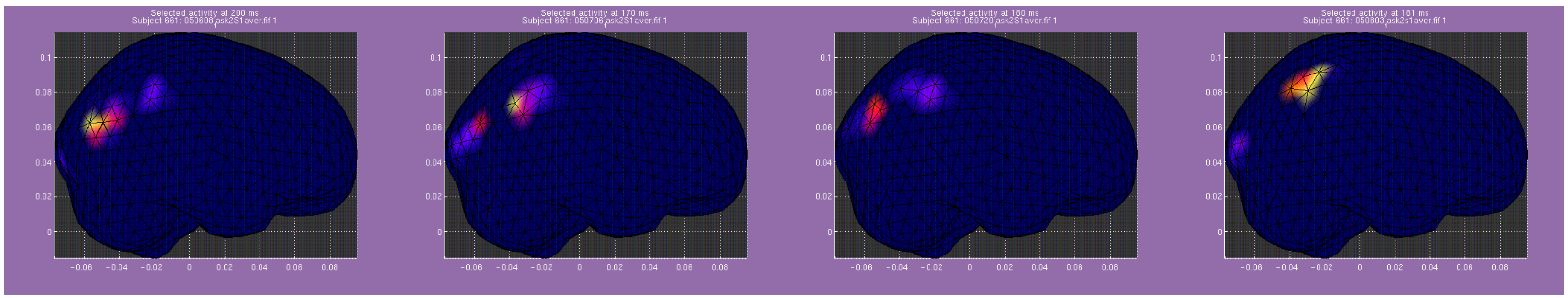


Kanji Reading

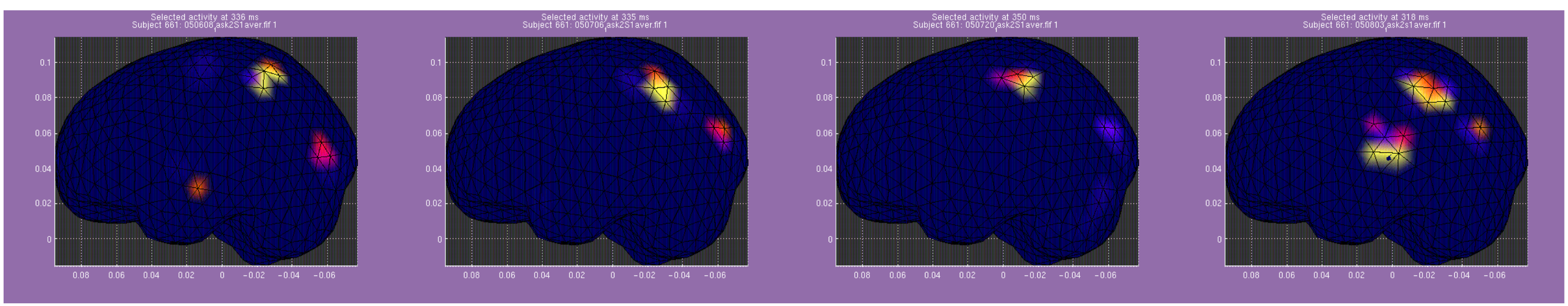
Left (Native), Right (Non-native)

Study of the Evolution of Neuronal Plasticity during the Learning of a New Language

Session: 1st 2nd 3rd 4th



Latency (ms): 200 170 180 181



Latency (ms): 336 335 350 318

Harvest time and seeding for tomorrow: List of Doctoral Degrees

Ph.D. in Graduate School of Medicine
Study on middle latency auditory evoked magnetic fields measured by MEG *
Takashi Yoshiura, February 1996
Study on the relationship between direction of induced electric fields and motor evoked potentials elicited by magnetic nerve stimulation with a figure-eight coil
Makoto Kobayashi, March 1998
Study on the effects of alternating magnetic fields on morphogenesis of SOD-deficient E. coli and slime molds**
Miyuki Kohno, March 1999
Dynamic encoding of facial information represented by neuronal responses in the primate temporal cortex
Yasuko Sugase, March 2000
Study on biological effects of repetitive pulsed magnetic stimulation and radio-frequency magnetic fields
Giichiro Tsurita, March 2000
Study on the effects of magnetic fields on bone formation in mice
Hiroko Kotani, March 2001
Study on vocabulary prosody (pitch accent) in understanding Japanese spoken language using MEG
Ryoko Hayashi, November 2001
Study on visually evoked magnetic fields associated with geometric and phonetic discrimination task
S F Huang, March 2003
Study on the effects of repetitive TMS on injured neurons in rat brain
Hirofumi Funamizu, March 2003
Study on injected current distribution images using diffusion weighted MRI
Kikuo Yamaguchi, March 2003
The effects of transcranial magnetic stimulation on the rat hippocampus
Mari Ogiue-Ikeda, March 2004
Study on the effects of repetitive TMS on autonomic nervous system in rats
Byonchoru Hong, March 2004
Study on the dominance of the left oblique view in activating the cortical network for face recognition
Yasuyuki Kowatari, March 2005
Source estimation of the P300 or P300m and P2 or P2m event-related responses using EEG and MEG
Takashi Maeno, March 2005
Study on evaluation of atrophic muscles after denervation using magnetic resonance imaging
Takako Saotome, March 2005
Study on character cognition processes in Chinese-Japanese bilingual using MEG
Hiroyuki Hara, September 2005
Study on reconstruction of nerve function under strong magnetic fields
Yawara Eguchi, March 2006

Dr. Eng. (Ph.D.) in Graduate School of Engineering
MEG measurements and source model in the brain*
Keiji Iramina, March 1991
H-reflex and modeling of nerve excitation elicited by magnetic stimulation*
Osamu Hiwaki, March 1992
Magnetic stimulation of the brain*
Tsuruo Matsuda, March 1992
High sensitive magnetic sensor by magneto-resistive effect using high-Tc superconducting ceramic materials*
Hideo Nojima, March 1993
Integrated DC-SQUID system for measurements of magnetic fields produced by the living body*
Kazuo Chinone, October 1993
Studies on the detection sensitivity of multinuclear magnetic resonance imaging and spectroscopy of biological tissues
Norio Iriguchi, December 1995
Effects of magnetic fields on blood coagulation and resolution processes
Masakazu Iwasaka, March 1996
Measurements and source estimation of the functional brain activities using MEG*
Hideki Yoshida, March 1996
Measurements and Inverse problem in MEG
Sunao Iwaki, March 1998
Modeling and estimation of distributed sources in the brain by EEG and MEG measurements
Kenichi Ueno, March 1998
Studies on transcranial magnetic stimulation (TMS): fabrication and safety aspects of TMS
Masaru Yarita, June 1998
Reduction of noise in SQUID magnetometer for measurement of living system
Yoichi Takada, September 1998
Source estimation of short-term memory and cognitive process in the human brain by MEG measurements
Seiji Nakagawa, March 1999
Cortical activations of Japanese-English mental transration revealed by fMRI and MEG
Netsiri Chaiyapoj, March 1999
Studies on behaviors of erythrocyte under strong magnetic and electric fields
Takao Suda, December 1999
Measurements of brain and cardiac electric activities of rats by a SQUID system with a high spatial and temporal resolution
Seiya Uchida, March 2001
Brain electrical activities associated with perception of visual apparent movement
Ryoichi Tsuda, March 2001
Studies on the effects of static magnetic fields on microcirculatory hemodynamics and blood pressure in mammals
Hideyuki Okano, September 2002
Magnetic resonance imaging and numerical simulations of electric phenomena in living bodies
Masaki Sekino, March 2005

Data processing in the brain associated with mental rotation task
Hiroaki Kawamichi, January 2006
RF inhomogeneity correction method for quantitative magnetic resonance imaging
Hiroaki Mihara, March 2006
Studies on relaxation and diffusion processes of water molecules in fibral gel states by magnetic resonance imaging technique
Michihiro Tekeuchi, 2006 (on going)

Master Degree in Medicine

Studies on the effects of pulsed magnetic fields on tumors
Sachiko Yamaguchi, March 2004

Master Degree in Engineering

Study of short-term memory processes in the human brain by MEG
Kenji Yamanami, March 1997
Study of induced electric fields and nerve excitation model in TMS
Ren Liu, March 1997
Studies on rf inhomogeneity and its correction in MR imaging
Hiroaki Mihara, March 1998
Effects of magnetic fields on hemoglobin oxygenation and deoxidation
Masakatsu Hori, March 1998
Auditory evoked magnetic fields responded to various sonic stimuli
Tomohiro Morikawa, March 1998
Effects of magnetic fields on oxygen dissolving process into water
Nobuo Yagi, March 1999
Study on a method to visualize tissue conductivity by MRI
Yasuhiro Yukawa, March 1999
Study on nerve excitation processes exposed to strong magnetic field exposures
Naoki Ishihama, March 2000
Studies on the effects of magnetic fields on oxygen adsorption of hemoglobin and oxygen dissociation
Yutaka Yoshimura, March 2000
Quantitative evaluation of alignment of adherent cells oriented by strong magnetic fields
Akinori Umeno, March 2002
Electric current imaging based on magnetic resonance imaging
Masaki Sekino, March 2002
Study on MR imaging using a frequency shift method
Tatsuki Matsumoto, March 2003
Studies on metabolism of muscles and evaluation of tissue structures using magnetic resonance
Ruwan Victor Perera, March 2004

Study on estimation of in vivo distortion by diffusion tensor magnetic resonance imaging
Akihisa Kaneko, March 2004
Study on restricted diffusion of water molecules in the living body using diffusion weighted MRI
Masato Sano, March 2004
Study on imaging of extremely weak magnetic fields caused by electric currents using MRI
Hirohisa Hatada, March 2005
Study on visually evoked magnetic fields responded to visual stimuli associated with sense of taste
Maki Tagaya, March 2006
Study of language and cognitive processes through magnetoencephalography
Takai Rafael Barbosa, Marc 2006
Study on source estimation in EEG and MEG using mutual correlation coefficient
Masuji Yamada, March 2006

Ph.D. candidates at Graduate School of Medicine

Study on measurement of electrical activities in nerve-muscle junctions using a high sensitive magnetic sensor
Hikari Tachikawa
Assessment of visual and auditory working memory processes in the human brain using noninvasive electromagnetic measurements
Klevest Gjini
Studies on the effects of pulsed magnetic fields on tumors
Sachiko Yamaguchi

*	given by Kyushu University
**	given by Osaka University
No marks	given by the University of Tokyo

Prof Ueno was awarded *Doctor Honoris Causa* from Linkoping University on 6th June 1998.

President Bertil Andersson and Professor Anders Tornval visited the University of Tokyo on 16th August 2001.

Professor Bertil Andersson, President, Linkoping University Sweden, enjoyed the TMS.

Tokyo-universitetet

dpunkten ligger på teknik-
men vi räknar med att
ofiska fakulteten ska kun-
tta av avtalet, säger Anders

fram till ett avtal har varit
första kontakten togs re-
m år när Anders Törnvall
l:s dekanus Mille Millnert
n dåvarande dekanen för
fakulteten. Men det var
rektor Bertil Andersson
sedan träffade sin rektors-
asaki som samarbetspla-
fastare form. Sedan dess
rån båda sidor filat på in-
avtalet.
kelperson i kontakterna

har varit professorn i medicinsk teknik Shoogo Ueno, vars mångåriga samarbete med Linköpingsprofessorn Åke Öberg ledde till att han blev hedersdoktor vid Linköpings universitet 1998. Professor Ueno är väl bekant med Linköping, inte minst efter sina två år som gästforskare här 1979-81.

Det var också professor Ueno som representerade Tokyo-universitetet vid undertecknandet av avtalet.

– Rektor Sasaki hade ingen möjlighet att komma nu, men kommer hit i höst tillsammans med sin vice rektor, berättar Anders Törnvall.

LENNART FALKLÖF

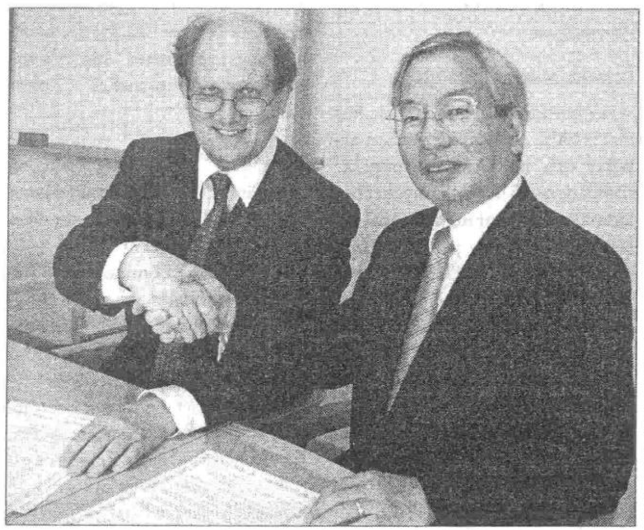


FOTO: GUNILLA PRAVITZ

Ett handslag för ett gott framtida samarbete! Rektor Bertil Andersson och den japanske professorn och hedersdoktorn Shoogo Ueno.

Prof Shoogo Ueno visited President Bertil Andersson at Linkoping University, Linkoping, Sweden, on behalf of President Takeshi Sasaki, the University of Tokyo, on 3rd June 2002.

International symposium on electromagnetics in biology and medicine, April 2-4, 2001

S. Ueno, Chairman, Commission K: Electromagnetics in Biology and Medicine, URSI (The International Union of Radio Science)

Boat cruise on the Sumida River, April 5th, 2001

VOLUME 20, NUMBER 2, 1999

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JOURNAL OF THE BIOELECTROMAGNETICS SOCIETY

THE SOCIETY FOR PHYSICAL REGULATION IN BIOLOGY AND MEDICINE

THE EUROPEAN BIOELECTROMAGNETICS ASSOCIATION

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S. Ueno, President, The Bioelectromagnetics Society (BEMS), 2003-2004


'05 6 20


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P-C-120
P-A-121
'05 6 21


'05 6 23


'05 6 22

ME Forum, Science Council of Japan

Sanjo Conference Hall,
the University of Tokyo

1	December	1994
2	December	1996
3	December	1998
4	December	1999
5	January	2001
6	January	2002
7	January	2003
8	January	2004
9	January	2005
10	January	2006

Discussion at ME Forum

Sanjo Conference Hall, the University of Tokyo

Annual Conference of Japanese Society for Medical and Biological Engineering
at Tsukuba, Japan, 24th~ 27th April 2005.


'97 3 11


'97 3 11

Annual Meetings of the Magnetics Society of Japan, Koganei, Tokyo, Japan, September 2002.

Annual Meeting of the Magnetics Society of Japan, Nagano, 19th~22nd September 2005.


'04 5 17


HISTORIC DISPLAY
'98 8 29


WELCOME
WELCOME
'06 1 13


'04 5 12


'04 3 27





'03 10 13


'03 10 12


Radi Flyer
RED WAGON
'03 10 11


'03 10 11

Mother Sue and Father Haruo Ueno

I thank all of you for your supports and guidance over the years.

I wish you all the best and success in the future.

I hope the University of Tokyo goes onward for further leap and development.

Thank you very much for your attention.

Thousand Thanks !!

Shoog Ueno