

Innovative Approaches to Engineering Education
CAETS/HAE Symposium
Hotel Gellert, Budapest, Hungary
June 27th, 2013

Brain-Science-Based Education A Frontier of Neuro-Engineering

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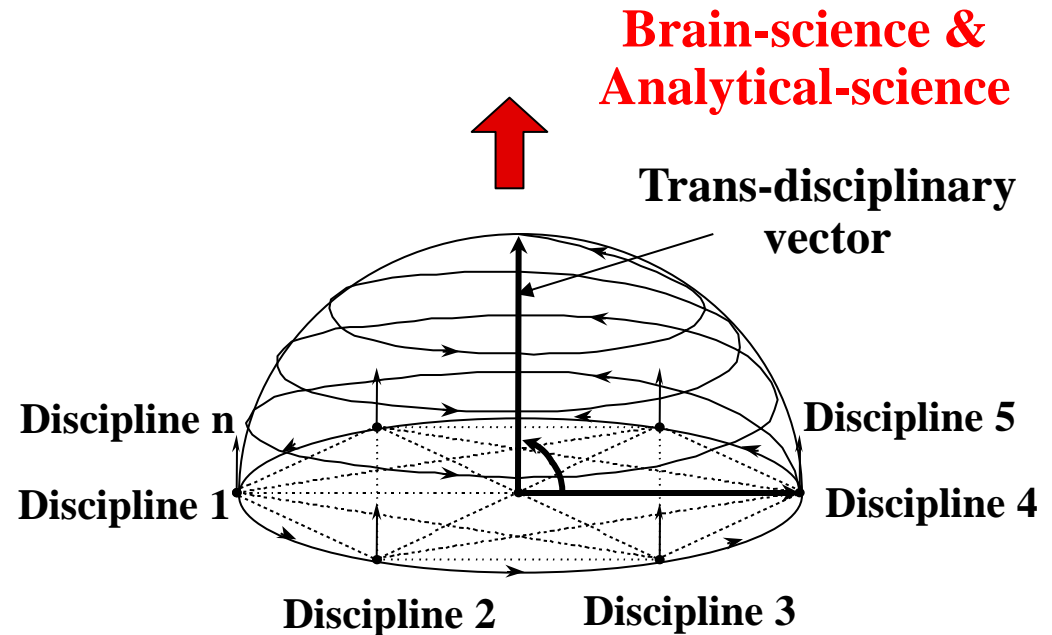
Fellow and Corporate Officer, Hitachi, Ltd.
Director, Chair of Committee on International Affairs,
Engineering Academy of Japan

Integration over Reductionism

Trans-disciplinary (TD) studies

- Dynamic process of adding a new dimension to multi-disciplinarity
- Fusing and bridging different disciplines to create a new field
- Collaboration between scientists/scholars and practitioners

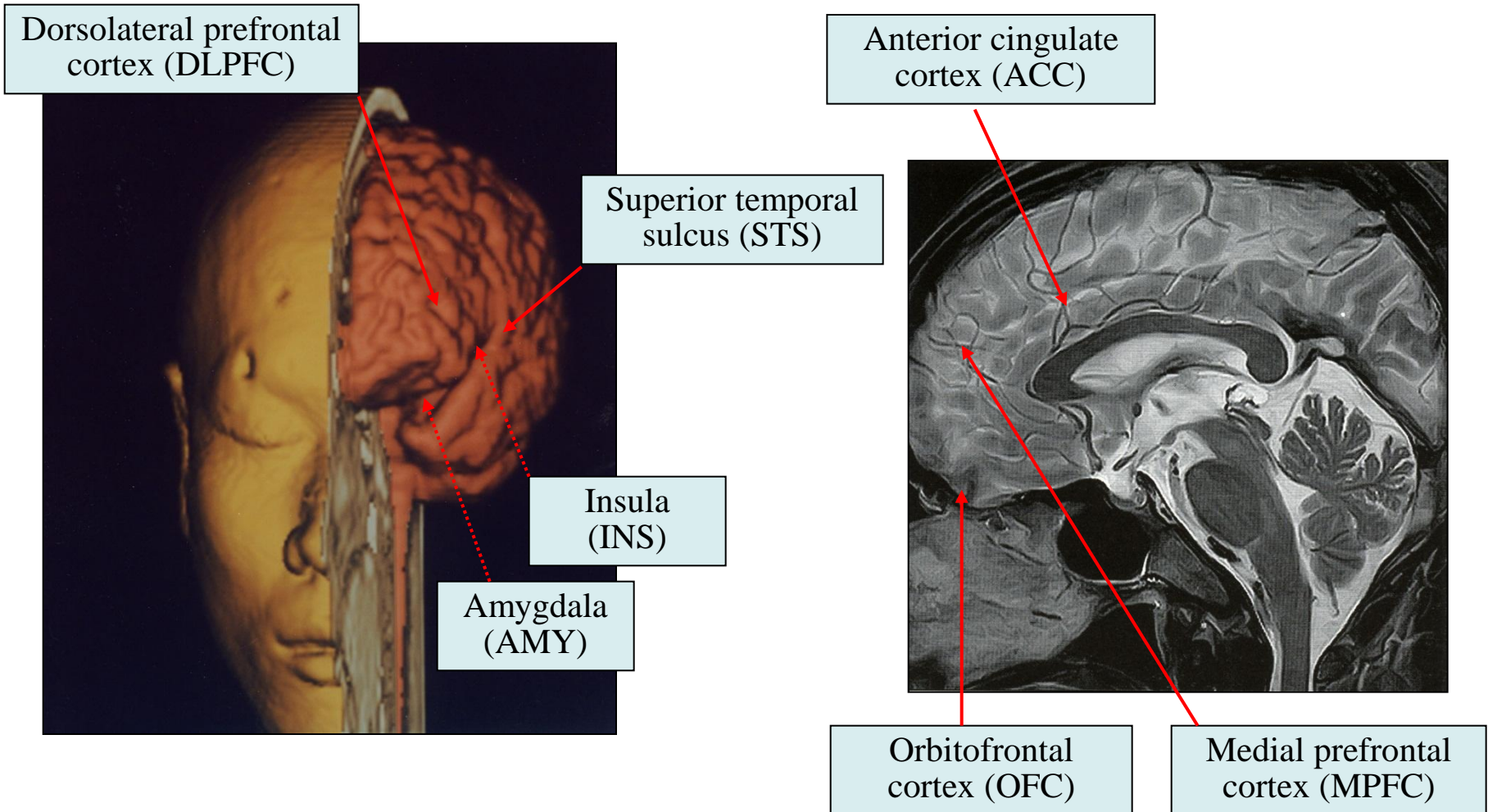
Emergence of a new field



Toward Human Security & Well-Being

Koizumi, H., *J. Seizon and Life Sci.* (1999);
Koizumi, H., *Neuro. Endocrinol. Lett.* (2001)

Brain Areas Activated in Social Decision Making



From the results in a Review by Sanfey, A.G.
“Social Decision -Making: Insights from Game
Theory and Neuroscience, *Science* (2007)

MR Images by Hitachi Ltd. and Hitachi Medical Co.

Difference between Human Beings and Chimpanzees



Modern Humans

- have language ability based on hierarchic grammar
- make and use complicated tools
- educate offspring
- have high-level emotions such as compassion or hatred
- have clear concept of the future



Chimpanzees

- do not have hierarchic grammar. Verbal communication is merely a line-ups of sounds.
- use extremely simple tools such as stone tools to crack nuts
- offspring learn through imitation
 - not purposeful education
- share primitive reflexes such as neonate smile with human beings.

New Definitions of Learning & Education for “Brain-Science & Education” Research

- **Learning**

The process of making neuronal connections
by external environmental* stimuli

*Environment: everything except self

- **Education**

The process of controlling or adding stimuli,
and of inspiring the will to learn

**These concepts are comprehensive, covering
the whole human life span**

Self-learning or self-education = self-preparation of environmental stimuli
Passive or active (emotion/reward)

A trial to separate “values” for scientific studies

( Brain-Science & Ethics)

Koizumi, H., *Kagaku (Science)* (2000);
Koizumi, H., *Brain & Development* (2004)

Two Aspects of Brain-Science & Ethics

1. Ethics of Brain-Science

Neuro-ethics

2. Brain-Science of Ethics

Neuroscience approach to ethics



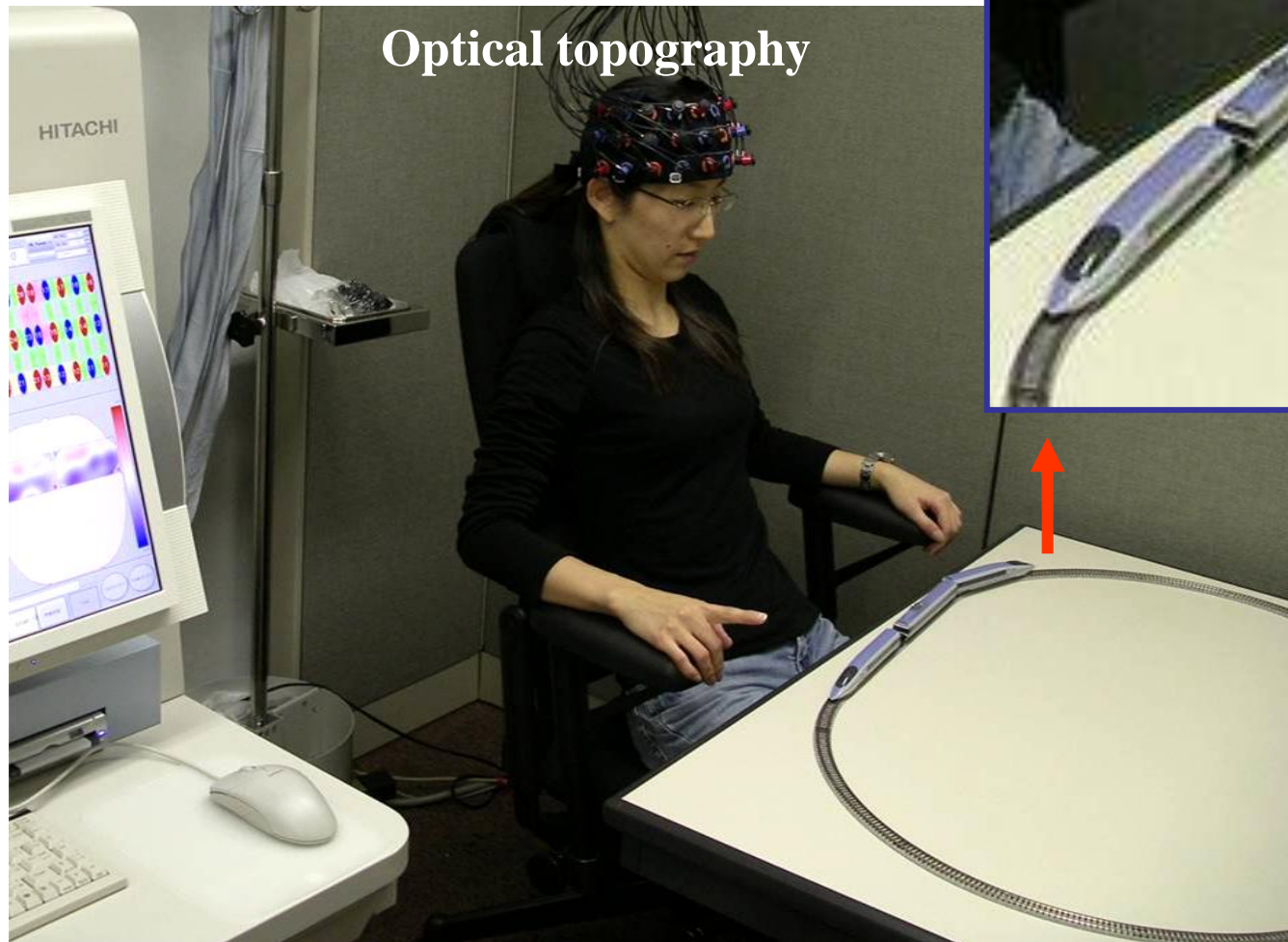
Brain-Science & Social Norms

Koizumi, H., Progress in Brain-Science, *Asahi-Newspaper*, July 11 (2005)
(This article was used for entrance examinations by three universities)

Aoki, R., Funane, T. & Koizumi, H., *MBE* (2010)

Control by Thought Only

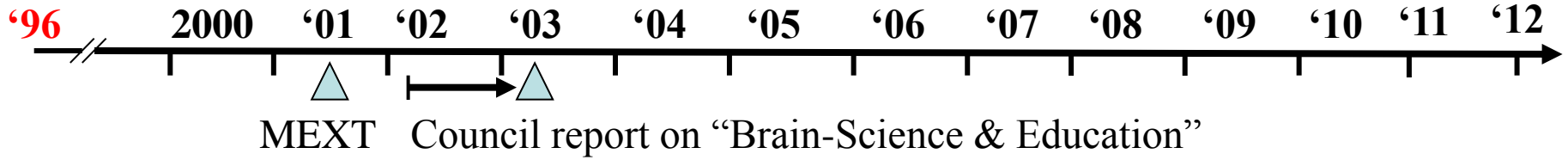
BMI: Brain Machine Interface



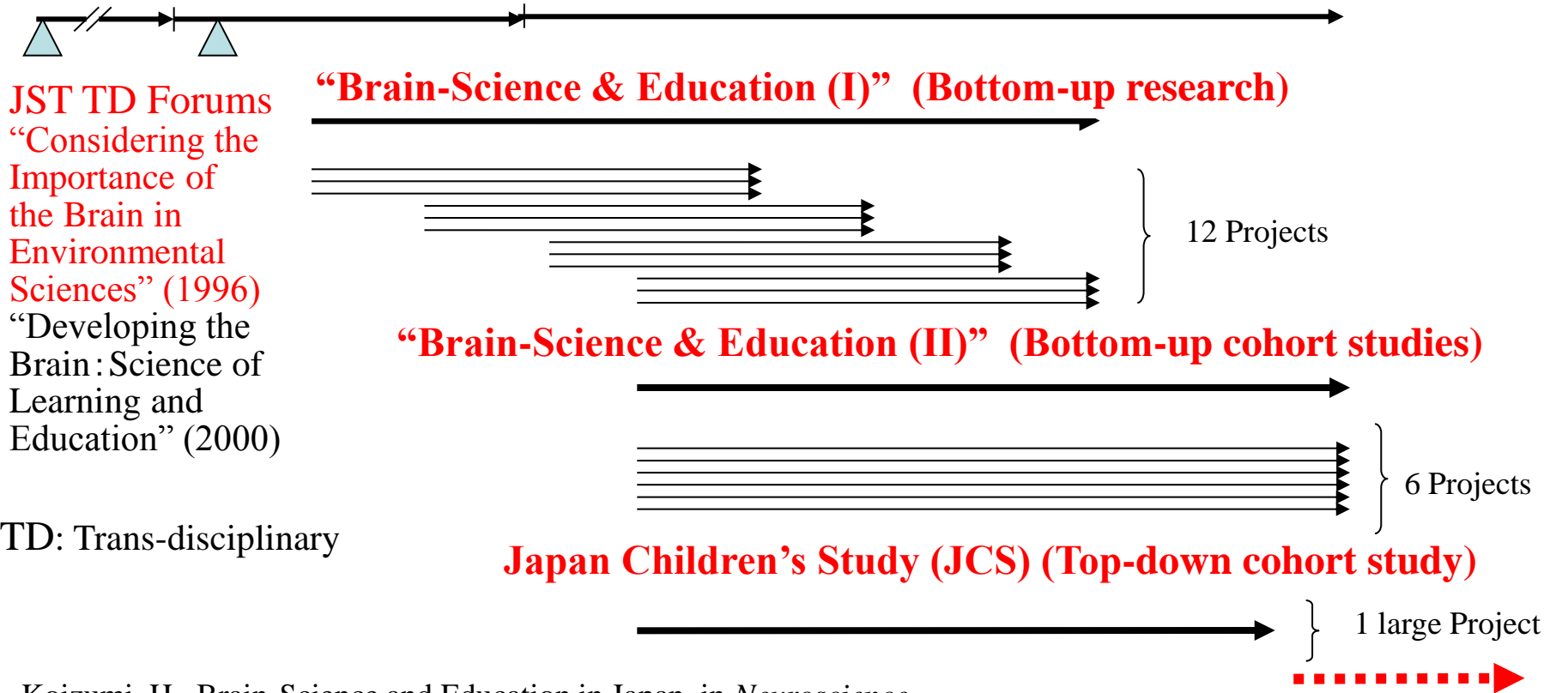
Hitachi CRL, SDL (2006), Utsugi T., Koizumi H., et al, *Conf Proc IEEE Med Biol Soc* (2007)

“Brain-Science & Education” Initiatives at JST

Director: Koizumi, H.



Japan Science and Technology Agency (JST)

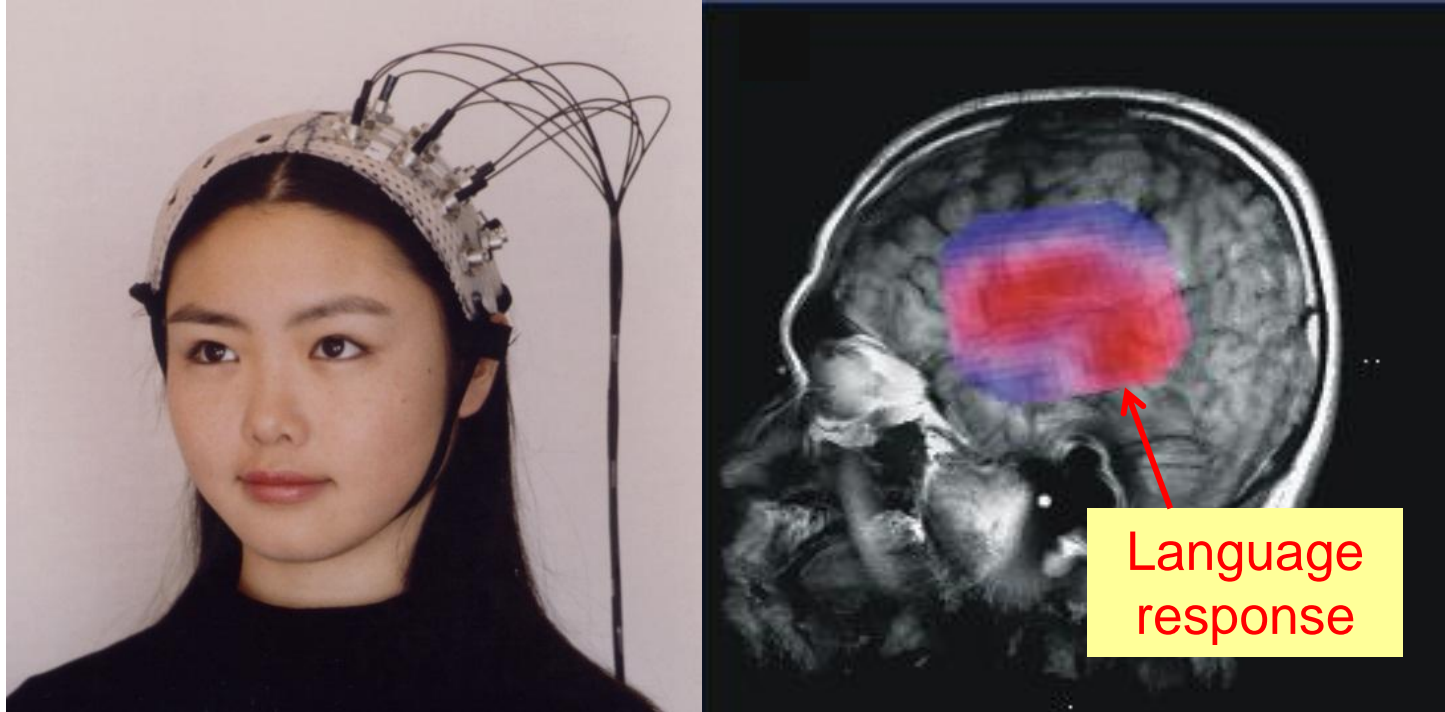


TD: Trans-disciplinary

Koizumi, H., Brain-Science and Education in Japan, in *Neuroscience in Education* (ed. Della Sala, S. et al.), Oxford University Press (2012)

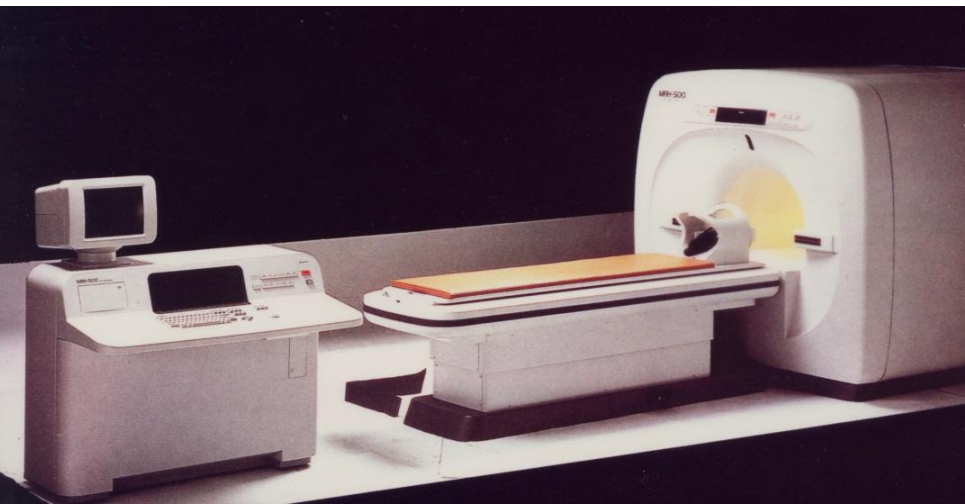
National plans in brain science

Optical Topography



One of the four breakthrough technologies nominated by MIT Technology Review in 2003

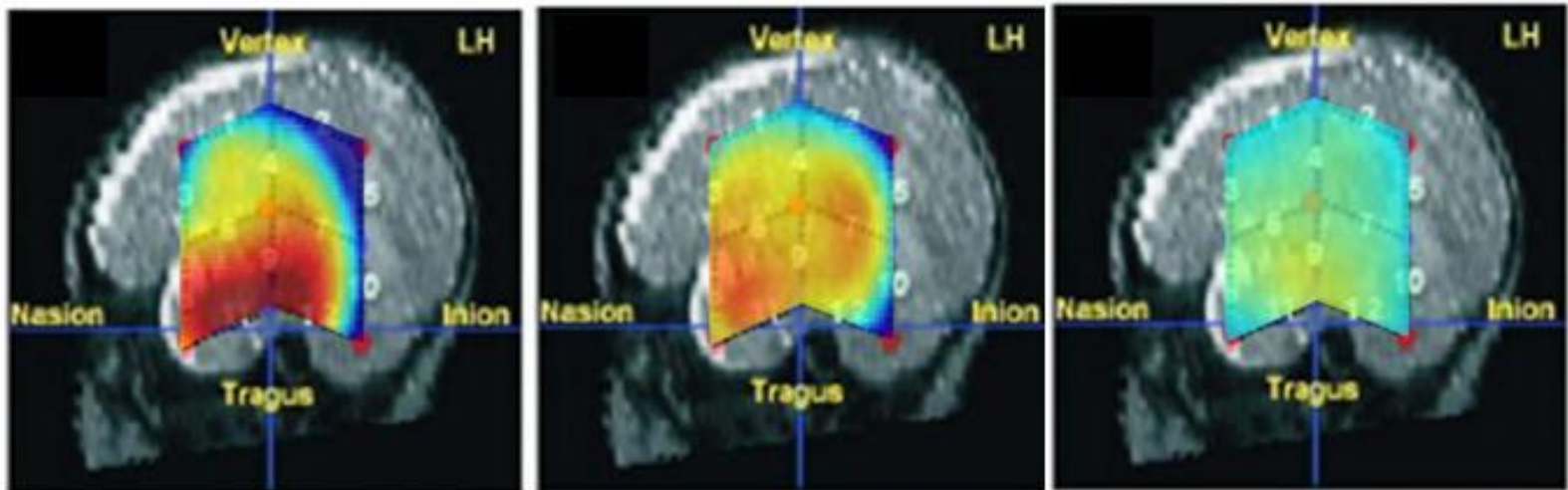
Maki A., Koizumi H. et al, *Med Phys* (1995); Yamashita Y., Koizumi H. et al, *Rev Sci Instrum* (1996);
Koizumi H., Yamashita Y., Maki A., et al, *J Biomed Opt* (1999)



MRI/MRA/fMRI

Koizumi H., *Rinsho Hosyasen (Clinical Radiology)* (1986)
Hitachi MRH-500 (Grand Prize in Health & Warfare Category,
Good Design Products selected by MITI 1990)

Brain Activity in Hearing the Mother Tongue



Mother tongue
listening

Reverse tape
listening

No sound

Neonates: Within 5 days of birth

Mother tongue: **Italian**

In collaboration with J. Mehler's group, International School for Advanced Studies in Italy, *Proc. Natl. Acad. Sci. USA* (2003)

Mobile Experimental Station with NIR-OT and EEG

Higher-order Brain-function imaging
at many schools



64 ch. near infrared optical topography (NIR-OT), 64 ch. Electroencephalography (EEG)

Hagiwara H., Tokyo Metropolitan University (JST/Brain-Science & Education (II))

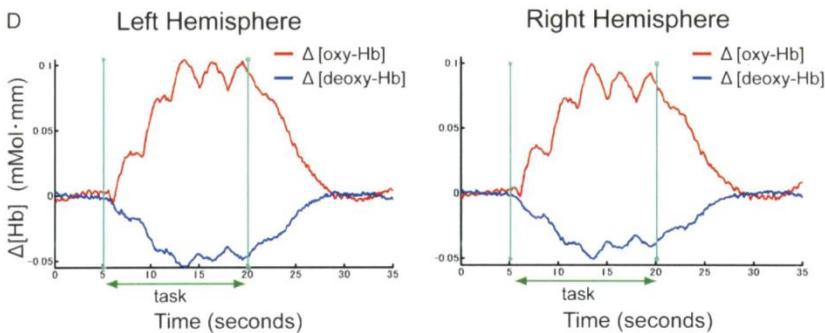
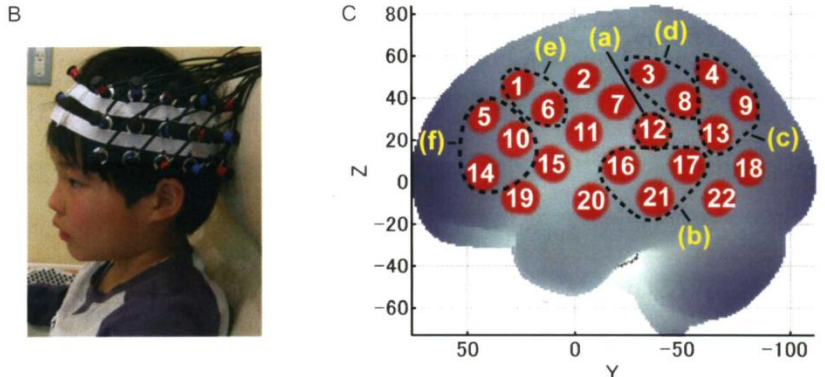
Cohort Study on 2'nd Language Acquisition

Method: Cohort Study with NIR-OT

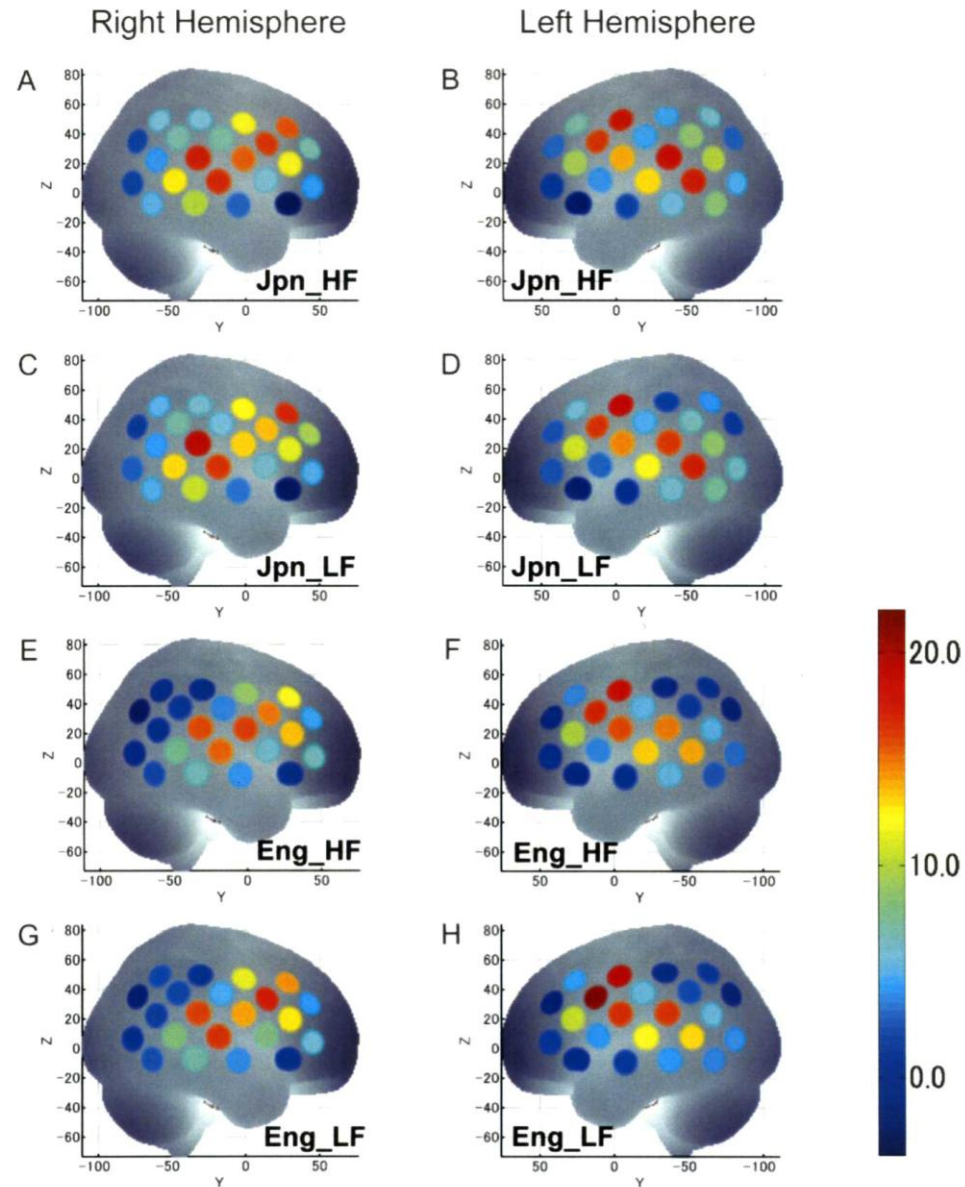
Subjects: 484 (248f., 236m.) children from 7 elementary schools aged 8.93 ± 0.89

Task: High & low freq. words reproduction

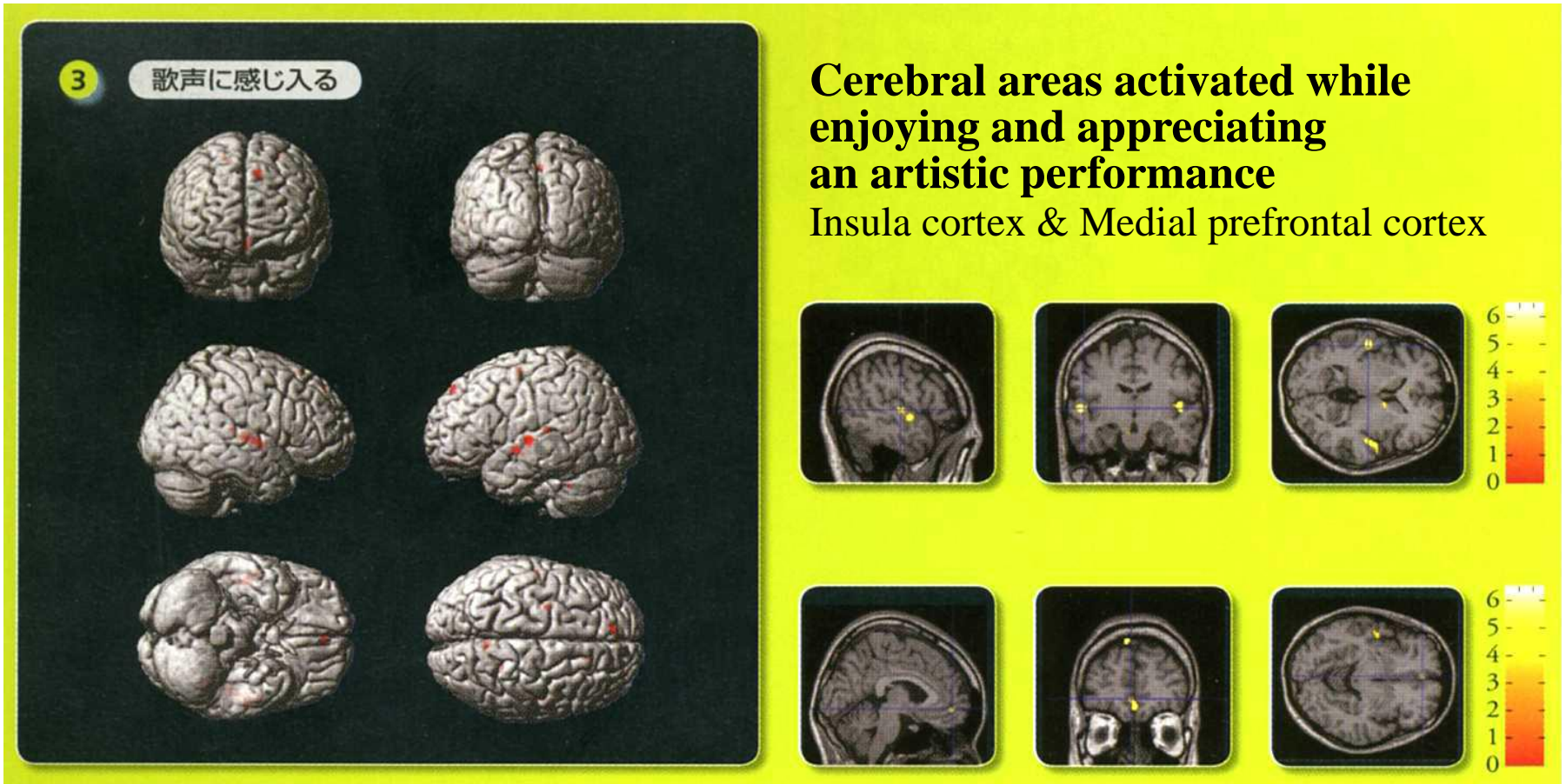
Sugiura, L., Hagiwara, T. et al., *Cerebral Cortex*, (2011)



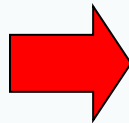
Ch.6 (BA44) for 392 subjects



Brain Activities when We are Emotionally Moved



Insular cortex is activated



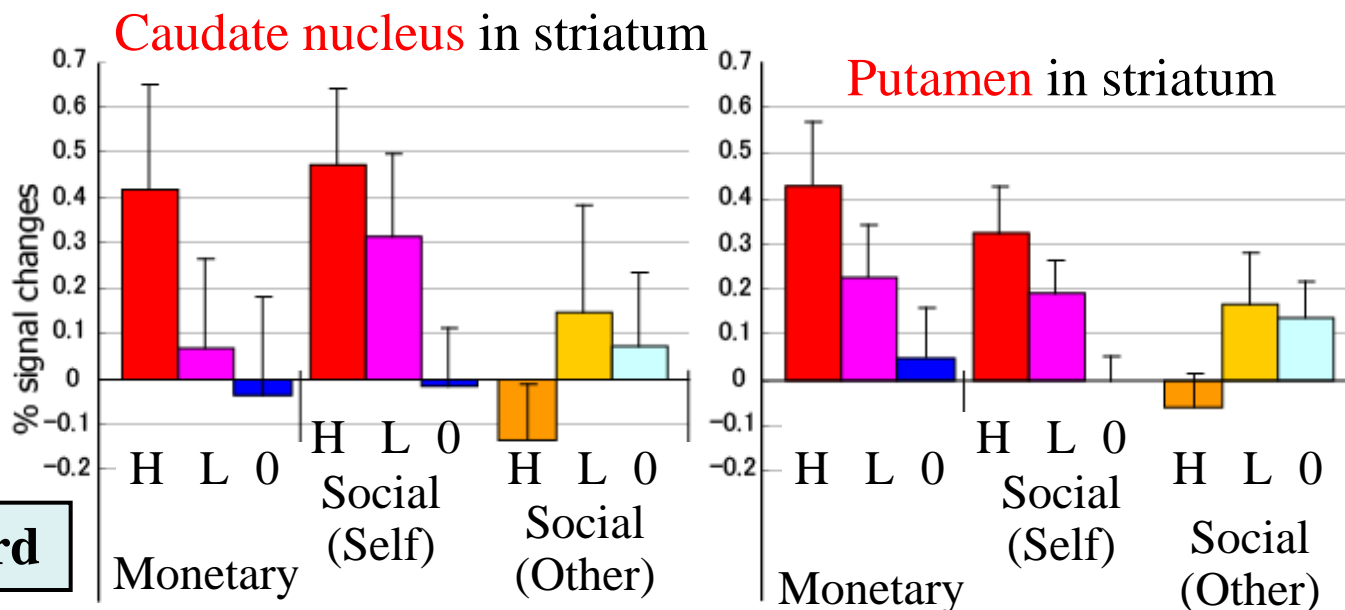
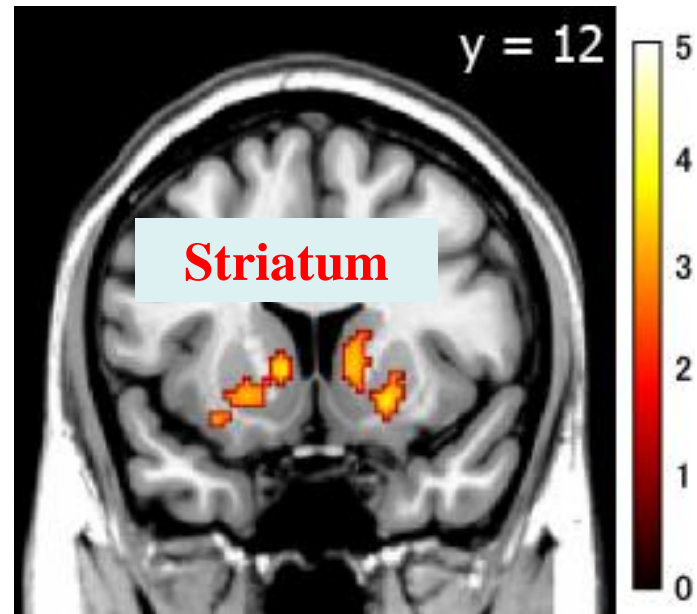
Integrated information processing from signals throughout the whole body

Courtesy of Turner, R. Compiled/edited by Koizumi, H., *Brain-Science and Art*, Kosakusha (2008)

Activation of the Striatum by Monetary and Social Rewards

Japan Children's Study (JCS), RISTEX/JST

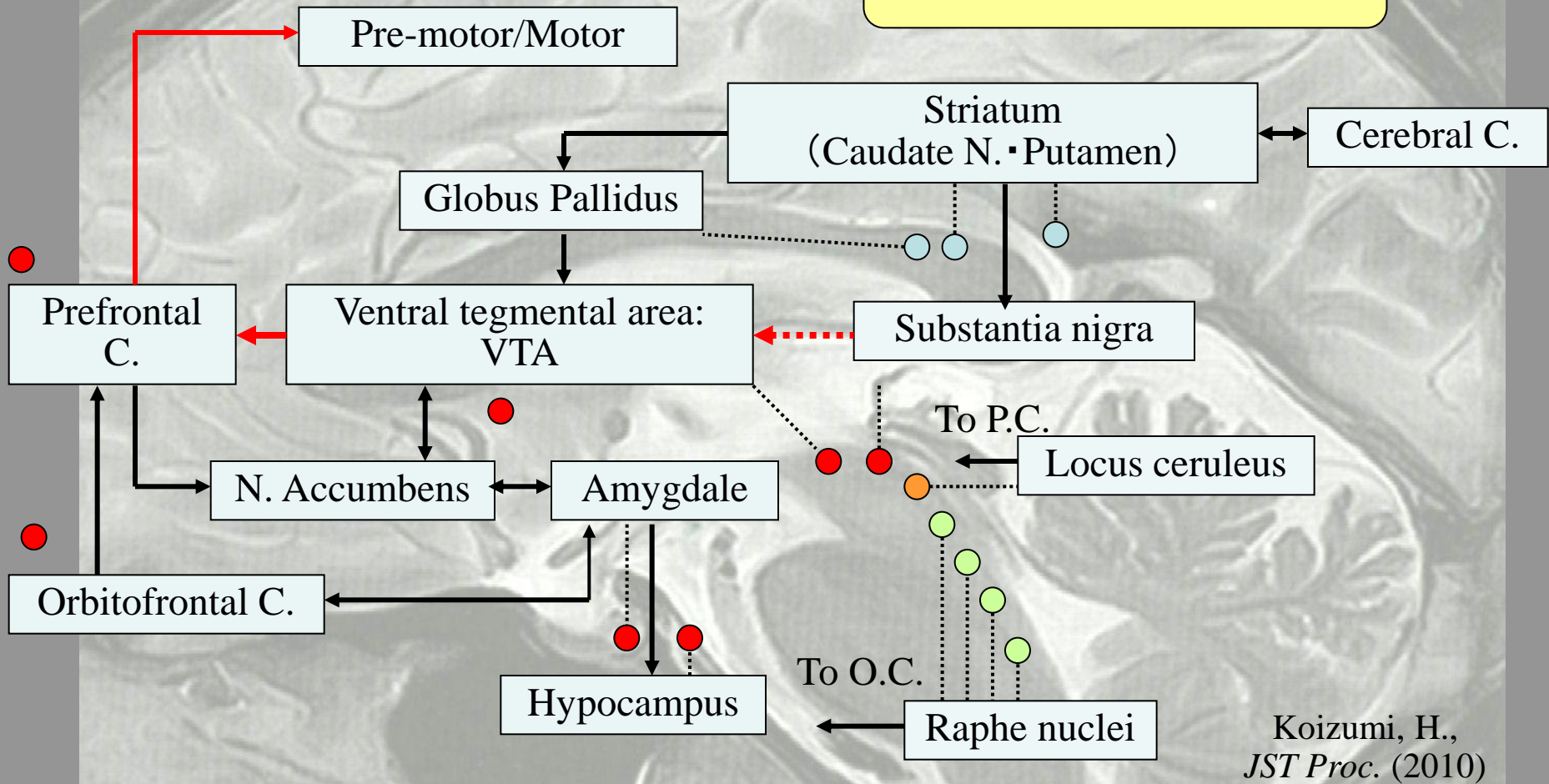
Izuma, K., Saito, D.N., Sadato, N., *Neuron* (2008)



Reward

Reward

Basis of Action



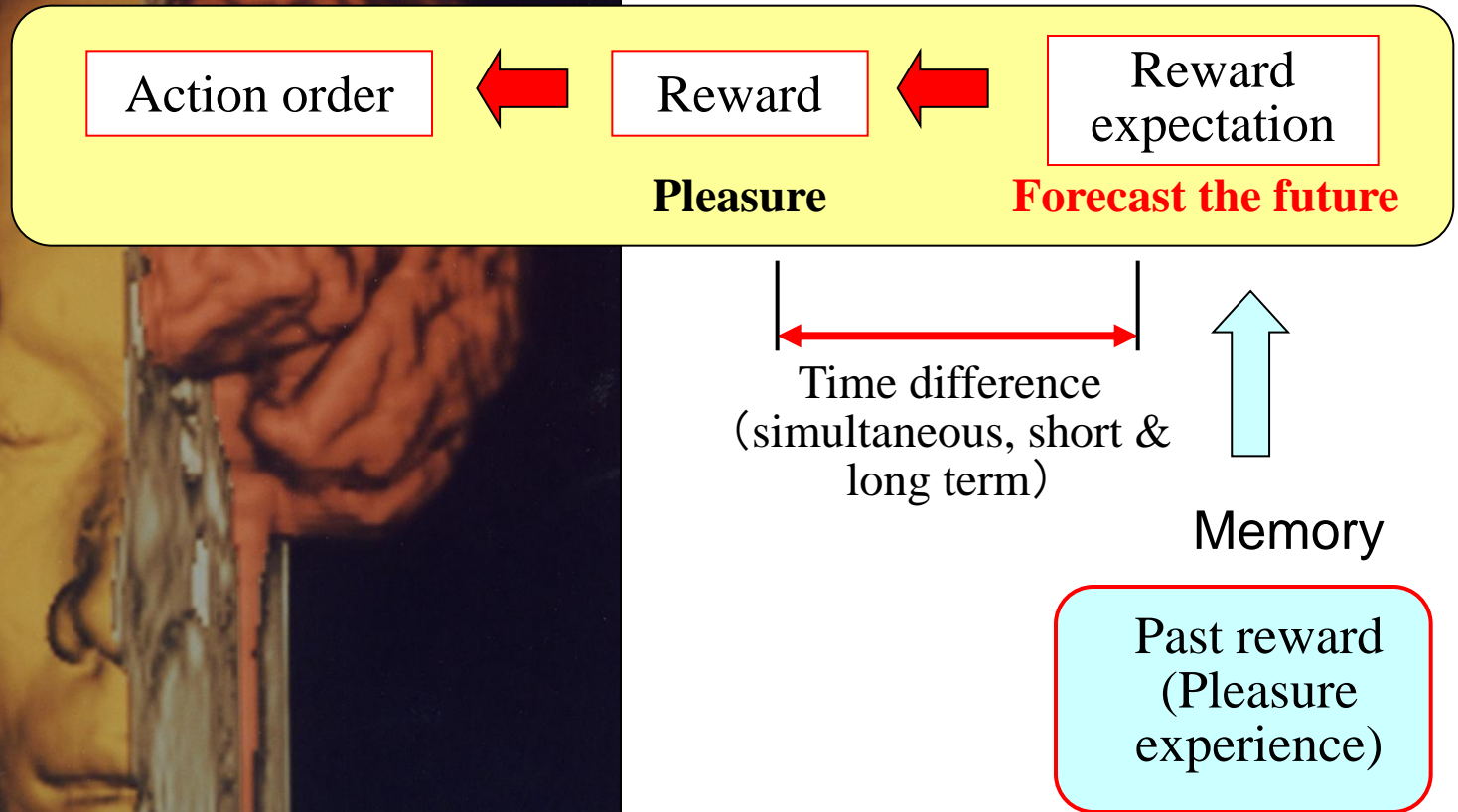
Koizumi, H.,
JST Proc. (2010)

Action order

Reward

Reward
prediction

Generation of the Feeling of Happiness



Koizumi, H., *History of Brain Science*, Kadokawa (2011).

The Future: Hard to Explain by Body Action

Mime performance has difficulty
to explain the future



Non-verbal expression
cannot give future tense

Human might be only a creature to
have the concept of the future

The phonological loop acts during thinking
of the future below consciousness

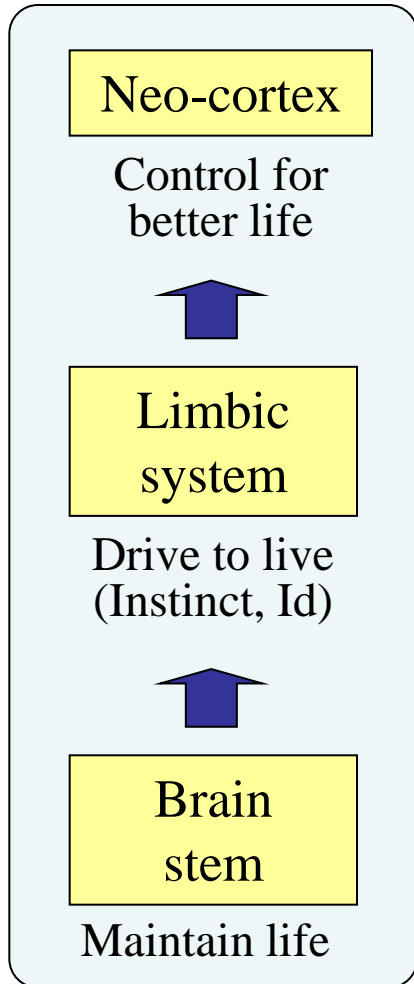
Koizumi, H., *Mind Morphology*,
MIT/UT Symposium (1997).



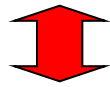
Evolution of the Brain

Passion and strong emotion drives innovation

Evolution



Intelligence
(Reason)

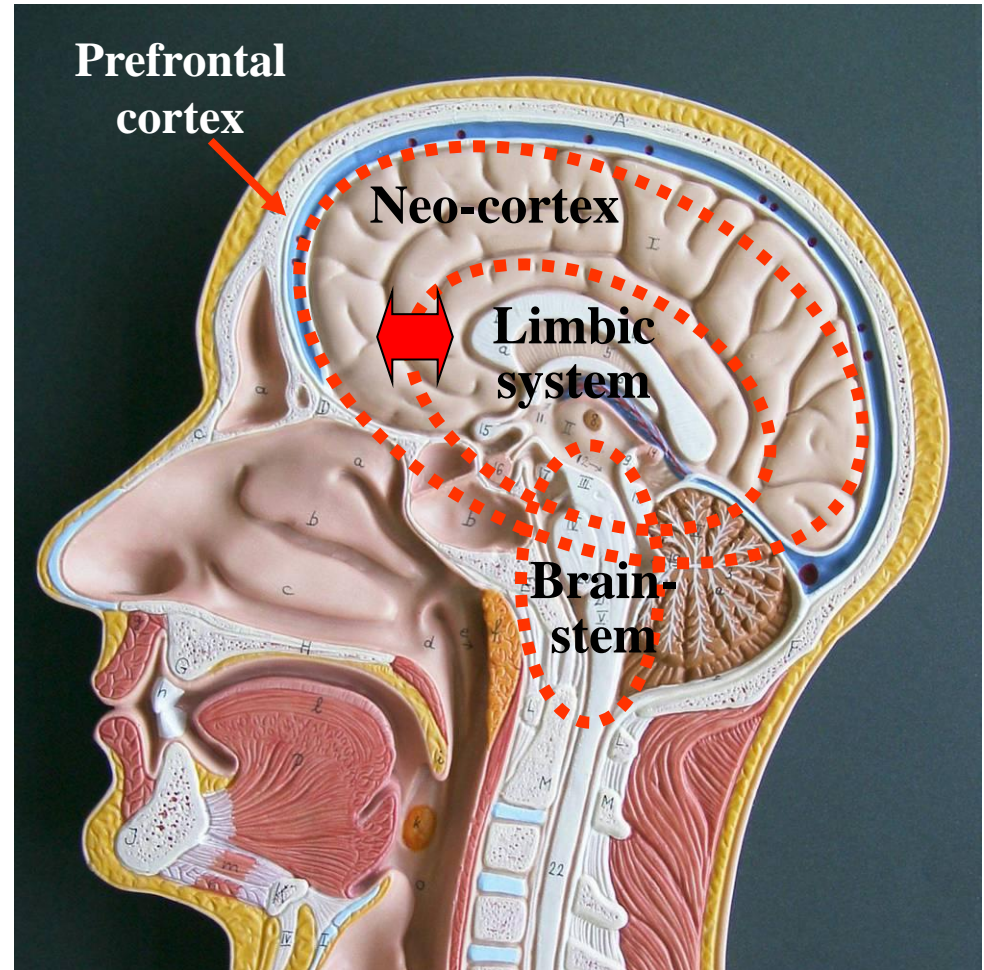


Emotion

Homo-sapiens

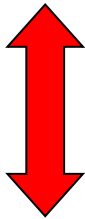
Mammals

Reptiles



Visualizing Invisible World & Interaction among S-E-T

Engineering
Technology



Science

Telescope

Magnification of distant 3D object



Hubble Space Telescope

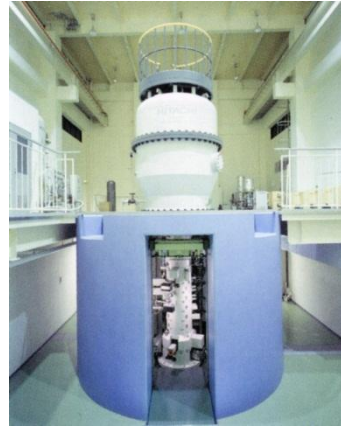
Courtesy of NASA

**Astronomy
Physics**



Microscope

Magnification of proximal 3D object



1MeV FE Electron Microscope

developed by A. Tonomura's team at Hitachi CRL/JST

**Biology
Medicine
Material**



Mindscope

Visualization of dimensionless mind

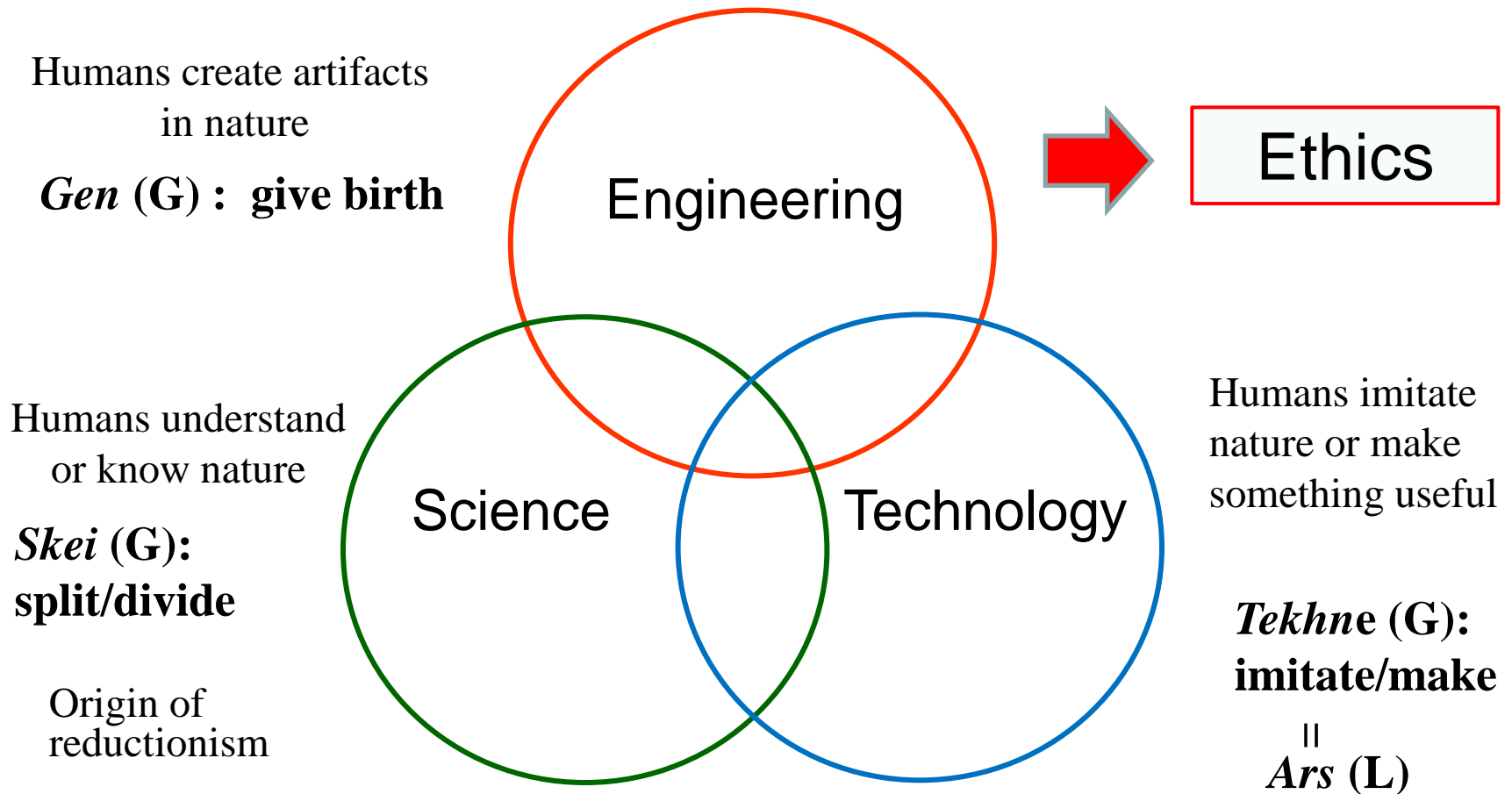


Wearable OT developed by

H. Koizumi's team at Hitachi CRL

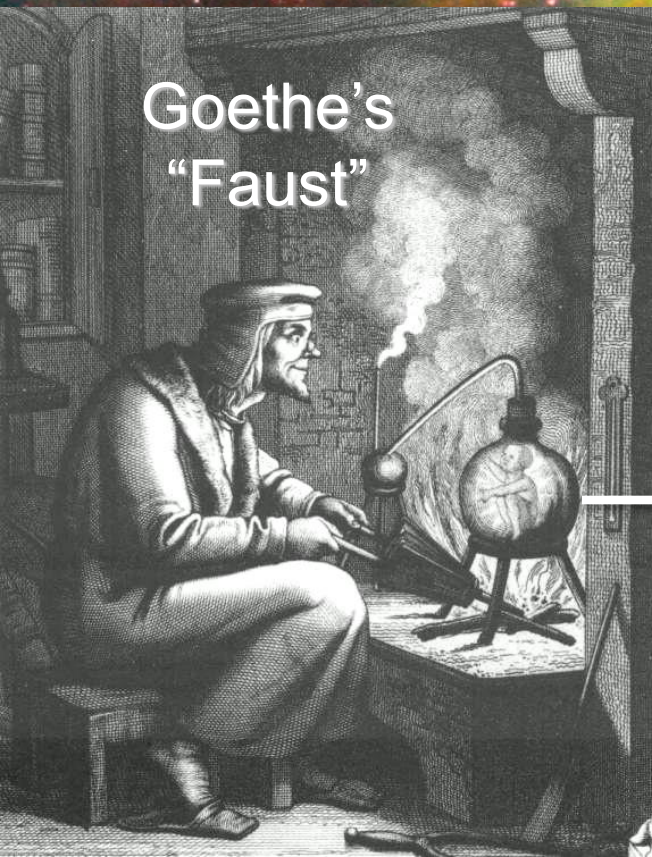
**Neuroscience
Psychology
Psychiatry**

SET: Science/Engineering/Technology

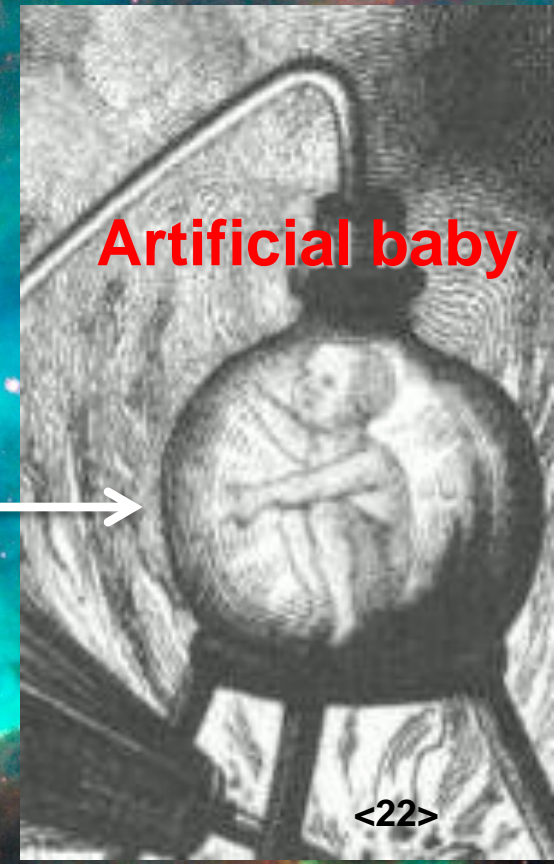


Koizumi, H., Invited Lecture at 11th General Assembly of Chinese Academy of Engineering (2012)

What was the hidden
objective of Alchemy?



Goethe's
"Faust"



Artificial baby