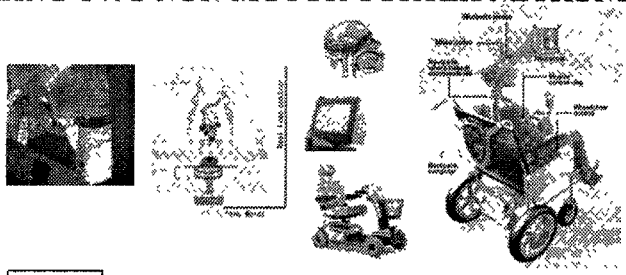
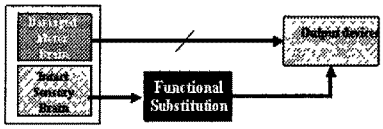
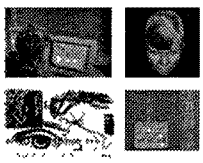
REAL-TIME INTENTION EXPRESSION THROUGH A BRAIN COMPUTER INTERFACE USING TWO NON-MOTOR CORTEX NEURONS





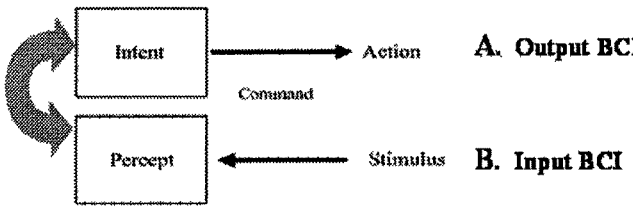
Hyung-Cheul Shin, Ph.D.
Dept. of Physiology, Coll. Of Medicine, Hallym University
Supported by KMOST 21st Century R&D Programs in Neuroscience, Brain Research Center
Nano Bioelectronics & Systems Research Center (ERC), KOSEF
Lims Technology http://www.lims.co.kr

A. Indirect BCI



B. Direct BCI

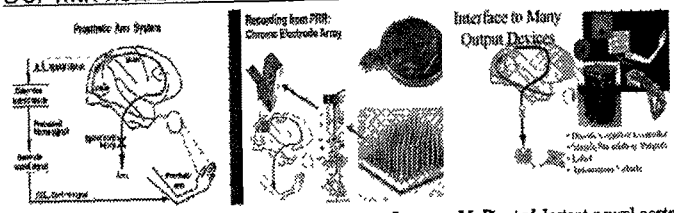
Brain Machine



Donoghue JP Connecting cortex to machines: recent advances in brain interfaces **Nature Neurosci. V.5 1085-1088 (2002)**

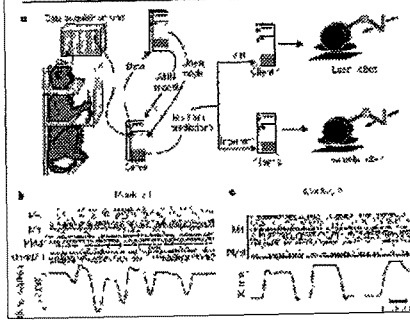
BCI-Hyung-Cheul Shin

BCI with neurons in association cortex



Serruya, M. D. *et al.* Instant neural control of a movement signal *Nature* **416, 141-142 (2002).**

BCI by decoding motor neuron activity

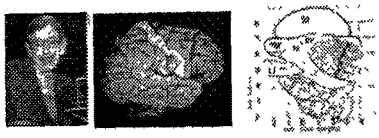


Duke University Medical Center neurobiologist Miguel Nicolelis with an owl monkey and a robot arm which monkeys learned to operate using only their brain signals

Chapin, J. K., Moxon, K. A., Markowitz, R. S. & Nicolelis, M. A. L. Real-time control of a robot arm using simultaneously recorded neurons in the motor cortex. *Nature Neurosci.* **2, 664-670 (1999).**

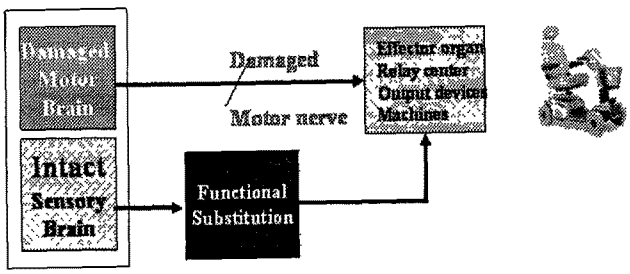
CNN.com

BCI-Hyung-Cheul Shin



If,
When

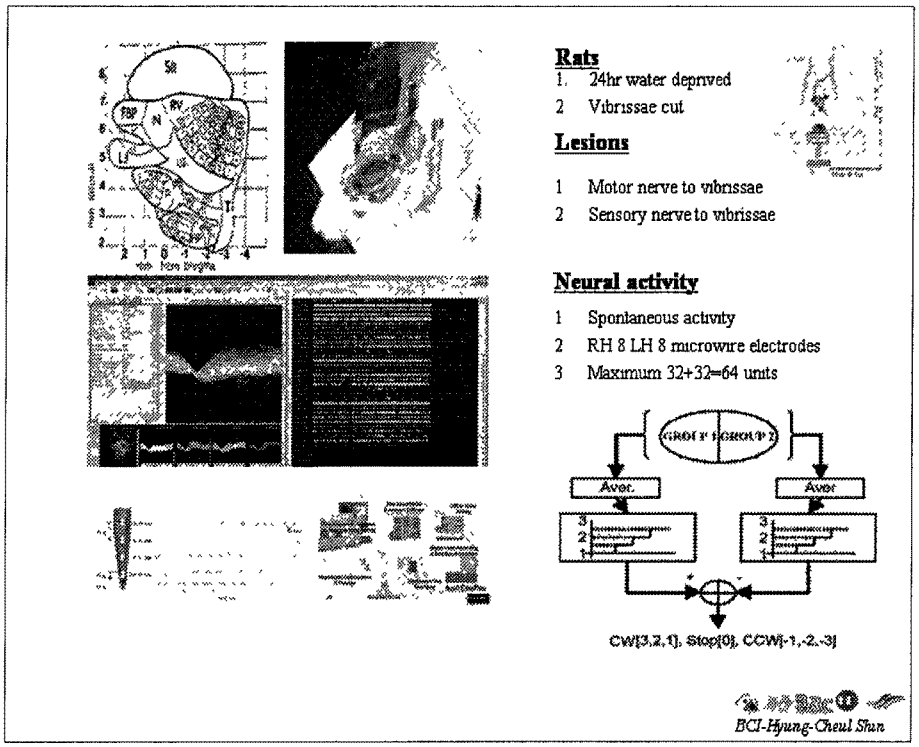
then

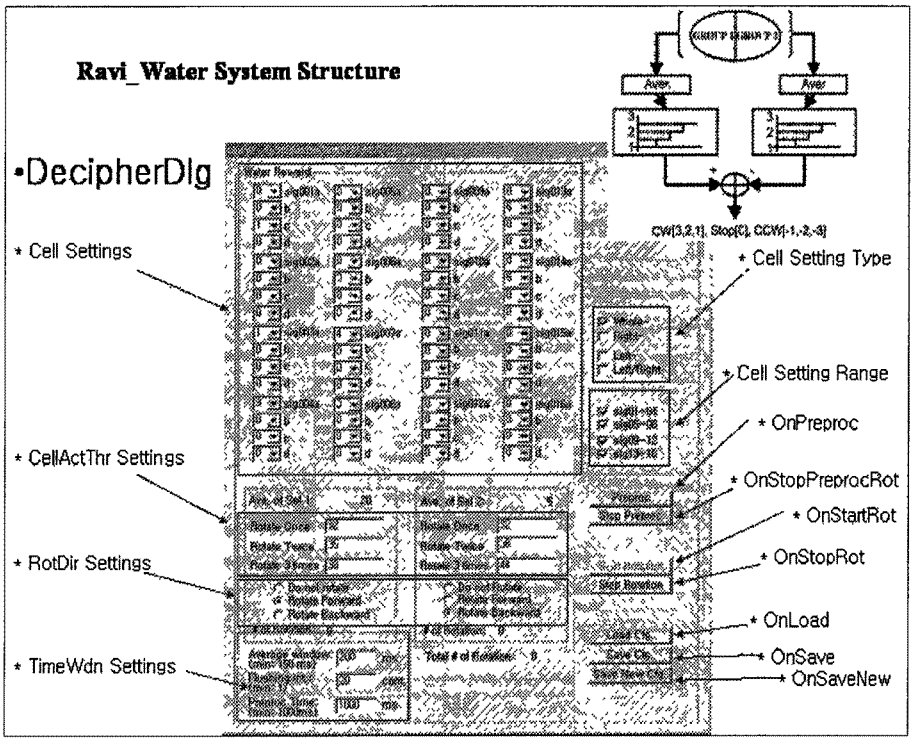


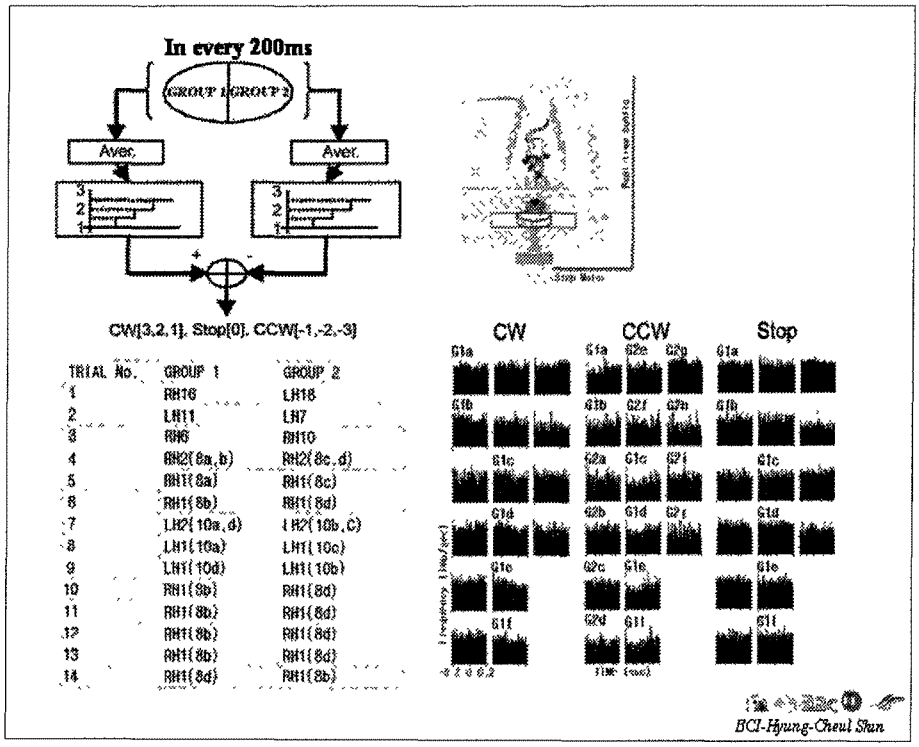
Questions

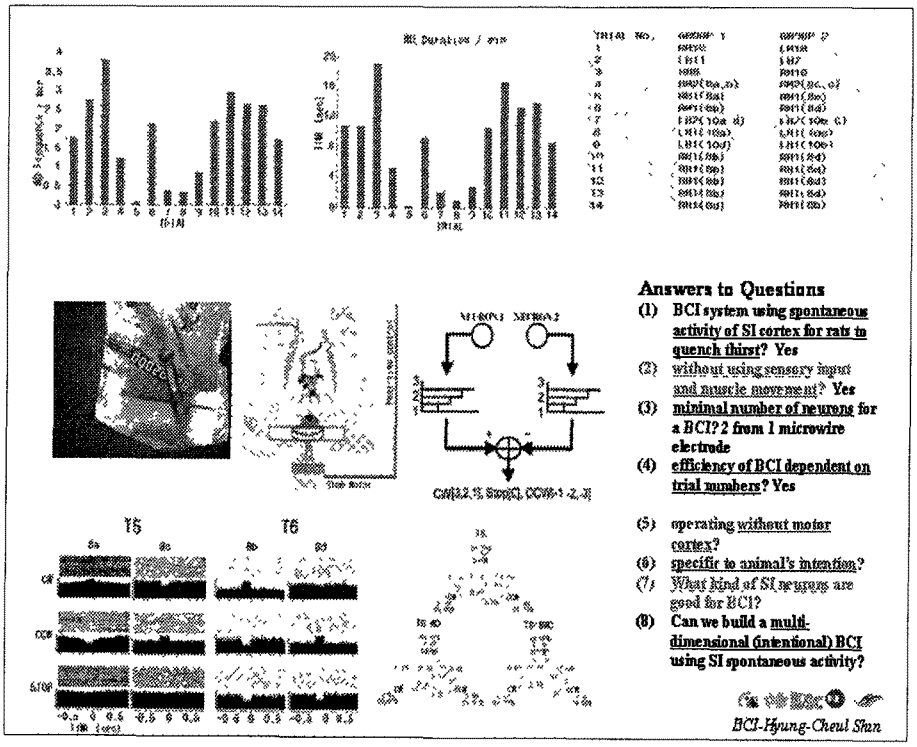
(1) a BCI system using spontaneous activity of SI cortex for rats to quench thirst?
(2) without using sensory input and muscle movement?
(3) minimal number of neurons for a BCI?
(4) efficiency of BCI dependent on trial numbers?
(5) without motor cortex?
(6) specific to animal's intention?
(7) What kind of SI neurons are good for BCI?
(8) Can we build a multi-dimensional (intentional) BCI using SI spontaneous activity?

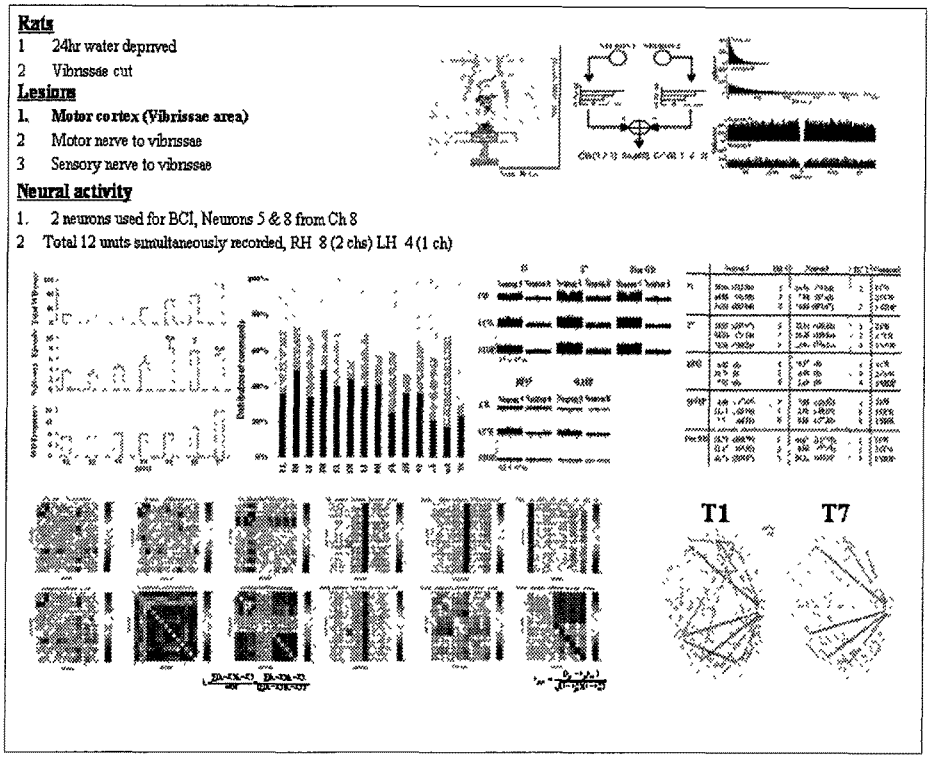
BCI-Hyung-Cheul Shin

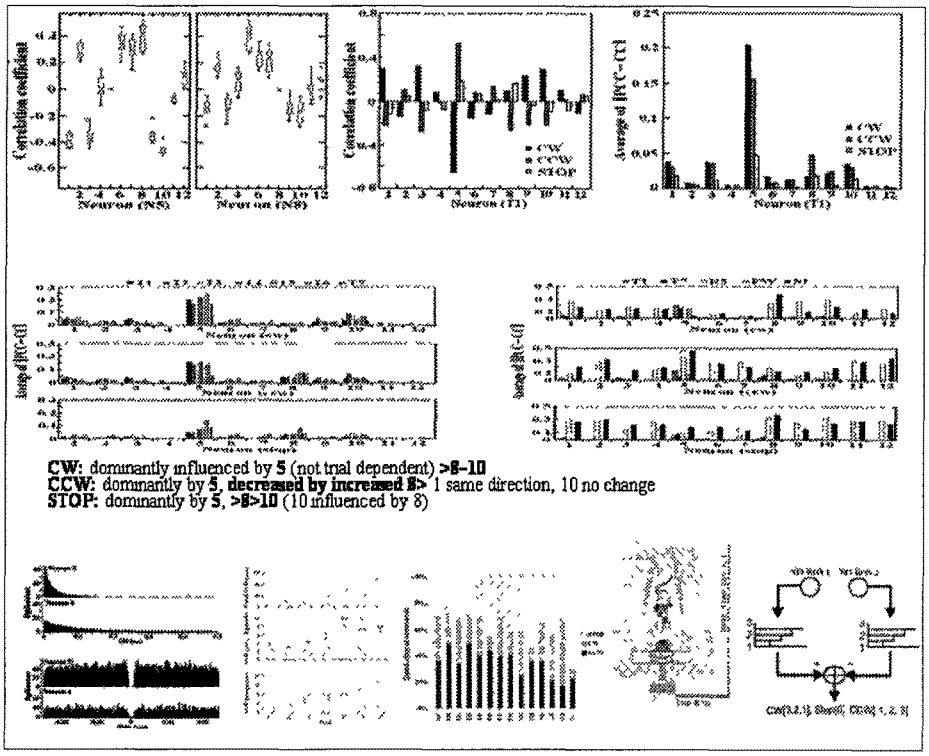

Rats
1. 24hr water deprived
2 Vibrissae cut
Lesions
1 Motor nerve to vibrissae
2 Sensory nerve to vibrissae
Neural activity
1 Spontaneous activity
2 RH 8 LH 8 microwire electrodes
3 Maximum 32+32=64 units
Aver.
Aver.
CW[3,2,1], Stop[0], CCW[-1,-2,-3]
BCI-Hyung-Cheul Shin

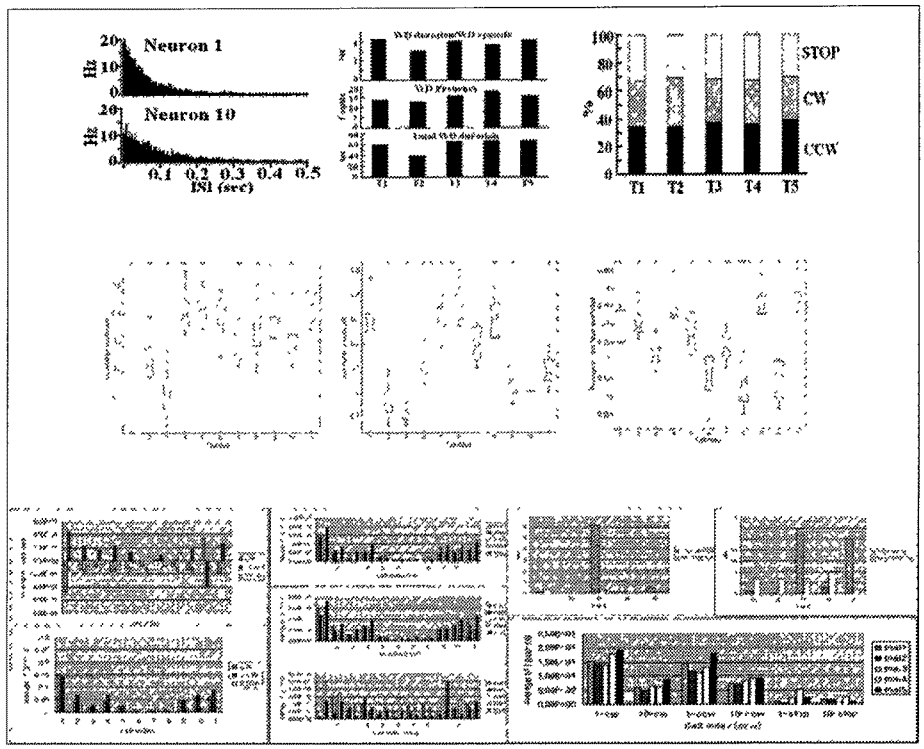

Ravi_Water System Structure
•DecipherDlg
* Cell Settings
* CellActThr Settings
* RotDir Settings
* TimeWdn Settings
* Cell Setting Type
* Cell Setting Range
* OnPreproc
* OnStopPreprocRot
* OnStartRot
* OnStopRot
* OnLoad
* OnSave
* OnSaveNew
CW[3,2,1], Stop[0], CCW[-1,-2,-3]

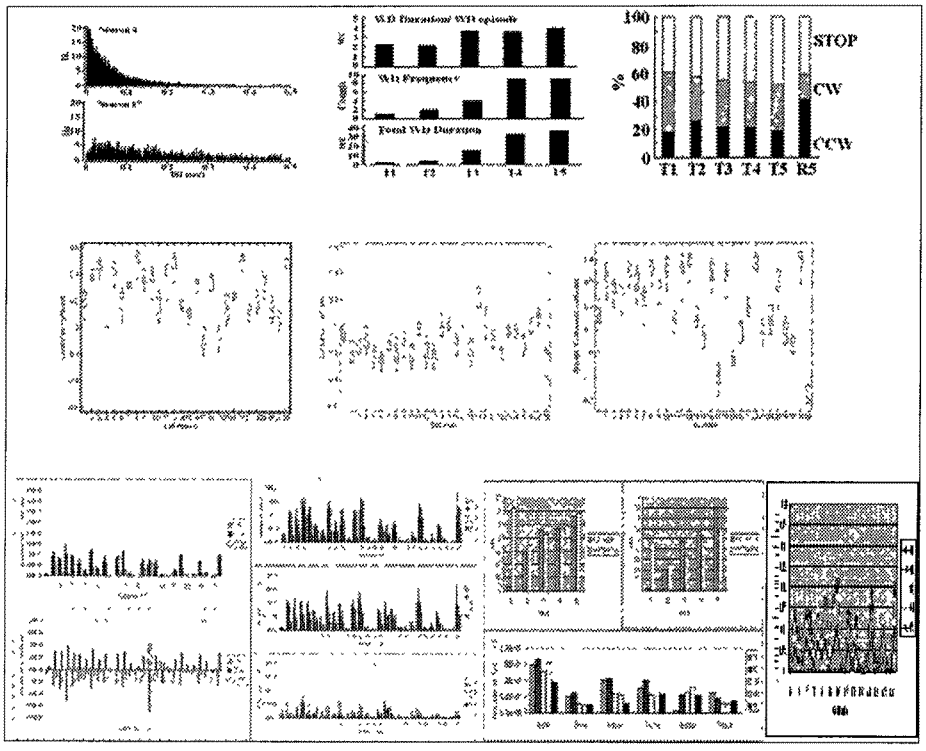

In every 200ms
GROUP 1
GROUP 2
Aver.
Aver.
CW[3,2,1], Stop[0], CCW[-1,-2,-3]
TRIAL No.
GROUP 1
GROUP 2
CW
CCW
Stop
BCI-Hyung-Cheul Shin


Answers to Questions
(1) BCI system using spontaneous activity of SI cortex for rats to quench thirst? Yes
(2) without using sensory input and muscle movement? Yes
(3) minimal number of neurons for a BCI? 2 from 1 microwire electrode
(4) efficiency of BCI dependent on trial numbers? Yes
(5) operating without motor cortex?
(6) specific to animal's intention?
(7) What kind of SI neurons are good for BCI?
(8) Can we build a multi-dimensional (intentional) BCI using SI spontaneous activity?
T5
T6
BCI-Hyung-Cheul Shin

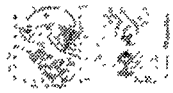

Rats
1 24hr water deprived
2 Vibrissae cut
Lesions
1. Motor cortex (Vibrissae area)
2 Motor nerve to vibrissae
3 Sensory nerve to vibrissae
Neural activity
1. 2 neurons used for BCI, Neurons 5 & 8 from Ch 8
2 Total 12 units simultaneously recorded, RH 8 (2 chs) LH 4 (1 ch)
T1
T7


CW
CCW
STOP
CW: dominantly influenced by 5 (not trial dependent) >8>10
CCW: dominantly by 5, decreased by increased 8> 1 same direction, 10 no change
STOP: dominantly by 5, >8>10 (10 influenced by 8)

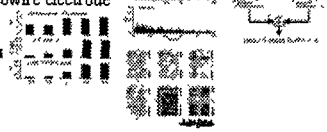

Neuron 1
Neuron 10
Hz
ISI (sec)
STOP
CW
CCW
%
T1 T2 T3 T4 T5


STOP
CW
CCW
%
T1 T2 T3 T4 T5 R5

Answers to Questions

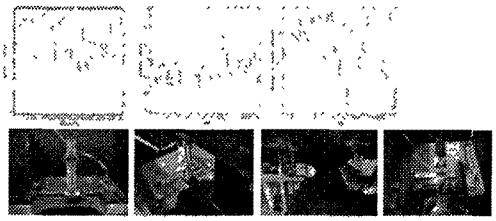


(1) BCI system using spontaneous activity of SI cortex for rats to quench thirst? Yes
(2) without using sensory input and muscle movement? Yes
(3) minimal number of neurons for a BCI? 2 from 1 microwire electrode

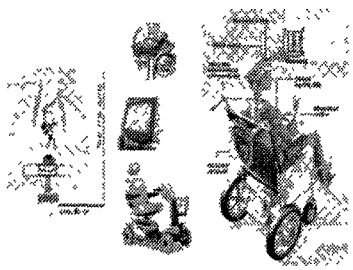


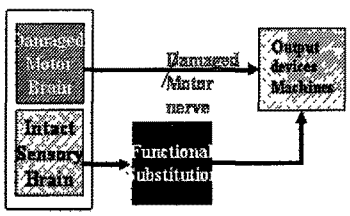
(4) efficiency of BCI dependent on trial numbers? Yes
(5) operating without motor cortex? Yes
(6) Is the BCI specific to animal's intention? Yes

(7) What kind of SI neurons are good for BCI? Weak negative CCs between 2 neurons, Dominant one showing strong CCs with others, non-dominant one showing weak CCs to other neurons
(8) Can we build a multi dimensional (intentional) BCI using SI spontaneous activity? Yes! Since cells showing heterogeneous CCs among them



BCI-Hyung-Cheul Shin





Future studies

1. **Multi-dimensional BCI**
2. **Modulation Source**
3. **1 neuron BCI**
4. **Different signal transformation algorithms**
5. **Automatic selection of optimal neurons for BCI**
6. **Network analysis**
7. **Other brain areas**
8. **Monkey BCI**
9. **Development of neural prosthesis**
10. **Use for disabled people**

Participants

Hyunjoo Lee
Kyung-seok Cho
Daehwan Kim
Youngsil Kim, MS
Meiying Jin, MS, MD
Unjoo Lee, Ph.D.
Sungho Song, Ph. D.
Sang-eok Kim, Ph.D.
Sung June Kim, Ph.D
Lims Technology
http://www.lims.co.kr

Patent No. 10-2005-0037579
NEURAL SIGNAL BASED CONTROL DEVICE AND CONTROL METHOD BASED NEURAL SIGNAL

BCI-Hyung-Cheul Shin