

# EEG

## Past, Present, and Future

Department of Biomedical Engineering, Hanyang University

**Chang-Hwan Im**

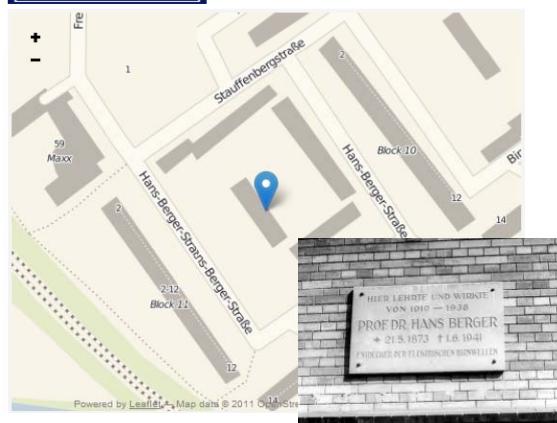


<http://cone.hanyang.ac.kr>

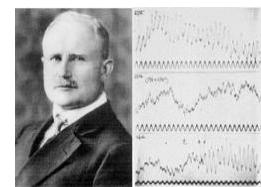
### Hans Berger (1873 – 1941)

Hans-Berger-Str. / Hans-Berger-Straße in 07747 Jena (Jena-Lobeda)

**Hans-Berger-Str.**



Jena, Germany



Hans Berger (1873-1941)

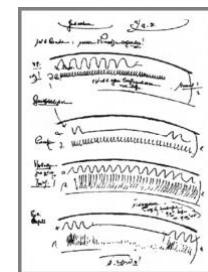


Image EEG: 1924

Magazine Section THE SYRACUSE HERALD, SUNDAY MORNING, JUNE 8, 1919. PICTURE

**New and Interesting Facts from Science and Life**

This Machine Records All Your Thoughts

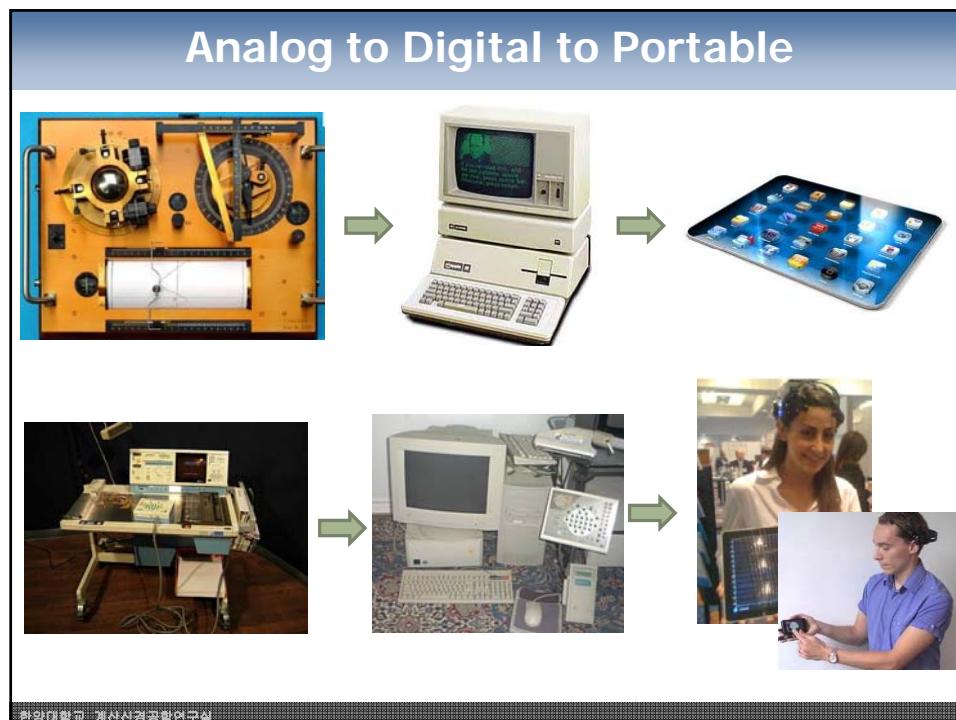
**This Machine Records All Your Thoughts**

The Thought Recorder Is an Instrument Recording Thoughts Directly by Electrical Means, on a Moving Paper Tape. The Illustration Shows What a Future Business Office Will Look Like When Such an Invention Has Been Perfected. By Pushing the Button A, the Tape Is Started and Stopped Automatically so That Thoughts That Are Wanted Are Recorded.

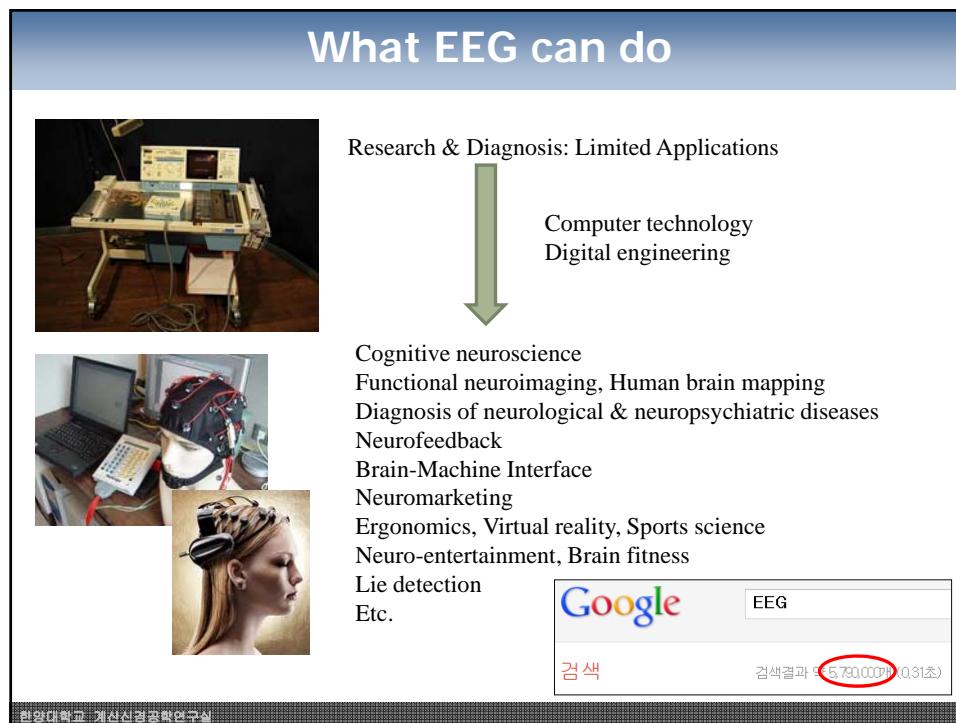
The Syracuse Herald, June 8, **1919**

## A hundred years of evolution

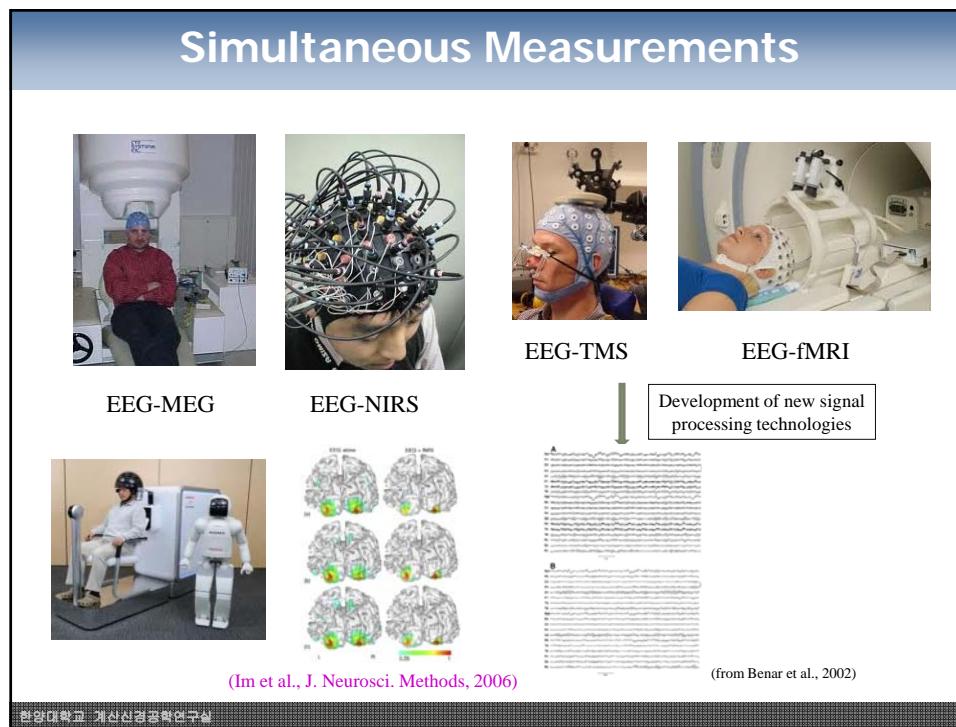
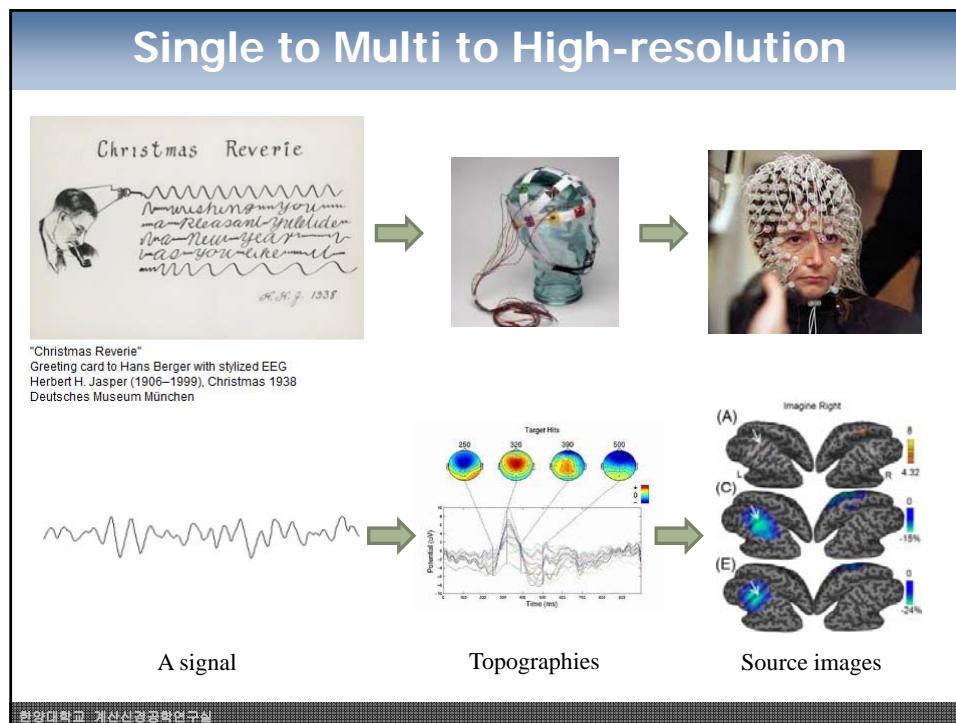
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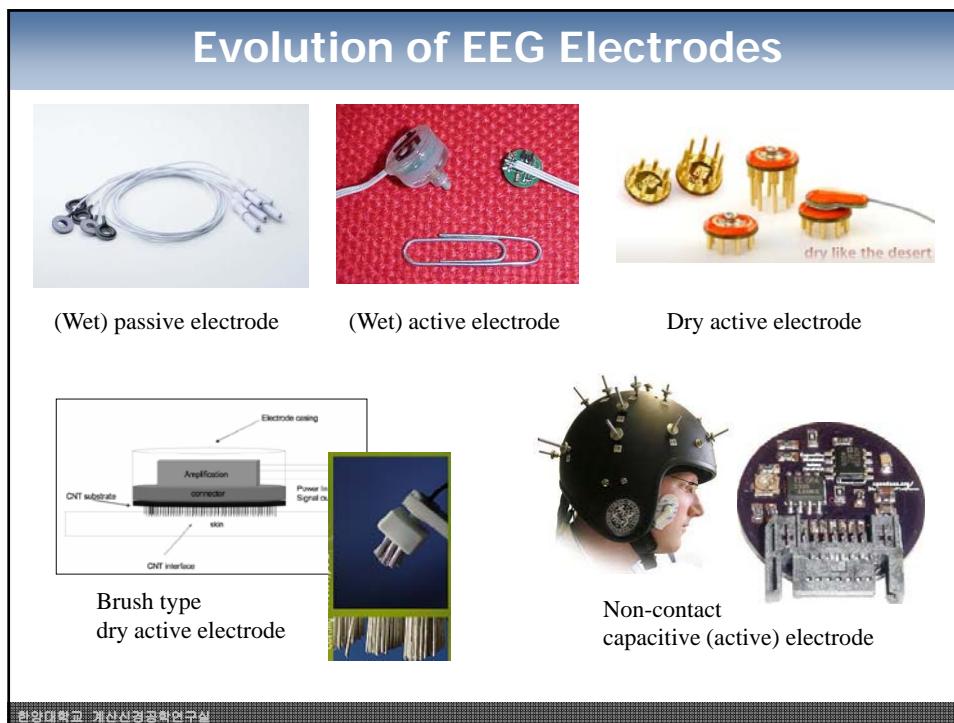


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## Analysis Methods (1)

### 1. Sensor-level analysis

- Event (wave) detection

Automatic spike detection  
(from Acir et al., 2003)

- Topographic map (scalp potential map)

(from BESA)

- Evaluation of qEEG parameters  
e.g. beta band power at CPz electrode, coherence between FPz and POz, etc.

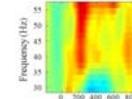
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## Analysis Methods (2)

### 1. Sensor-level analysis

- Time-Frequency Analysis

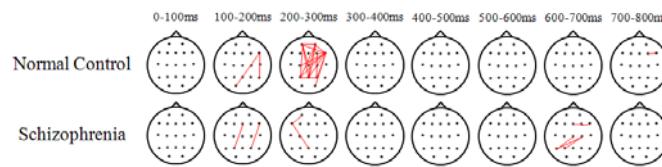
FFT, STFT, Wavelet →



- Indices to Measure Global Synchronization: e.g. GFS (global field synchronization), GSI (Global Synchronization Index), etc.

- Nonlinear Analysis: e.g. Dimensional Complexity (D2), Entropy, etc.

- (Sensor-level) Functional Connectivity Analysis



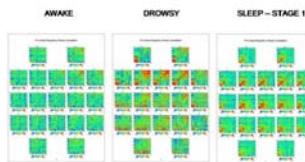
(Lee et al., Schizophr. Res., 2010)

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## Analysis Methods (3)

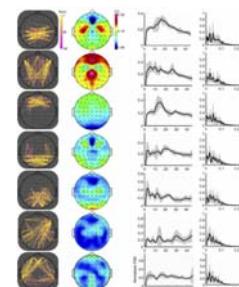
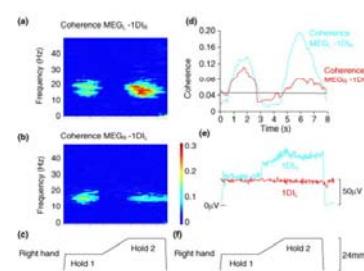
### 1. Sensor-level analysis

- Cross-frequency coherence



- Graph Theoretical Analysis of Functional Connectivity

- Cortico-muscular Coherence

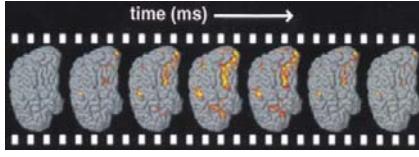


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## Analysis Methods (4)

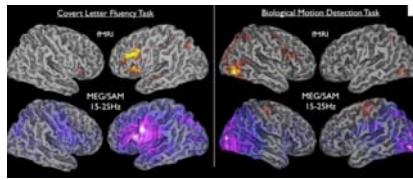
### 2. Source-level analysis

- Time-Domain Analysis



(from Dale et al., 2000)

- Frequency-Domain Analysis



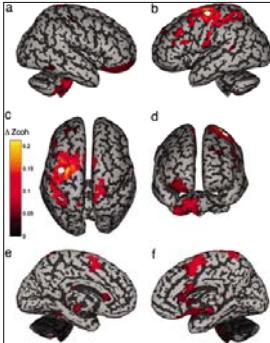
(from Singh, 2012)

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## Analysis Methods (5)

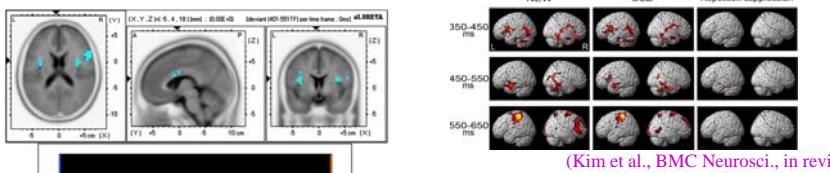
### 2. Source-level analysis

- Coherent source imaging



Dynamic Imaging of  
Coherent Sources  
(DICS)

- Group Analysis



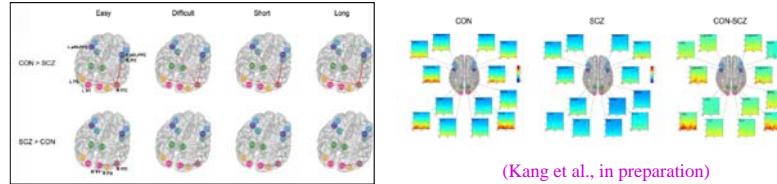
(Kim et al., BMC Neurosci., in revision)  
(Bae et al., Prog. Neuro-Psychopharmacol. Biol. Psychiat., 2011)

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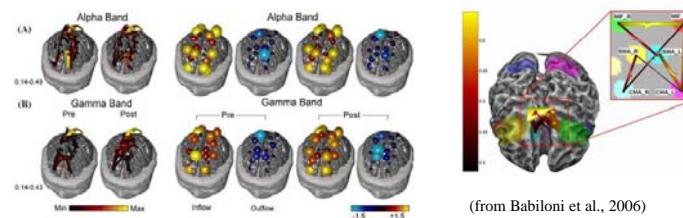
## Analysis Methods (6)

### 2. Source-level analysis

- Source-level Connectivity Analysis



- Source-level Causality Analysis



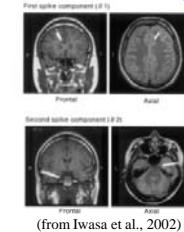
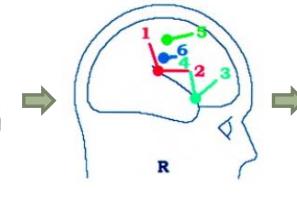
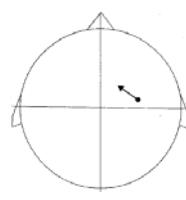
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## Evolution of Source Analysis (1)

Source imaging can potentially enhance the resolution of EEG



**Equivalent current dipole (ECD) localization**



Single equivalent  
current dipole (ECD)

Multiple ECDs

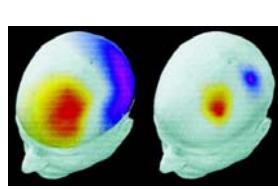
Anatomical  
coregistration

Need to estimate the number of ECDs  
and initial locations of ECDs

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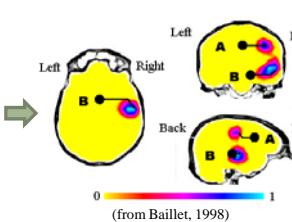
## Evolution of Source Analysis (2)

Distributed source model (cortical source imaging)  
 - does not need to estimate the number or initial locations of sources



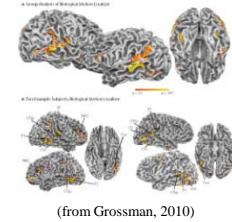
(from Rossini et al., 1999)

Surface Laplacian



(from Baillet, 1998)

Volume source model

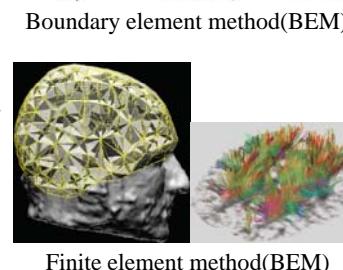
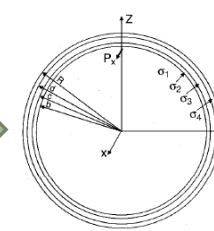
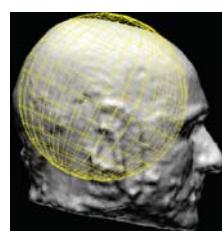
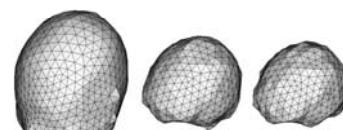
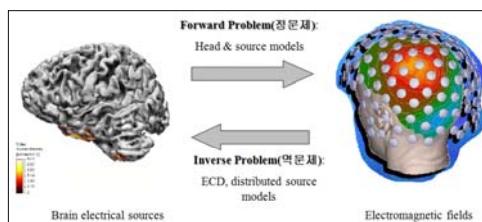


(from Grossman, 2010)

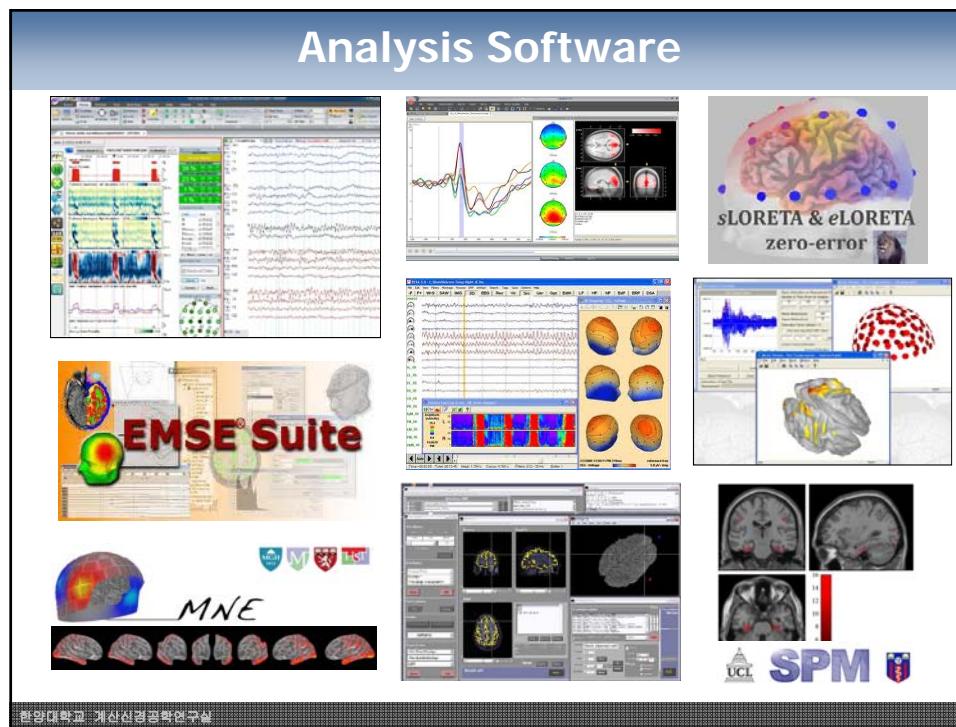
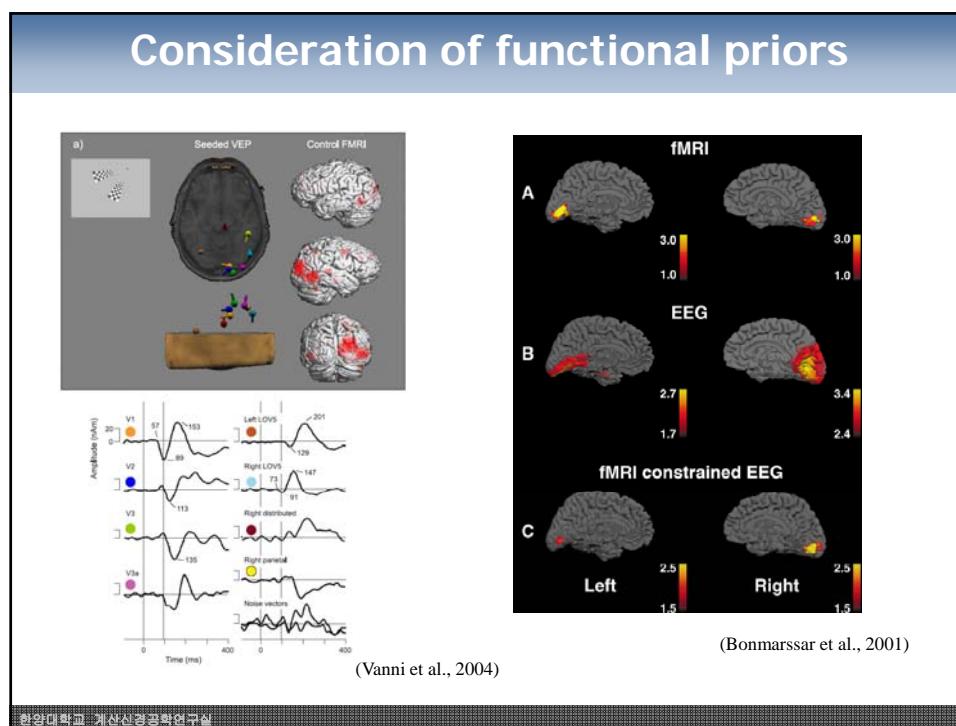
Anatomical constraint  
Functional constraint

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## Development of Forward Solvers

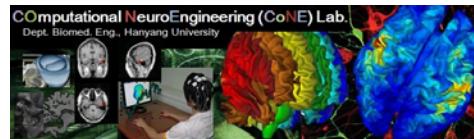


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## Examples of EEG Applications in Our Lab.

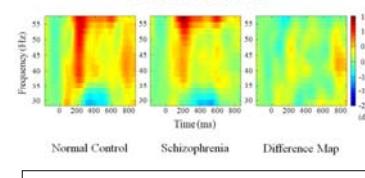
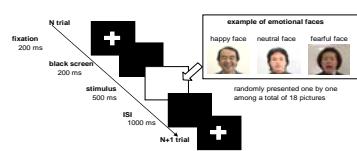
1. Examples of EEG Applications in Neurology, Psychiatry, and Cognitive Neuroscience
2. Brain-Computer Interfaces



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## Gamma-band Synchrony Analysis of Schizophrenia

### Dysfunctional Gamma-Band Activity During Facial Structure Processing in Schizophrenia Patients



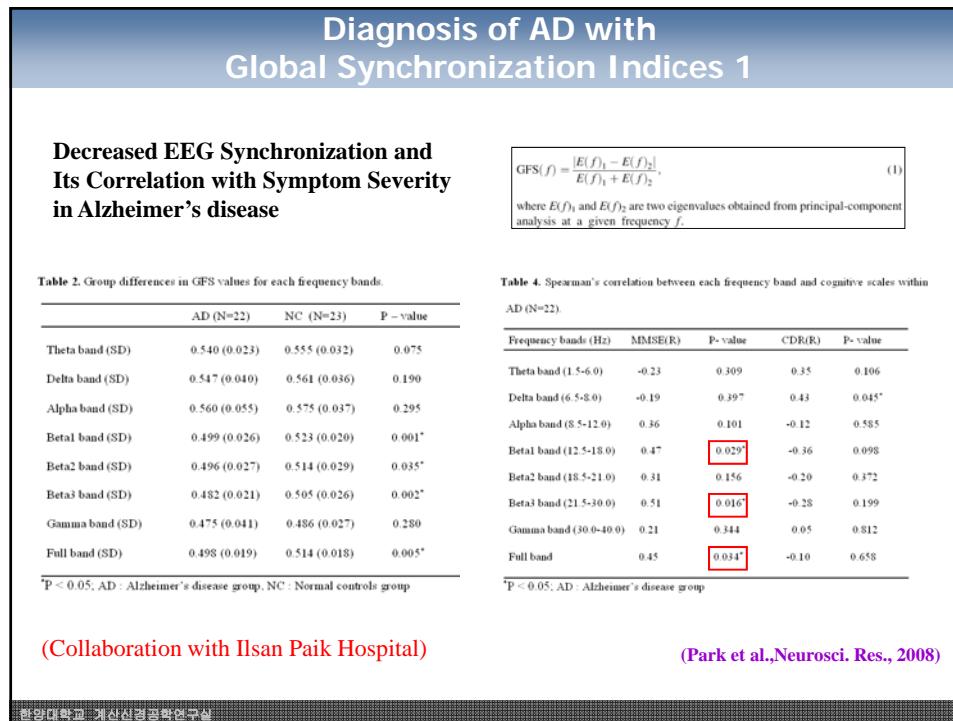
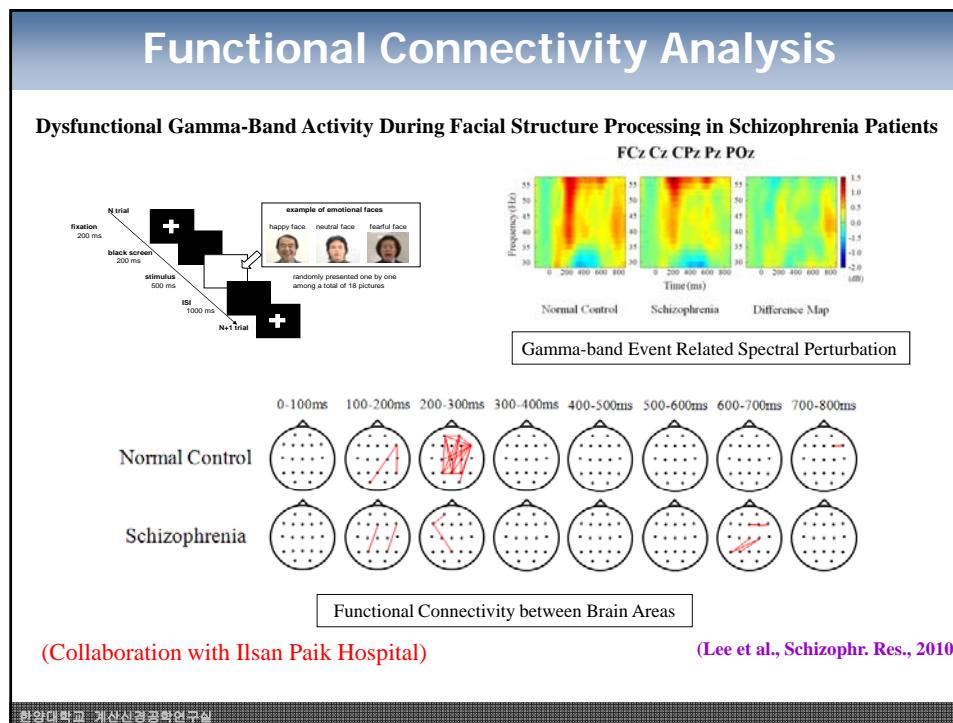
Gamma-band Event Related Spectral Perturbation

- Spearman correlation coefficients between GBA and symptomatic and demographic data.
- Significant correlations were founded between GBA at 700-800 ms and several variables; number of hospitalization (at FCz, rho=-0.455, p=0.022), PANSS negative symptom score (at Cz, rho=-0.435, p=0.03; at CPz, rho=-0.628, p=0.001; at Pz, rho=-0.404, p=0.045), and PANSS total score (at Cz, rho=-0.406, p=0.044; at CPz, rho=-0.535, p=0.006; at Pz, rho=-0.489, p=0.013).

(Collaboration with Ilsan Paik Hospital)

(Lee et al., Schizophr. Res., 2010)

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## Diagnosis of AD with Global Synchronization Indices 2

**Global Synchronization Index as a Biological Correlate of Symptom Severity in Alzheimer's disease**

GSI  $\leftarrow$  eigenvalues of correlation matrix

Frequency bands (Hz)	$\lambda_1$ - MMSE(R)	P- value	$\lambda_1$ - CDR(R)	P- value
Delta (1-3 Hz)	-0.480	0.018	0.586	0.003
Theta (4-7 Hz)	-0.472	0.020	0.375	0.071
Alpha (8-12 Hz)	0.343	0.101	-0.281	0.184
Beta1 (13-18 Hz)	0.382	0.065	-0.244	0.250
Beta2 (19-21 Hz)	0.357	0.087	-0.379	0.067
Beta3 (22-30 Hz)	0.336	0.108	-0.415	0.044
Gamma (31-50 Hz)	0.497	0.014	-0.616	0.001
Full (1-50 Hz)	0.101	0.639	-0.099	0.645

MMSE: Mini-Mental Status Examination CDR: Clinical Dementia Rating scale

**Table 5.** Classification table of logistic regression for Alzheimer's dementia (AD) and normal controls (NC) using three GSI values (theta, beta 3, gamma band).

	Predicted Group		Percentage Correct
	AD	NC	
Observed group	AD (N=25) NC (N=22)	21 5	84.0 77.3
Overall Percentage			80.9

(Collaboration with Ilsan Paik Hospital) (Lee et al., Neurosci. Res., 2010)

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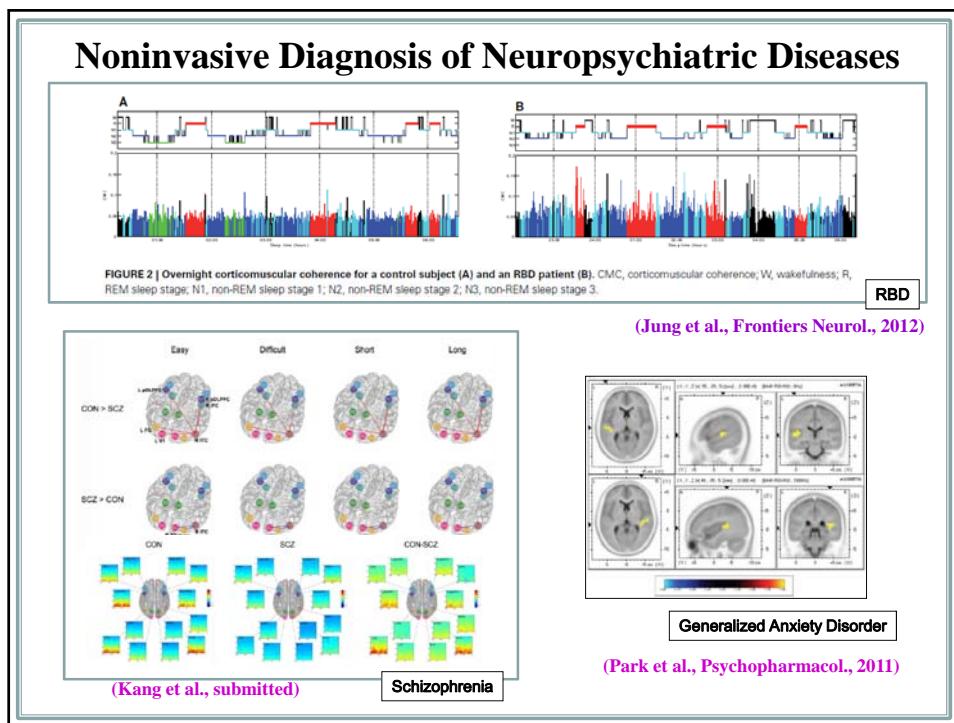
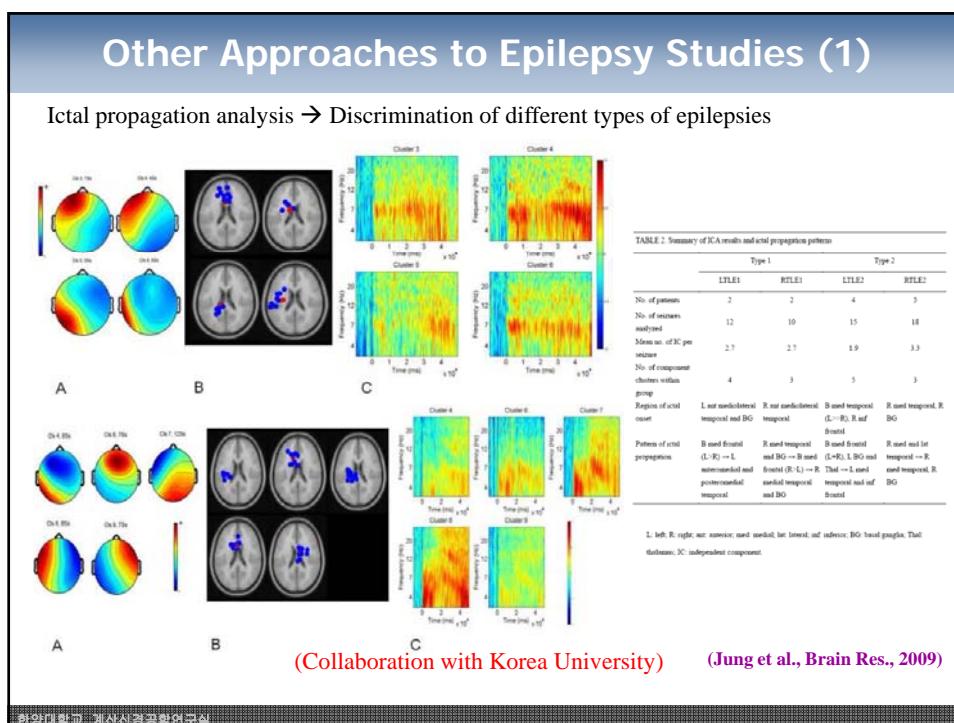
## Functional Dysintegration Syndrome of Schizophrenia

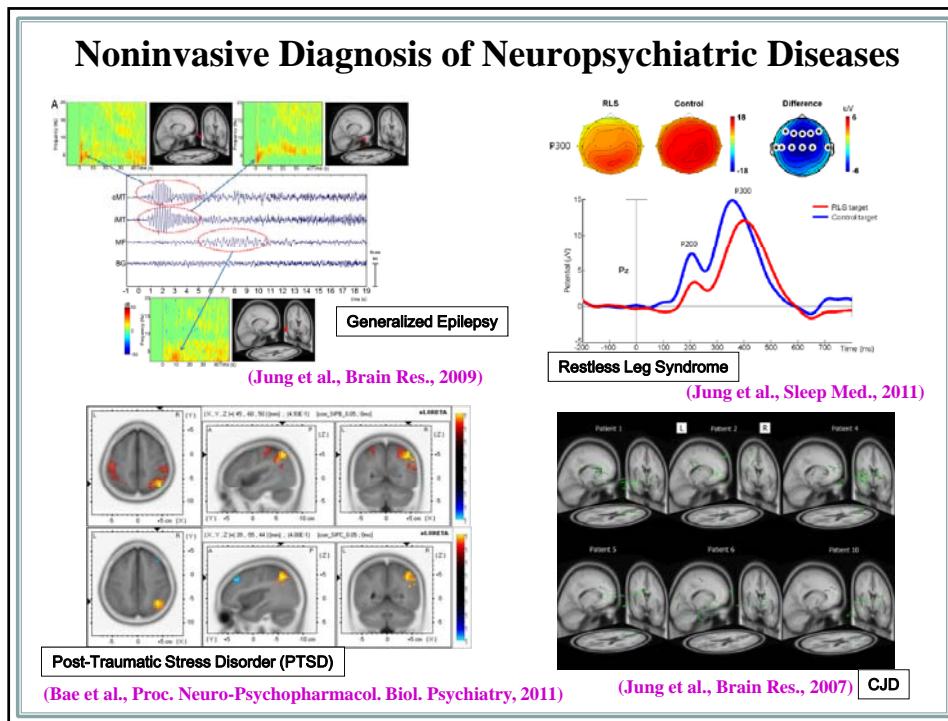
- Multimodal neuroimaging (fMRI + MEG)
- Source level connectivity analysis
- High correlation with symptom severity

Figure 26. Scatter plots of schizophrenia symptom scores with the functional connectivity indices.

(Collaboration with University of Minnesota) (Kang et al., in preparation)

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## 뇌-컴퓨터 접속(BCI) 연구의 필요성

**종합 NEWS**

호킹박사 '컴퓨터목소리' 미자…  
병세 악화로 1분에 한 단어밖에 말 못해  
기사입력 2012.01.06 17:10:54 | 최종수정 2012.01.06 17:33:27

기사 태그 [이벤트] 다양한 이벤트가 언제나 한가득

‘휠체어 위의 천재’ 스티븐 호킹 박사(69)가 지난 36년간 컴퓨터에 의해  
준해 내왔던 목소리를 잊을 위기에 처했다.

영국 일간지 데일리메일은 5일 호킹 박사가 1분에 1개 단어밖에 말할  
수 없는 상태에 처했다고 밝혔다.

그는 지난 50년간 근위축성측색경화증(두개막병)을 앓았으며 1985년  
에는 폐렴에 따른 후유증으로 목소리까지 잃었다.

두개막병에 걸리면 온몸의 근육 전체가 서서히 마비된다. 호킹 박사는  
지금까지는 손가락 2개를 움직일 수 있어 컴퓨터 화면에 나타난 글자를 손가락으로 눌러 문장을  
만들어낼 수 있었다. 이렇게 만든 문장을 컴퓨터가 소리로 합성하는 방법으로 그는 그동안 목  
소리를 내왔다.

데일리메일은 ‘두개막병이 심각해 진행돼 호킹 박사는 이제 온몸 근육과 신경마저 마비된 상  
태’라며 “이 장치를 더 이상 사용할 수 없어 언어를 상실할 위기에 처했다”고 밝혔다.

호킹 박사의 대학원생 제자인 생 블랙번은 “호킹 박사가 이 장치를 계속 이용하기를 바란다”며  
“지도 가능하다면 눈과 안면 움직임 인식, 뇌 스캐닝 등 대체장치를 개발해야 할 것”이라고  
밝혔다.

(2012년 1월 6일, 중앙일보)

**헨리 루이스 루 게릭**  
(Henry Louis Lou Gehrig)  
1903.06.19 - 1941.06.02  
야구선수

**근위축성 측색경화**  
(Amyotrophic Lateral Sclerosis: ALS)

- 매년 140,000 – 210,000명 발병
- 부분 혹은 전신의 운동기능 상실
- 본인의 의지로 타인과 의사소통 어려움

## 뇌-컴퓨터 접속(BCI) 연구의 필요성

산업재해와 사고  
(한국 OECD 국가 중 교통사고율 1위)

급성 심장질환  
(서구화된 식습관, 고령화)

퇴행성 뇌질환  
(ALS, 파킨슨병, 뇌출증, 진행성연수마비, 척수근육위축)

- 신체 일부 혹은 전신의 기능 상실
- 심할 경우 식물인간
- 매년 증가

- 미국에서만 200만 명 이상의 신경계 손상 환자들이 보고 (Carter, 1997)  
- 국내에서 언어를 직간접적으로 생성하지 못하는 환자의 수는 약 10만 명 (임창환, 2010)

의사소통이 불가능하거나 제한적  
의료 및 간병 서비스 어려움

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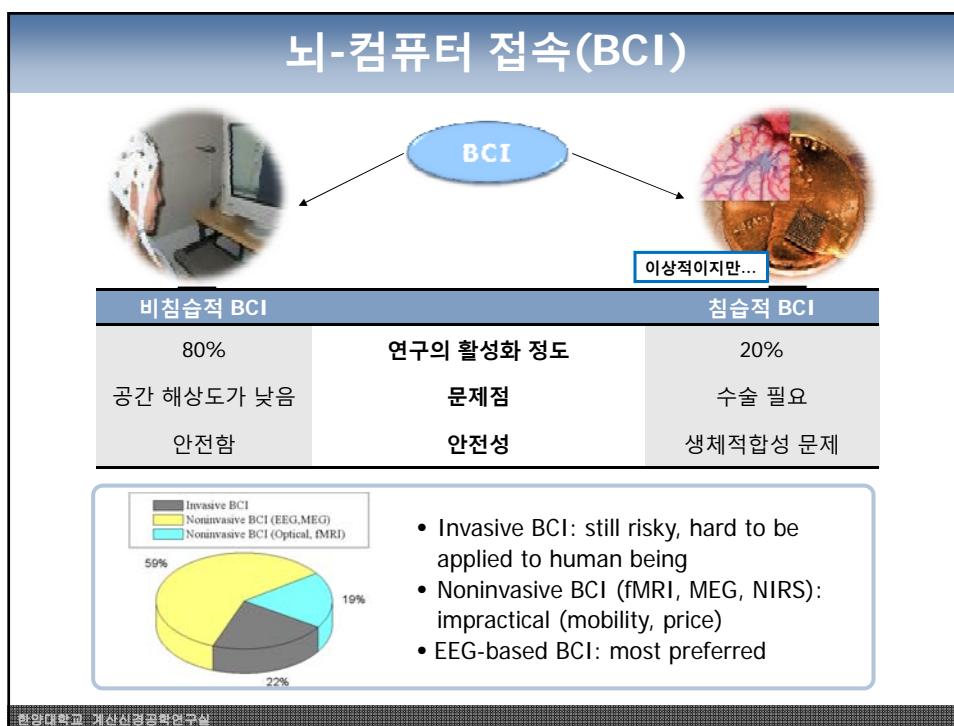
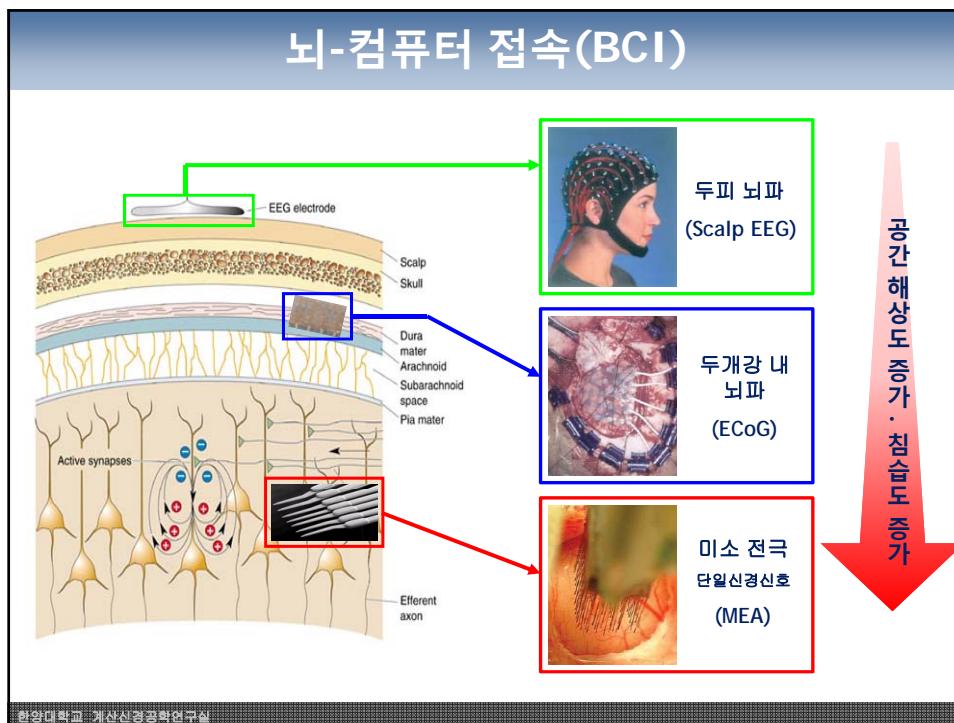
## 뇌-컴퓨터 접속(BCI)

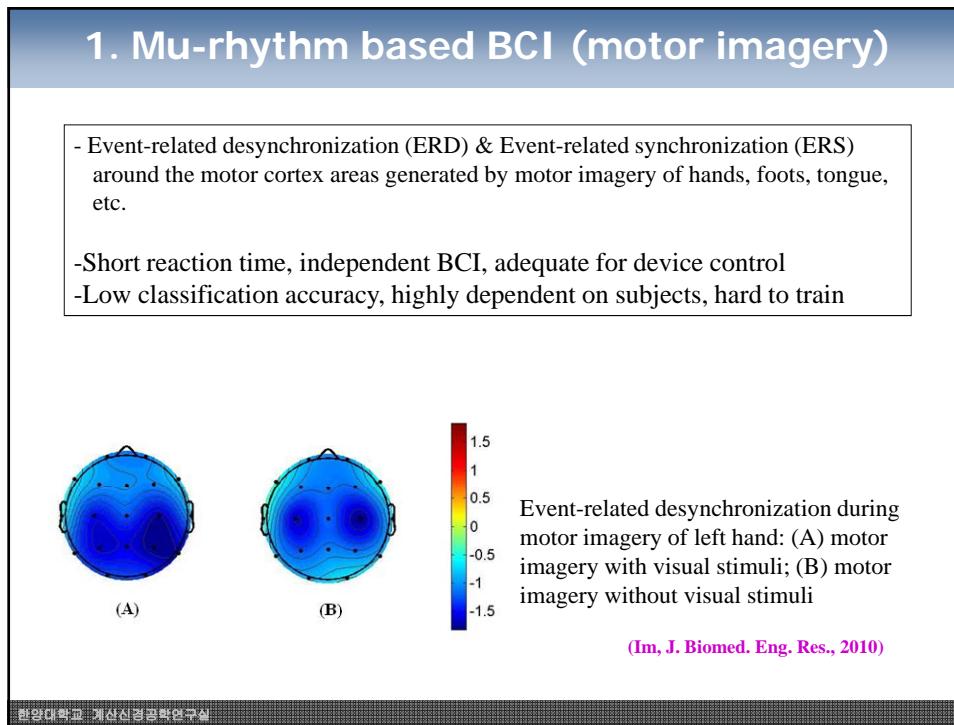
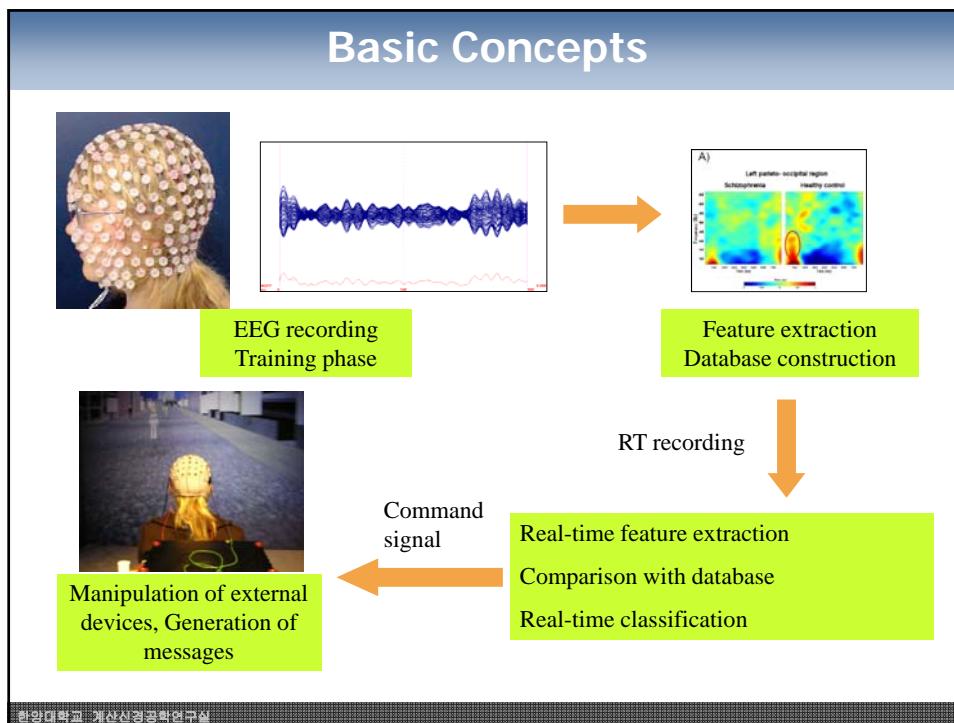
**뇌-컴퓨터 접속 (Brain-Computer Interface: BCI)**  
또는  
**뇌-기계 접속 (Brain-Machine Interface: BMI)**

뇌신경계로부터 측정된 신호를 분석하여 컴퓨터 또는 외부기기 제어  
사용자의 의사를 외부에 전달하기 위한 기술

뇌의 신호 → 일종의 번역기 → 의사 소통 수단

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## Neurofeedback-based Motor Imagery Training for BCI

- Motor Imagery is defined as **mental simulation of a kinesthetic movement**.
- Many individuals (including patients) have difficulty in getting used to the feel of motor imagery, since most people do not easily recognize how they can have a concrete feeling of motor imagery and tend to imagine the images of moving their hands or legs instead (visual motor imagery).
- We developed a kind of **neurofeedback systems to train motor imagery** by presenting participants with time-varying activation maps of their brain, using a real-time cortical rhythmic activity monitoring system.
- Half of ten human volunteers were asked to imagine either left or right hand movement while they were watching their cortical activation maps through the real-time monitoring system.
- During the experiment, the participants were asked to continuously try to increase their mu-rhythm activations (8-12 Hz) around the sensorimotor cortex areas.

(Hwang, Kwon, Im, J. Neurosci. Meth., 2009)

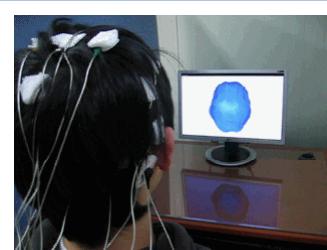
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## Real-time Rhythmic Activity Monitoring System

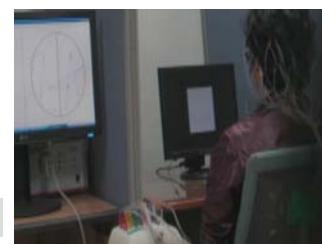


Real-time cortical alpha (8-13 Hz) activity imaging

(Im et al., Physiol. Meas., 2007)  
 (Lee et al., Arch. Phys. Med. Rehab., 2012)  
 (Shin et al., NeuroRehab., 2012)



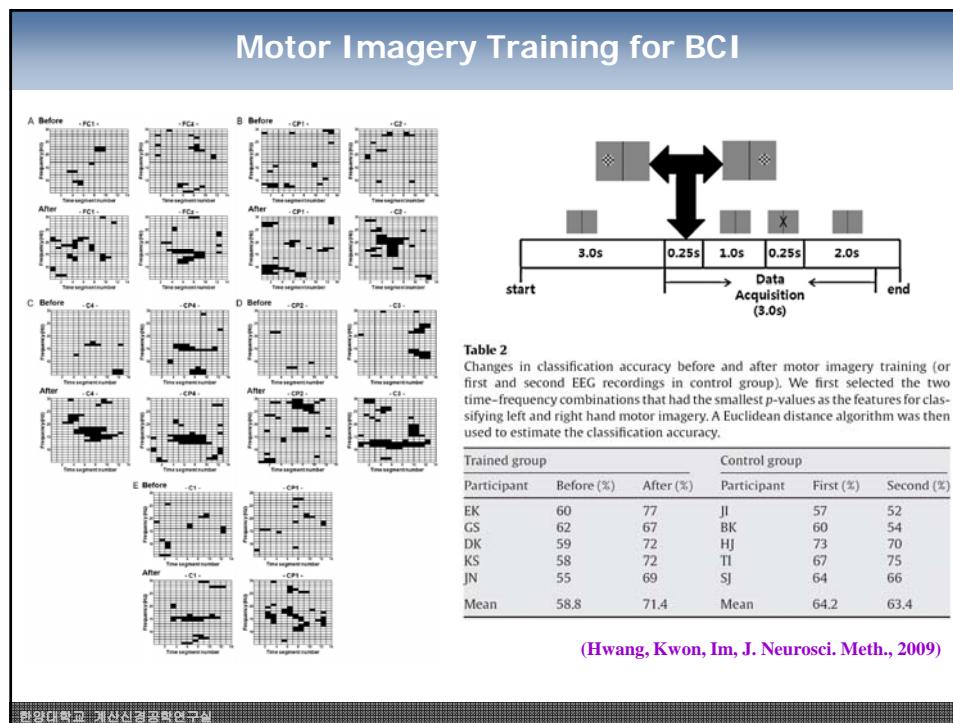
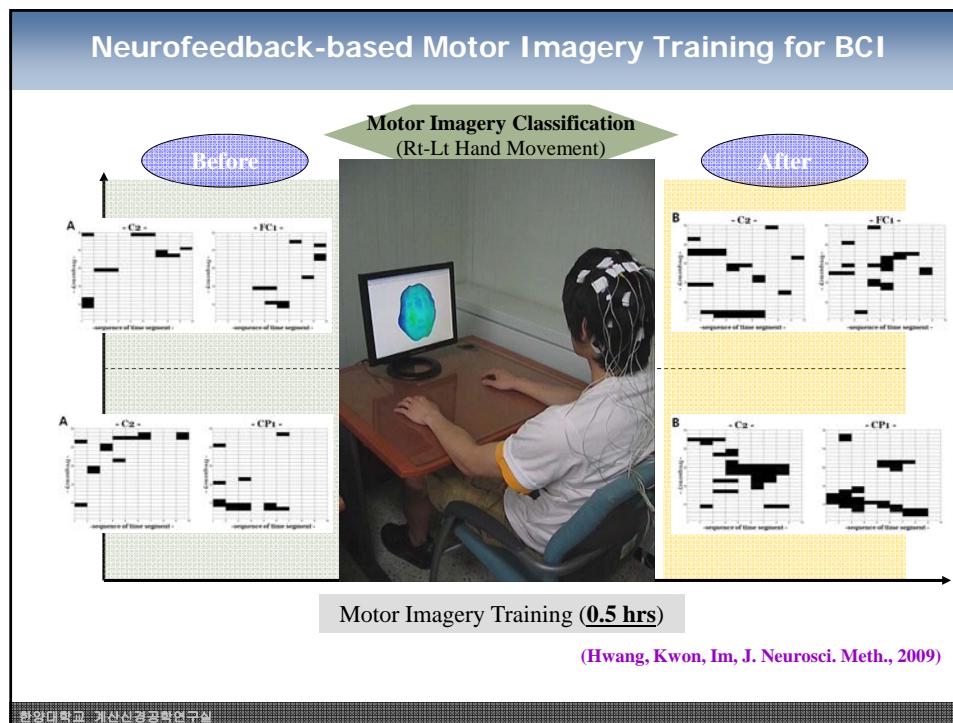
Real-time cortical mu (8-12 Hz) activity imaging



Real-time connectivity monitoring at 30 Hz (Gamma)

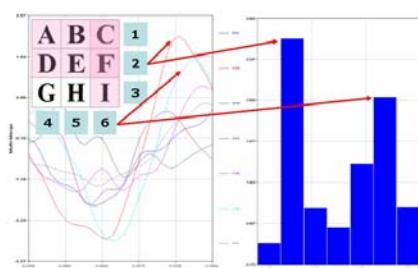
(Hwang, Im et al., Med. Biol. Eng. Compt., 2011)

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## 2. P300-Based BCI

-High accuracy, less dependent upon subjects, easy to train



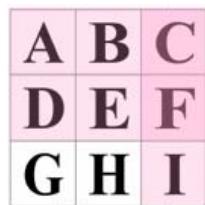
An example of P300-based BCI:  
Results of a test experiment



Austria Guger Technologies – P300 speller

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## P300-based BCI



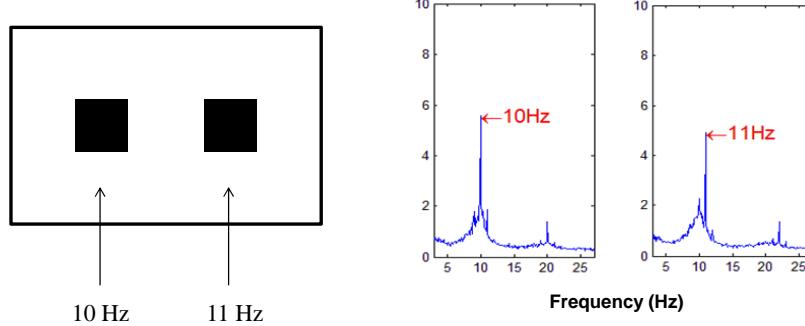
P300-based BCI in Hanyang University  
Collaboration with RIKEN, Japan

(Hwang et al., in prep.)

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### 3. SSVEP-based BCI

Steady-state visual evoked potential (SSVEP)  
a periodic brain response elicited by the continuous presentation of a visual stimulus  
flickering or reversing at a certain frequency



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### 3. SSVEP-based BCI

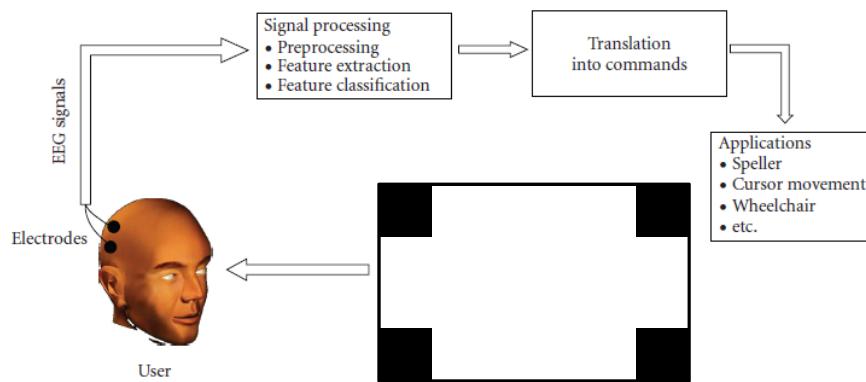


FIGURE 1: Functional model of an SSVEP-based BCI.

From (Zhu et al., 2010)

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## SSVEP-Based Mental Speller

(Volosyak et al., 2011)

(Cecotti et al., 2010)

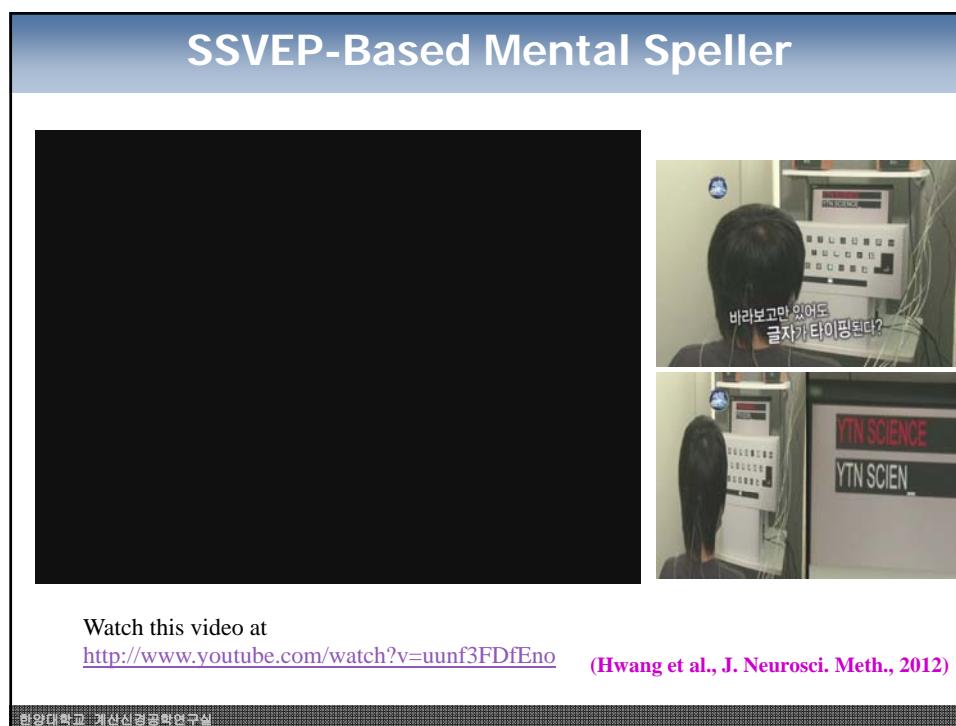
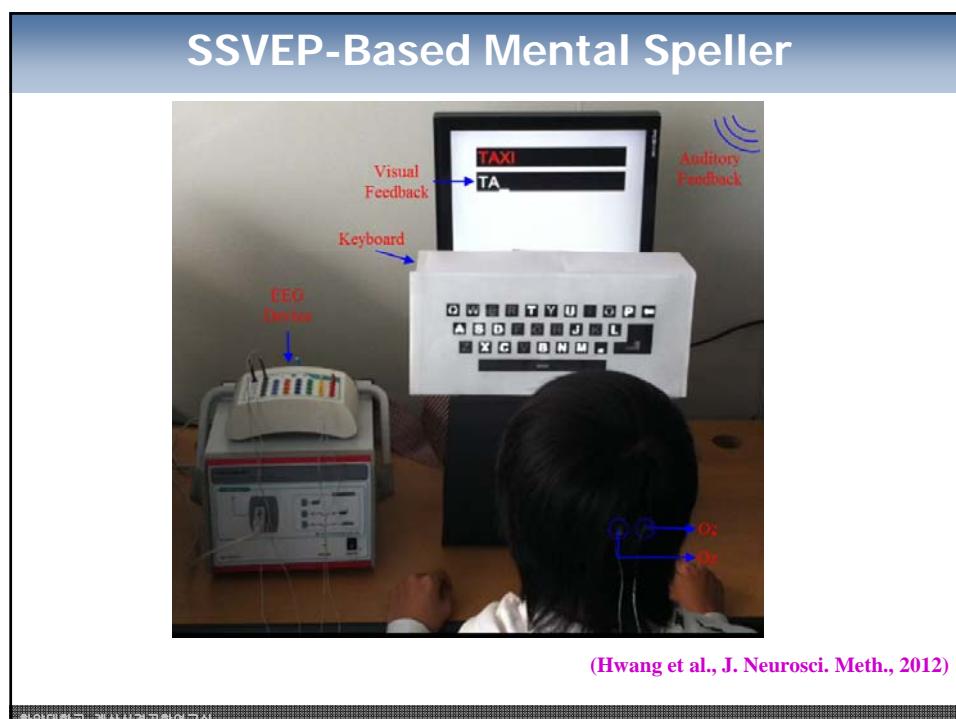
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## SSVEP-Based Mental Speller

- Conventional electroencephalography (EEG) mental spelling systems based on P300 or steady-state visual evoked potential (SSVEP) generally arrange characters alphabetically in a rectangular 2-D array structure, which makes it difficult for the users to realize the locations of target characters easily.
- Considering that acquired factors are the main cause of disabilities for disabled individuals, the majority of the target subjects are more familiar with a QWERTY style keyboard not having a rectangular array structure.
- In this study, we implemented an SSVEP-based mental spelling system adopting a QWERTY style keyboard layout with 30 LEDs flickering with different frequencies.

(Hwang et al., J. Neurosci. Meth., 2012)

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Watch this video at

<http://www.youtube.com/watch?v=uunf3FDfEno> (Hwang et al., J. Neurosci. Meth., 2012)

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## SSVEP-Based Mental Speller

- Online Experimental Results

Participants	Time Period (s)	Correct/ Total	Accuracy (%)	ITR (bits/min)	LPM (letters/min)
	5	83/98	84.69	42.55	10.16
P5	6	81/94	86.17	36.55	8.62
	7	77/86	89.53	33.55	7.64
	4	91/114	79.82	48.02	11.97
P6	5	69/70	98.57	56.75	11.83
	6	68/68	100	49.07	10
P7	6	78/88	88.64	38.44	8.86
P8	6	84/100	84	34.95	8.40
P9	6	90/112	80.36	32.38	8.04
P10	6	84/100	84	34.95	8.40
<b>Mean</b>		<b>87.58</b>	<b>40.72</b>	<b>9.39</b>	
S.D.		6.9	8.12	1.54	

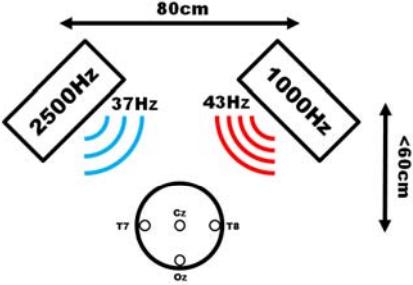
**LPM of 9.39 is one of the best results reported in BCI literatures!**

(Hwang et al., J. Neurosci. Meth., 2012)

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## BCI Paradigm Based on Auditory Selective Attention

In the present study, we investigated whether ASSR can be a feasible feature for a practical BCI system by implementing a modified BCI paradigm to classify one's auditory selective attention and by evaluating the classification accuracy of the BCI system.




(Kim et al., J. Neurosci. Meth., 2011)

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## BCI Paradigm Based on Auditory Selective Attention

EEG signals were recorded at multiple electrodes mounted over the temporal, occipital, and parietal cortices.

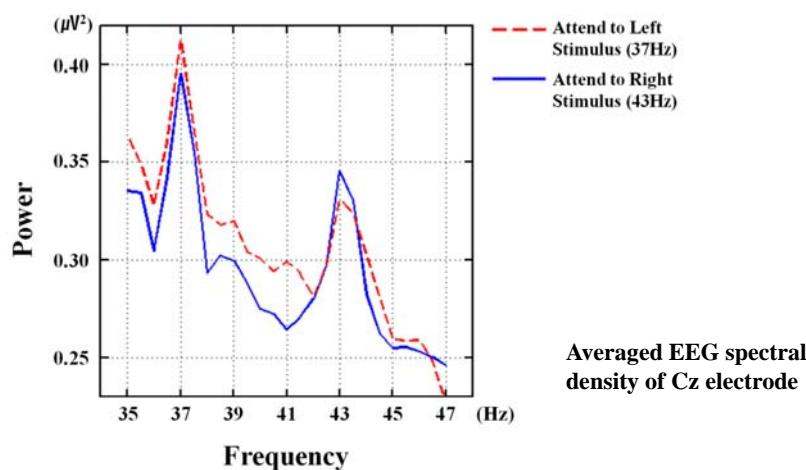
We then extracted feature vectors by combining spectral power densities evaluated at the two beat frequencies.

As candidates of feature vectors, we first evaluated the EEG spectral densities of each electrode averaged over  $37 \pm 1$  Hz (denoted as  $Cz_{37}$ ,  $Oz_{37}$ ,  $T7_{37}$ ,  $T8_{37}$ ) and  $43 \pm 1$  Hz ( $Cz_{43}$ ,  $Oz_{43}$ ,  $T7_{43}$ ,  $T8_{43}$ ). We also evaluated the ratios between all possible pairs of spectral densities evaluated at the same modulation frequency ( $Cz_{37}/T7_{37}$ ,  $Cz_{37}/T8_{37}$ ,  $Cz_{37}/Oz_{37}$ ,  $T7_{37}/T8_{37}$ ,  $T7_{37}/Oz_{37}$ ,  $T8_{37}/Oz_{37}$ ,  $Cz_{43}/T7_{43}$ ,  $Cz_{43}/T8_{43}$ ,  $Cz_{43}/Oz_{43}$ ,  $T7_{43}/T8_{43}$ ,  $T7_{43}/Oz_{43}$ ,  $T8_{43}/Oz_{43}$ ) as well as the ratios between the spectral powers of each electrode evaluated at different modulation frequencies ( $Cz_{37}/Cz_{43}$ ,  $T7_{37}/T7_{43}$ ,  $T8_{37}/T8_{43}$ ,  $Oz_{37}/Oz_{43}$ ).

(Kim et al., J. Neurosci. Meth., 2011)

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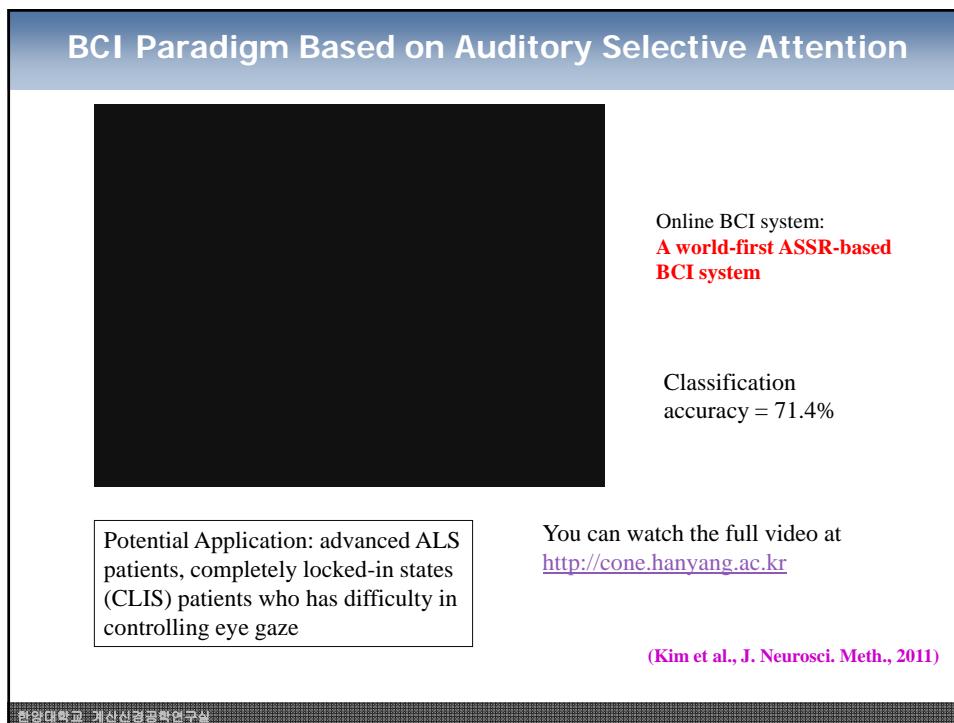
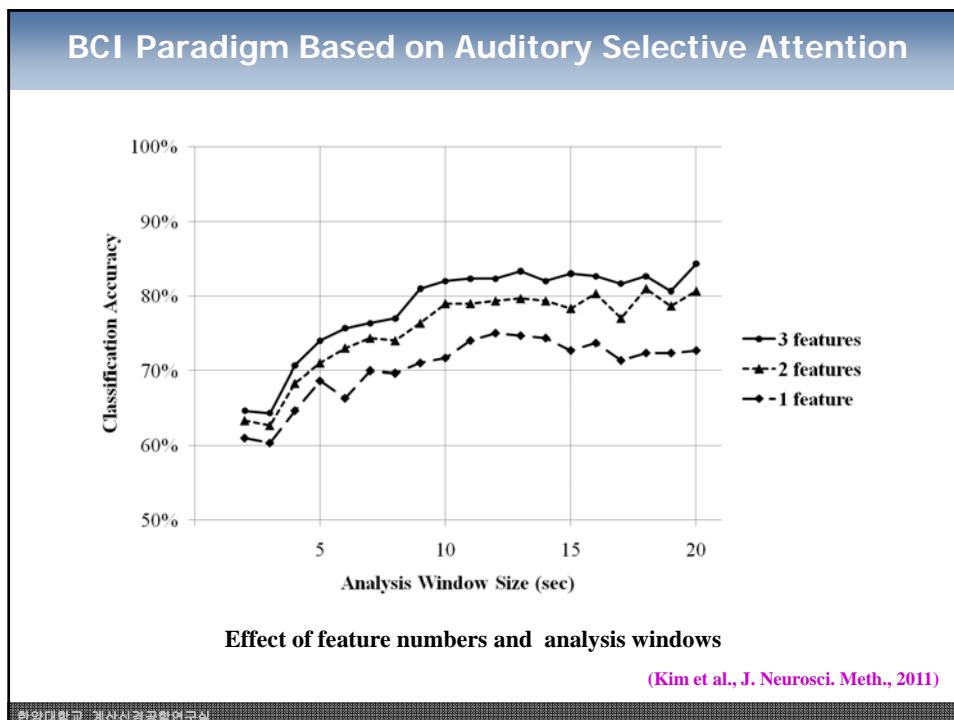
## BCI Paradigm Based on Auditory Selective Attention



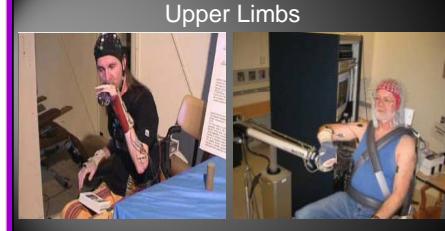
The EEG spectral density was modulated by auditory selective attention to a specific sound source, demonstrating that switching attentions between two different sounds would generate classifiable feature vectors

(Kim et al., J. Neurosci. Meth., 2011)

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### Brain-Computer Interface (BCI)

External Device Control	Rehabilitation
<b>Wheelchair</b> 	<b>Robot Arm</b> 
<b>Mental Speller</b> 	<b>Phone</b> 
	<b>Upper Limbs</b> 
	<b>Lower Limbs</b> 



## Popularization of EEG



**TI ADS1298**

8채널, 24비트 ADS1298  
 - 채널당 1mW의 전력효율  
 - 8개의 저잡음 프로그래머블 게인 증폭기  
 - 8개의 높은 분해능, 동시 샘플링 ADS  
 - 커맨드 노이즈 캔슬레이션 통합 증폭기  
 - WGT 및 GCT 위한 통합 증폭기  
 - 디지털 속도 감지 성능  
 - 연속 리드-오프 감지 기능  
 - 저저력 애플리케이션이나 소형기기를 위한 온보드 오실레이터 및 레퍼런스

A new era is coming!

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## Popularization of EEG

보급형, 무선 뇌파 측정 장치의 개발  
No-gel, dry active electrode system  
Price: \$100 ~ \$500

제품명(개발사, 국가)	제품 이미지
Mindwave (NeuroSky, 미국)	
Xwave (PLX Devices, 미국)	
NIA (Neural Impulse Actuator) (OCZ Technology, 미국)	
Mynd (NeuroFocus, 미국)	

BCI 견용 뇌파 측정 헤드셋 (Hulle 교수, 벨기에)	
EPOC neuroheadset (Emotiv, 호주)	
DSI10/20 무선 뇌파 측정 시스템(수) 전식 능동 전극(과) (Quasar, 미국)	
무선 뇌파 측정 시스템 (IMEC, 벨기에, Holst Centre, 네덜란드, 공동연구)	
Enobio (Starlab, 스페인)	

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## 기타 응용 분야

Neuromarketing





**Neurofocus社**  
 -World largest neuromarketing company (\$34M in 2010)  
 - EEG, eyetracking



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## 기타 응용 분야

Neuromarketing - An example

**Can neuroscience help Gap produce a better logo?**

17:05 20 October 2010  
*(Being Human) Life*  
 Jessica Hamzelou, reporter



Neuromarketing company [NeuroFocus](#) reckon they can piece apart how the human brain responds to bad advertising. The group used EEG and eye-tracking techniques to investigate the neural responses of a group of volunteers who were shown both Gap logos. Neurofocus explained that [the new logo didn't register as novel or stylish in the volunteer's brains](#), two big no-nos for a successful logo. The old logo on the other hand was a big hit, scoring high in the company's "stylish" metric.

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# EEG as a New Input Device

## Kinect Research Director Says 'Brain-Computer Interfaces are Amazing'

*What would be the killer app of a thought-controlled computer?*

*Thought control might be at its best when we are wandering around the street. As we said, it's already acceptable to have ear phones plugged into your head, but if I want to find my way through the city I'm going to look a bit wally chatting about where I want to go. If I could replace that by thinking, great.*

*Even more so, there's what I think of as a The Devil Wears Prada scenario. Meryl Streep is at a party and wants to network but she can't actually remember everybody's name, so her two lovely assistants have memorised an entire album full of faces and biographies. Whenever someone comes up they whisper to her who it is, so she goes "Oh, darling, John!" as if she knew who it was. If I could have that in my phone, it would be fantastic.*


  
Professor Andrew Blake,  
Managing Director of  
Microsoft Research  
Cambridge, England





Neurosky와 Emotiv는 mobile 기기와 연동되는 무선 뇌파 헤드셋을 개발하여 다양한 App을 출시 중

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MS의 kinect의 research director  
도 BCI를 새로운 input 방식으로 생각

→ Neurotainment

# 기타 응용 분야

## ■ 생의학으로 게임 속 캐릭터 조종한다 뇌파로 움직이는 철단 무선 헤드셋 컨트롤러 개발… 게임 산업체 혁명적 변화 불러올 가능성

### Game control

플레이어스미션, 게이트스 등 혼술형 게임기의 보급으로 미체험 집에서도 신나고 재미있는 게임을 만끽할 수 있게 됐다.  
하지만 이와 같은 혼술형 게임기는 장시간 게임을 끊을 때 순간 음악에 무리가 갈 수 있다는 단점이 있다.  
특히 작은 버튼과 조이스틱을 조작해야 하는 업자손기술은 한 두 시간만 게임을 해도 통통 부어오르기 일쑤다.  
하지만 내년이면 게이머들이 이런 고생에서 완전히 해방될 수 있을 전망이다.

미국 벤리파니아 주립 외지한 이큅먼트시스템즈(Equipped Systems)사가 생각하는 것만으로 게임 속의 캐릭터를 마음대로 조종할 수 있는 철단 무선 헤드셋 컨트롤러를 개발했기 때문이다.

'에스(Escape)' 혹은 몇몇 흔히 알고 있는 사람들의 뇌파를 보여 페팅컵을 조종하는 신개념의 컨트롤러다.  
헤드셋은 칼슘된 16개의 전극이 뇌파를 분석, 게이머가 원하는 행동을 정확히 파악한 뒤 명령을 내리는 것.  
즉 게이머에게 게임을 하는 내용 손가락 하나 깨닫히지 않도록 한다.  
畢竟하게 누워 앉은 쪽 주먹을 내린다. '한발'을 물어 물진다. '한디', '총을 촌다'를 캐릭터가 해야 할 동작을 머릿속으로 떠올리기만 하면 된다.





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## 기타 응용 분야



**EEG biofeedback  
Neurofeedback**

a technology to control your brain wave



Meditation, Brain Fitness, Mind Games and More with Mindwave

By MARK HARRIS / AUGUST 2010

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## 기타 응용 분야

### Lie Detection

**MRI Lie Detectors**

Can magnetic-resonance imaging show whether people are telling the truth?

By MARK HARRIS / AUGUST 2010

[Email](#) [Print](#) [Share](#)

Page 1 2 3 // View All



Nervously, my heart pounding, I remove my clothing, watch, and wedding ring. No, it's not an extramarital tryst. The only affair I'm involved in is reporting on a new form of lie detector, one that uses magnetic resonance imaging (MRI). That explains the need to shed my clothes, which might have magnetizable metal parts in them, along with the watch and ring, which could be sucked with dangerous force into the powerful magnet of the apparatus. (Accidents from flying metal have injured and even killed MRI subjects in the past.) I then don hospital garb and climb onto a platform that glides me into the heart of an impressively large if somewhat cramped scanner.

**Brainwave Lie Detection – Criminals can't Fool Brain Fingerprinting**

Posted on Jun 16, 2011

Details of any crime are always imprinted on the brain of the criminal that can be retrieved and recorded on an Electro-encephalograph (EEG). This is the philosophy behind a novel test to catch the actual culprit.

When the brain recognizes something, the memory centers are stimulated. The neurons fire synchronously, eliciting characteristic changes in brain activity. It is these changes, which can be measured using electrodes, which investigators look for when trying to determine whether someone recognizes a particular piece of information.



No-lie MRI社 (미국)

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## 관련 분야에 대한 대중의 관심 증가

관련 영화  
매트릭스, 아바타  
써로게이트

드림스케이퍼  
뇌-컴퓨터 접속

### 큰 사회 경제적 파급효과 기대

뇌과학 관련 드라  
마 및 서적  
브레인, 신드롬, 뇌

거짓말 탐지 MRI  
Brain-Machine

미디어

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**COmputational NeuroEngineering (CoNE) Lab.**

since 2006

한양대학교 계산신경공학연구실은 2001년 한양대학교 전기영재학부 경계융합학전공에 설립되었으며, 이 나-컴퓨터 인터페이스 기술, 생활, 교육, 경신기술을 통한 경영신 디자인과 비즈니스 프로세스 혁신 기반 기술, 디지털 신경학, 신경학 및 신경의학 분야에서 기초 및 응용 연구를 실시하는 연구실입니다. 본 연구실은 현재 서울대학교, 세브란스병원, 고려대학교, 인제대학교, 삼성서울병원, 한국외국어대학 등 국내 우수 병원의 연구과, 경인고, 경인대학원, 유품연구소, 소프트웨어 기업과 공동으로 국제화 연구 프로그램을 운영하고 있습니다.

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[CoNE-IntraNet](#)

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