

1

2

:

: 24

20

6

4

. 2

2

10

10

3

가

가

가

(I)

가

(II)

(III)

40

(IV)

1.5T MRI head coil

EPI

Z-score Evaluated Mean/curve

: 24

48

32

Brodmann 6

. I

, 5

3

. II

, 5

1

III

, 5

3

. IV

5

3

:

fMRI 66.7%

가

(supplementary motor area, SMA)

(M1)

(Brodmann's area) 6

(1).

(4,5). 1993 Rao (3)

(functional magnetic resonance imaging,

가

fMRI)

(cingulate sulcus)

(2).

SMA

SMA

Lim (2)

(1).

(numbness),
sation)(tingling sensation),
SMA가

(pressure sen-

(3),

fMRI

SMA

(1).

SMA

1

2

1998 8 25

1999 3 2

24

20-30

6 4 . z-score 0.9-0.99

I 가 가 T1 가

, II SMA

가 , III SMA

, IV Evaluated Mean/curve ROI

40

. I II SMA

가 , II SMA가

(fine movement)

IV , SMA 가

III 24 48 32

I 5/6 (9/12) SMA

(Fig. 1A),

, SMA

1.5T (Vision, Siemens, Erlangen, Germany)

, head coil

echo planar imaging(EPI) (TR/TE = 1.68/64ms,

fiap angle: 90 , slice thickness: 3mm, matrix: 64 × 128, FOV:

210mm, scan interval: 1-3sec) fMRI

10 10

60-180 60

10

fMRI

T1 III 5/6 (9/12) SMA

(Fig. 3A),

(bilateral activity) ROI

(Fig. 3B).

600

480

480

Z-score (Evaluated Z-score) IV 5/6 (8/12) SMA

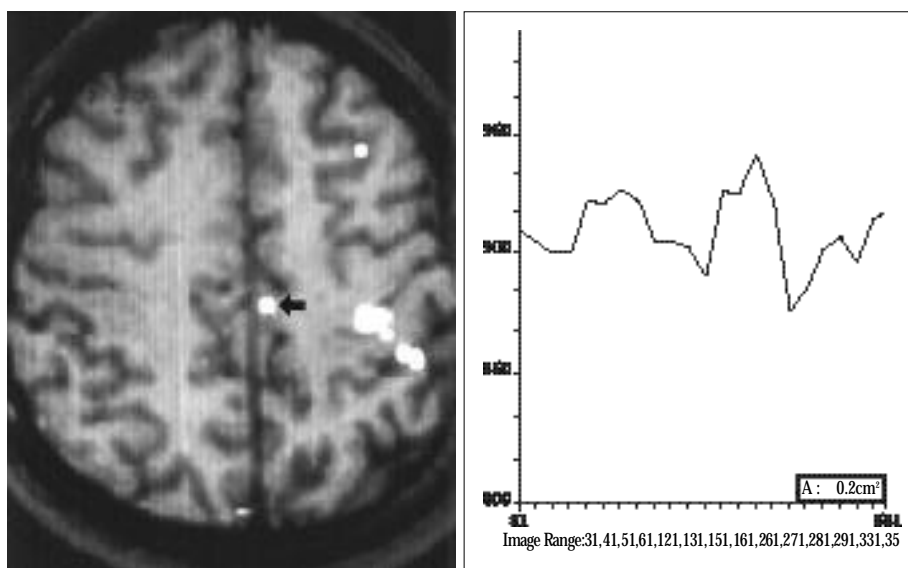


Fig 1. Right hand complex movement
A. Activation image shows activations in the left sensorimotor cortex and supplementary motor area(SMA) (black arrow).
B. Average time course plot obtained from a ROI including the SMA during the alternative tasks shows cyclic change of signal intensity which follows the periodicity of the task.

ROI
(Fig. 4B).

가 (Fig. 4A).

SMA 1949 Penfield (2)

Brodmann 6

가

danger (4)

dextran amine, BDA)

(biotinylated

(cholera toxin-B)

가

SMA

SMA

가

SMA가

가

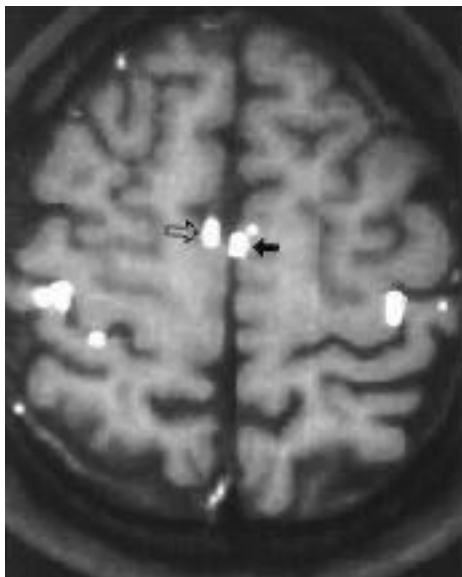
SMA

(3).

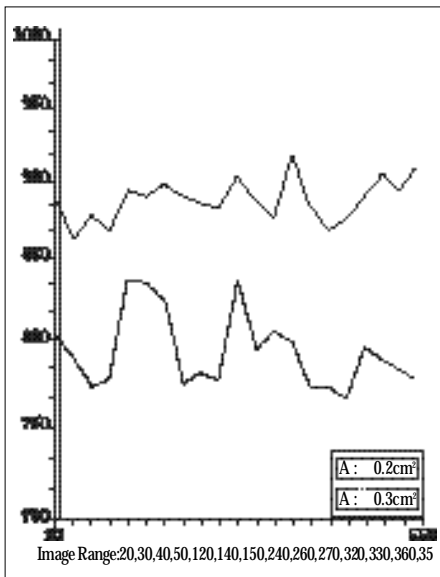
Brodmann 6

가

가 (3-6).

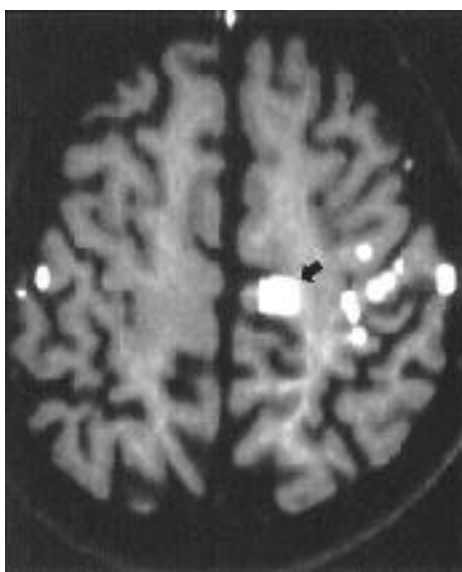


A

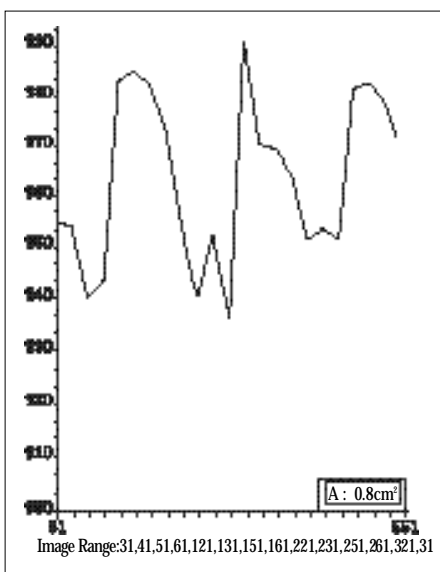


B

Fig 2. Right hand fine movement.
A. Activation image shows activation in the sensorimotor cortex and SMA, bilaterally(right SMA : white arrow, left SMA : black arrow).
B. Average time course plot obtained from a ROI including the left SMA during the alternative tasks shows cyclic change of signal intensity which follows the periodicity of the task.

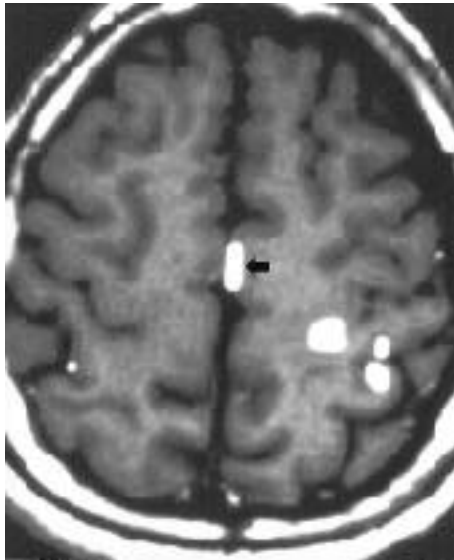


A

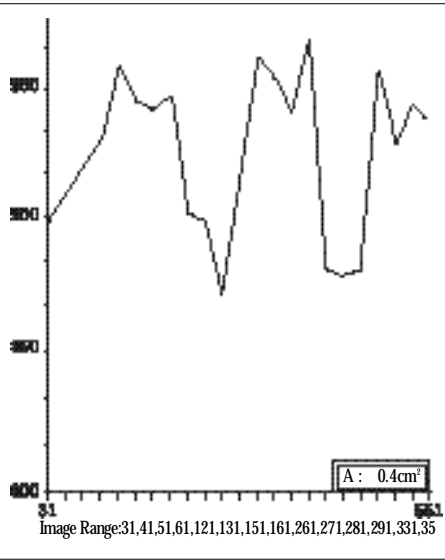


B

Fig 3. Right hand touch sensation.
A. Activation image shows activation in the left sensorimotor area and S-MA(black arrow).
B. Average time course plot obtained from a ROI including the SMA during the alternative tasks shows cyclic change of signal intensity which follows the periodicity of the task.



A



B

Fig 4. Right hand heat sensation.
A. Activation image shows activation in the left sensory area and SMA (black arrow).
B. Average time course plot obtained from a ROI including the SMA during the alternative tasks shows cyclic change of signal intensity which follows the periodicity of the task.

(7).
Shibasaki (8) Sadato (9)
(positron emission tomography, PET) ^{15}O
belled water) SMA
가
, SMA,
(cerebellum) 가
Shibasaki (8) 가
가
I II
SMA 6 5 MA)
SMA가
(pre-SMA), SMA, (supplementary eye field, SEF)
SMA
SMA
가
fMRI
(frontal eye field)
(brainstem oculomotor center)
(1). I II S-
MA
가 Sadato (9) PET 10
Chung (10) 10
Rao (3) fMRI
SMA 264
Shin (11) EPI
EPI

180

. EPI 1

가

가

Brodmann 6
(medial frontal cortex)

EPI

SMA가 Brodmann 6

SMA가

가

가

SMA

1. Tanji J. New concepts of the supplementary motor area. *Curr Opin*

Neurobiol 1996;6:782-787

2. Lim SH ,Dinner DS,Pillay PK, et al. Functional anatomy of the human supplementary sensorimotor area: results of extraoperative electrical stimulation. *Electroencephalogr Clin Neurophysiol* 1994;91: 179-193
3. Rao SM, Binder JR, Bandettini PA, et al. Functional magnetic resonance imaging of complex human movement. *Neurology* 1993;43: 2311-2318
4. Wiesendanger M, Rouiller EM, Kazennikov O,Perrig S. Is the supplementary motor area a bilaterally organized system? *Adv Neurol* 1996;70:85-93
5. Penfield W, Welch K. The supplementary motor area of the cerebral cortex: A clinical and experimental study. *Arch Neurol Psychiat* 1951;66:289-317
6. Wildgruber D, Erb M, Klose V, Grodd W. Sequential activation of supplementary motor area and primary motor cortex during self-placed finger movement in human evaluated by functional MRI. *Neurosci Lett* 1997;227:161-164
7. Ackermann D, Daum I, Schugens MM, Grodd W. Impaired procedural learning after damage to the left supplementary motor area. *J Neurol Neurosurg Pshychiatry* 1996;60:94-97
8. Shibasaki H, Sadato N, Lyshkow H, et al. Both primary motor cortex and supplementary motor area play an important role in complex finger movement. *Brain* 1993;116:1387-1398
9. Sadato N, Ibanez V, Deiber MP, Campbell G, Leonardo M, Hallett M. Frequency-dependent changes of regional cerebral blood flow during finger movements. *J Cereb Blood Flow Metab* 1996;16:23-33
10. , , , et al. EPI 1998;38:957-964
11. , , . et al. 1998;38:965-970

A Study on the Activation of Supplementary Motor Area in Functional Magnetic Resonance Imaging of the Brain¹

Gong-Yong Jin, M.D., Gyung-Ho Chung, M.D., Hark-Hoon Park, M.D., Hee-Sul Oh, M.D.,
Jin-Young Chung, M.D., Chong-Soo Kim, M.D.

¹Department of Diagnostic Radiology Research Chonbuk National University Medical School

²Department of Diagnostic Radiology, Eulji College of Medicine

Purpose : To evaluate the activated zone of the supplementary motor area through motor and sensory stimulation of both hands by fMRI.

Materials and Methods : Twenty-four healthy volunteers, ranging in age from 20 to 30 years, served as subjects. They were divided into four groups and performed one of the four activation tasks : complex movement, fine movement, touch sensation, heat sensation. Complex movement consisted of a finger task in which subjects flexed and extended all fingers repeatedly in union, without the fingers touching each other(group I). Fine movement involved a thumb task in which subjects flexed and extended the thumb repeatedly without touching the other fingers(group II). Touch sensation consisted of a palm task in which another person repeatedly drew a circle on the subject's palm (group III), and heat sensation involved of a palm task in which subject's palm was touched by another person with a 40°C water-bag (group IV). F-MRI was conducted on a commercial 1.5-T scanner equipped with echo-planar imaging. After overlapping images were obtained using a Z-score, and the mean/curve in the MR devices was evaluated, the activated zone of the supplementary motor area was also evaluated.

Results : Thirty-two of 48 images(20 of the 24 men) revealed activated zones in the supplementary motor area. In group I, activation was observed in five subjects, in three of whom it was bilateral (contralateral activation). In group II, activation was observed in five subjects, in one of whom it was bilateral. In group III, activation occurred in five subjects(bilateral in four, and contralateral in three), and In group IV, activation was also observed in five ; in three of these it was bilateral.

Conclusion : Using fMRI, and in association with motor and sensory tasks, the supplementary motor area was activated in 66.7% of healthy volunteers (32/48).

Index words : Magnetic resonance(MR), motion studies
Magnetic resonance(MR), technology
Brain, MR

Address reprint requests to : Gyung-Ho Chung, M.D., Department of Diagnostic Radiology, Chonbuk National University Medical School
#634-18 Keumam-Dong, Chonju-shi, Chon Buk, 560-182, Korea
Tel. 82-652-250-1177 Fax. 82-652-272-0481