

# **Analysis of Traditional Scalp Acupuncture Point Locations as Local Cortical Region and Functional Network Node Targets in Non-Invasive Brain Network Neuromodulation**

## **Section 2 - The Motor, Premotor, and Sensory Cortices**

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### **Abstract**

**Background/Objective:** Non-invasive neuromodulation techniques have increasingly been utilized and investigated as potential treatment approaches for neurological and psychiatric disorders. Increasing evidence supports the possibility of non-invasive neuromodulation affecting larger scale brain networks rather than just local stimulation targets. In this article, this concept and implications thereof are explored within the context of traditional acupuncture points located on the scalp and their cortical region correlates.

**Method:** This article addresses the conceptual framework of traditional acupuncture point locations on the scalp as potential local cortical region and/or neural network nodes of non-invasive neuromodulation modalities and may expand existing understanding of the influence of scalp acupuncture points based on these network connections. Studies that support this hypothesis are provided followed by an exploration of functionally and structurally connected brain parcellations elucidated by connectomic mapping and correlations with traditional acupuncture points. In this installment cortical regions of the motor, premotor, and sensory cortices are explored.

**Main Results/Conclusion:** Studies stimulating brain regions by various non-invasive methods including manual and laser scalp acupuncture, repetitive Transcranial Magnetic Stimulation (rTMS), and transcranial Direct Current Stimulation (tDCS) offer evidence of underlying neuromodulatory mechanisms and clinical therapeutic effect in cases of various neuropathologies. These effects have evidence to support that in addition to local cortical region responses; structural and functional brain network modulatory influence including influence upon deeper brain structures, have been demonstrated. In light of this evidence, it is proposed that applying a network perspective to non-invasive transcranial stimulation may lend a broader understanding of therapeutic potential in using these techniques.

**Keywords:** scalp acupuncture, connectome, neuromodulation, brain networks, brain hubs, motor cortex, premotor cortices, sensory cortex, somatosensory cortices

# Primary Motor Cortex

## Area 4

### Location:

Found in the precentral gyrus. Predominantly on the posterior half of the gyrus, making up the anterior bank of the central sulcus.

### Function:

- Fine motor movements of the distal forearm and fingers.
- Giving a muscle its tone and producing forceful muscle contractions.
- Also thought to play a role in visual learning of motor-based skills in the early stages of life.

### Functional Connectivity:

- Sensory strip: areas 1, 2, 3a, and 3b
- Premotor regions: areas SCEF, 55b, 6d, 6v, and 6mp
- Middle cingulate regions: areas 24dd, 24dv, 5m, and 5L
- Superior insular opercular regions: areas 43, OP1, OP2-3, OP4, IG, and FOP2
- Lower opercula/Heschl's gyrus regions: areas A4, A5, RI, PBelt, LBelt, TA2, and STV
- Parietal lobe: areas VIP, IPS1, LIPv, and 7PC
- Medial occipital lobe: areas V2, V3, and V4
- Dorsal visual stream: areas V6, V6a, V3a, and V7
- Ventral visual stream: area FFC
- Lateral occipital lobe: areas PH, TPOJ1, FST, V4t, MT, and LO3

### White Matter Connections?

Structurally connected to pyramidal tracts, the contralateral hemisphere, and the parietal lobule. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem. Contralateral connections course through the corpus callosum to parcellations 4, 6ma, and 6mp. Parietal projections are portions of the SLF and connect to PFM. Local short association fibers are connected with 3a, 3b, 2, 1, and 6v

### Traditional Acupoint Correlates:

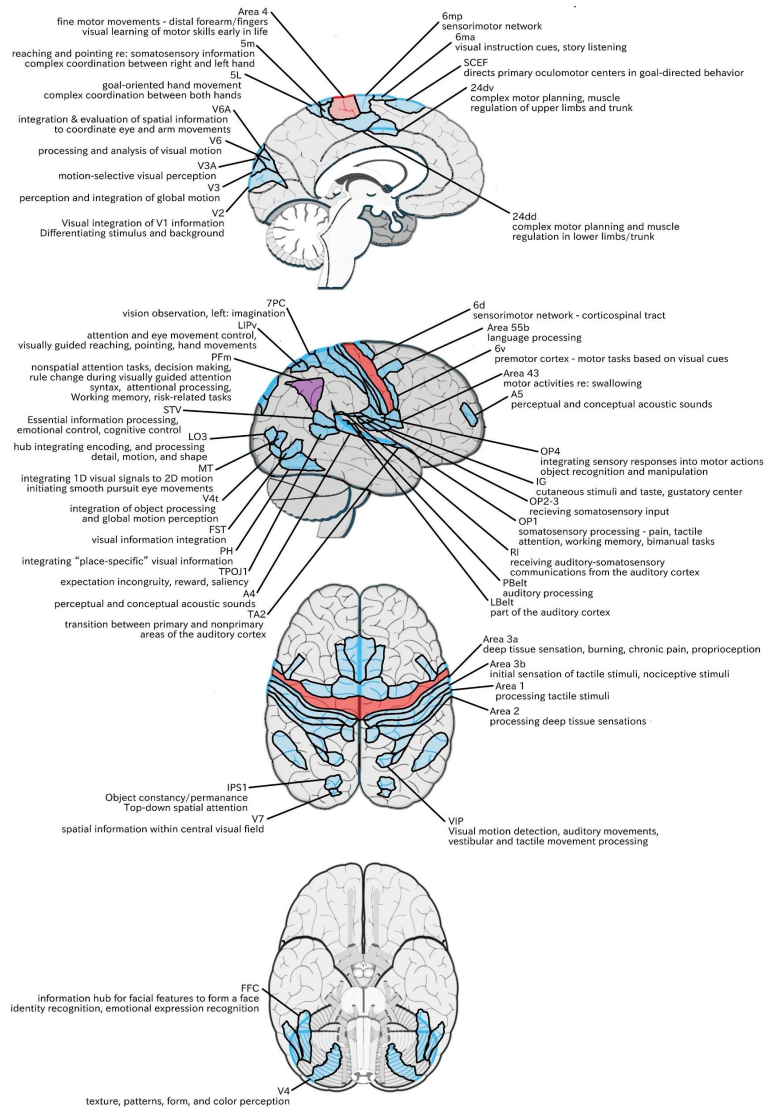
Local Acupoint: GV20

### Functionally Connected Acupoints:

- BL6 (6d, 6mp)
- GB4 (Area 43)
- GB14 (A5)
- GB18 (7PC, LIPv)
- GV20 (Area 1, 3a, 3b)
- BL7 (Area 2, 7PC)
- GB5 (A4, TA2)
- GB16 (55b)
- ST8 (6v)
- GV21 (SCEF)

### Structurally Connected Acupoints:

- GB17 (Area1, 2, 3a, 3b, 4)
- GV20 (1, 3a, 3b, 4)
- GB18 (PFM)
- ST8 (6v)
- BL8 (IPS1, V7)
- GB9 (FST, PH)
- GB17 (Area 1, 2, 3a, 3b)
- GV18 (V2)



# Primary Sensory Areas

## Area 3a

### Location:

Found in the depth of the central sulcus. It follows this sulcus up to the midline.

### Functions:

- Receives sensory information from deep body tissues.
- Involved in the burning, chronic pain sensations that originate from deep somatic tissue suggesting relevance in many chronic pain ailments.
- Involved in proprioception.

### Functional Connectivity:

Motor and sensory strips: areas 1, 2, 4, 3b  
 Premotor regions: SCEF, 55b, 6d, 6v, 6mp  
 Middle cingulate regions: 24dd, 24dv, 5m, 5L  
 Superior insula opercular regions: 43, OP1, OP2-3, OP4, IG, FOP2  
 Lower opercula/Heschl's gyrus regions: Pol2, 52, A4, A5, RI, A1, MBelt, PBelt, LBelt, TA2, STV  
 Parietal lobe: PFcm, 7AL, 7PC  
 Medial occipital lobe: V2, V3, V4  
 Dorsal visual stream: V6, V6a, V3a, V7  
 Ventral visual stream: FFC  
 Lateral occipital lobe: PH, TPOJ1, FST, V4t, MST, MT, and LO3

### White Matter Connections:

Structurally connected to the pyramidal tracts, thalamocortical projections, contralateral hemisphere, and the parietal lobe.  
 Pyramidal tract connections descend to the brainstem.  
 Thalamocortical tracts run medial to enter the thalamus.  
 Contralateral connections course through the corpus callosum to parcellations 3b and 4.  
 Parietal projections are part of SLF, connecting to PFm.  
 Local short association fibers are connected with 4, 3b, 2, 1, and 6v.

### Traditional Acupoint Correlates:

GV20, GB17

### Functionally Connected Acupoints:

BL6 (6d, 6mp)  
 GB4 (Area 43)  
 GB9 (PH, FST)  
 GB17 (Area 1, 2, 3b)  
 GV20 (Area 1, 3a, 4)

BL7 (Area 2, 7PC, 7AL)  
 GB5 (A1, A4, POL2, TA2)  
 GB14 (A5)  
 ST8 (6v)  
 GV21 (SCEF)

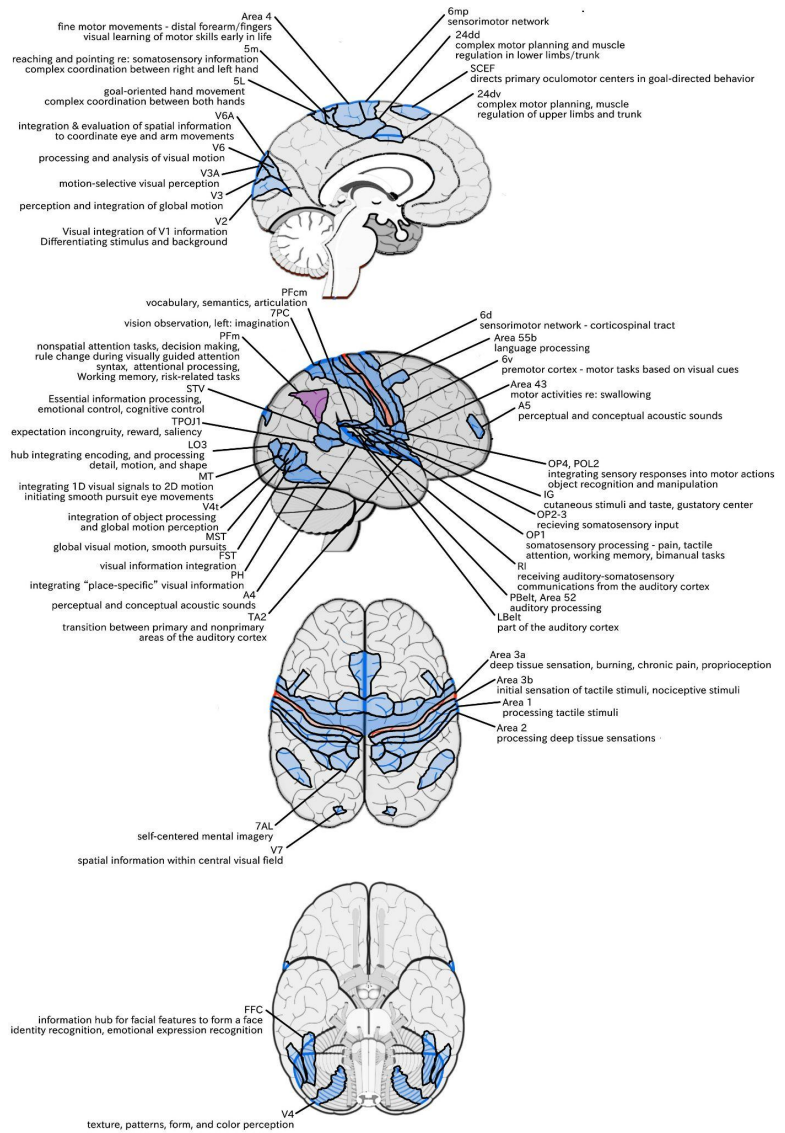
BL8 (V7)  
 GB8 (PH)  
 GB16 (55b)  
 GV18 (V2)

### Structurally Connected Acupoints:

GB17 (Area 1, 2, 3b, 4)  
 GV20 (Area 1, 3b, 4)

GB18 (PFm)

ST8 (6v)



# Area 3b

## Location:

Area 3b makes up the entire anterior bank of the postcentral gyrus. It does not reach the Sylvian fissure or fold onto the medial hemispheric face.

## Functions:

- Sensation of tactile stimuli. Specifically, the initial region of activation in tactile stimulation, followed by area
- Localization of sensation on the skin and distinguishing its features For example, more focal sensation such as finger-specific information
- Exclusive activation of nociceptive stimuli.

## Functional Connectivity:

- Sensory strip: areas 1, 2, and 3a
- Motor strip: area 4
- Premotor regions: SCEF, 6d, 6v
- Middle cingulate regions: 24dd, 24dv, 5m, 5L
- Superior insula opercular regions: areas 43, OP1, OP2-3, OP4, IG, PFcm, FOP2
- Lower opercula / Heschl's gyrus regions: A4, A5, RI, 52, A1, MBelt, LBelt, PBelt, TA2, STV
- Parietal lobe: 7AL, 7PC
- Medial occipital lobe: V2, V3, V4
- Dorsal visual stream: V6, V6a, V3a, V7
- Ventral visual stream: FFC
- Lateral occipital lobe: TPOJ1, FST, V4t, MST, MT, and LO3

## White Matter Connections:

Structurally connected to the pyramidal tracts, thalamocortical projections, contralateral hemisphere, and the parietal lobe. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem. Thalamocortical tracts run medial to enter the thalamus. Contralateral connections course through the corpus callosum to parcellations 3a, 3b, and 4. Parietal projections are portions of the SLF and connect with IP1 and IP2.

Local short association fibers are connected with 1, 2, 3a, and 4.

## Traditional Acupoint Correlates:

GV20, GB17

## Functionally Connected Acupoints:

- BL6 (6d)
- GB4 (Area 43)
- GB14 (A5)
- ST8 (6v)
- GV21 (SCEF)

- BL7 (Area 2, 7PC, 7AL)
- GB5 (A4, TA2)
- GB17 (Area1, 2, 3a)
- GV18 (V2)

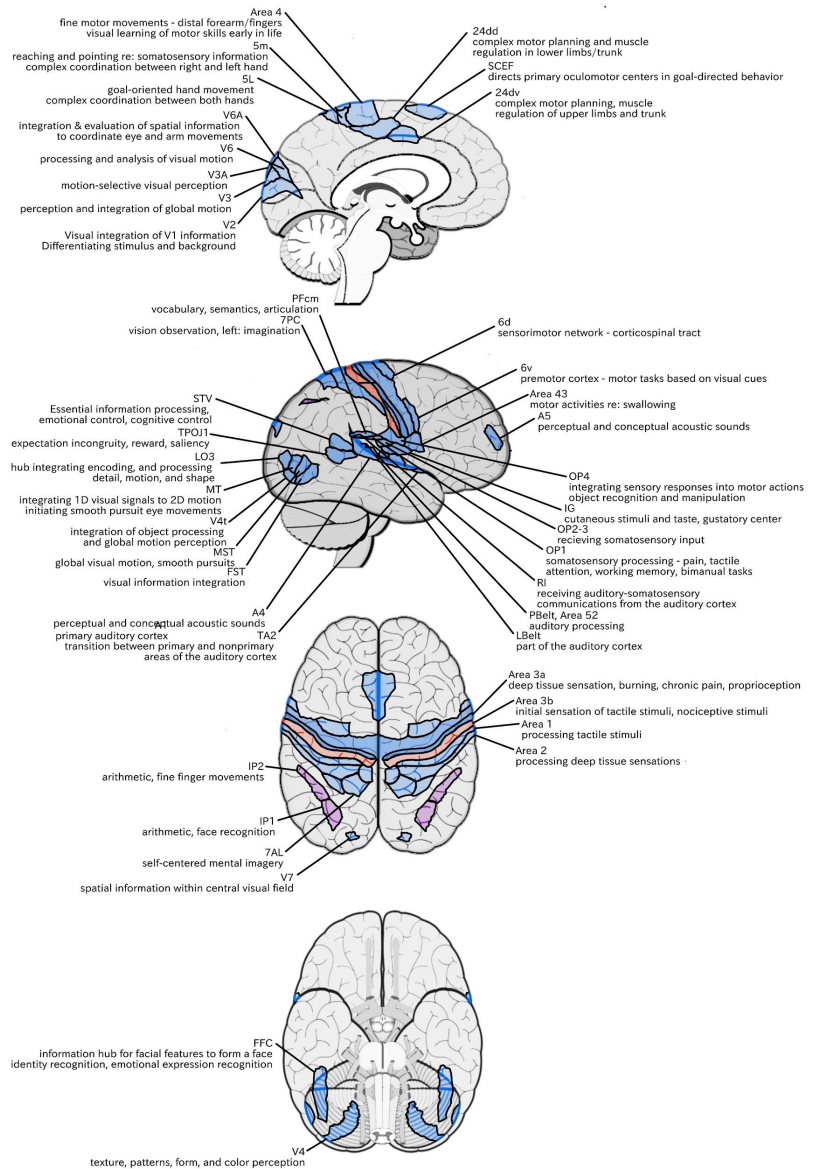
- BL8 (V7)
- GB9 (FST)
- GB18 (7P)
- GV20 (Area 1, 3a, 4)

## Structurally Connected Acupoints:

- BL8 (IP1)
- GV20 (Area 1, 3a, 4)

- GB17 (Area 1, 2, 3a, 4)

- GB18 (IP1)



# Area 1

## Location:

On the visible surface of the postcentral gyrus. It forms the largest bulk of the postcentral operculum. It continues up to the midline, but does not fold onto the medial face.

## Functions:

- Processing tactile stimuli, along with 3b. Specifically, the secondary point of activation following area 3b.
- Functions along with area 2 in receiving information related to bilateral tactile stimulation of the hands.

## Functional Connectivity:

- Sensory strip: areas 2, 3a
- Motor strip: area 4
- Premotor regions: SCEF, 6mp, 6d, 6v
- Middle cingulate regions: 24dd, 24dv, 5m, 5L
- Superior insula opercular regions: areas 43, OP1, OP2-3, OP4, IG, PFcm, FOP2
- Lower opercula / Heschl's gyrus regions: A4, A5, RI, 52, MBelt, LBelt, PBelt, TA2, STV
- Parietal lobe: LIPv, VIP, IPS1, 7AL, 7PC
- Medial occipital lobe: V2, V3, V4
- Dorsal visual stream: V6, V6a, V7
- Ventral visual stream: FFC
- Lateral occipital lobe: PH, TPOJ1, FST, V4t, MST, MT, LO3

## White Matter Connections:

- Structurally connected to the pyramidal tracts, thalamocortical projections, and the parietal lobe. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem.
- Thalamocortical tracts run medial to pyramidal projections to enter the thalamus.
- Parietal projections are portions of the SLF and connect to PFm.
- Local short association fibers are connected with 1, 2, 3a, 3b, 4, and 6.
- White matter tracts of area 1 in the right hemisphere have less consistent projections to surrounding parcellations.

## Traditional Acupoint Correlates:

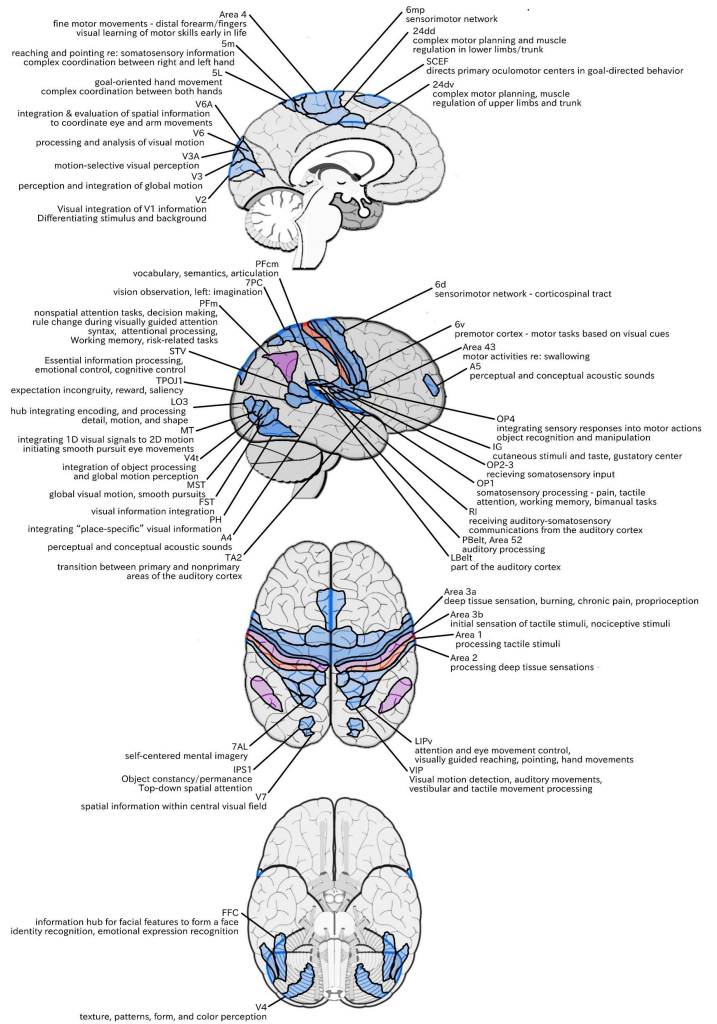
GB17, GV20

## Functionally Connected Acupoints:

- |               |                     |                |
|---------------|---------------------|----------------|
| BL6 (6d)      | BL7 (Area2)         | BL8 (IPS1, V7) |
| GB4 (Area 43) | GB5 (A4, TA2)       | GB8 (PH)       |
| GB9 (PH, FST) | GB14 (A5)           | ST8 (6v)       |
| GV18 (V2)     | GV20 (Area 3a,3b,4) | GV21 (SCEF)    |

## Structurally Connected Acupoints:

- |                          |            |                       |
|--------------------------|------------|-----------------------|
| GB17 (Area 2, 3a, 3b, 4) | GB18 (PFm) | GV20 (Area 3a, 3b, 4) |
|--------------------------|------------|-----------------------|



## Area 2

### Location:

Makes up most of the anterior bank of the postcentral sulcus

### Functions:

- Processing of deep tissue sensations.
- Activated in bilateral tactile stimulation of the hands.

### Functional Connectivity:

Sensory strip: areas 1, 3a, and 3b

Motor strip: area 4

Premotor regions: SCEF, FEF, 6a, 6mp, 6d, 6v

Middle cingulate gyrus: 24dd, 24dv p32prime, 5mv, 5m, 5L

Superior insula opercular regions: areas 43, OP1, OP2-3, OP4, IG, PFcm, FOP1, FOP2

Lower opercula / Heschl's gyrus regions: Pol1, Pol2, A4, A5, RI, 52, A1, MBelt, LBelt, PBelt, TA2, STV

Parietal lobe: AIP, VIP, LIPv, PFop, PFT, IPS1, 7AL, 7PC

Medial occipital lobe: V2, V3

Dorsal visual stream: V6

Ventral visual stream: FFC

Lateral occipital lobe: PH TPOJ1, TPOJ2, FST, V4t, MST, MT, and LO3

### White Matter Connections:

Structurally connected to the pyramidal tracts, thalamocortical projections, contralateral hemisphere, and the parietal lobe.

Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem.

Thalamocortical tracts run medial to pyramidal projections to enter the thalamus.

Contralateral connections course through the body of the corpus callosum to parcellation 7am. Parietal projections are portions of the SLF and connect to PFm, IP1, and IP2.

Local short association fibers are connected with 6r, 7PC, AIP, 1, 3a, 3b, and 4.

### Traditional Acupoint Correlates:

BL8 (also 1/2 way between BL GB17/18)

### Functionally Connected Acupoints:

BL6 (6a, 6d)  
GB4 (Area 43)  
GB9 (PH, FST)  
GB17 (Area1, 3a, 3b)  
GV18 (V2)

BL7 (7PC, 7AL)  
GB5 (A1, A4, POL2, TA2)  
GB14 (A5)  
GB18 (LIPv, AIP, 7PC)  
GV20 (Area 1, 3a, 4)

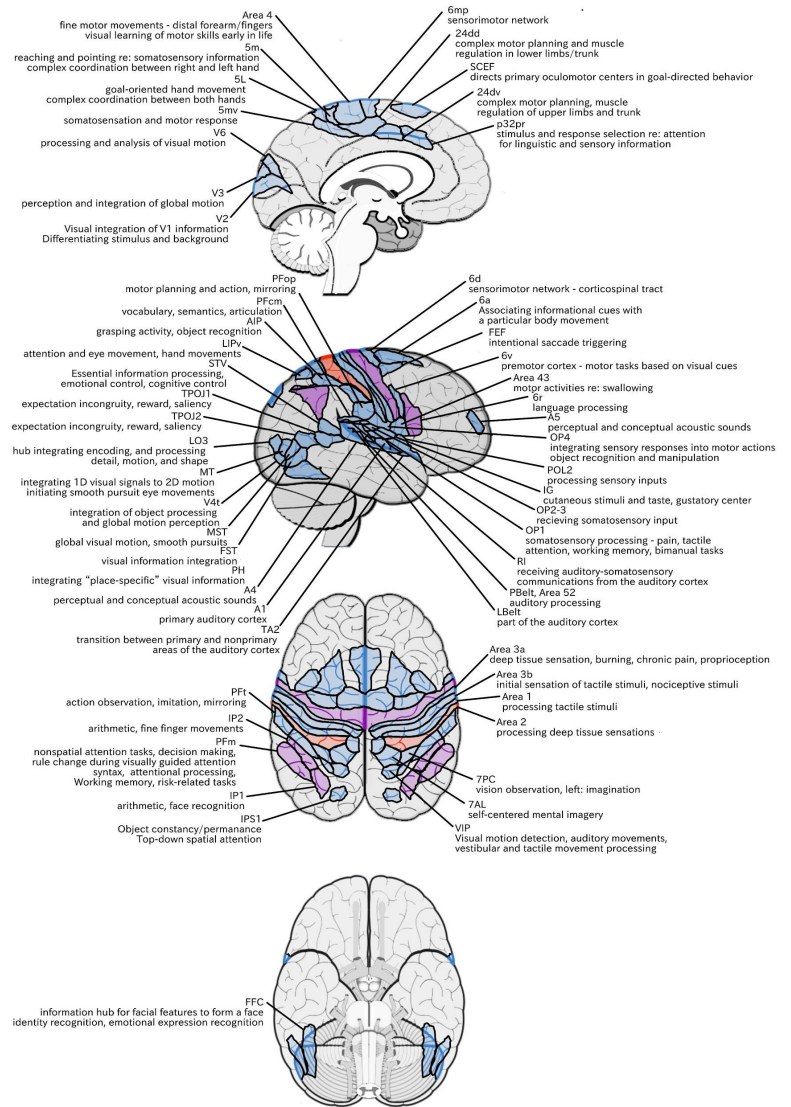
BL8 (IPS1)  
GB8 (PH)  
GB16 (FEF)  
ST8 (6v)  
GV21 (SCEF)

### Structurally Connected Acupoints:

BL7 (7PC)  
GB17 (Area 1, 3a, 3b, 4)  
GV20 (Area 1, 3a, 3b, 4)

BL8 (IP1)  
GB18 (AIP, PFm, IP1)

GB4 (6r)  
ST8 (6r)



# Paracentral lobule areas

## Area 5L (5 lateral)

### Location:

On the posterior superior most portion of the postcentral gyrus. It is located at the angle where the gyrus folds onto the interhemispheric surface.

### Functions:

- Goal-oriented hand movement, specifically movement that is not based on visual cues.
- Suggested activation in tasks that require complex coordination between the right and left hand, along with 5m

### Functional Connectivity:

Sensory strip: areas 1, 2, 3a, and 3b

Motor strip: area 4

Premotor regions: areas 6mp and 6d

Middle cingulate regions: areas 5m and 5mv

Superior insula opercular region: areas OP1

Lower opercula and Heschl's gyrus regions: area A4

Parietal lobe: areas 7AL and 7PC

### White Matter Connections?

Area 5l is structurally connected to pyramidal tracts and the contralateral hemisphere. Connections to pyramidal tracts descend through the internal capsule and cerebral peduncle to the brainstem.

Contralateral connections course through the body of the corpus callosum to parcellations 5m, 5l, and 5mv.

Local short association fibers connect with 5m and 5mv.

### Traditional Acupoint Correlates:

N/A (~1/3 the distance from GV20 ->GV19)

### Functionally Connected Acupoints:

BL6 (6d)

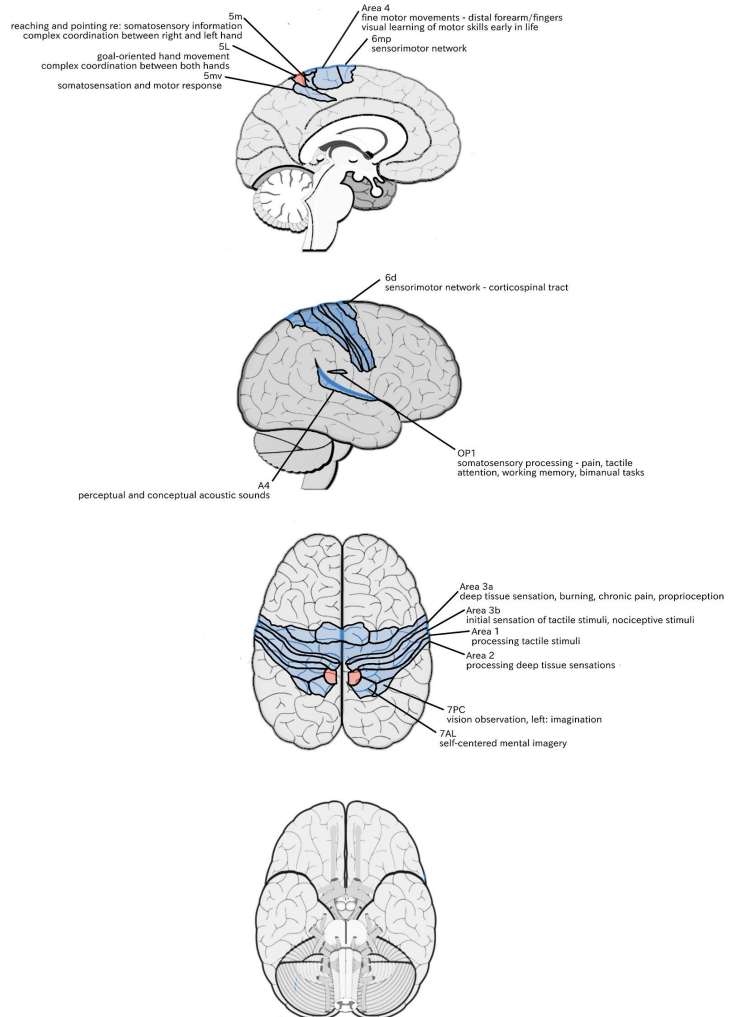
7AL)GB5 (A4)

BL7 (Area 2, 7PC,

GB17 (Area1, 2, 3a, 3b, 4)

### Structurally Connected Acupoints:

GV20 (5m)



## Area 5m (5 medial)

### Location:

In the posterior superior portion of the medial face of the paracentral lobule.

### Functions:

- Integrates somatosensory and visuomotor information
- Activities such as reaching or pointing, especially when these movements are based on somatosensory information, as opposed to visual stimuli.
- Suggested activation when performing tasks that require complex coordination between the right and left hand, along with 5L.

### Functional Connectivity:

Sensory strip: areas 1, 2, 3a, and 3b

Motor strip: area 4

Premotor regions: areas 6mp and 6d

Middle cingulate regions: area 5L

Lower opercula and Heschl's gyrus regions: Area A4

### White Matter Connections:

Structurally connected to the contralateral hemisphere.

Contralateral connections course through the body of the corpus callosum to parcellations 4 and 5L.

No local short association fibers can be visualized.

### Traditional Acupoint Correlates:

BL8 (also ½ way between BL GB17/18)

### Functionally Connected Acupoints:

BL6 (6d)

BL7 (Area 2)

GB5 (A4)

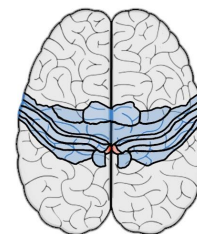
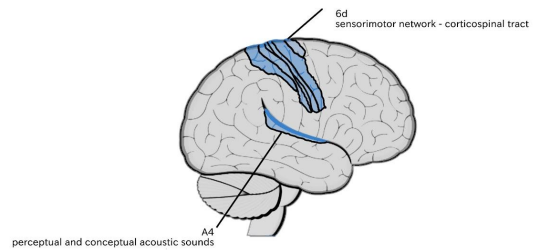
GB17 (Area 1, 2, 3a, 3b, 4)

GV20 (Area 1, 3a, 3b)

### Structurally Connected Acupoints:

GB17 (Area 4)

GV20 (Area 4)





## Area 5mv (5 medial ventral)

### Location:

Area 5mv (5 medial-ventral) is located on the posterior inferior paracentral lobule, and makes up the anterior bank of the ascending ramus of the cingulate sulcus.

### Functions:

- Somatosensation and motor response
- Some positive findings between activation and increased accuracy when imitating an upper body movement following observation of the task

### Functional Connectivity:

Sensory strip: area 2

Premotor regions: areas SCEF, FEF, 6r, 6a, 6mp, and 6ma

Middle and posterior cingulate: areas 24dd, 24dv

a24prime, p24prime, p32prime, 23c, and 5L

Dorsolateral frontal lobe: areas 9-46d and 46

Superior insula opercular regions: areas 43, OP4, PFcm, FOP1, FOP3, and FOP4

Lower opercula and Heschl's gyrus regions: areas 52, Pol1, Pol2, and MI

Lateral parietal lobe: areas AIP, MIP, LIPv, LIPd, IP0, PGp, PFop, PF, PFT, 7AL, and 7PC

Medial parietal lobe: areas 7am, PCV, and DVT

Medial occipital lobe: areas V1, V2, and V3

Dorsal visual stream: areas V6 and V6a

Lateral occipital lobe: areas PHT, PH, TPOJ2, TPOJ3, FST, and LO3

### White Matter Connections:

Structurally connected to the contralateral hemisphere and cingulate cortex.

Contralateral connections course through the body of the corpus callosum to parcellations 5mv, 4, 5l, and 5m.

Fibers to the cingulate cortex projects anteriorly from 5mv to end at 24sv, p24r.

No local short association fibers can be visualized.

### Traditional Acupoint Correlates:

N/A

### Functionally Connected Acupoints:

BL4 (Area 46, 9-46d)

BL8 (IP0)

GB8 (PHT)

GB16 (FEF)

GV18 (V1, V2)

BL6 (6a, 6d)

GB4 (6r, Area 43)

GB9 (PH, PHT, FST)

GB18 (AIP, LIPv, 7PC)

GV19 (V6a)

BL7 (Area 2, 7AL, 7PC)

GB5 (A4, POL2)

GB15 (Area 46)

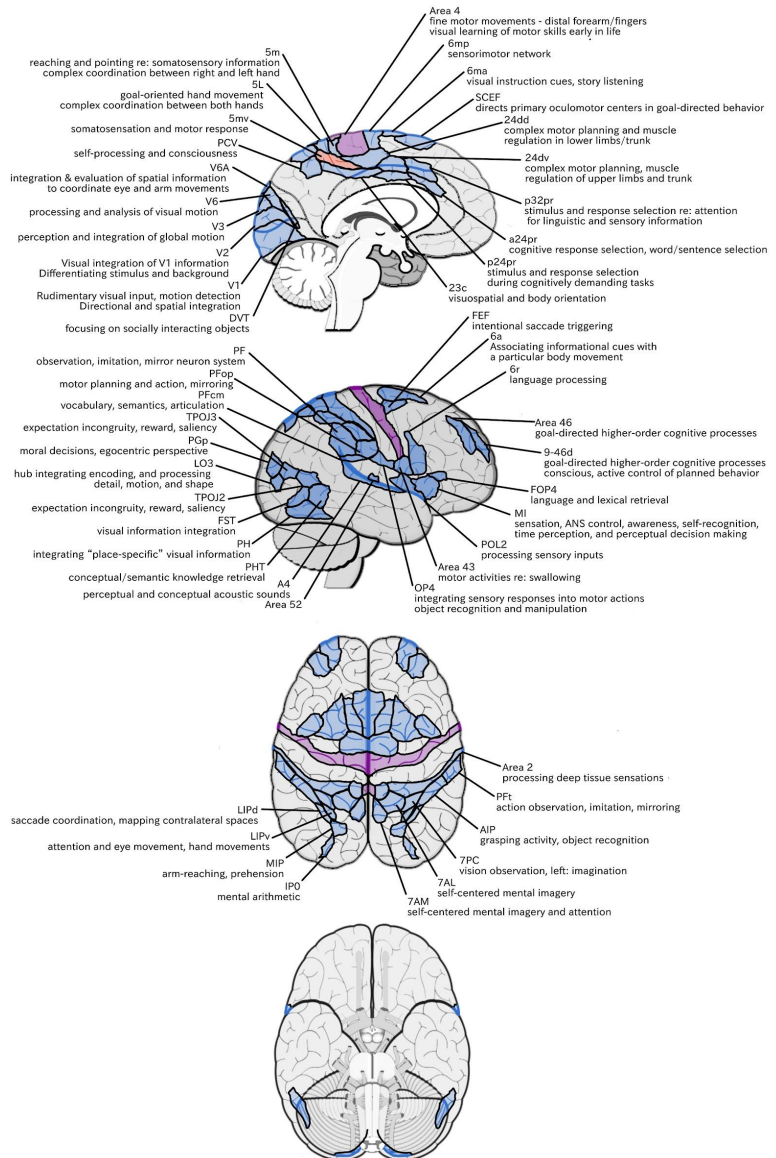
ST8 (6r)

GV21 (SCEF)

### Structurally Connected Acupoints:

GB17 (Area 4)

GV20 (Area 4, 5m)



# Supplementary motor areas

## Area 6ma (6 medial anterior)

### Location:

Makes up the lateral posterior portion of the superior frontal gyrus. It mainly straddles the interhemispheric angle.

### Functions:

-Subdivided from adjacent parcellations due to differences in myelin thickness and functional activity.

-Compared to 6mp, SFL, or s-6-8: more activation when individuals are given a visual instruction cue.

-Compared to SFL: greater deactivation when individuals are told a story

-Compared to s6-8: Showed less functional activity when matching objects based on given verbal categories.

### Functional Connectivity:

Premotor regions: SCEF, PEF, FEF, 6r, 6a, 6v, 6mp

Middle and posterior cingulate: a24prime, p24 prime,

a32prime, p32prime, 23c, 5mv

Dorsolateral frontal lobe: IFSa, 9-46d a9-46v, p9-46v, 46

Insula opercular regions: Pol1, Pol2, AVI, MI, 43, PFCm,

FOP1, FOP3, FOP4, and FOP5

Lateral parietal lobe: IP2, IP0, AIP, MIP, LIPd, PGp, PFop, PF,

PFt, 7AL, 7PL, and 7PC

medial parietal lobe: 7am, 7pm, PCV, and DVT

### White Matter Connections:

Area 6ma is structurally connected to the pyramidal tracts, the FAT, and contralateral hemisphere.

Connections to pyramidal tracts descend through the internal capsule and cerebral peduncle to the brainstem. The FAT connects 6ma with the inferior frontal gyrus terminating at parcellations 44, FOP4, and AAIC.

Contralateral connections course through the body of the corpus callosum to 6ma.

Local short association fibers connect 6mp, SFL, 6a, i6-8, and s6-8.

### Traditional Acupoint Correlates:

N/A (just lateral to GV21)

### Functionally Connected Acupoints:

BL4 (Area 46, 9-46d)

BL8 (IP0)

ST8 (6r, 6v, PEF)

BL6 (6a)

GB4 (6r, Area 43)

GV19 (7PM)

BL7 (7PC, 7AL)

GB5 (POL2)

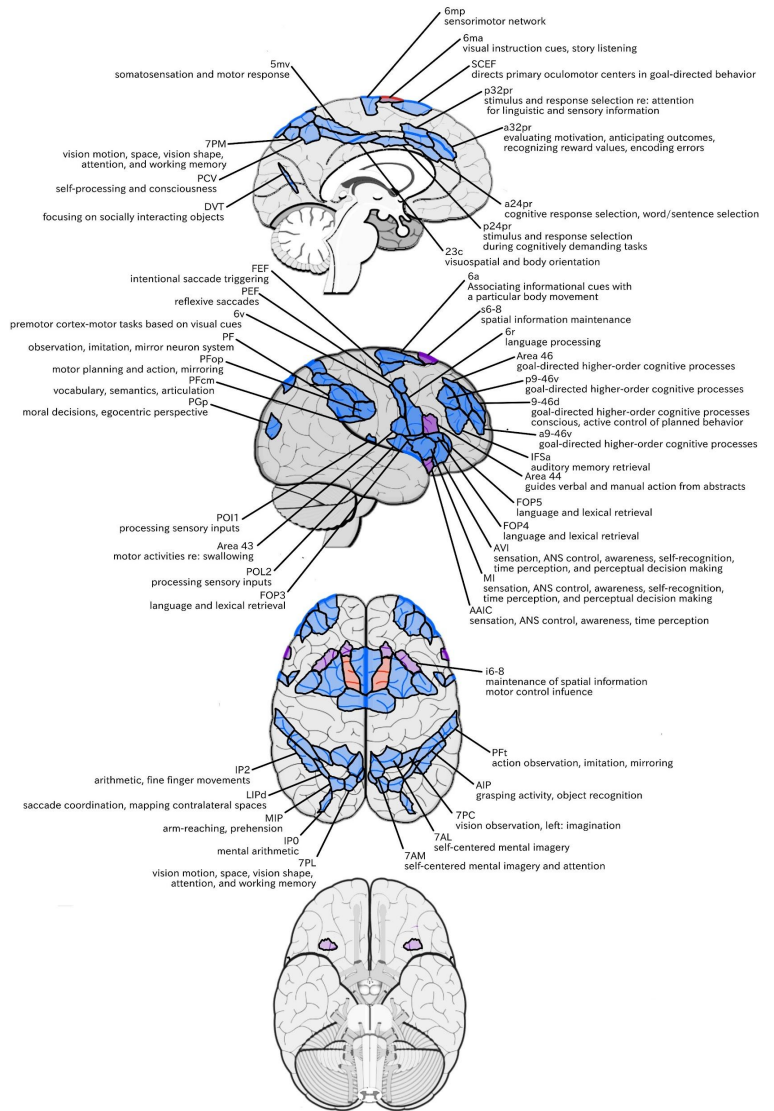
GV21 (SCEF)

### Structurally Connected Acupoints:

BL5 (i6-8)

BL6 (6a)

GV21 (SFL)



## Area 6mp (6 medial posterior)

### Location:

Makes up the area where the SFG joins with the precentral gyrus. It makes up the medial bank of the SFG at this junction, as well as spilling onto the superior surface of the posterior most SFG and the anterosuperior portion of the precentral gyrus.

### Functions:

-Subdivided from adjacent parcellations due to differences in myelin thickness and functional activity.

-Compared to 6ma: shows less activation when an individual was given a visual instruction cue and when moving their feet.

-Compared to 6d: shows greater deactivation when listening to a story or solving a math problem

-Compared to 6a: shows less activation in social interaction settings.

### Functional Connectivity:

Sensory strip: areas 1, 2, 3a, 3b

Motor strip: area 4

Premotor regions: SCEF, 6a, 6ma, 6d

Middle cingulate regions: 24dd, 24dv, p32prime, 5mv, 5L

Superior insula opercular regions: area 43, OP1, OP4, PFcm, FOP1, FOP2

Lower opercula and Heschl's gyrus regions: A4, RI, PBelt

Parietal lobe: PFop, PFT, IPS1, 7AL, 7PC

Lateral occipital lobe: FST

### White Matter Connections:

Area 6mp is structurally connected to the pyramidal tracts and contralateral hemisphere. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem.

Contralateral connections course through the body of the corpus callosum to 6ma, 6mp, and FEF.

Local short association fibers connect with 24dd, 6a, and 6d.

### Traditional Acupoint Correlates:

N/A (medial to BL6)

### Functionally Connected Acupoints:

BL6 (6a, 6d)

GB4 (Area 43)

GB17 (Area1, 2, 3a, 3b, 4)

GV21 (SCEF)

BL7 (Area 2, 7PC, 7AL)

GB5 (A4)

GB18 (7PC)

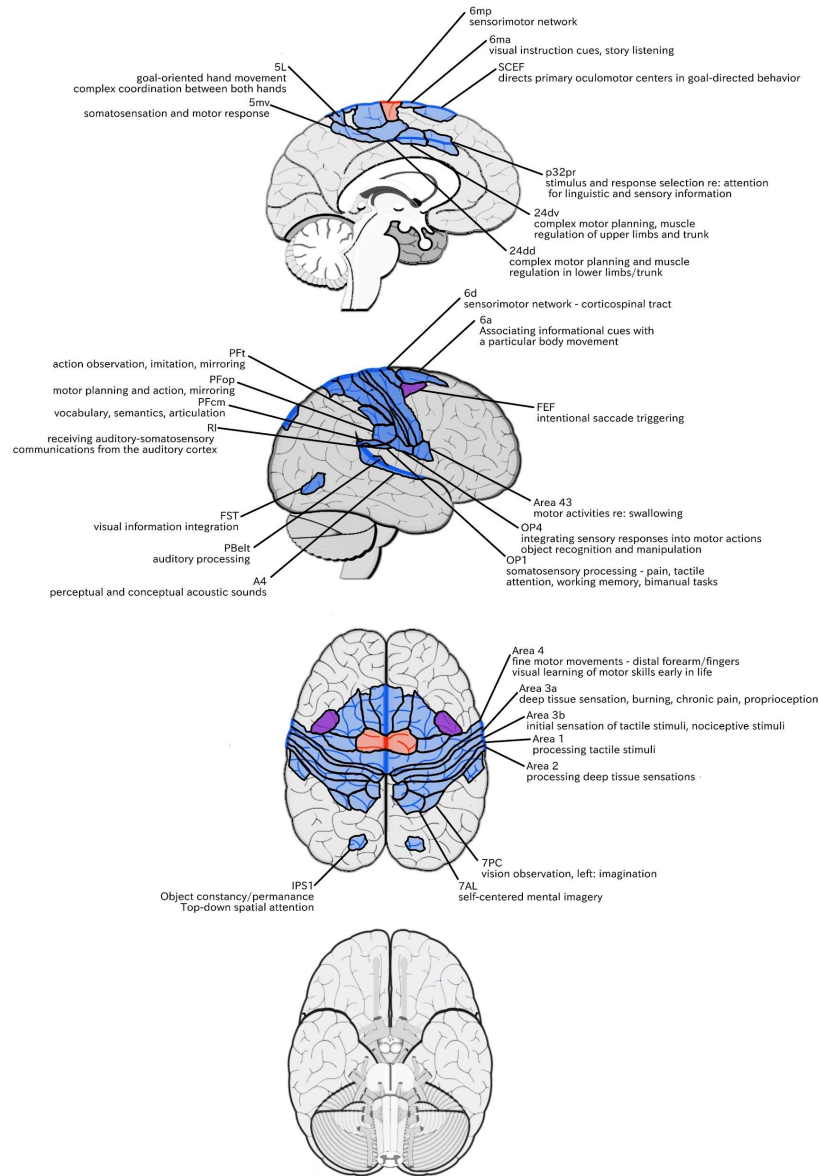
BL8 (IPS1)

GB9 (FST)

GV20 (Area 1, 3a, 3b, 4)

### Structurally Connected Acupoints:

GB16 (FEF)



# Area SFL

## Location:

Area SFL is located on the posterior medial SFG straddling over the interhemispheric cleft.

## Functions:

Area SFL was subdivided from adjacent parcellations due to differences in myelin thickness and functional activity.  
 -Hemispherically asymmetric  
 Left hemisphere: more activity when listening to stories and when a participant is matching objects based on a verbal cue.

Compared to area 8BL: more activation when listening to a story, matching objects based on verbal cues and in social interaction settings

Compared to area s6-8: more activation in the left hemisphere when individuals listen to a story.

Right hemisphere: activated in social interaction settings and is deactivated during object feature comparison tasks.

## Functional Connectivity:

- Dorsolateral frontal lobe: 8BL, 8AV, 9a, 9p, 9m
- Inferior frontal lobe: 8BM, d32, 44, 45, 47L, 47s
- Premotor areas: 55b
- Temporal lobe: STSda, STSdp, STSva, STSvp, TE1a, TGd
- Lateral parietal lobe: PGi
- Medial parietal lobe: 31pv, 31pd

## White Matter Connections:

Structurally connected to pyramidal tracts, the FAT, and contralateral hemisphere. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem.  
 The FAT connects SFL with the inferior frontal gyrus, terminating at parcellations 44, IFSp, and MI.  
 Contralateral connections course through the body of the corpus callosum to SCEF and 8BL. Local short association fibers connect with SCEF, 8BL, SFL, and 6ma.

## Traditional Acupoint Correlates:

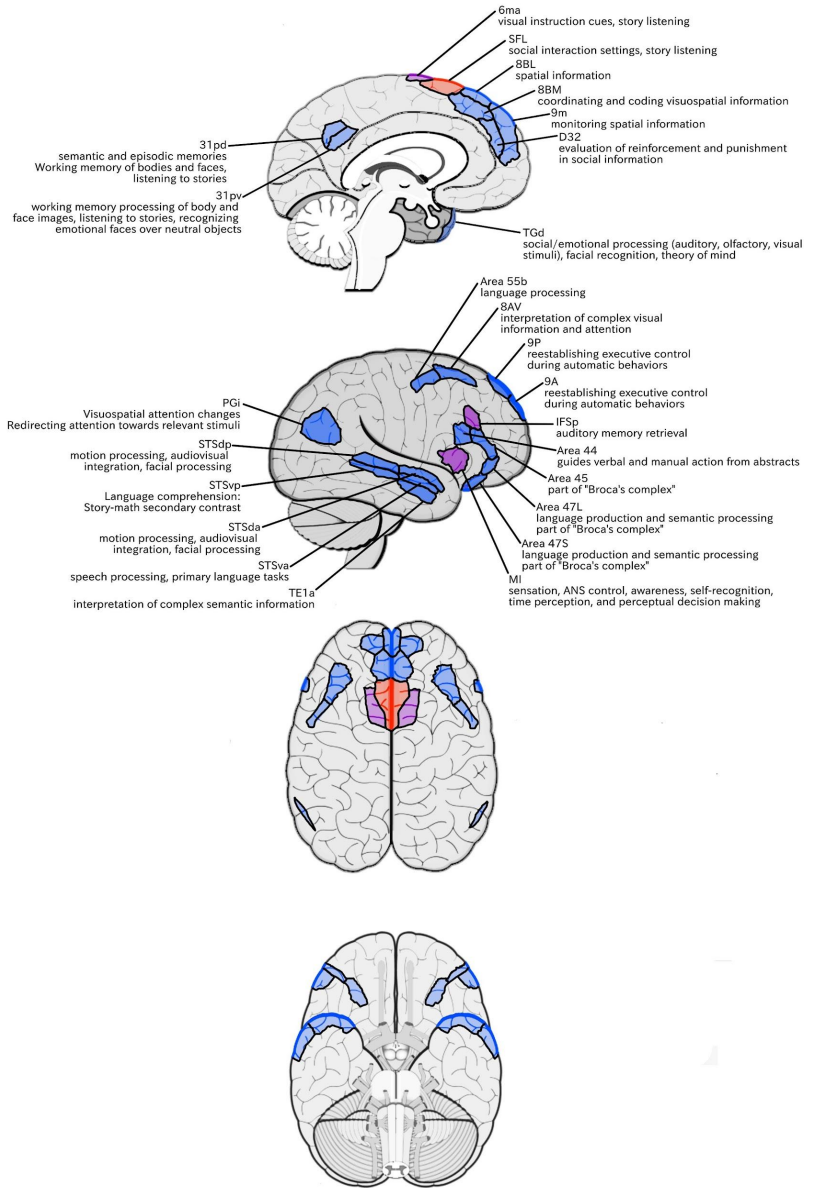
GV21

## Functionally Connected Acupoints:

- BL3 (8BL, 9P)
- GB6 (STSds, STSdp, STSva, STSvp, TE1a)
- GV21 (SCEF)

## Structurally Connected Acupoints:

BL3 (BL)



- BL4 (8AV)
- GB15 (8AV)
- GV22 (8BL)

- BL5 (8AV)
- GB16 (55b)
- GV23 (9m)

GV21 (SCEF, SFL)

GV22 (8BL)

# Premotor areas

## Area 6a (6 anterior)

### Location:

makes up the posterior superior most bank of the superior frontal sulcus and the adjacent portions of the superior frontal gyrus, principally forming this bank just as the sulcus forms the right angle with the precentral sulcus.

### Functions:

Areas 6a and 6d are newly described subdivisions of the premotor cortex. While the precise function of these areas is unknown, the functions of the premotor cortex are well characterized:

Premotor cortex (overall): preparation of voluntary movements.

Dorsal premotor cortex: associating informational cues with a particular body movement. These could be learned and arbitrary in nature or they can be based on other forms of somatosensation, such as visual or auditory.

Ventral premotor area: hand movement manipulation of objects (eg grasping or lifting) as well as more complex cortical functions such as when individuals learn actions or movements while observing others.

6a is distinguished from adjacent areas of the cortex based on differences in myelin thickness and functional activity.

Compared to s6-8: greater activation when solving math problems, social interaction settings, and object feature comparison tasks.

Compared to i6-8: greater activation in social interaction settings; relative deactivation in emotion identification and object feature comparison.

Compared to area FEF: less activation in both gambling and object feature comparison.

### Functional Connectivity:

Sensory strip: area 2

Premotor regions: SCEF, PEF, FEF, 6ma, 6mp, 6d, 6v

Middle cingulate: a24prime, p32prime, 5mv, 23c

Lateral frontal lobe: IFSa, IFJa, i6-8, 46, p9-46v, 9-46d

Superior insula opercular regions: OP4, PFCm, FOP4, FOP2

Lower opercula and Heschl's gyrus: Pol1, Pol2

Temporal lobe: TE2p, PHA3, PHT

Lateral parietal lobe: AIP, MIP, VIP, LIPd, LIPv, PFop, PF, PFt, PGp IP2, IP1, IP0, IPS1, 7AL, 7PL, 7PC

Medial parietal lobe: 7pm, 7am, DVT, PCV

Occipital lobe: V2

Lateral occipital lobe: PH, TPOJ2, TPOJ3, FST

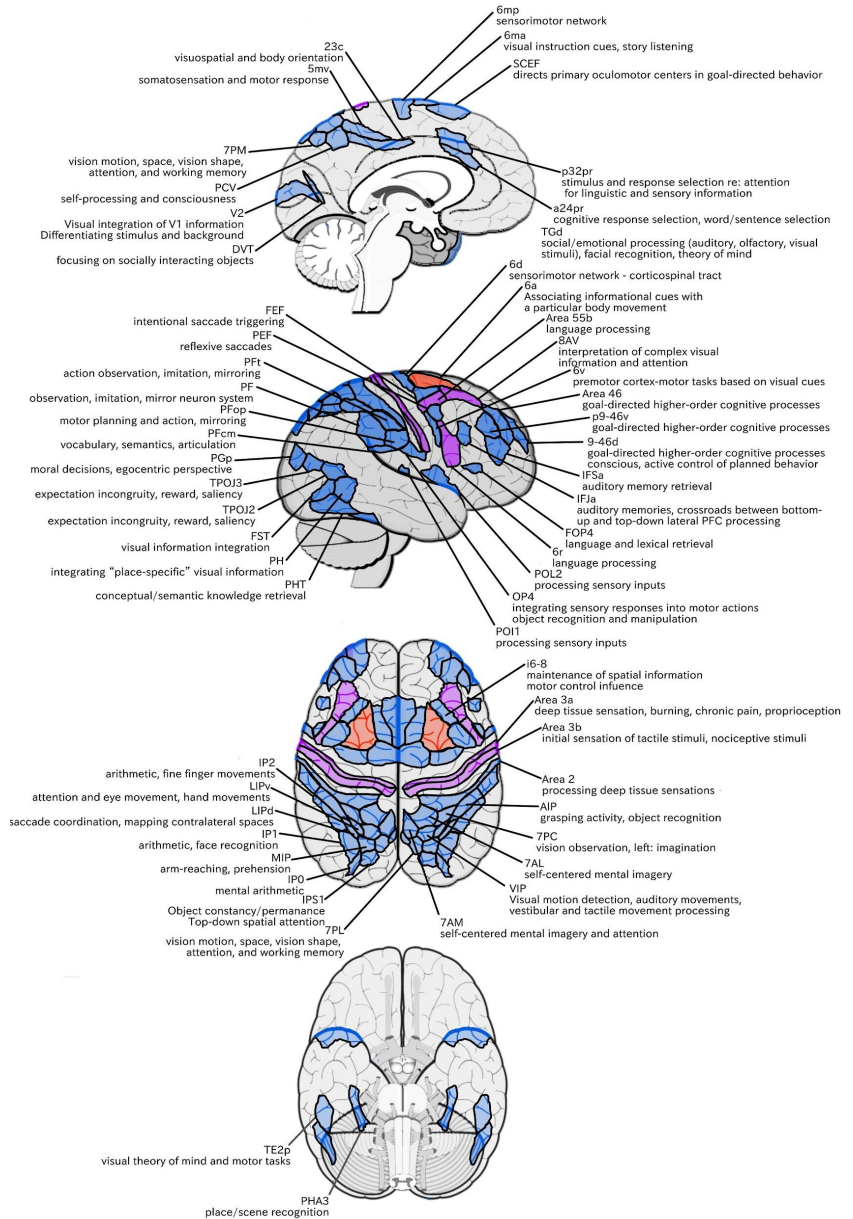
### White Matter Connections:

Structurally connected to the pyramidal tracts and the parietal lobe.

Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem.

Parietal projections are portions of the SLF and connect with 3a, 3b, 7PC, and 7AL.

Local short association fibers connect with FEF, i6-8, 55b, 8AV, 46, and 6r.



**Traditional Acupoint Correlates:**

BL6

Functionally Connected Acupoints:

BL4 (Area 46, 9-46d)

BL7 (Area 2, 7AL, 7PC)

GB9 (FST, PH, PHT)

GB16 (FEF)

ST8 (6v, PEF)

GV21 (SCEF)

BL5 (i6-8)

BL8 (IP0, IPS1)

GB13 (p9-46v)

GB18 (7PC, Lipv)

GV18 (V2)

BL6 (6d)

GB5 (POL2)

GB15 (Area 46, p9-46v)

TW20 (TE2p)

GV19 (7PM)

Structurally Connected Acupoints:

BL4 (Area 46, 8AV)

GB4 (6r)

GB17 (Area 3a, 3b)

BL5 (8AV, i6-8)

GB15 (8AV)

ST8 (6r)

BL7 (7AL, 7PC)

GB16 (55b, FEF)

GV20 (Area 3a, 3b)

# Area 6d (6 dorsal)

**Location:**

located on the anterosuperior portion of the precentral gyrus, just inferior to its junction with the SFG. It makes up the posterior bank of the adjacent precentral sulcus.

**Functions:**

Distinguished from adjacent areas of the cortex based on differences in myelin thickness and functional connectivity.

- Compared to FEF: less activation during gambling tasks, in social interaction settings, and during object feature comparison.
- Compared to 6a: less activation in solving math problems and social interaction settings.

**Functional Connectivity:**

- Sensory strip: areas 1, 2, 3a, 3b
- Motor strip: area 4
- Premotor regions: 6a, 6mp, 6v
- Middle cingulate regions: 5L, 24dd
- Insula opercula regions: FOP2, OP4, OP1, A4, PBelt
- Parietal lobe: 7PC, 7AL, PFT
- Lateral occipital lobe: FST

**White Matter Connections:**

Structurally connected to the pyramidal tracts and contralateral hemisphere. Connections to pyramidal tracts descend through the posterior limb of the internal capsule and cerebral peduncle to the brainstem. Contralateral connections course through the body of the corpus callosum to end at 6mp, FEF, and 55b. Local short association fibers connect with 4, 3a, 3b, 6a, FEF, i6-8, 8AV, 6ma, and 6d.

**Traditional Acupoint Correlates:**

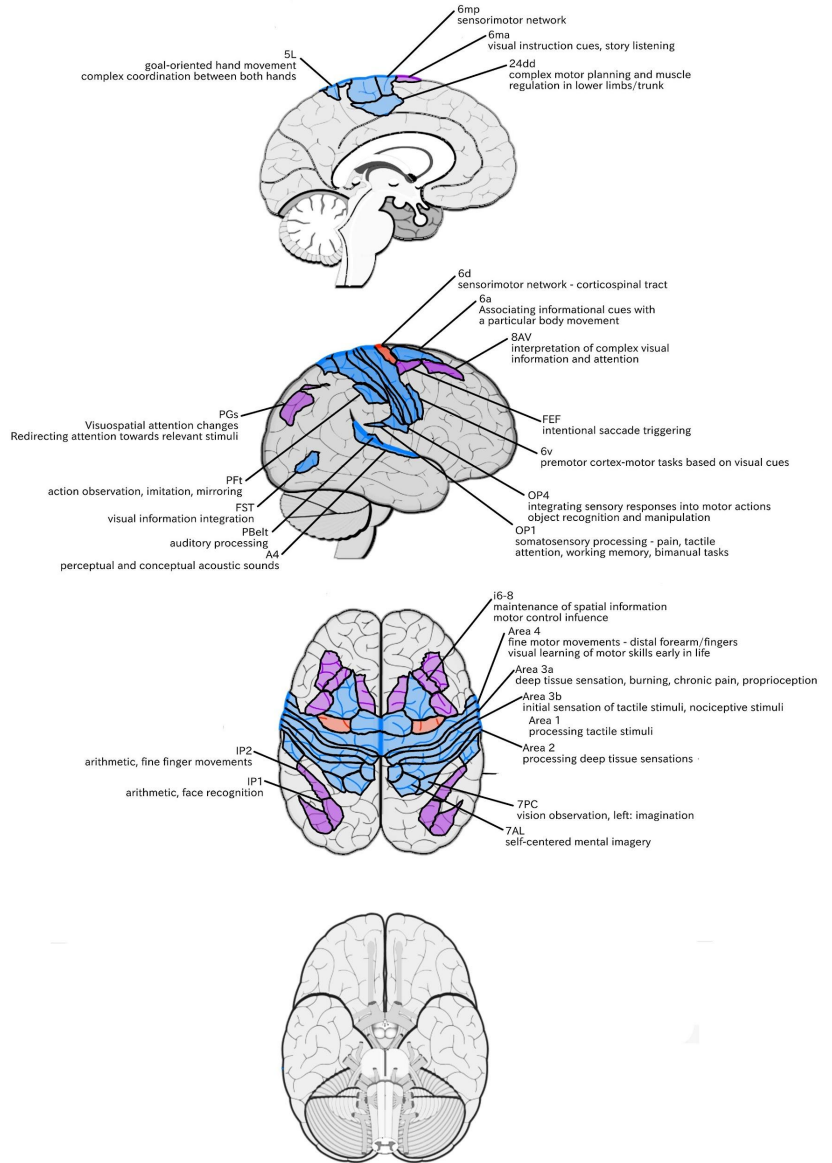
BL6

**Functionally Connected Acupoints:**

- BL6 (6a)
- BL7 (Area 2, 7AL, 7PC)
- GB5 (A4)
- GB9 (FST)
- GB17 (Area 1, 2, 3a, 3b, 4)
- ST8 (6v)
- GV20 (Area 1, 3a, 3b, 4)

**Structurally Connected Acupoints:**

- BL4 (8AV)
- BL5 (8AV, i6-8)
- GB15 (8AV)
- GB`16 (55b, FEF)
- GV20 (Area 3a, 3b, 4)



- BL6 (6d)
- GB17 (Area 3a, 3b, 4)

## Area FEF (Frontal Eye Field)

### Location:

Located on the anterior half of the precentral gyrus, approximately half way down its length along the convexity, just inferior to the junction point of the precentral and superior frontal sulci. It also forms the adjacent floor of the precentral sulci and straddles slightly onto the posterior edge of the middle frontal gyrus.

### Functions:

- Intentional saccades
- Smooth pursuit eye movements

Together, these movements help create a salience map for visual attention

### Functional Connectivity:

Sensory strip: area 2  
 Premotor regions: SCEF, PEF, 6r, 6v  
 Middle cingulate regions: a24prime, p32prime, 5mv, 23c  
 Lateral frontal lobe: IFSa, IFJa, 46, 9-46d  
 Superior insula and operculas regions: area 43, OP4, PFcm, FOP1, FOP3, FOP4, FOP5  
 Lower opercula and Heschl's gyrus: STV, LBelt, PBelt, A4, MI, 52, RI, Pol1, Pol2  
 Temporal lobe: TE2p, PHT  
 Lateral parietal lobe: AIP, MIP, VIP, LIPd, LIPv, PFop, PF, PFt, PGp, IP0, IPS1, 7AL, 7PL, 7PC  
 Medial parietal lobe: 7am, DVT, PCV  
 Medial occipital lobe: V1, V2, V3, V4  
 Dorsal visual stream: V3a, V3b, V6, V6a, V7  
 Ventral visual stream: V8, PIT, FFC, VVC, VMV1, VMV2, VMV3  
 Lateral occipital lobe: V3cd, LO1, LO2, LO3, PH, TPOJ1, TPOJ2, TPOJ3, V4t, MST, FST

### White Matter Connections:

Structurally connected to the contralateral hemisphere and superior longitudinal fasciculus. Contralateral connections course through the body of the corpus callosum to i6- 8 and SFL. Connections with the superior longitudinal fasciculus connect FEF to the intraparietal sulcus and the inferior parietal lobe terminating at IP1, IP2, and PGs.  
 Local short association fibers connect with 6d, 55b, i6-8, 8AV, 6a, and PEF.

### Traditional Acupoint Correlates:

GB16

### Functionally Connected Acupoints:

BL4 (Area 46, 9-46d)  
 GB4 (Area 43, 6r)  
 GB9 (FST, PH, PHT)  
 TW20 (TE2p)  
 GV21 (SCEF)

BL7 (Area 2, 7AL, 7PC)  
 GB5 (A4, POL2)  
 GB15 (Area 46)  
 ST8 (6r, 6v, PEF)

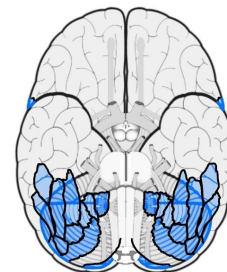
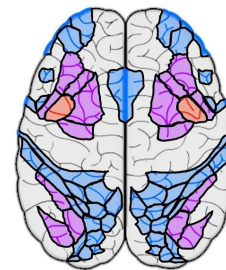
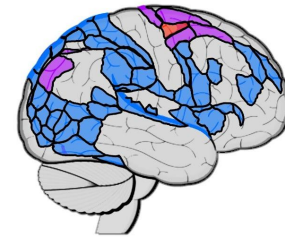
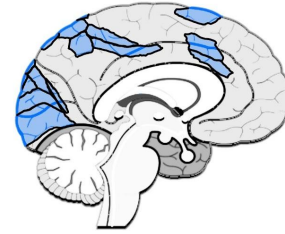
BL8 (IP0, IPS1, V7)  
 GB8 (PHT)  
 GB18 (Lipv)  
 GV18 (V1, V2)

### Structurally Connected Acupoints:

BL4 (8AV)  
 BL8 (IP1)  
 GB18 (PGs, IP1)

BL5 (8AV, i6-8)  
 GB15 (8AV)  
 ST8 (PEF)

BL6 (6a, 6d)  
 GB16 (55b)  
 GV21 (SFL)





# Area 55b

## Location:

On the anterior half of the precentral gyrus, approximately half way down its length along the convexity, just inferior to FEF. It also forms the adjacent floor of the precentral sulci and straddles slightly onto the posterior edge of the middle frontal gyrus.

## Functions:

Area 55b is a relatively uncharacterized region.  
 -Plays a role in language processing

## Functional Connectivity:

Motor strip: area 4  
 Premotor areas: areas SCEF, SFL  
 Lateral frontal lobe: IFSp, IFJa, 8AV, 44, 45, 47L  
 Temporal lobe: STSda, STSdp  
 Posterior opercular cortices: PSL, STV  
 Lateral occipital lobe: TPOJ1

## White Matter Connections:

Structurally connected to the contralateral hemisphere and the superior longitudinal fasciculus.  
 Contralateral connections course through the body of the corpus callosum to 6ma, 6a, and 6mp. Connections with the superior longitudinal fasciculus connect 55b to parcellations PHT and PFm, and this tract terminates eventually in the temporal lobe at TGD.  
 Local short association fibers connect with 8AV, 8C, IFJp, 3a, 3b, and PEF.

## Traditional Acupoint Correlates:

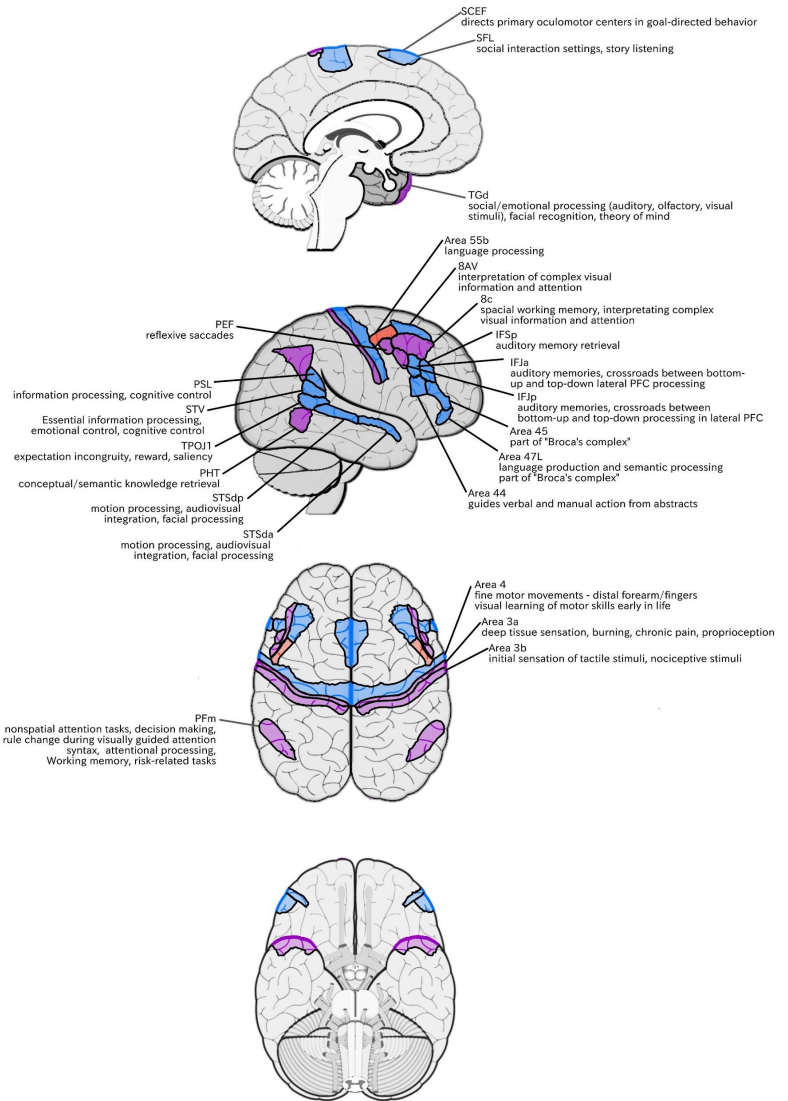
GB16

## Functionally Connected Acupoints:

BL4 (8AV)	BL5 (8AV)
GB6 (STSda, STSdp)	GB15 (8AV)
GB17 (Area 4)	GV20 (Area 4)
GV21 (SCEF, SFL)	

## Structurally Connected Acupoints:

BL4 (8AV)	BL5 (8AV)	GB8 (PHT)
GB9 (PHT)	GB15 (8AV, 8C)	GB16 (PEF)
GB17 (Area 3a, 3b)	GB18 (PFm)	ST8 (IFJp)
GV20 (Area 3a, 3b)		



# Area PEF (Posterior Eye Field)

## Location:

A small area located in the floor of the precentral sulcus at the junction of the precentral and inferior frontal sulci. It spills slightly onto the adjacent precentral gyrus and unlike FEF and area 55b, it is mostly vertically oriented.

## Function:

-Reflexive saccades

## Functional Connectivity:

Premotor regions: SCEF, FEF, 6ma, 6r, 6a, 6v  
 Middle cingulate regions: a24 prime, p32prime, 23c  
 Lateral frontal lobe: IFSa, IFJp, 9-46d  
 Superior insula opercular regions: area 43, PFcm, FOP4, FOP5  
 Lower opercula and Heshl's gyrus: MI, Pol2  
 Temporal lobe: TE2p, PHT  
 Lateral parietal lobe: AIP, MIP, LIPd, LIPv, PFop, PFt, PGp, IPO, 7PL, 7PC  
 Medial parietal lobe: 7am  
 Lateral occipital lobe: PH, FST

## White Matter Connections:

Structurally connected to the superior longitudinal fasciculus. PEF does have connections to the contralateral hemisphere but this is inconsistent across individuals.  
 Connections with the superior longitudinal fasciculus connect 55b to inferior parietal lobe parcellations PHT, TPOJ2, FST, and PFm.  
 Local short association fibers connect with 6r, 8C, and IFJp

## Traditional Acupoint Correlates:

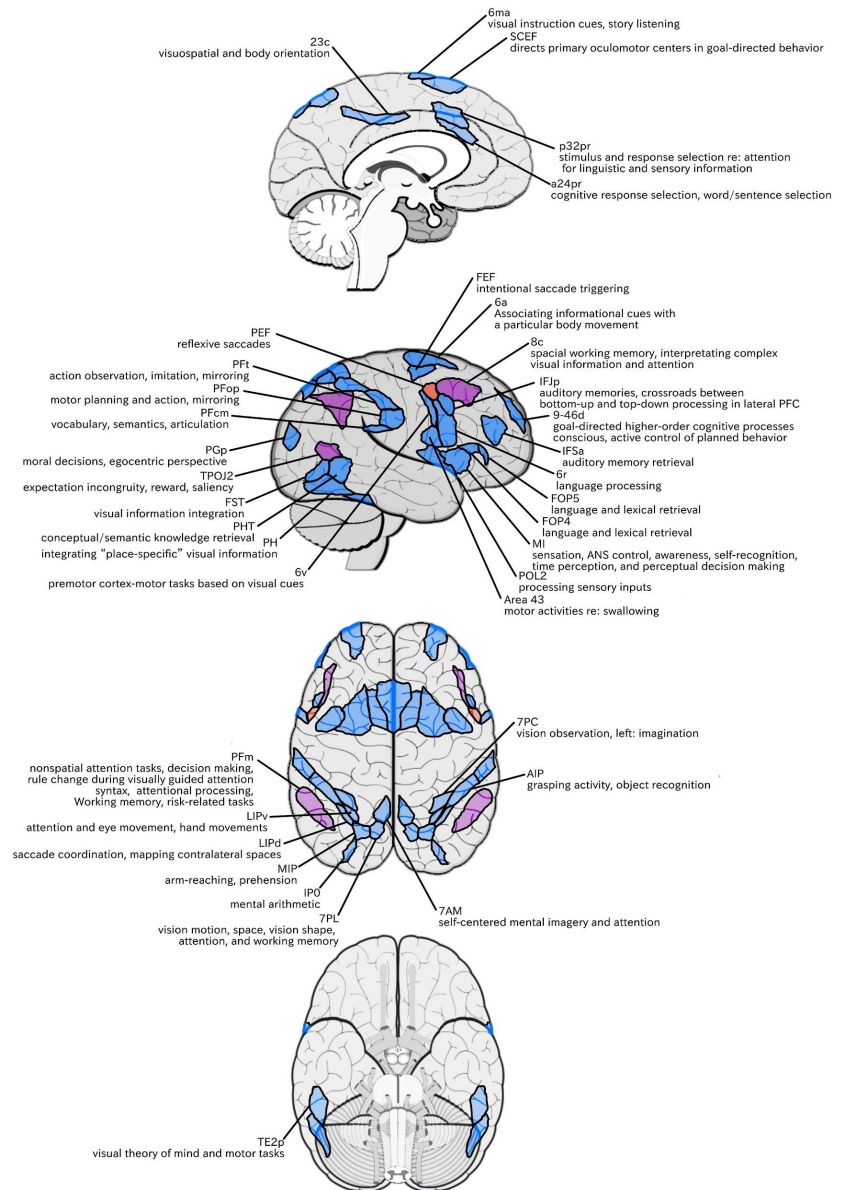
ST8

## Functionally Connected Acupoints:

BL4 (9-46d)	BL6 (6a)
BL8 (IPO)	GB4 (Area 43, 6r)
GB5 (POL2)	GB8 (PHT)
GB9 (PH, PHT, FST)	GB16 (FEF)
GB18 (AIP, LIPv)	TW20 (TE2p)
ST8 (6r, 6v, IFJp)	GV21 (SCEF)

## Structurally Connected Acupoints:

GB4 (6r)	GB8 (PHT)
GB9 (FST, PHT)	GB12 (6r)
GB15 (8C)	GB18 (PFm)
ST8 (6r, IFJp)	



# Area 6V (6 ventral)

## Location:

Makes up the anteroinferior one-third of the precentral gyrus. It only minimally forms the posterior bank of the precentral sulcus, which is primarily formed by area 6r.

## Functions:

- Comprises what is classically known as the premotor cortex.
- Ventral premotor area: active in the control of hand movements that occur while manipulating objects (eg grasping and lifting objects)
- Dorsal premotor area: involved in performing specific motor tasks based on visual cues.

## Functional Connectivity:

Sensory strip: areas 1, 2, 3a, 3b

Motor strip: area 4

Premotor regions: areas SCEF, FEF, PEF, 6ma, 6mp, 6r, 6d

Middle cingulate regions: 24dd, p32prime

Superior insula opercular: area 43, OP4, OP2-3, OP1, PFcm, FOP1, FOP2, FOP3, FOP4

Lower opercula and Heschl's gyrus regions: A4, PBelt, RI, Pol2

Lateral parietal lobe: AIP, MIP, VIP, LIPv, PFop, Pft, 7AL, 7PC,

Dorsal visual stream: V3a, V3b, V6, V6a, V7

Ventral visual field: FFC

Lateral occipital lobe: PH, TPOJ2, MST, FST

## White Matter Connections:

Structurally connected to the contralateral hemisphere and the superior longitudinal fasciculus.

Contralateral connections course through the body of the corpus callosum to FEF. Connections with the superior longitudinal fasciculus connect 6v to inferior parietal lobe parcellations PHT, FST, PH, and PF.

Local short association fibers connect with 4, 6r, PEF, 43, 3a, and 3b

## Traditional Acupoint Correlates:

ST8

## Functionally Connected Acupoints:

BL6 (6d)

GB4 (Area 43, 6r)

GB16 (FEF)

ST8 (6r, PEF)

BL7 (Area 2, 7AL, 7PC)

GB5 (A4, POL2)

GB17 (Area 1, 2, 3a, 3b, 4)

GV20 (Area 1, 3a, 3b, 4)

BL8 (V3b, V7)

GB9 (FST, PH)

GB18 (AIP, Lipv)

GV21 (SCEF)

## Structurally Connected Acupoints:

GB4 (Area 43, 6r)

GB12 (6r)

ST8 (6r, PEF)

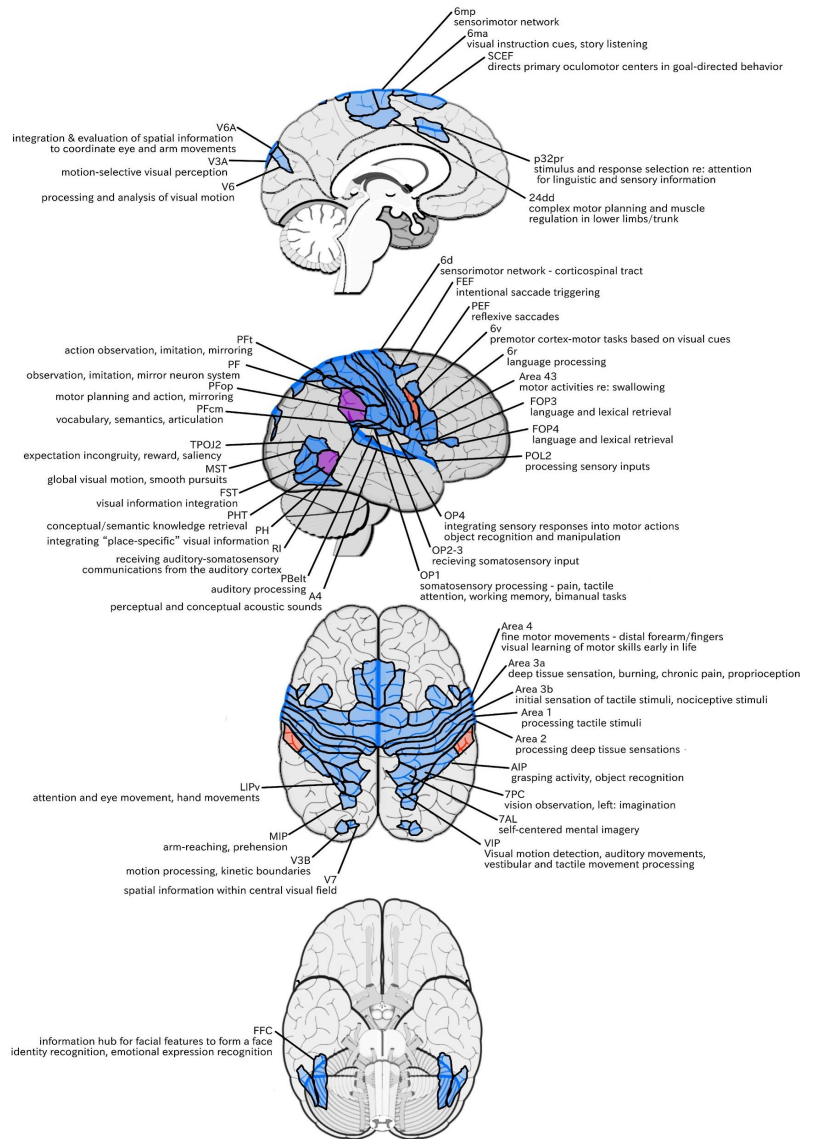
GB8 (PHT)

GB16 (FEF)

GV20 (Area 3a, 3b, 4)

GB9 (FST, PH, PHT)

GB17 (Area 3a, 3b, 4)



# Area 6R (6 rostral)

## Location:

The inferior portion of the precentral sulcus, including its floor and both banks. The latter point implies that some of area 6r lies on both the anterior inferior portion of the precentral gyrus and the posterior portion of the pars opercularis of the inferior frontal gyrus.

## Functions:

Area 6r has not been extensively studied.  
-Functionally related to Broca's area, an area essential to language processing.

## Functional Connectivity:

Premotor regions: SCEF, FEF, PEF, 6ma, 6a, 6v

Middle cingulate regions: 23c, 5mv, a24prime, p24prime, p32

Lateral frontal lobe: area 46, p9-46v, 9-46d, IFSa, IFJa, IFJp, p47r

Superior insula opercular regions: area 43, OP4, PFcm, FOP2, FOP3, FOP4, FOP5

Lower opercula and Hechl's gyrus: area AVI, MI, Pol1, Pol2

Temporal lobe: TE2p, PHT

Lateral parietal lobe: AIP, MIP, LIPd, LIPv, PFop, PF, Pft, IP0, 7PL, 7AL, 7PC

Lateral occipital lobe: PH, FST

## White Matter Connections:

Structurally connected to the superior longitudinal fasciculus and FAT. FAT connects 6r with the superior frontal gyrus at parcellation SFL.

Connections with the superior longitudinal fasciculus connect 6r to posterior temporal parcellations TE1a and TE2a.

Local short association fibers connect with 6v, 44, IFJa, IFJp, 8C, and IFSa

## Traditional Acupoint Correlates:

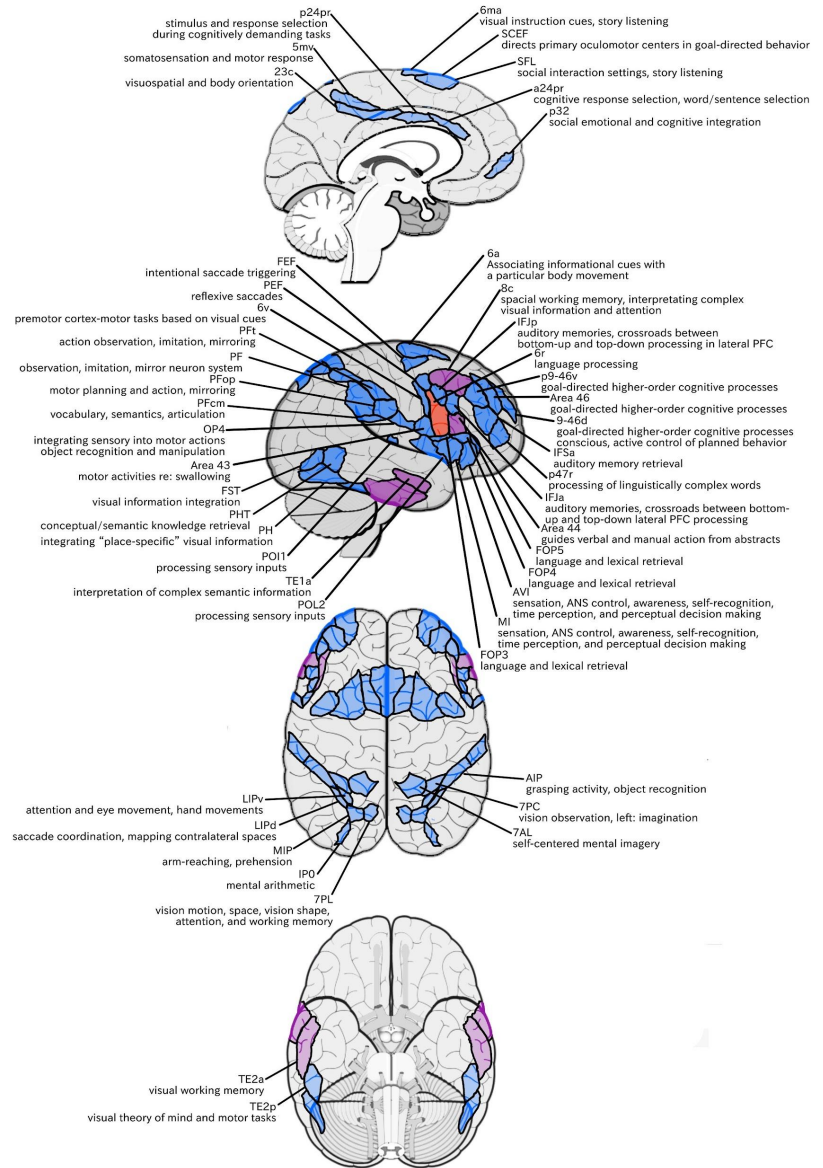
GB4, ST8

## Functionally Connected Acupoints:

BL4 (Area 46, 9-46d)  
BL8 (IP0)  
GB8 (PHT)  
GB15 (Area 46, p9-46v)  
TW20 (TE2p)

## Structurally Connected Acupoints:

GB6 (TE1a)  
TW22 (TE2a)



BL6 (6a)  
GB4 (Area 43, 6v)  
GB9 (FST, PH, PHT)  
GB16 (FEF)  
ST8 (6v, IFJp, PEF)

GB7 (TE2a)  
ST8 (6v, IFJp)

BL7 (7AL, 7PC)  
GB5 (POL2)  
GB13 (p9-46v)  
GB18 (AIP, LIPv)  
GV21 (SCEF, SFL)

GB15 (8C)  
GB21 (SFL)

## **Conflict of Interest Statement**

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.