Analysis of Traditional Scalp Acupuncture Point Locations as Local Cortical Region and Functional Network Node Targets in Non-Invasive Brain Network Neuromodulation
Section 3 - The Medial Frontal Lobe, Anterior Cingulate Gyrus, and Orbitofrontal Cortex

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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 medial frontal lobe, anterior cingulate gyrus, and the orbitofrontal gyrus 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, orbitofrontal, anterior cingulate, medial frontal lobe

Anterior Cingulate Regions

Area 33 prime

Location: In the depths of the anterior callosal sulcus.

Functions:
-Major role in coordinating autonomic, visceromotor, and endocrine activity that accompany emotion

Functional connectivity:
Lateral frontal lobe: IFSa, IFJa, p9-46v
Medial frontal lobe: a24pr, p24pr
Temporal lobe: areas TE1p, PHT
Parietal lobe: areas IP1, IP2

White matter connections:
Structurally connected to the cingulum. Fibers project anteriorly above the corpus callosum to end at a24, p32, and 10r, anterior fibers also curve around the rostrum of the corpus callosum to end at 25. Posterior cingulum fibers terminate at the precuneus to end at areas 7m and v23ab. Posterior fibers also curve around the splenium of the corpus callosum to end at the RSC.

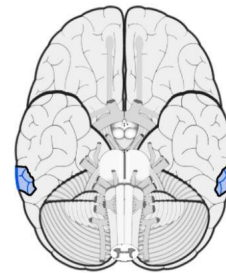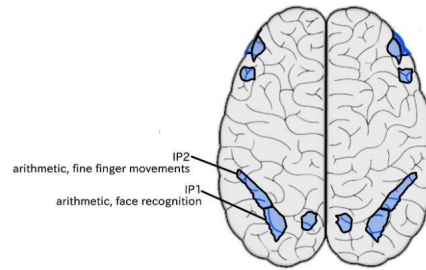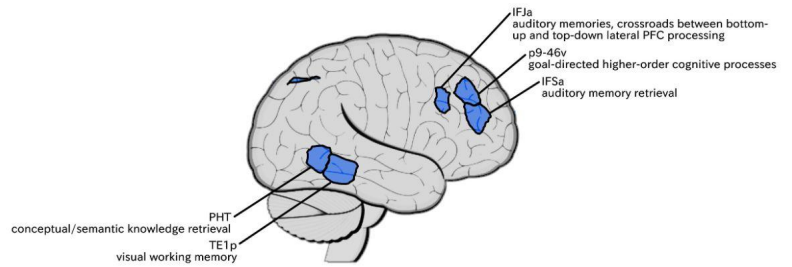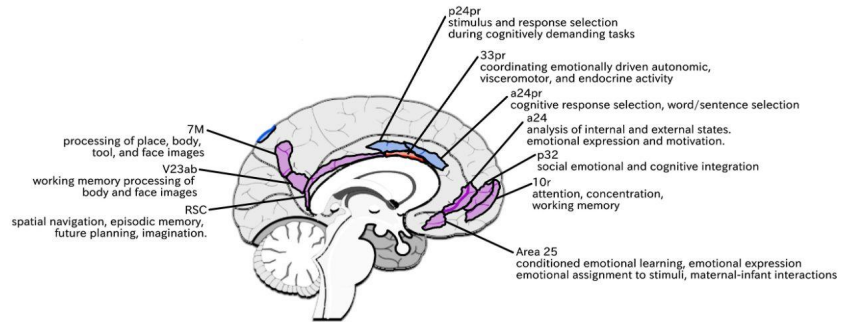**Traditional Acupoint Correlates**:
N/A

Functionally Connected Acupoints:

BL8 (IP1)	GB7 (TE1p)
GB8 (PHT, TE1p)	GB9 (PHT)
GB13 (p9-46v)	GB15 (p9-46v)

Structurally Connected Acupoints:
N/A

p24pr
stimulus and response selection
during cognitively demanding tasks

33pr
coordinating emotionally driven autonomic, visceromotor, and endocrine activity

a24pr
cognitive response selection, word/sentence selection

a24
analysis of internal and external states. emotional expression and motivation.

p32
social emotional and cognitive integration

10r
attention, concentration, working memory

7M
processing of place, body, tool, and face images

V23ab
working memory processing of body and face images

RSC
spatial navigation, episodic memory, future planning, imagination.

Area 25
conditioned emotional learning, emotional expression emotional assignment to stimuli, maternal-infant interactions

IFJa
auditory memories, crossroads between bottom-up and top-down lateral PFC processing

p9-46v
goal-directed higher-order cognitive processes

IFSa
auditory memory retrieval

PHT
conceptual/semantic knowledge retrieval

TE1p
visual working memory

IP2
arithmetic, fine finger movements

IP1
arithmetic, face recognition

Area 24dd (24 dorsal dorsal)

Location:
In the anterior inferior paracentral lobule straddling into the upper bank of the
cingulate sulcus.

Functions:
-Complex motor planning and regulation of muscles in the lower limb and lower trunk through coordination with the supplemental motor area and connections to the spinal cord.

Functional Connectivity
Sensory strip: areas 1, 2, 3a, and 3b
Motor strip: area 4
Premotor regions: areas 6mp, 6v, and 6d
Middle cingulate regions: areas 5mv, SCEF, and 24dv
Superior opercular areas: areas OP4, OP1, and 43
Lower opercula and Heschl's gyrus: areas PBelt and A4
Parietal lobe: area 7PC
Primary visual areas: area V2
Lateral occipital lobe: areas FST and MST

White matter connections:
Structurally connected to the contralateral hemisphere.
Fibers from 24dd project through the body of the corpus callosum to end at
24dd, 4, 5mv, 23c, SCEF, 6mp, and 24dv.
Local short association bundles connect with 4, 5mv, 23c, SCEF, and 6mp.

Traditional Acupoint Correlates:
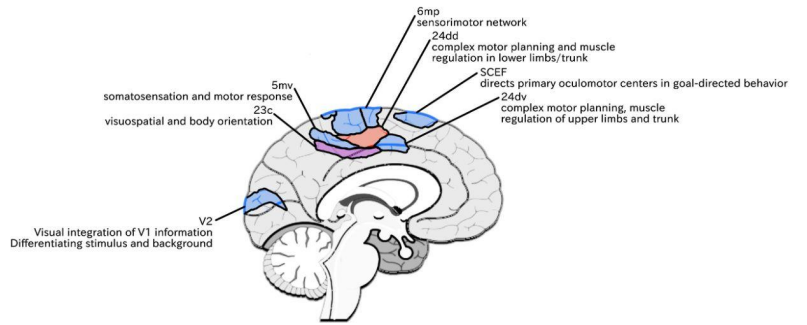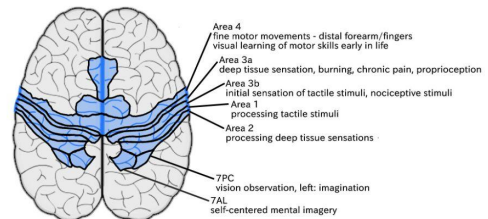N/A

Functionally Connected Acupoints:
BL6 (6d)   BL7 (Area 2/7PC)
GB4 (Area 43)   GB5 (A4)
GB9 (FST)   GB17 (1/2/3a/3b/4)
ST8 (6v)   GV18 (V2)
GV20 (1/3a/3b/4)   GV21 (SCEF)

Structurally Connected Acupoints:
GV20 (4)   GV21 (SCEF)
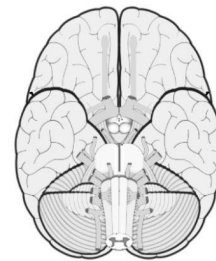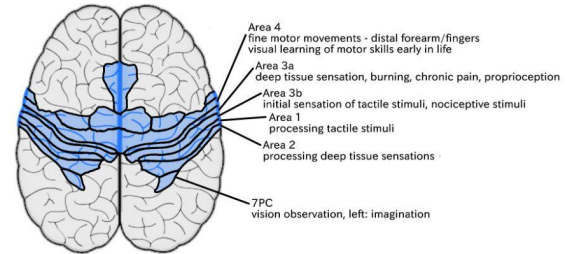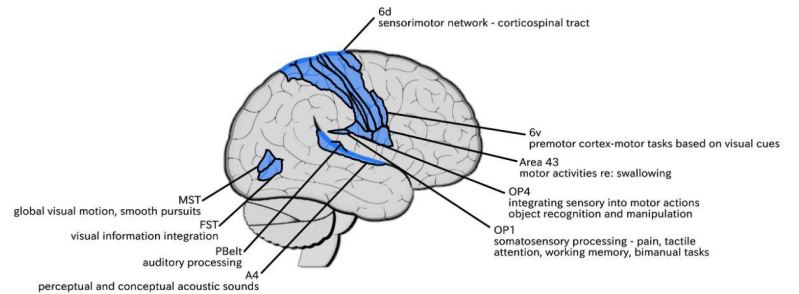
Area 24dv (24 dorsal ventral)

Location:
In the anterior inferior paracentral lobule and straddles into the upper bank of the cingulate sulcus.

Functions:
-Complex motor planning and regulation of muscles in the upper limb and upper trunk muscles through coordination with the supplemental motor area and connections to the spinal cord

Functional Connectivity:
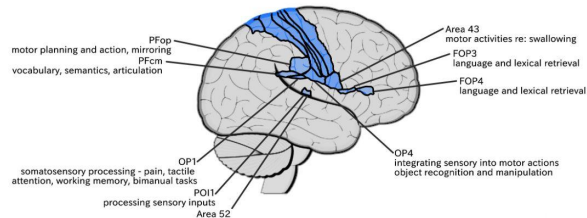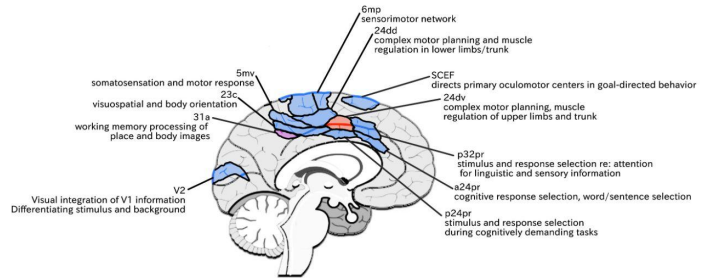Sensory strip: areas 1, 2, 3a, 3b
Motor strip: area 4
Premotor regions: 6mp
Middle cingulate regions: 5mv, SCEF, a24pr, p24pr, p32pr, 23c, 24dd
Superior opercular regions: FOP1, FOP3, FOP4, PFcm, OP4, OP1, 43
Lower opercula and Heschl's gyrus:PoI1, 52
Parietal lobe: 7AL, 7PC, PFop
Primary visual area: V2

White matter connections:
Structurally connected to the contralateral hemisphere, marginal branch of the cingulate sulcus and precuneus.
Contralateral connections course through the body of the corpus callosum to 24dv, SCEF,and p32pr.
Fibers from 24dv project posterior to the marginal branch of the cingulate sulcus and precuneus areas to 23c and 31a.
Local short association fibers connect with SCEF, p32pr, and 24dv.

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL7 (Area 2/7AL/7PC)   GB4 (Area 43)
GB17 (1/2/3a/3b/4)   GV18 (V2)
GV20 (1/3a/3b/4)   GV21 (SCEF)

Structurally Connected Acupoints:
GV21 (SCEF)

Area p24pr (posterior 24 prime)

Location: In the middle cingulate gyrus.

Functions:
-Part of the "cognitive division" of the ACC
-Stimulus and response selection during cognitively demanding tasks that may require movement.

Functional connectivity:
Cingulate areas: 33pr, 24dd, 24dv, 5mv, 23d, a24pr, p32pr
Premotor areas: 6ma, 6r
Lateral frontal lobes: area 46
Insula opercular areas: FOP4, FOP5, PFcm, MI, 43, PoI1
Parietal lobe: PF, PFop, 7AL
Lateral occipital lobe: TPOJ2

White matter connections:
Structurally connected via fibers from p24pr projecting posteriorly to the marginal branch of the cingulate sulcus and precuneus to end at parcellations 23c, 31a, 31pd, and 7m.

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL4 (Area 46)   BL7 (7AL)
GB4 (Area 43/6r)   GB15 (Area 46)
ST8 (6r)

Structurally Connected Acupoints:
N/A
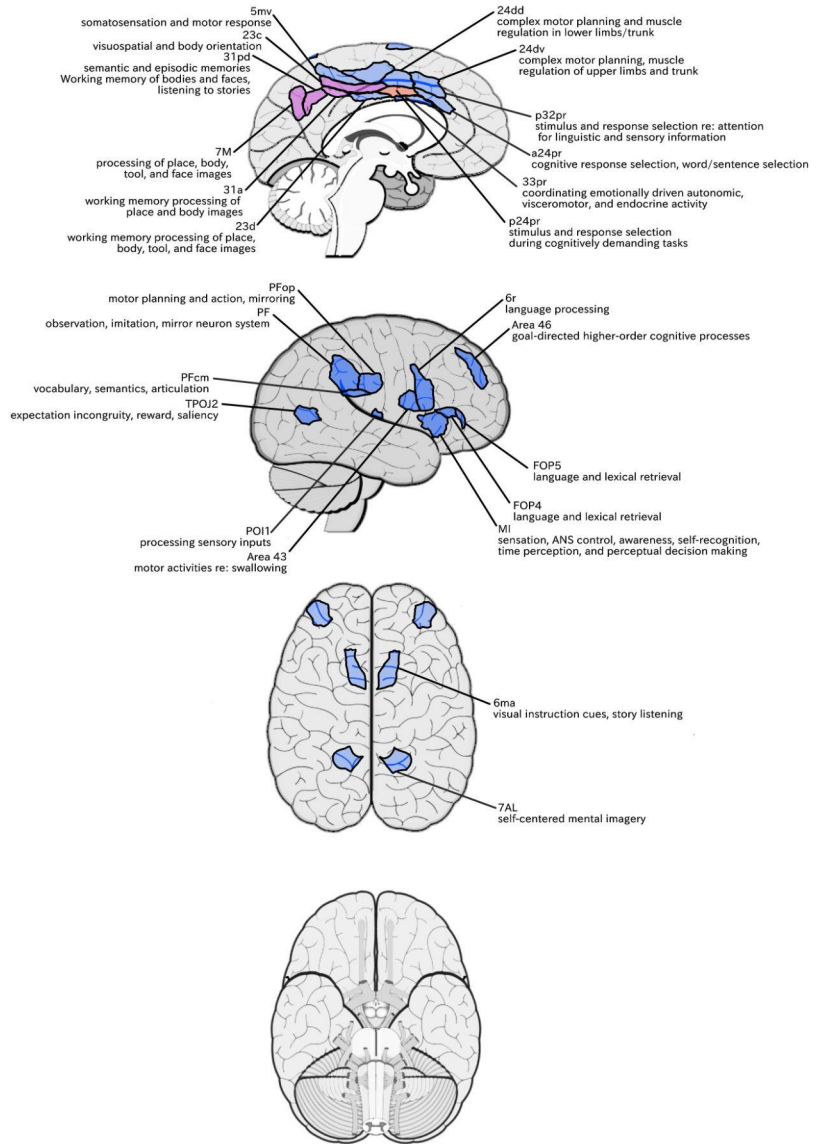
Area a24pr (anterior 24 prime)

Location:
In the middle cingulate gyrus. It is primarily located in the superior half of the gyrus, and straddles into the inferior bank of the cingulate sulcus.

Functions:
-Cognitive response selection
-Word and sentence selection during language-based tasks.

Functional Connectivity:
Cingulate areas: 33prime, 5mv, 23d, 24dv, p24, p24pr, a32pr, p32pr
Premotor areas: SCEF, FEF, PEF, 6a, 6r
Lateral frontal lobe: 9–46d, 46
Insula opercular areas: aFOP1, FOP3, FOP4, FOP5, OP4, PFcm, MI, 43, 52, Pol2, Pol1
Temporal lobe: PHT
Lateral parietal lobe: PGp, PF, PFop, 7AL
Medial parietal lobe: DVT, 7am, PCV
Medial occipital lobe: V1, V2, V3, V4
Dorsal visual stream: V6, V6a, V3a, V3b, V7

White matter connections:
Structurally connected to the cingulum. Some individuals have contralateral connections through the body of the corpus callosum but this tract is inconsistent.
Fibers project anteriorly above the corpus callosum to end at p32, anterior cingulum fibers also curve around the rostrum of the corpus callosum to end at 25. Posterior cingulum fibers end at the precuneus to end at areas POS1 and 31pv, posterior fibers also curve around the splenium of the corpus callosum to end at RSC.

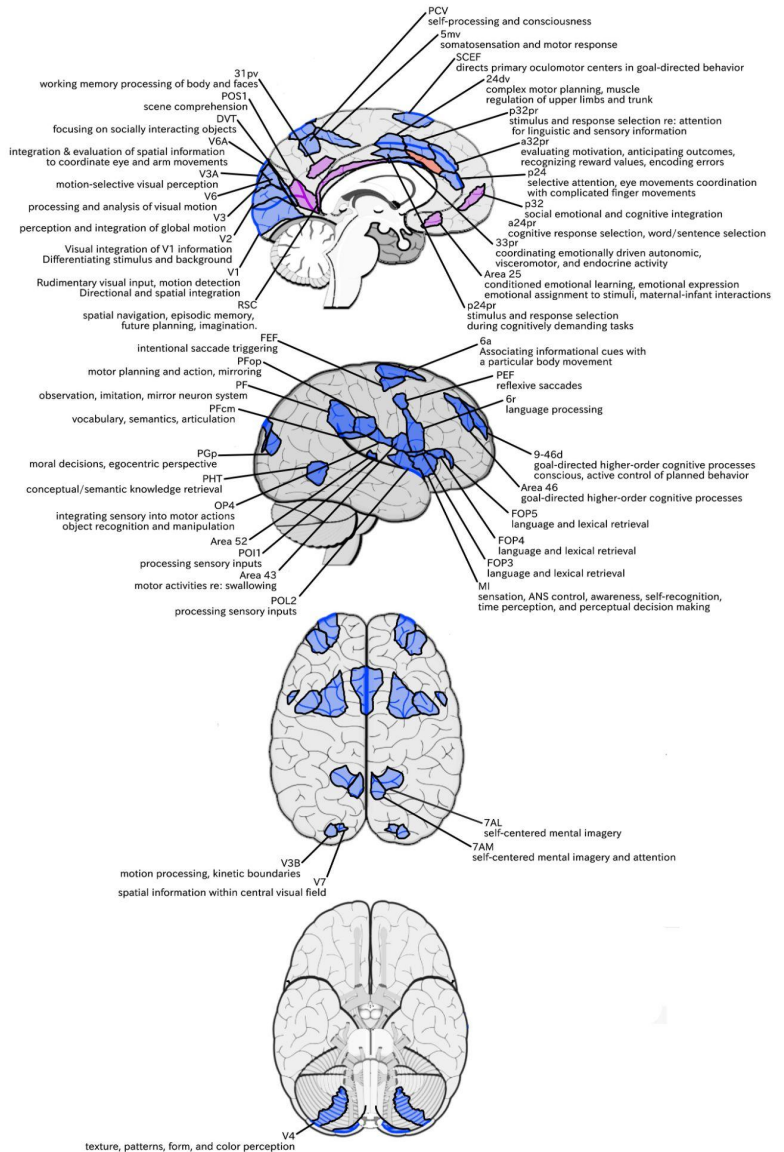**Traditional Acupoint Correlates**:
N/A

Functionally Connected Acupoints:

BL4 (9-46d/Area 46)	BL6 (6a)
B7 (7AL)	BL8 (V3b/V7)
GB4 (Area 43/6r)	GB5 (POL2)
GB8 (PHT)	GB9 (PHT)
GB15 (Area 46)	GB16 (FEF)
ST8 (6r)	GV18 (V1/V2)
GV21 (SCEF)	

Structurally Connected Acupoints:
GV21 (SCEF)

Area p24 (posterior 24)

Location: In the anterior cingulate gyrus. It covers the entire gyrus and is just anterosuperior to the genu of the corpus callosum.

Functions:
Compared to a24:
-More prominent role in selective attention
-Coordination of conscious eye movements with complicated finger movement sequences
-Stimulus/response selection

Functional Connectivity:
Medial frontal lobe: a24, d32, 23c, a24pr, a32pr
Lateral frontal lobe: 9–46d
Medial parietal lobe: RSC, POS2
Medial occipital lobe: V1

White matter connections:
Structurally connected to the cingulum. Cingulum fibers project anteriorly to end at frontal lobe parcellations p32 and 10r, anterior fibers also curve around the rostrum of the corpus callosum to end at 25. Posterior cingulum fibers end at the precuneus, near the splenium of the corpus callosum to areas POS1, v23ab and RSC
Local short association bundles connect with a24, d32, and a32pr.
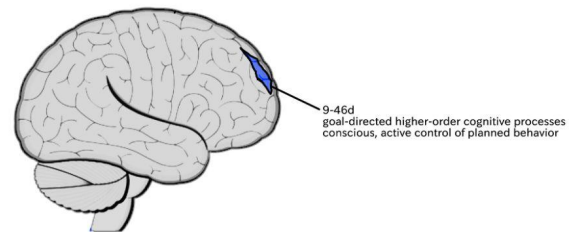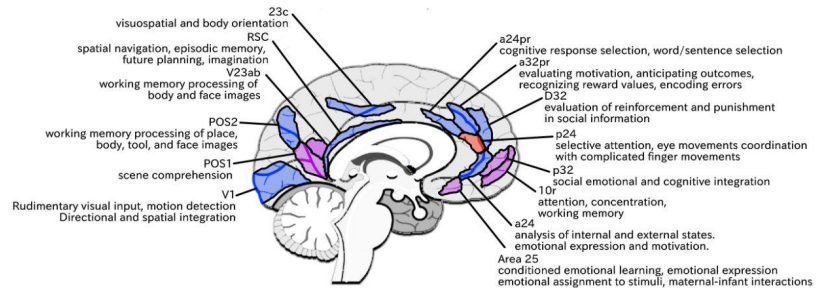
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL4 (9-46d)   GV18 (V1)

Structurally Connected Acupoints:
N/A
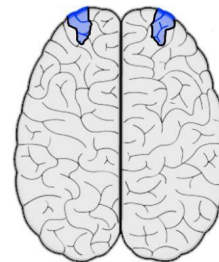
Area a24 (anterior 24)

Location:
In the anterior cingulate gyrus just anterior to the genu of the corpus callosum.

Functions:
-Part of the "affect division" of the ACC
-Analysis of internal and external states to play a role in emotional expression and motivation.

Functional Connectivity:
Medial frontal lobe: p24, d32, p32, s32, 10d, 10r, 9p, 9m
Lateral frontal lobe: 8ad
Temporal lobe: TE1a
Lateral parietal lobe: PGs
Posterior cingulate areas: RSC, 31pv, 31pd, 23d, d23ab, v23ab, 7m, POS1

White matter connections:
Structurally connected to the cingulum. Cingulum fibers project anteriorly to end near the rostrum of the corpus callosum at 25. Posterior cingulum fibers end at the precuneus, near the splenium of the corpus callosum to areas 31pv and 23d.
Local short association bundles connect with p32 and 9m.

Traditional Acupoint Correlates:
N/A

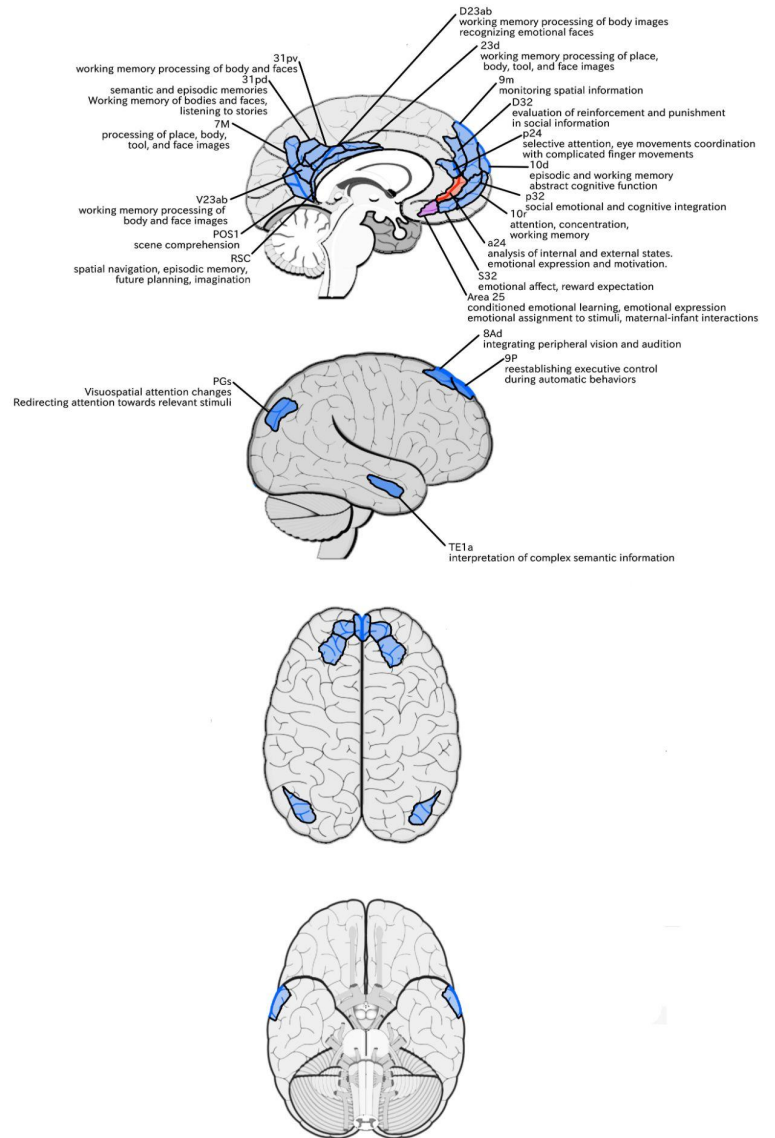Functionally Connected Acupoints:
BL3 (8Ad/9p)   BL4 (8Ad)
BL5 (8Ad)   GB6 (TE1a)
GV23 (9m)

Structurally Connected Acupoints:
GV23 (9m)

Area p32pr (posterior 32 prime)

Location:
In the posterior inferior portion of the superior frontal gyrus (SFG). It wraps into the superior bank of the cingulate sulcus

Functions:
-Part of the "cognitive division" of the ACC
-Stimulus and response selection in tasks that require attention for linguistic and sensory information.

Functional Connectivity:
Sensory strip: area 2
Cingulate areas: 5mv, 23d, 24dv, p24, p24pr, a32pr
Premotor areas: SCEF, PEF, 6a, 6v, 6ma, 6mp
Lateral frontal lobe: 9–46d, 46
Insula opercular areas: FOP1, FOP3, FOP4, FOP5, OP4, PFcm, MI, 43, 52, PoI2, PoI1
Temporal lobe: PHT
Lateral parietal lobe: PGp, PFt, PF, PFop, LIPd, 7PC, 7PL, 7AL
Medial parietal lobe: DVT, 7am
Medial occipital lobe: V1, V2, V3, V4
Dorsal visual stream: V6, V6a, V3a, V3b, V7
Lateral occipital lobe: FST

White matter connections:
Structurally connected to the cingulum and contralateral hemisphere.
Cingulum fibers project posteriorly to end at precuneus areas 31a, 31pd, 31pv, PCV, and v23ab.
Contralateral connections course through the corpus callosum to end at p32pr, SCEF, and a32pr.
Local short association fibers connect with p32pr, SCEF, and a32pr
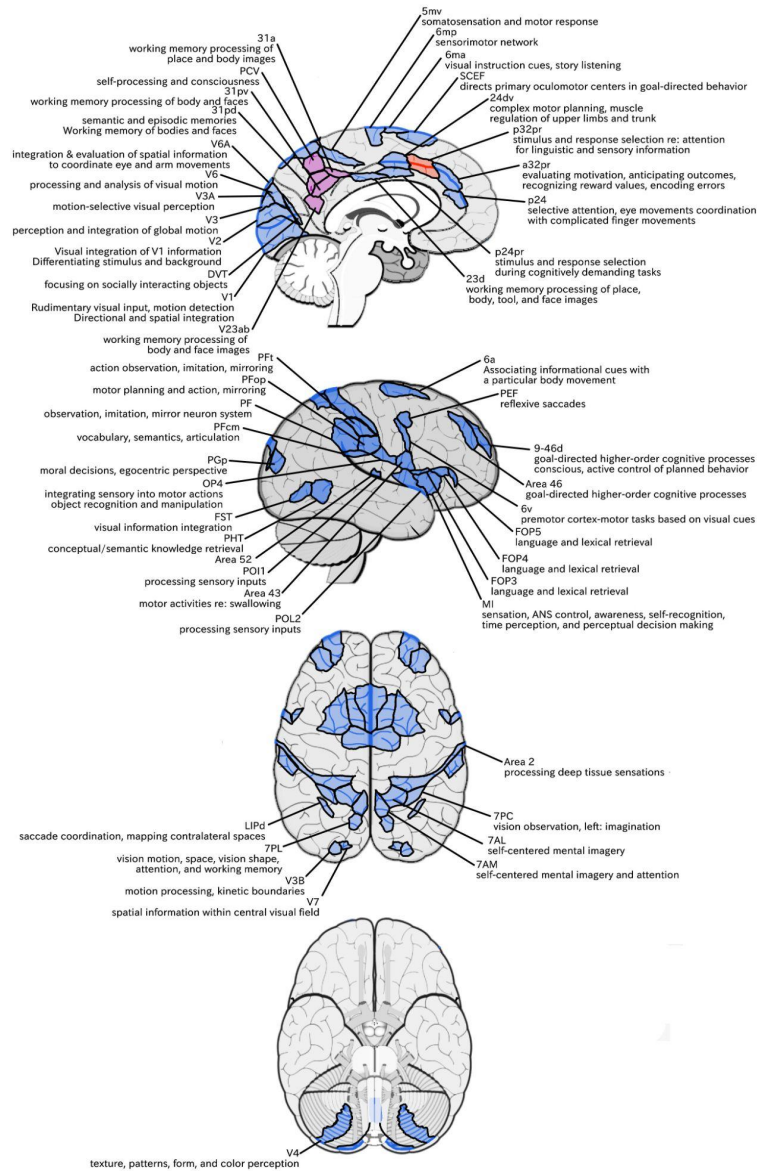
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL4 (9-46d/Area 46)   BL6 (6a)
BL7 (Area 2/7AL/7PC)   BL8 (V3b/V7)
GB4 (Area 43)   GB5 (POL2)
GB8 (PHT)   GB9 (FST/PHT)
GB15 (Area 46)   GB16 (PEF)
GB17 (Area 2)   ST8 (6v/PEF)
GV18 (V1/V2)   GV21 (SCEF)

Structurally Connected Acupoints:
GV21 (SCEF)

Area a32pr (anterior 32 prime)

Location: In the posterior inferior portion of the SFG. It wraps into the superior bank of the cingulate sulcus.

Functions:
-Helps guide behavior by evaluating motivation, anticipating outcomes, recognizing reward values, and encoding errors to influence attention allocation and motor preparation.

Functional Connectivity:
Medial frontal lobe: areas 8BM, SCEF, p24, d32, 23c, p24pr, and p32pr
Lateral frontal lobe: areas a9-46v, 9–46d, and 46
Insula opercular areas: areas FOP4, FOP5, AVI, and MI
Medial parietal lobe: areas 7pm, RSC, and POS2
Medial occipital lobe: area V1

White matter connections?
Structurally connected to the cingulum and contralateral hemisphere.
Contralateral connections course through the body of the corpus callosum to end at a32pr, p32pr, 8BM, and 9m. Cingulum fibers project posteriorly from a32pr to end at precuneus areas 7m, 31a, 31pd, 31pv, RSC, and v23ab.
Local short association fibers connect with p24, 8BM, SCEF, and d32

Traditional Acupoint Correlates:
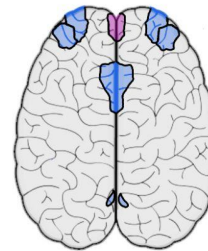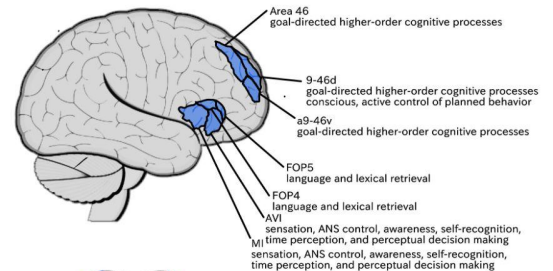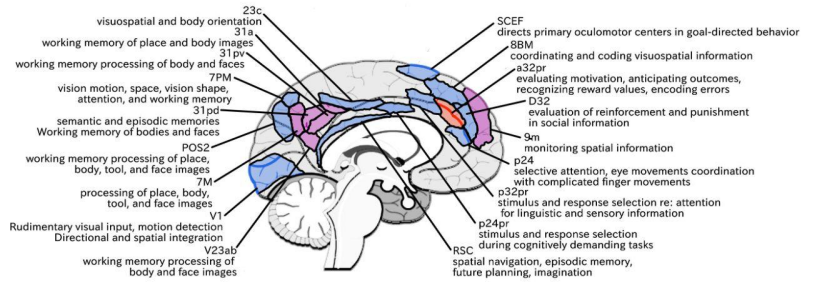N/A

Functionally Connected Acupoints:
BL4 (9-46d/Area 46)   GB15 (Area 46)
GV21 (SCEF)

Structurally Connected Acupoints:
GV21 (SCEF)   GV23 (9m)
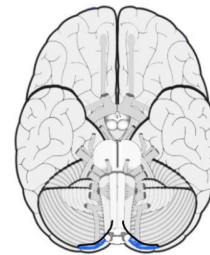
Area d32 (dorsal 32)

Location: Vertically oriented area in the inferior SFG. It is somewhat different in orientation to the other cingulate areas.

Functions:
-Evaluation of reinforcement and punishment in assigning value to social information.

Functional Connectivity:
Medial frontal lobe: p32, a24, p24, a32pr, 9m, 10d, 8BM, SFL
Lateral frontal lobe: 8AV, 8AD, 8BL, 8C, 9a, 9p, a10p, p10p, i6-8, s6-8, 47s
Insula: AVI
Temporal lobe: STSvp
Lateral parietal lobe: PFm, PGs, PGi
Posterior cingulate areas: RSC, 31a, 31pv, 31pd, d23ab, 7m, POS2, POS1

White matter connections:
Structurally connected to the contralateral hemisphere, the cingulum, and abundant local parcellations. Connections to the contralateral hemisphere course through the corpus callosum to areas d32, 8BM, and 9m. Cingulum fibers project posteriorly to precuneus areas 31pv, POS1, v23ab, and RSC. Local short association bundles connect with 8BM, 9m a32pr, and 10d.

Traditional Acupoint Correlates:
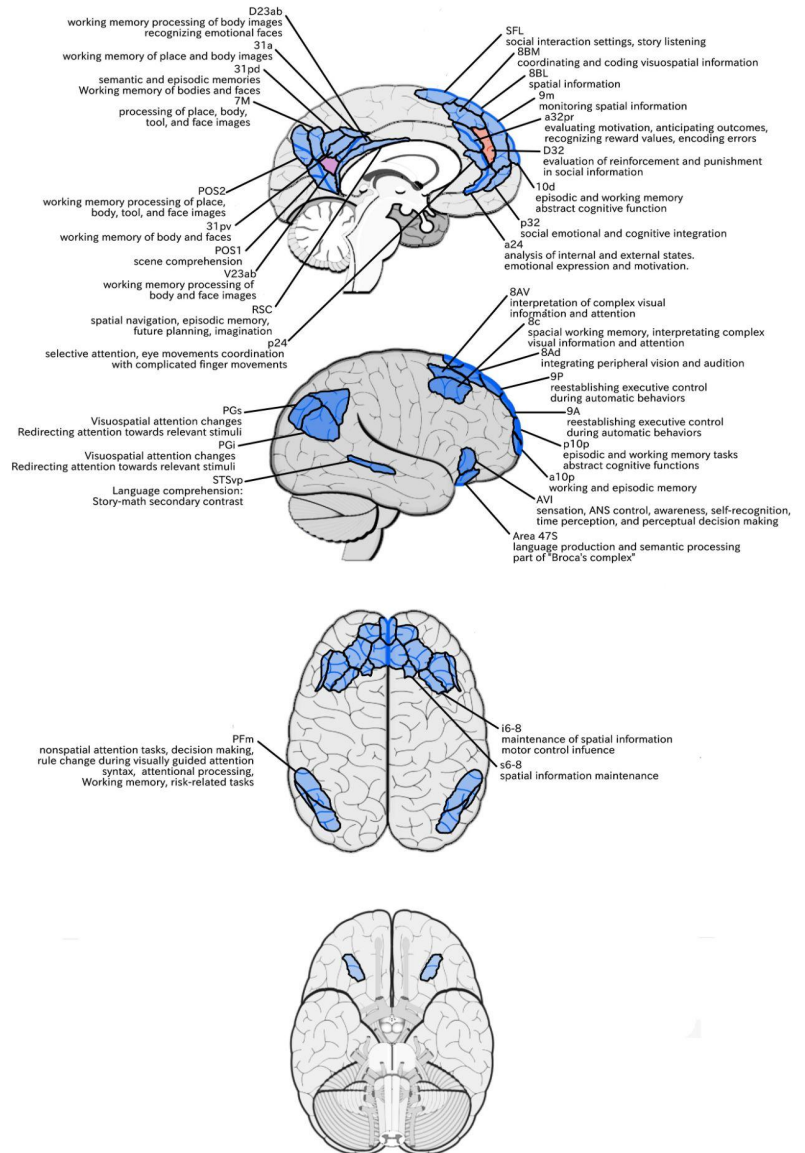N/A

Functionally Connected Acupoints:
BL3 (8AD/8BL/9p)   BL4 (8AD/8AV)
BL5 (8AD/8AV/i6-8)   GB6 (STSvp)
GB14 (a10p/p10p)   GB15 (8AV/8C)
GB18 (PFm, PGs)   GV22 (8BL)
GV23 (9m)   GV24 (10d)

Structurally Connected Acupoints:
GV23 (9m)   GV24 (10d)

Area p32 (posterior 32)

Location:
The central portion of the medial SFG. It borders the anterior bend of the callosal sulcus.

Functions:
-Emotional and cognitive integration of information during social interaction tasks
-Some role in error monitoring.

Functional Connectivity:
Medial frontal lobe: d32, a24, p24, a32pr, 10r
Lateral frontal lobe: area 8AD
Posterior cingulate areas: RSC, 31a, 31pv, POS2, POS1

White matter connections:
Structurally connected to the contralateral hemisphere and cingulum.
Connections to the contralateral hemisphere course through the genu of the corpus callosum to areas p32, 9m, 10d, and 10v.
Cingulum fibers project posteriorly to precuneus areas POS1, 31pv, RSC, and v23ab.
Local short association bundles connect with 9m, 10d, 10r, and p24

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
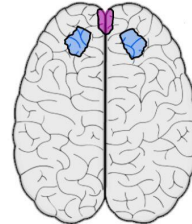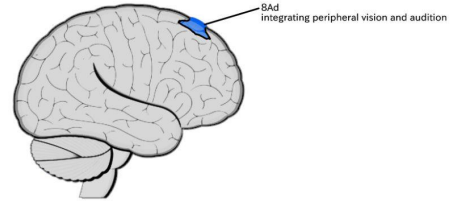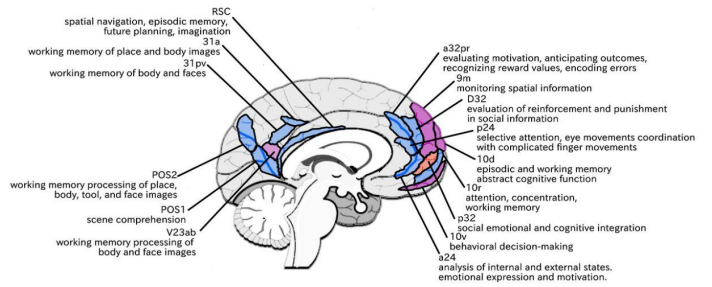BL3 (8AD)   BL4 (8AD)
BL5 (8AD)

Structurally Connected Acupoints:
GV23 (9m)   GV24 (10d)
Yintang (10v)

Area s32 (subcallosal 32)

Location:
Lies in the subcallosal gyri.

Functions:
-Heavily interconnected to other areas of the limbic system
-Higher order role in emotional affect & reward expectation.

Functional Connectivity:
Medial frontal lobe: a24, 25, 10d, 10r
Lateral frontal lobe: 8AD
Lateral parietal lobe: PGs
Posterior cingulate areas: v23ab, POS1

White matter connections:
Structurally connected to local parcellations. S32 has posterior connections to 25 and anterior connections to p32.

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8AD)   BL4 (8AD)
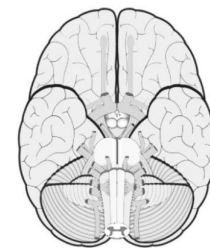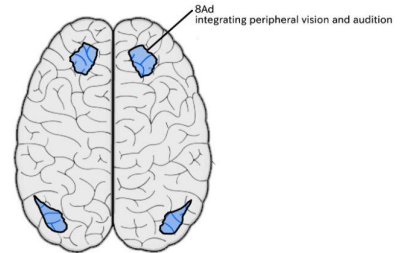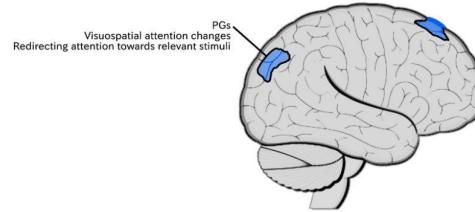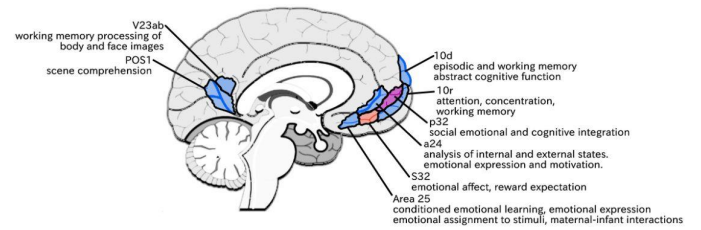BL5 (8AD)   GB18 (PGs)
GV24 (10d)

Structurally Connected Acupoints:
N/A

Area 25

Location: Located in the most posterior portion of the subcallosal area.

Functions:
-Part of the "affect division" of the ACC
-Conditioned emotional learning, emotional expression, assessment of motivational content, assignment of emotional valence to internal and external stimuli, and maternal-infant interactions.

Functional Connectivity:
Area s32

White matter connections:
Area 25 is connected to the cingulum.
White matter tracts from this parcellation are variable. Some individual tracts connect to anterior parcellations; however, this is inconsistent across individuals.
Fibers from 25 project posterior above the corpus callosum to areas v23ab and 31pv.

Traditional Acupoint Correlates:
N/A

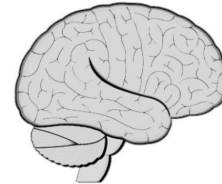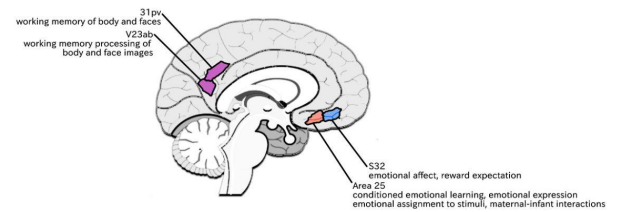Functionally Connected Acupoints:
N/A

Structurally Connected Acupoints:
N/A

Note:
Due to lack of superficial points directly connected to area 25 consideration may be given to points that are functionally connected to the adjacent and functionally connected parcellation s32; specifically points BL3, BL4, BL5, GB18, and GV24

Medial SFG Regions

Area SCEF
(supplementary and cingulate eye field)

Location:
In the posterior medial SFG.

Functions:
-Higher order oculomotor center implicated in appraising all
possible oculomotor behaviors to direct primary oculomotor centers
in goal-directed behavior.

Functional Connectivity:
Sensory strip: areas 1, 2, 3a, and 3b
Motor strip: area 4
Premotor regions: PEF, FEF, 55b, 6ma, 6mp, 6a, 6r, 6v
Middle cingulate regions: a24pr, p32pr, a32pr, 5mv, 23c
Lateral frontal lobe: IFJa, 46, 9–46d
Superior insula and opercular regions: OP4, OP1, PFcm, 43, FOP1,
FOP2, FOP3 FOP4, FOP5
Lower opercula & Heshl's gyrus region: PSL, 52, A4, MI, Pol1, Pol2
Temporal lobe: PHT
Lateral parietal lobe: AIP, MIP, VIP, LIPd, LIPv, PFop, PF, PFt, IP0,
IPS1, 7AL, 7PL, 7PC
Medial parietal lobe: 7am, DVT
Medial occipital lobe: V1, V2, V3, V4
Dorsal visual stream: V3a, V3b, V6, V6a, V7
Ventral visual stream: FFC
Lateral occipital lobe: PH, TPOJ2, LO3, MST, FST

White Matter Connections:
Structurally connected to contralateral hemisphere and thalamus.
Contralateral connections course through the body of the corpus
callosum to end at SCEF, 8BL, SFL, and 8BM.
Thalamic projections travel to the brainstem.
Local short association bundles connect with 8BM, SFL, and 8BL.

Traditional Acupoint Correlates:
GV21

Functionally Connected Acupoints:

BL4 (9-46d/Area 46)	BL6 (6a/6d)	BL7 (Area 2/7AL/7PC)	BL8 (IP0/IPS1/V3b/V7)
GB4 (Area 43/6r)	GB5 (A4/POL2)	GB8 (PHT)	GB9 (PH/PHT/FST)
GB15 (Area 46)	GB16 (55b/FEF)	GB17 (1/2/3a/3b/4)	GB18 (AIP/LIPv)
GV18 (V1/V2)	GV20 (1/3a/3b/4)		
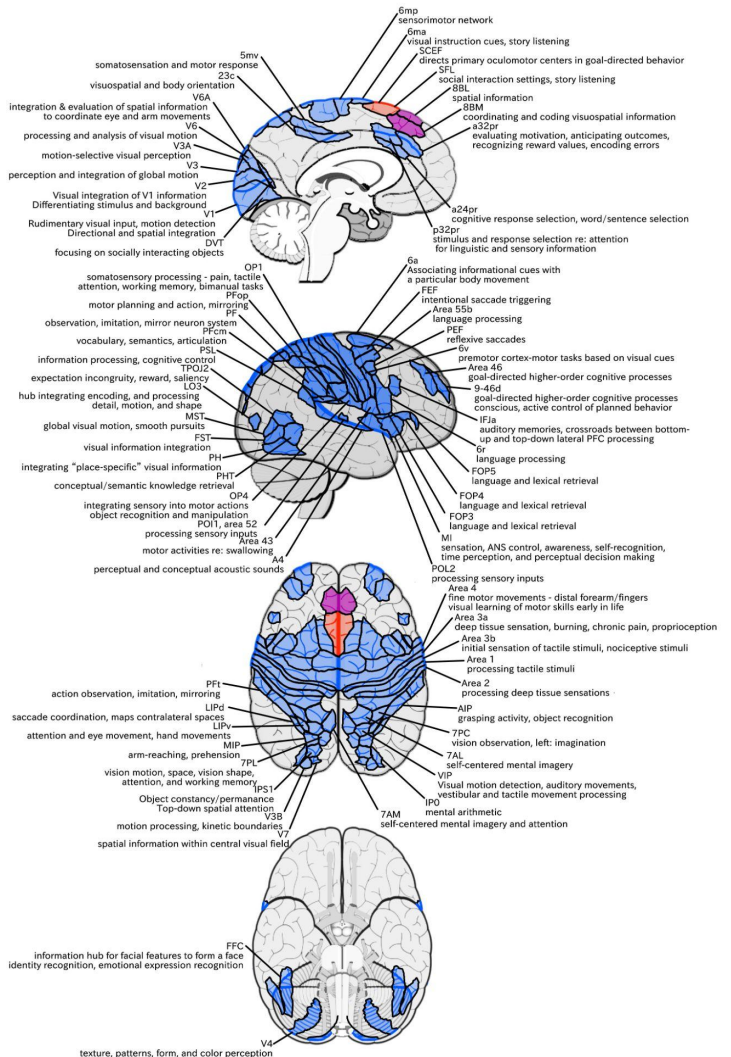
Structurally Connected Acupoints:

GV21 (SFL)	GV22 (8BL)

Area 8BM (8b medial)

Location:
In the posterior medial SFG..

Functions:
-Maintaining visuospatial information
-Coordinating and coding visuospatial information in terms of oculomotor and other body-centered coordinate systems.

Functional Connectivity:
Dorsolateral frontal lobe: i6-8, s6-8, a10p, a9-46v, p9-46v, 8C, 8BL, 8AD, 8AV
Medial frontal lobe: SFL, a32pr, d32
Inferior frontal lobe:IFSa, IFSp, IFJp, 44, 45, a47r, p47r
Premotor areas: 55b
Insula areas: AVI
Temporal lobe: TE1m, TE1p, STSvp
Lateral parietal lobe: LIPv, IP1, IP2, PFm, PGi, PGs
Medial parietal lobe: 7pm, 31a, d23ab

White matter connections:
Connected to the contralateral hemisphere, frontal aslant tract, inferior fronto-occipital fasciculus, and thalamus. Contralateral connections course through the corpus callosum to end at 8BM and 9m.
Frontal aslant tract fibers from 8BM project inferolaterally to end at area 44.
Thalamic connections run inferior to 8BM and continue in the brainstem. Fibers with the inferior fronto-occipital fasciculus project inferior and posterior through the extreme/external capsule through the temporal lobe to end at parietal and occipital connections 7PC, V1, V2, and V3. Local short association bundles connect with 9m, d32, and SCEF.
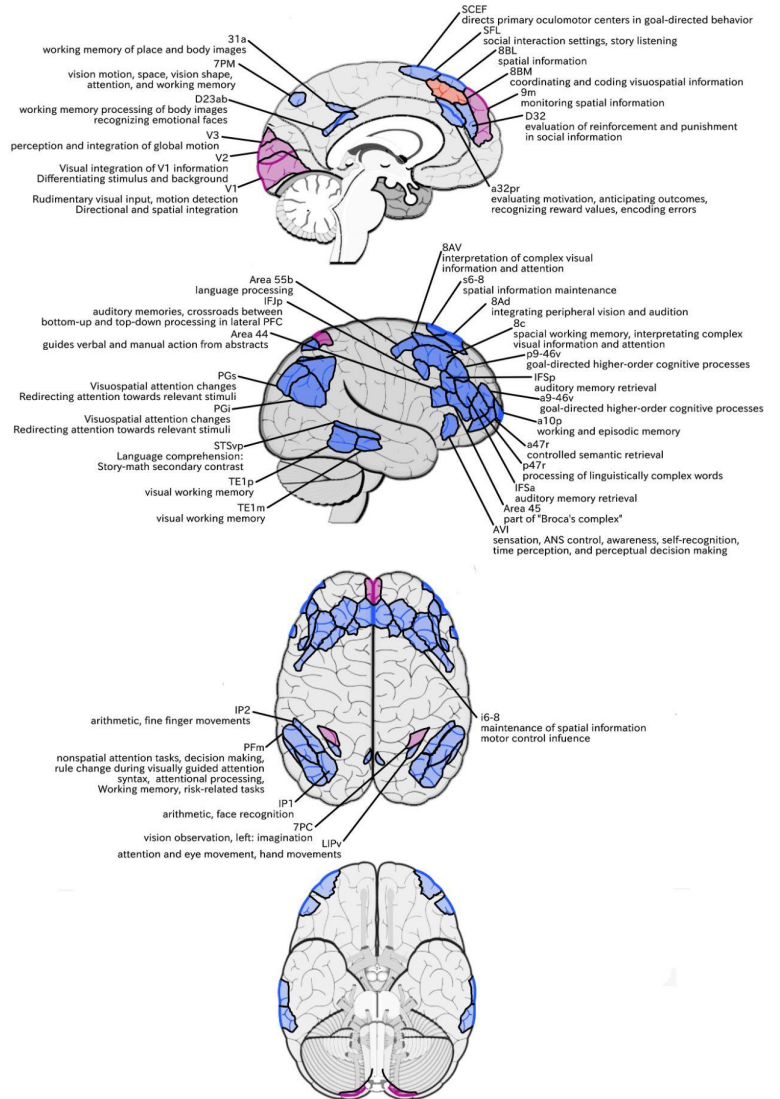
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8AD)	BL4 (8AD/8AV)
BL5 (8AD/8AV/i6-8)	BL8 (IP1)
GB6 (STSvp)	GB7 (TE1m/TE1p)
GB8 (TE1p)	GB13 (p9-46v)
GB14 (a10p/a47r)	GB15 (8AD/8AV/8C)
GB16 (55b)	GB18 (LIPv/PFm/PGs/IP1)
ST8 (IFJp)	GV18 (V1/V2)
GV19 (7PM)	GV22 (8BL)

Structurally Connected Acupoints:
BL7 (7PC)	GV18 (V1/V2)
GV21 (SCEF)	GV23 (9m)

Area 9m (9 medial)

Location: In the anterior medial SFG.

Functions:
A major constituent of the dorsolateral prefrontal cortex.
-Increased activity when monitoring multiple pieces of spatial information.

Functional Connectivity:
Dorsolateral frontal lobe: 9a, 9p, 10d, 8BL, 8AD, 8AV
Medial frontal lobe: SFL, a24, 10r, 10v, d32
Inferior frontal lobe: 44, 45, 47s, 47l
Insula: AVI
Temporal lobe: TGd, TE1a, STSdp, STSva, STSvp
Lateral parietal lobe: PGi, PGs
Medial parietal lobe: 7m, POS1, 31pv, 31pd, 23d, v23ab, d23ab

White matter connections?
Structurally connected to the contralateral hemisphere and cingulum.
Connections to the contralateral hemisphere course through the corpus callosum to 9m, 8BL, and 8BM.
Cingulum fibers project posteriorly, above the corpus callosum to end at precuneus areas 31pv, v23ab, and POS1.
Local short association bundles connect with p32, 10d, and a24

Traditional Acupoint Correlates:
GV23

Functionally Connected Acupoints:
BL3 (8AD/8BL/9p)   BL4 (8AD/8AV)
BL5 (8AD/8AV)
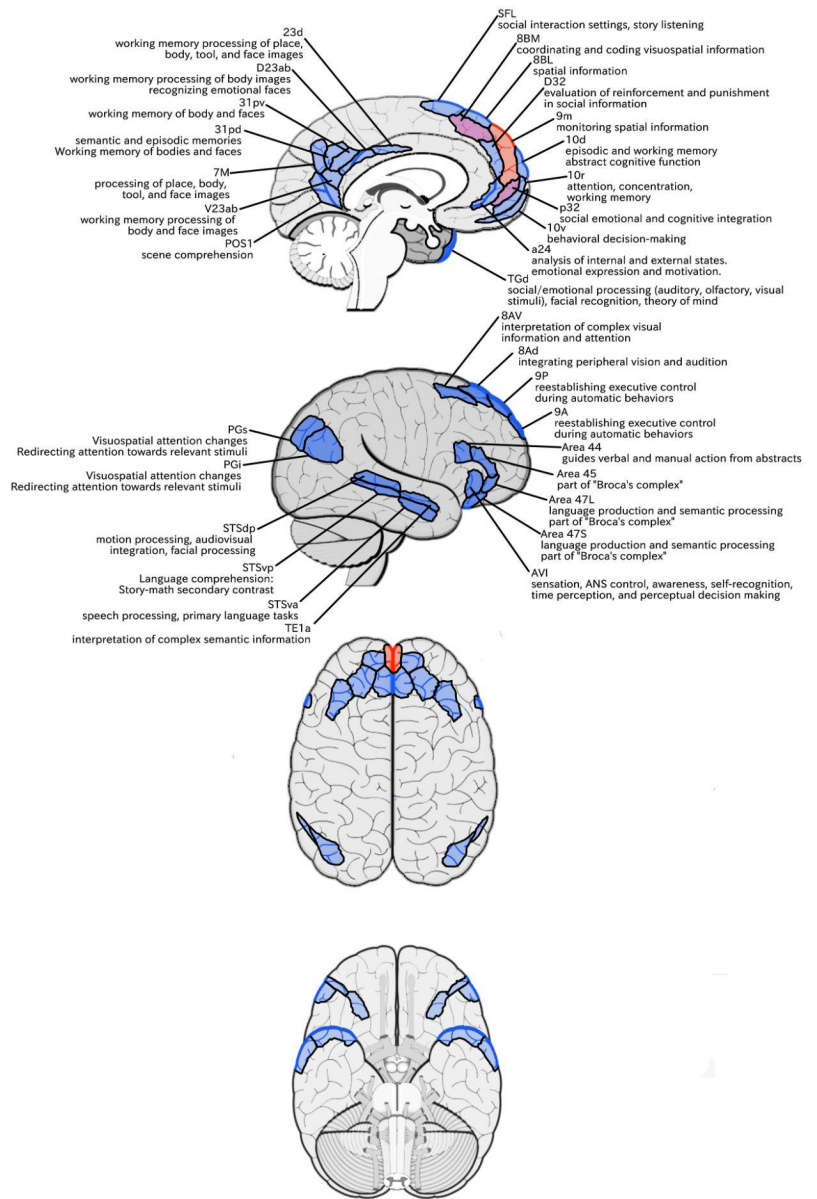GB6 (STSdp/STSva/STSvp/TE1a)
GB15 (8AV)   GV22 (8BL)
GV24 (10d)   Yintang (10v)

Structurally Connected Acupoints:
GV23 (9m)   GV24 (10d)

Area 10r (10 rostral)

Location:
In the anterior inferior portion of the medial SFG.

Functions:
-Important role in stimulus-oriented attention
-Importance in concentration and working memory.

Functional Connectivity:
Dorsolateral frontal lobe: 9p, 10d, 8AD
Medial frontal lobe: 9m, a24, 10v, s32, p32
Temporal lobe: TGd, TE1a, STSva, PHA1, hippocampus
Lateral parietal lobe: PGi, PGs
Medial parietal lobe: 7m, POS1, 31pv, 31pd, v23ab, d23ab

White Matter Connections:
Connected to the contralateral hemisphere and cingulum. Connections to the contralateral hemisphere course through the corpus callosum to end at areas 10r and 10v. Cingulum fibers project posteriorly from 10r to precuneus areas v23ab, POS1, and RSC.
Local short association bundles connect with p32, 10d, and 10v.
White matter tracts in the right hemisphere have less consistent connections with the cingulum.
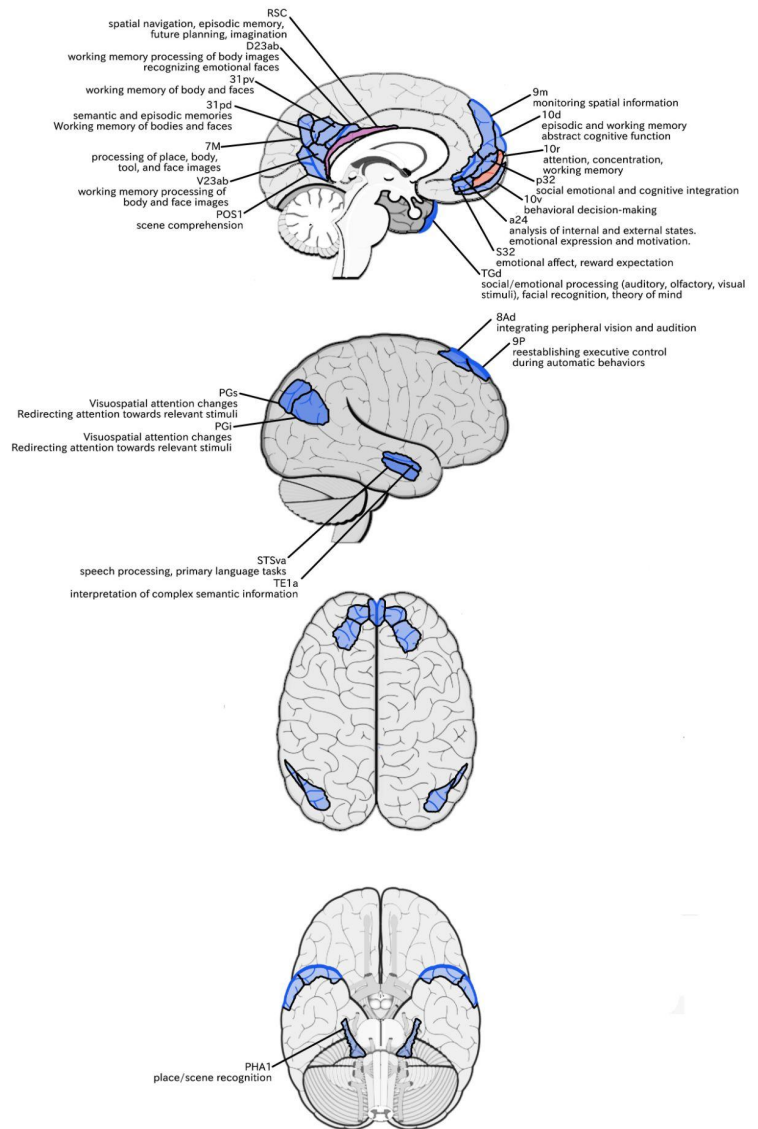
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8AD/9p)   BL4 (8AD)
BL5 (8AD)   GB6 (STSva/TE1a)
GB18 (PGs)   GV23 (9m)
GV24 (10d)   Yintang (10v)

Structurally Connected Acupoints:
GV24 (10d)   Yintang (10v)

Area 10v

Location:In the depths of the inferior anterior most region of medial SFG.

Functions:
-Often associated with the ventromedial prefrontal cortex
-Thought to play a role in behavioral decision making by integrating value appraisals from the OFC and ACC.

Functional Connectivity:
Dorsolateral frontal lobe: 10d, 47l, 8BL
Medial frontal lobe: 9m, 10r, s32
Temporal lobe: TGd, TE1a, STSva, STSvp
Lateral parietal lobe: PGi, PGs
Medial parietal lobe: 7m, POS1, 31pv, 31pd, v23ab

White Matter Connections:
Structurally connected to the contralateral hemisphere and the uncinate fasciculus. Connections with the uncinate fasciculus are not consistent across individuals. Contralateral connections course through the corpus callosum to end at areas 10v and 10d. Uncinate fasciculus fibers project through the limen insulae to temporal pole parcellation TGd.
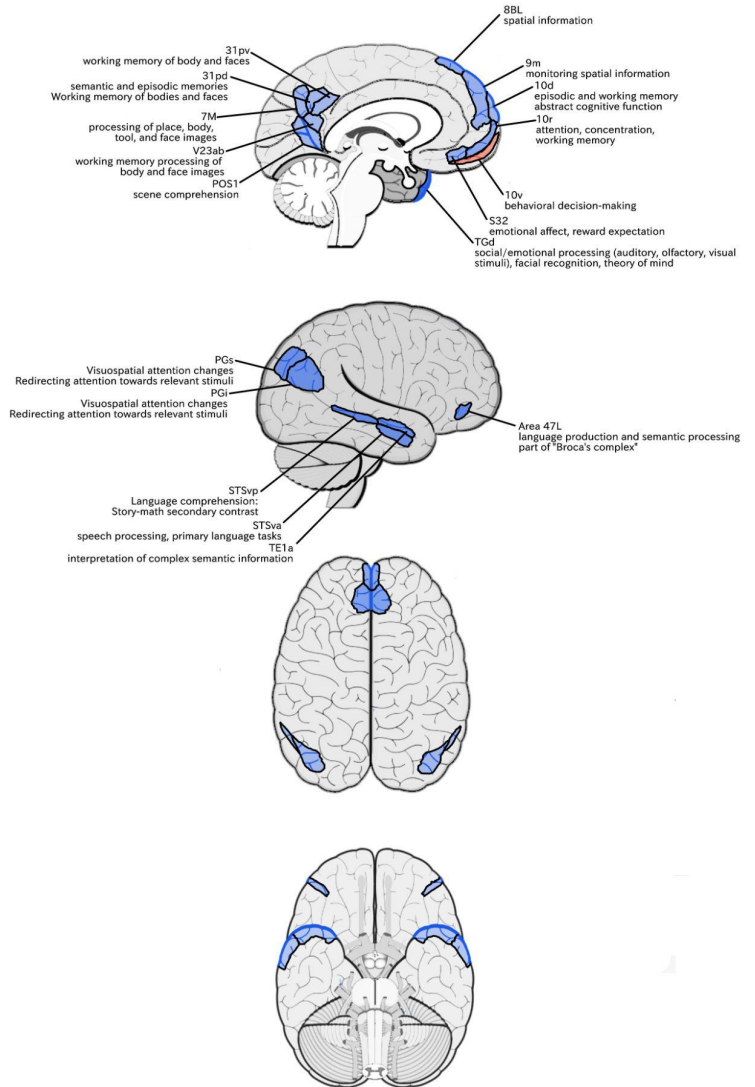
Traditional Acupoint Correlates:
Yintang

Functionally Connected Acupoints:

BL3 (8BL)	GB6 (STSva/STSvp/TE1a)
GB14 (a10p/p10p)	GB18 (PGs)
GV22 (8BL)	GV23 (9m)
GV24 (10d)	

Structurally Connected Acupoints:

GV24 (10d)

Orbitofrontal Regions

Area OFC (orbitofrontal complex)

Location: In the gyrus rectus, the medial orbitofrontal cortices, and the intervening sulcus.

Functions:
-Integral role in the evaluation of rewards and punishment
-Suggested to be involved in self-regulation, behavioral inhibition, and emotional control by predicting the moment-to-moment value of stimuli, actions, and choices based on internal states

Functional Connectivity:
Areas pOFC and 13L

White Matter Connections:
Structurally connected to the contralateral hemisphere, the uncinate fasciculus, and inferior fronto-occipital fasciculus. Contralateral connections course through the corpus callosum to end at 10d, 10r, and 10v. Uncinate fasciculus fibers project through the limen insulae to temporal pole parcellation TGd.
IFOF connections project posteriorly through the extreme/external capsule to occipital lobe area V1.
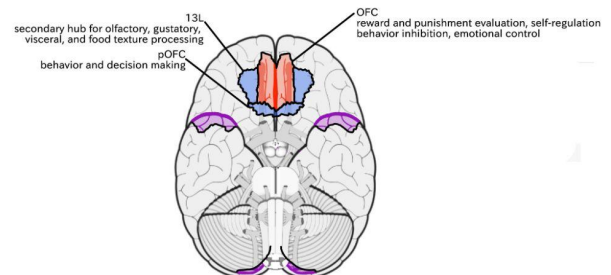
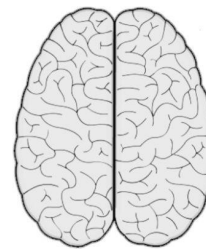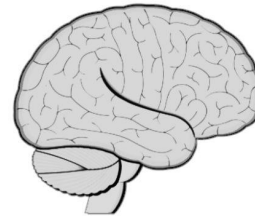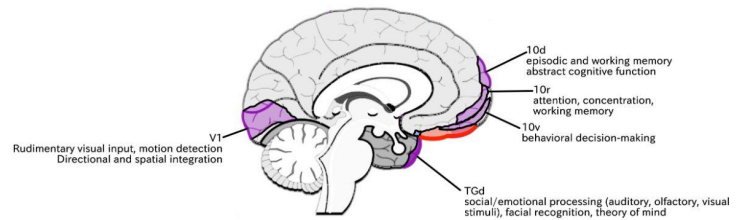**Traditional Acupoint Correlates**:
N/A

Functionally Connected Acupoints:
N/A

Structurally Connected Acupoints:
GV24 (10d)
Yintang (10v)

Area pOFC
(posterior orbitofrontal complex)

Location:
In the posterior gyrus rectus and the medial posterior most portions of the orbitofrontal cortices.

Functions:
-Behavior and decision making by evaluating sensory reinforcers, such as taste and odor.

Functional Connectivity:
Area OFC

White Matter Connections:
Connected to local parcellations.
Short association bundles connect to the temporal pole through the insula to end at area
TGd. There are anterior projections to OFC, 13L and PeEc.

Traditional Acupoint Correlates:
N/A
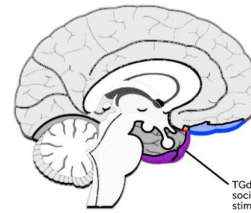
Functionally Connected Acupoints:
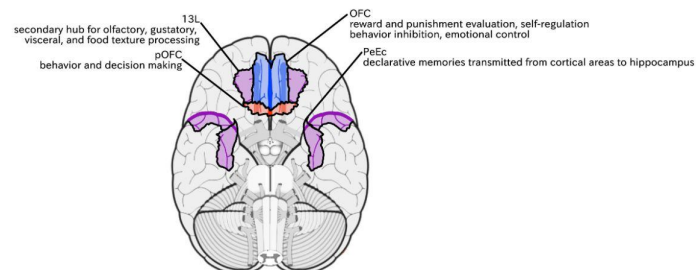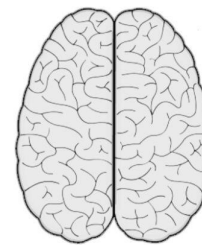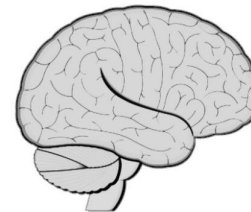N/A

Structurally Connected Acupoints:
N/A

Note:
Due to lack of superficial points directly connected to pOFC consideration may be given to points that are structurally connected to the adjacent and functionally connected

parcellation OFC; specifically points GV24 and Yintang

TGd
social/emotional processing (auditory, olfactory, visual stimuli), facial recognition, theory of mind

13L
secondary hub for olfactory, gustatory, visceral, and food texture processing

OFC
reward and punishment evaluation, self-regulation behavior inhibition, emotional control

pOFC
behavior and decision making

PeEc
declarative memories transmitted from cortical areas to hippocampus

Area 11L

Location: In the anterior OFC.

Functions:
-Receive, integrate, and modulate olfactory information to evaluate food-related reinforcers and analyze satiety and anticipation of food rewards.

Functional Connectivity:
Frontal lobe: areas 46, a9-46v, p9-46v, IFSa
Parietal lobe: IP2

White Matter Connections:
Structurally connected to the occipital lobe through the inferior fronto- occipital fasciculus. In some individuals 11L also connects with the uncinate fasciculus but this tract is inconsistent. Inferior fronto- occipital fasciculus fibers project through the extreme/external to
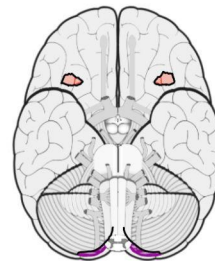end at occipital lobe area V1.

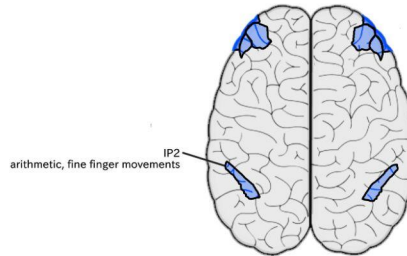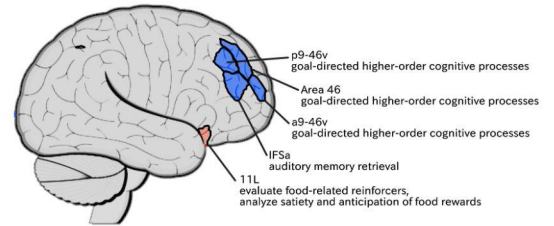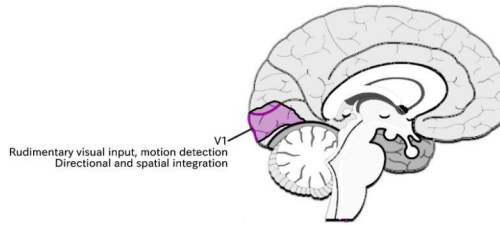**Traditional Acupoint Correlates:**
N/A (~½ the distance between GB1 and GB4)

Functionally Connected Acupoints:
BL4 (Area 46)   GB13 (p9-46v)
GB15 (p9-46v/Area 46)

Structurally Connected Acupoints:
GV18 (V1)

V1
Rudimentary visual input, motion detection
Directional and spatial integration

p9-46v
goal-directed higher-order cognitive processes
Area 46
goal-directed higher-order cognitive processes
a9-46v
goal-directed higher-order cognitive processes
IFSa
auditory memory retrieval
11L
evaluate food-related reinforcers,
analyze satiety and anticipation of food rewards

IP2
arithmetic, fine finger movements

Area 13L

Location:
In the posterior OFC

Functions:
-Secondary hub for olfactory, gustatory, visceral and food texture processing, integrating this information to assess satiety based on a comparison between food reward and current internal states.

Functional Connectivity:
Areas 47m and OFC

White Matter Connections:
Structurally connected to local parcellations.
Short association bundles connect with 11l, 47m, and 47s.

Traditional Acupoint Correlates:
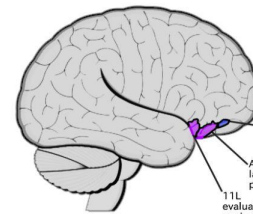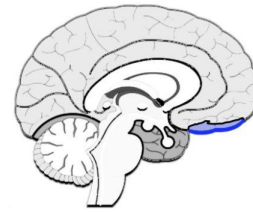N/A

Functionally Connected Acupoints:
N/A

Structurally Connected Acupoints:
N/A

Note:
Due to lack of traditional superficial points directly connected to 13L consideration may be given to structurally connected regions 47s/11L located approximately ½ the distance between GB1 and GB4

Area 47M
emotional integration, cognitive appraisals, physiological internal states to aid in emotional regulation

Area 47S
language production and semantic processing part of "Broca's complex"

11L
evaluate food-related reinforcers, analyze satiety and anticipation of food rewards
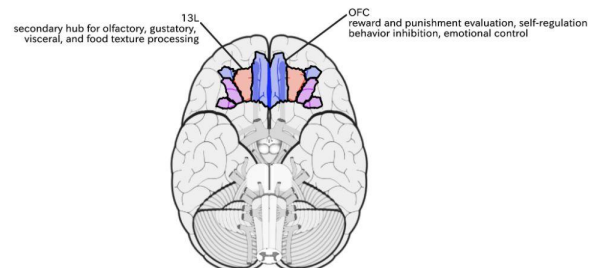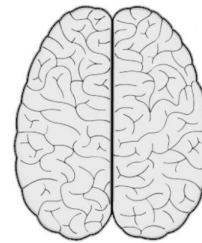
13L
secondary hub for olfactory, gustatory, visceral, and food texture processing

OFC
reward and punishment evaluation, self-regulation behavior inhibition, emotional control

Area 47m (47 medial)

Location:
In the posterior lateral OFC.

Functions:
-Integrates emotional information, cognitive appraisals, and physiological internal states to aid in emotional regulation and assist in decision-making processes.

Functional Connectivity:
Orbitofrontal region: 13L
Frontal lobe: 8AD, IFSp
Temporal lobe: TE1p, PHA2
Parietal lobe: PGs, POS1

White Matter Connections:
Structurally connected to local parcellations and the inferior fronto-occipital fasciculus. Fibers from the inferior fronto-occipital fasciculus project posteriorly through the extreme/external capsule to end at occipital lobe area V1. Local short association bundles connect with 13L, 47L, 47s, AAIC, and Pir.

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8AD)   BL4 (8AD)
BL5 (8AD)   GB7 (TE1p)
GB8 (TE1p)   GB13 (IFSp)
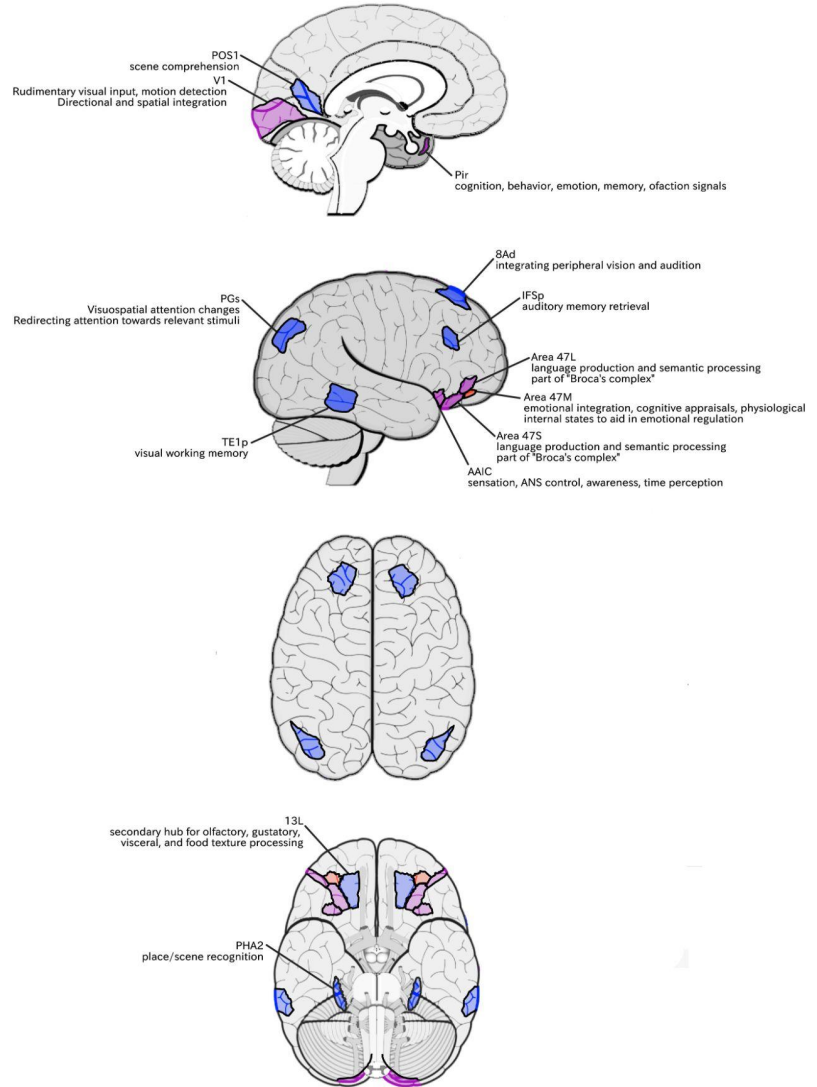GB18 (PGs)

Structurally Connected Acupoints:
GV18 (V1)

Table 1 Traditional Acupuncture Point Associations With Medial Frontal, Anterior Cingulate, and Orbitofrontal Regions

Acupoint	Cortical Parcellation Correlation
BL3	8Ad, 8BL, 9P
BL4	8Ad, 8AV, 9-46d, Area 46
BL5	8Ad, 8Av, i6-8
BL6	6a, 6d
BL7	Area 2, 7AL, 7PC
BL8	IP0, IP1, IPS1, V3b, V7
GB4	Area 43, 6r
GB5	A1, A4, POL2, TA2
GB6	STSds, STSdp, STSva, STSvp, TE1a, TE1p
GB7	TE1m, TE1p, TE2a, TE2p
GB8	PHT, TE1p
GB9	PH, PHT, FST
GB12	6r
GB13	p9-46v
GB14	a10p, a47r, p10p, A5
GB15	8AD, 8AV, 8C, p9-46v, Area 46
GB16	55b, FEF
GB17	Area 1, 2, 3a, 3b, 4
GB18	AIP, Lipv, PFm, PGs, IP1
ST8	6r, 6v, IFJp, PEF
TW20	TE2p
TW22	TE2a
GV18	V1, V2
GV19	7PM, V6a
GV20	Area 1, 3a, 3b, 4, 5m
GV21	SCEF, SFL
GV22	8BL
GV23	9m, 10d
GV24	10d
Yintang	10v

Conflict of Interest Statement