Analysis of Traditional Scalp Acupuncture Point Locations as Local Cortical Region and Functional Network Node Targets in Non-Invasive Brain Network Neuromodulation
Section 5 - The Temporal Lobe

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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 temporal lobe 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, temporal lobe

STS Areas

Area STSda
(Superior Temporal Sulcus dorsal anterior)

Location:
On the anterior half of the lateral face of the STG and the anterior half of the superior bank of the superior temporal sulcus

Functions:
-The STS in general has been implicated in theory of mind
-The STS is also involved in motion processing, speech processing, and facial processing
-STS exhibits even stronger activation with combined audio and visual stimuli indicating a role in audiovisual integration.
-STSda, STSva, STSdp, and STSvp may be categorized as belonging to an auditory association cortex

-Primarily implicated in speech processing
-Activated in language-related task contrasts
Compared to STSva: greater activation in motor tasks and less deactivation in tasks involving reward processing and decision making

Functional Connectivity:
Frontal lobe: 9m, 45, 47L, SFL, 55b
Insula opercular area: STV, PSL, A5, STGa
Temporal lobe: STSva, STSvp, STSdp, TGd, TE1a
Parietal lobe: PGi, 31pd

White matter connections:
Structurally connected to the arcuate/superior longitudinal fasciculus (SLF), middle longitudinal fasciculus (MdLF), and the "u" fibers of the occipitotemporal system. In some individuals, the STSda may also connect to the superior temporal terminations of inferior longitudinal fasciculus (ILF), though this is inconsistent across individuals and difficult to distinguish from the superior tracts of the MdLF.
Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe to terminate at FOP1, FOP3, and FOP4. MdLF tracts project through the temporal lobe to end at V1, V2, V3, and V4.
Local short association fibers include "u" fibers of the occipitotemporal system that connect to TGd, STSva, and A5
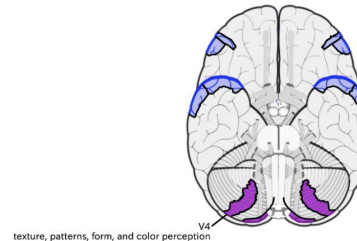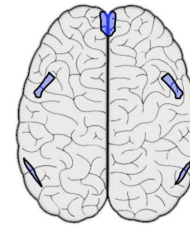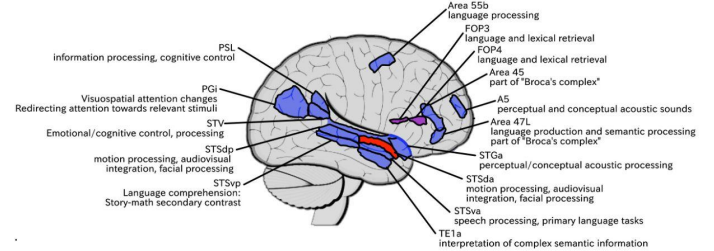
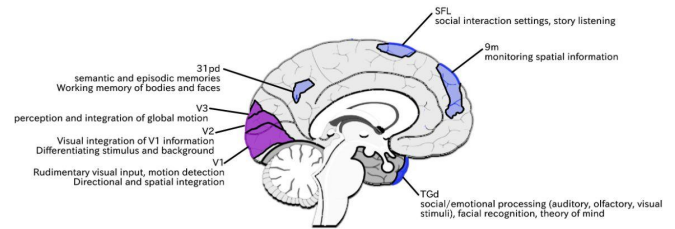**Traditional Acupoint Correlates**:
GB6

Functionally Connected Acupoints:
GB5 (A5)   GB6 (STSdp/STSva/STSvp/TE1a)
GB16 (FEF)   GV23 (9m)

Structurally Connected Acupoints:
GB5 (A5)   GB6 (STSva)
GV18 (V1/V2)

Area STSdp
(Superior Temporal Sulcus dorsal posterior)

Location:
On the posterior half of the lateral face of the STG and the posterior half of the superior bank of the superior temporal sulcus

Functions:
-The posterior portion of the STS is primarily involved in motion processing, audiovisual integration, and facial processing
-The posterior half of STSdp (like the posterior half of STSvp) is strongly activated in the story-math secondary contrast, indicating a role in language comprehension
-Responds more strongly than STSvp to primary language tasks and to social cognition and motor tasks

Functional Connectivity:
Frontal lobe: 9m, 8BL, 44, 45, 47L, IFSp, SFL, 55b
Insula opercular area: STV, PSL, A5, STGa
Temporal lobe: STSva, STSvp, STSda, TGd
Lateral occipital lobe: TPOJ1
Parietal lobe: PGi, 31pd

White matter connections:
Structurally connected to the "u" fibers of the occipitotemporal system and the arcuate/SLF. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe and turn medially to terminate at 44, FOP4, IFJa, IFJp, and IFSp.
Local short association fibers include "u" fibers of the occipitotemporal system that connect to STSda, STSva, STSvp, PSL, and PF
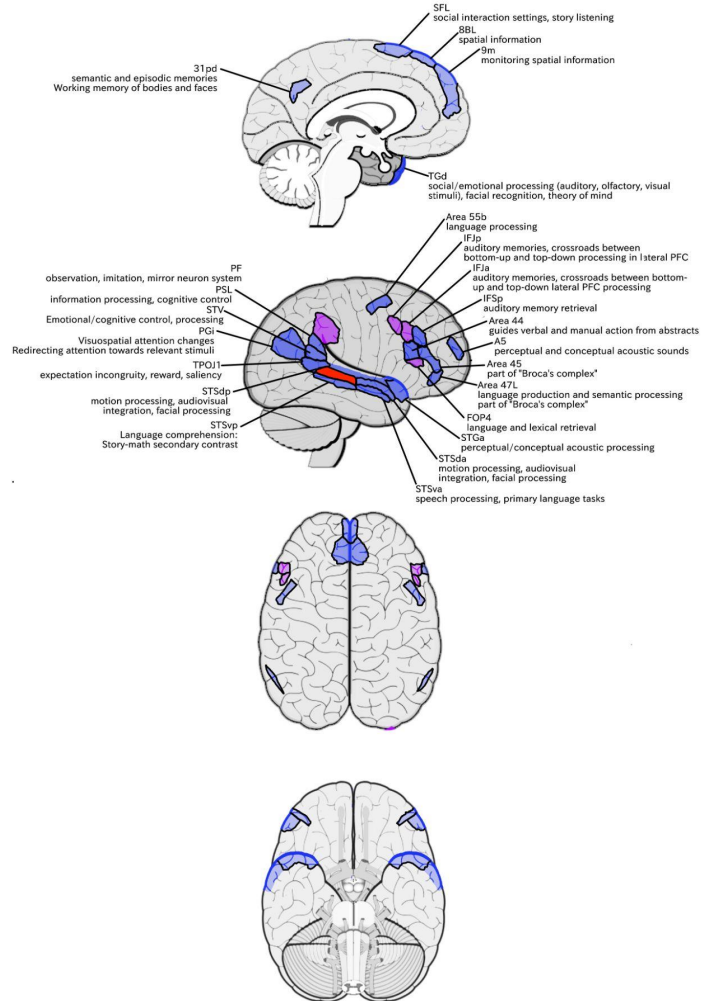
Traditional Acupoint Correlates:
GB6

Functionally Connected Acupoints:
BL3 (8BL)	GB5 (A5)
GB6 (STSda/STSva/STSvp)	GB16 (FEF)
GV22 (8BL)	GV23 (9m)

Structurally Connected Acupoints:
ST8 (IFJp)   GB6 (STSda/STSva/STSvp)

Area STSva
(Superior Temporal Sulcus ventral anterior)

Location:
on the anterior half of the inferior bank of the superior temporal sulcus

Functions:
-Primarily implicated in speech processing
-Activated in the story-math contrast as well as in primary language tasks
Compared to STSda: less activated in motor tasks and more deactivated in tasks involved with reward processing and decision making

Functional Connectivity:
Frontal lobe: 8AV, 8BL, 8AD, 9a, 9m, 45, 47s, 47L, 10d, 10r, 10v, SFL
Temporal lobe: STSda, STSvp, STSdp, TGd, hippocampus, TE1a
Parietal lobe: PGi, 7m, d23ab, 23d, 31pv, 31pd

White matter connections:
Structurally connected to the MdLF, "u" fibers of the occipitotemporal system and the arcuate/SLF. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe and turn medially to terminate at 44, IFJa, 6r, and 43. MdLF fibers course through the temporal lobe to end at V1, V2, V3, V4, and V3a. This tract may involve superior portions of the ILF. Local short association fibers include "u" fibers of the occipitotemporal system that connect to STSda, STSdp, STSvp, PSL, PFm, and PF
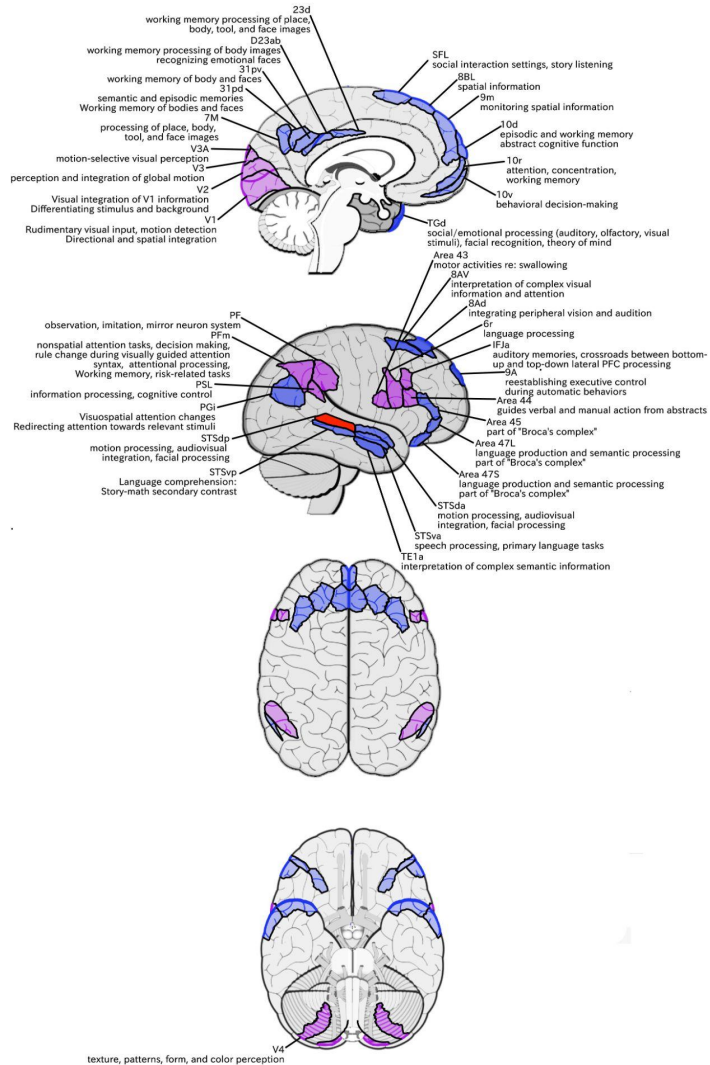
Traditional Acupoint Correlates:
GB6

Functionally Connected Acupoints:
BL3 (8AD/8BL)	BL4 (8AD/8AV)
GB6 (STSda/STSdp/STSvp/TE1a)	GB15 (8AD/8AV)
GV22 (8BL)	GV23 (9m/10d)

Structurally Connected Acupoints:
GB4 (area 43/6r)	GB6 (STSda/STSdp/STSvp)
GB18 (PFm)	ST8 (6r)
GV18 (V1/V2)	

Area STSvp
(Superior Temporal Sulcus ventral posterior)

Location:
on the posterior half of the inferior bank of the superior temporal sulcus

Functions:
-The posterior half of STSvp (like the posterior half of STSdp) is strongly activated by the story-math secondary contrast, indicating a role in language comprehension
-Compared to STSva: does not respond as strongly to primary language tasks, and is less active in social cognition and motor tasks

Functional Connectivity:
Frontal lobe: 8AV, 8BL, 8BM, 8C, 9a, 9p, 9m, 44, 45, 47s, 47L, a47r, IFSP, d32, 10v, SFL, 55b
Insula opercular area: PSL
Temporal lobe: STSva, STSda, STSdp, TGd, hippocampus, TE1a, TE1m, TE1p, TE2a
Parietal lobe: PGs, PGi, 7m, POS1, d23ab, 31pv, 31pd

White matter connections:
Structurally connected to "u" fibers of the occipito-temporal system and the arcuate/SLF. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe to turn medially and terminate at 6r, IFJp, IFJa, FOP2, FOP3, FOP4, and 44. There are posterior projections from the arcuate/SLF as it wraps around the Sylvian fissure to terminate at the inferior parietal lobule at PF, PFm, PSL, PGi, and STV. Local short association fibers include "u" fibers of the occipitotemporal system that connect to STSdp, STSva, TE1p, TE1m, PF, PFm, PSL, PGi, and STV
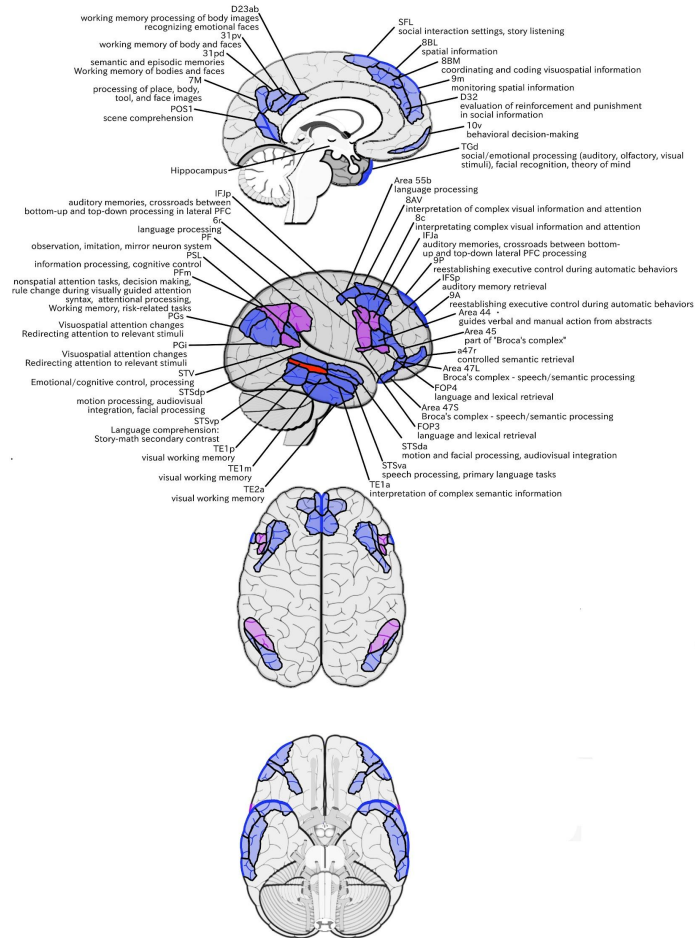
Traditional Acupoint Correlates:
GB6

Functionally Connected Acupoints:
BL3 (8AD/8BL/9P)	BL4 (8AV)
BL5 (8AV)	GB6 (STSda/STSdp/STSva/TE1a/TE1m)
GB7 (TE1m/TE1p/TE2a)	GB8 (TE1p)
GB14 (a47r)	GB15 (8AV/8C)
GB16 (FEF)	GB18 (PGs)
TW22 (TE2a)	GV22 (8BL)
GV23 (9m)	

Structurally Connected Acupoints:
GB4 (6r)	GB6 (STSdp/STSva/TE1p)
GB7 (TE1m)	GB18 (PFm)
ST8 (6r/IFJp)	

Area TE1a (Temporal Area 1 anterior)

Location:
on the anterior third of the lateral face of the middle temporal gyrus up to the edge of the inferior temporal sulcus

Functions:
- The inferior temporal area (TE) is thought to be the final stage of the ventral visual processing pathway, therefore likely responsible for processing and representing information about complex visual objects
-TE is also important for short term maintenance of visual object information as part of working memory
-Both TE1 and TE2 are thought to be primarily unimodal visual areas and not heavily involved with processing of audio or somatosensory inputs

-More active in semantic pathways than visual pathways
-Deactivated rather than activated during tasks requiring recognition of relationships between visual objects, visual working memory tasks, and motor activity tasks
-Compared to TE1m: more activation in language processing tasks
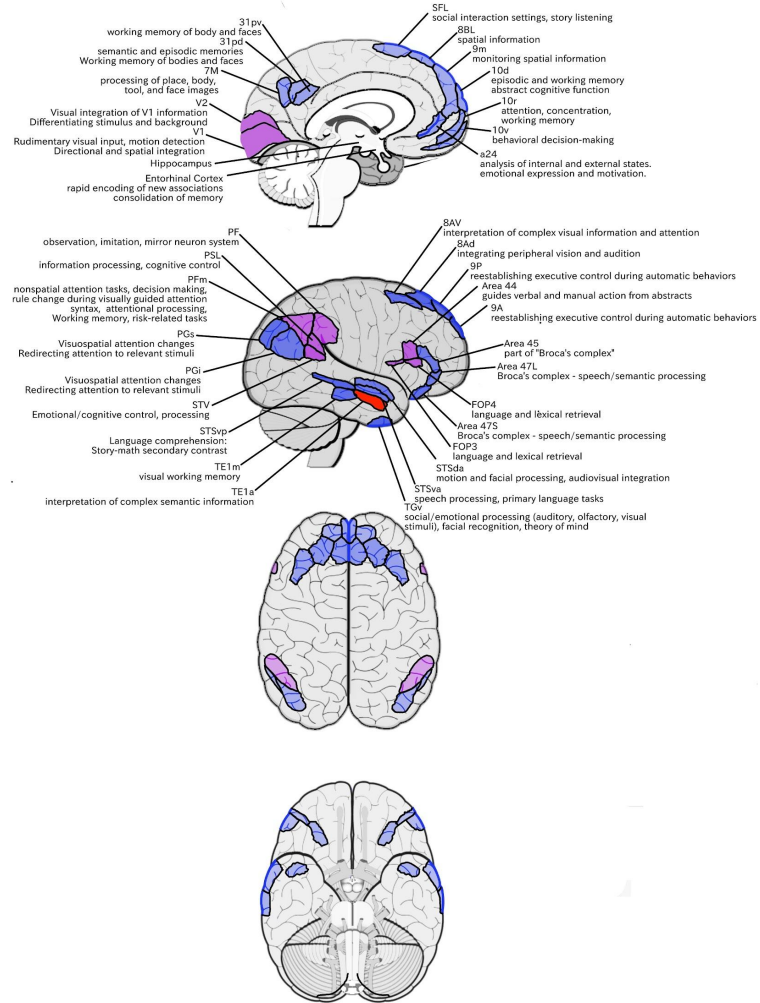
Functional Connectivity:
Frontal lobe: 8AV, 8AD, 8BL, 9a, 9p, 9m, a24, 45, 47s, 47L, 10d, 10v, 10r, SFL
Temporal lobe: STSva, STSvp, STSda, TGv, EC, hippocampus, TE1m
Parietal lobe: PGs, PGi, 7m, 31pv, 31pd

White matter connections:
Structurally connected to the arcuate/SLF, "u" fibers of the occipitotemporal system and the ILF. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe to turn medially and terminate at 44, FOP4, and FOP3. There are posterior projections from the arcuate/SLF as it wraps around the Sylvian fissure to terminate at the inferior parietal lobule at PFm, PF, PSL, and STV. The ILF courses through the inferior temporal lobe to terminate at V1 and V2. Local short association fibers include "u" fibers of the occipitotemporal system that connect to STSva, STSvp, and TE1m. White matter tracts of TE1a in the right hemisphere have more consistent connections with the MdLF.

Traditional Acupoint Correlates:
GB6

Functionally Connected Acupoints:
BL3 (8AD/8BL/9P)	BL4 (8AD/8AV)
BL5 (8AD/8AV)	GB6 (STSda//STSva/STSvp//TE1m)
GB7 (TE1m)	GB15 (8AD/8AV)
GB18 (PGs)	GV22 (8BL)
GV23 (9m/10d)	Yintang (10v)

Structurally Connected Acupoints:
GB6 (STSva/STSvp/TE1m)	GB18 (PFm)
GV18 (V1/V2)	GB4 (6r)
GB6 (STSdp/STSva/TE1p)	GB7 (TE1m)
GB18 (PFm)	ST8 (6r/IFJp)

Area TE1m (Temporal Area 1 middle)

Location:
On the lateral surface of the middle portion of the medial temporal gyrus. It spills across the corresponding portion of the inferior temporal sulcus and occupies some of the superior portion of the corresponding portion of the inferior temporal gyrus

Functions:
-Primarily related to visual pathways
-Compared to TE1a: Like TE1p, shows greater activation in the visual working memory
-Compared to TE1p: Deactivated during language tasks and more deactivated in theory of mind tasks

Functional Connectivity:
Frontal lobe: a47r, 8AV, 8BL, 8AD, 8C, 9p, 47L, i6-8, s6-8
Temporal lobe: STSvp, TE2a, TE1p, TE1a
Parietal lobe: PGs, PFm, IP1, 7m, d23ab, 31pv, 31pd

White matter connections:
Structurally connected to the arcuate/SLF and "u" fibers of the occipitotemporal system. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe to turn medially and end at 44, 45, IFJa, IFJp, and 8C. There are posterior projections from the arcuate/SLF that terminate at the inferior parietal lobule at PGi and PFm. Local short association fibers include "u" fibers of the occipitotemporal system that connect to TE1p and TE1a
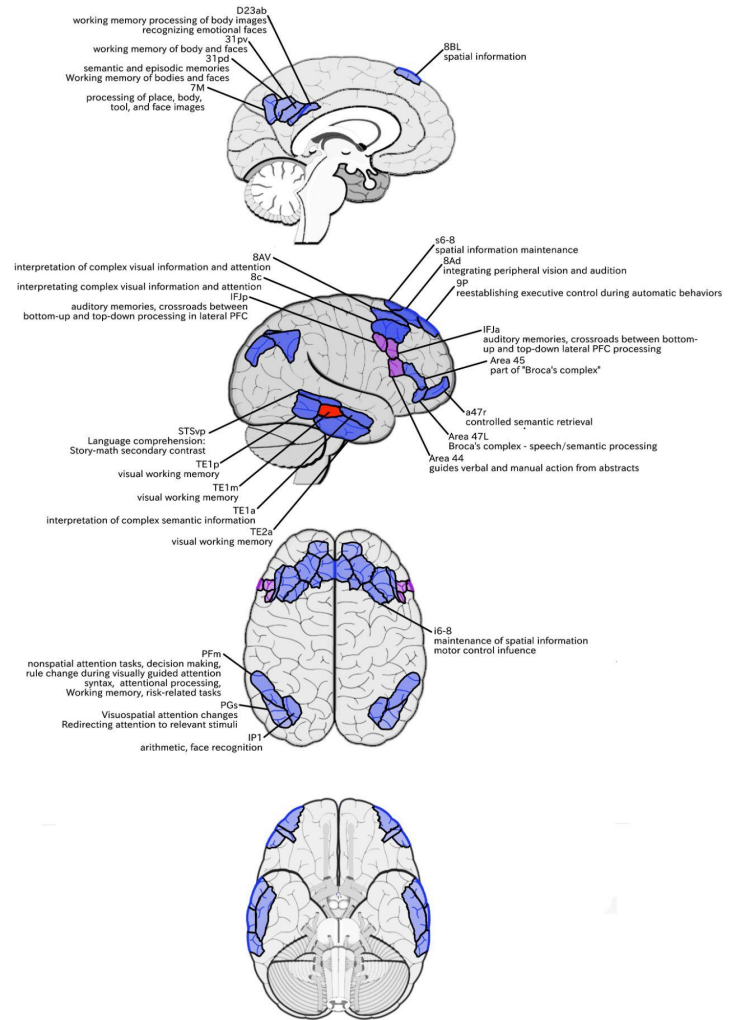
Traditional Acupoint Correlates:
GB6

Functionally Connected Acupoints:
BL3 (8AD/8BL/9P)	BL4 (8AD/8AV)
BL5 (8AD/8AV/i6-8)	BL8 (IP1)
GB6 (STSvp/TE1a)	GB7 (TE1p/TE2a)
GB8 (PHT/TE1p)	GB14 (a47r)
GB15 (8AD/8AV/8C)	GB18 (PFm/PGs/IP1)
TW22 (TE2a)	GV22 (8BL)

Structurally Connected Acupoints:
GB6 (TE1a)	GB7 (TE1p)
GB8 (TE1p)	GB15 (8C)
GB18 (PFm)	ST8 (IFJp)

Area TE1p (Temporal Area 1 posterior)

Location:
On the posterior most portions of the middle and inferior temporal gyri and the intervening inferior temporal sulcus. It spills onto the basal face of the temporal lobe and extends up to the occipitotemporal sulcus

Functions:
-Primarily related to visual pathways
-Compared to TE1a: like TE1m, shows greater activation in the visual working memory
-Compared to TE1m: more deactivated during language tasks and more activated during facial recognition tasks

Functional Connectivity:
Frontal lobe: 33pr, 8AV, 8AD, 8BM, 8C, IFSa, IFSp, IFJp, a47r, p47r, 47m, a9-46v, p9-46v, i6-8, s6-8
Temporal lobe: STSvp, PHT, TE1m, TE2a
Parietal lobe: PGs, PGi, PFm, IP2, IP1, IP0, 7pm, 7m, d23ab, 31a

White matter connections:
Structurally connected to the arcuate/SLF and "u" fibers of the occipitotemporal system. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe to turn medially and end at 45. There are abundant posterior projections from the arcuate/SLF that terminate at the inferior parietal lobule at STV, PFm, PSL, PGi, TPOJ1, TPOJ2, and STV. Local short association fibers include "u" fibers of the occipitotemporal system that connect to TE2a and perirhinal ectorhinal cortex
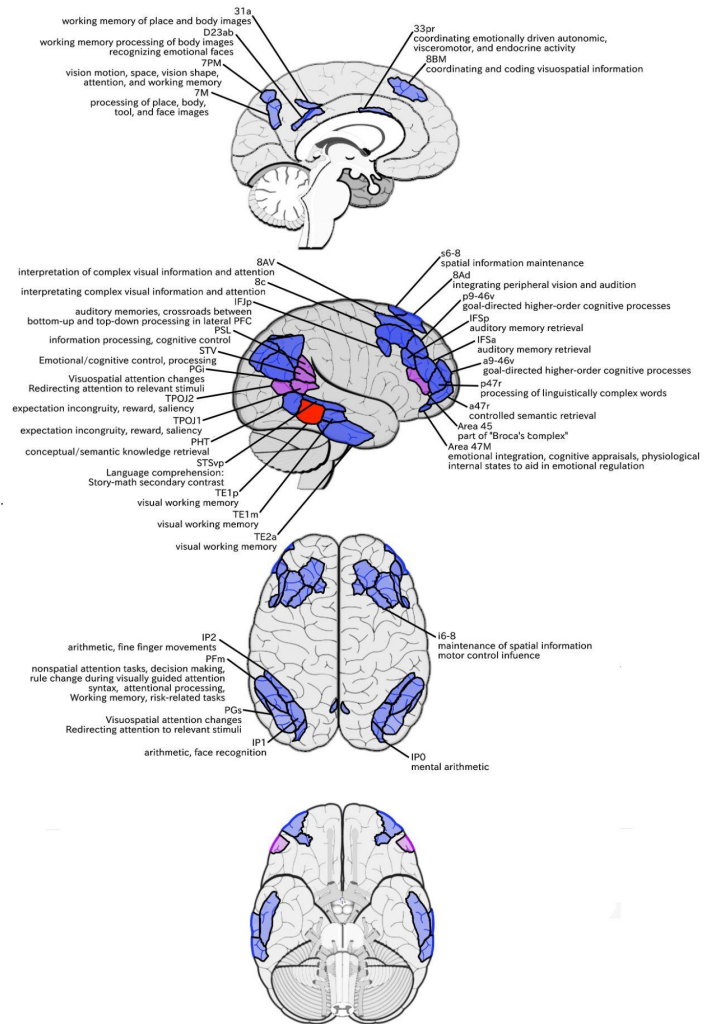
Traditional Acupoint Correlates:
GB7 and GB8

Functionally Connected Acupoints:
BL3 (8AD)	BL4 (8AD/8AV)
BL5 (8AD/8AV/i6-8)	BL8 (IP0/IP1)
GB6 (STSvp/TE1m)	GB7 (TE1m/TE2a)
GB8 (PHT)	GB9 (PHT)
GB13 (p9-46v)	GB14 (a47r)
GB15 (8AD/8AV/8C/p9-46v)	GB18 (PFm/PGs/IP1)
TW22 (TE2a)	ST8 (IFJp)
GV19 (7PM)	

Structurally Connected Acupoints:
GB7 (TE2a)	GB18 (PFm)
TW22 (TE2a)	

Area PHT

Location:
On the anterior portions of the subcentral gyrus. It involves the lateral surface of that operculum as well as the inferior surface that faces the Sylvian Fissure

Functions:
-The posterior middle temporal gyrus is involved in processes related to the controlled retrieval of conceptual knowledge, while the anterior gyrus is involved in the automatic retrieval of specific semantic information
-In contrast to the other parcellations of the lateral temporal cortex and temporal pole (TE1p, TE1m, TE1a, TE2p, TE2a, TGv, TGd, and TF) that are all strongly associated with the task negative network, PHT is strongly associated with the task positive network
-Deactivated during language recognition tasks (like TE1p)

Functional Connectivity:
Frontal lobe: IFSa, IFJa, IFJp, 6a, 6ma, 6r, 46, 9-46d, p9-46v, p47r, FEF, PEF, SCEF, a24pr, p24pr, p32pr, 33pr, 23c, 5mv
Insula opercular area: FOP1, FOP3, FOP4, FOP5, 43, PFcm, 52, MI, PoI1, PoI2
Temporal lobe: TE1p, TE2p, PHA3
Parietal lobe: AIP, MIP, VIP, LIPv, LIPd, IPS1, IP0, IP1, IP2, PF, PFop, PFt, PGp, 7PC, 7pm, 7AL, 7PL, PCV, DVT
Occipital lobe: V1, V2, FST, PH, TPOJ2

White matter connections:
Structurally connected to the arcuate/SLF. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe and turn medially to end at 44, IFJa, IFJp, and IFSp. There are abundant posterior projections from the arcuate/SLF that terminate at the inferior parietal lobule at PGs, STV, PFm, PGi, TPOJ1, and TPOJ2
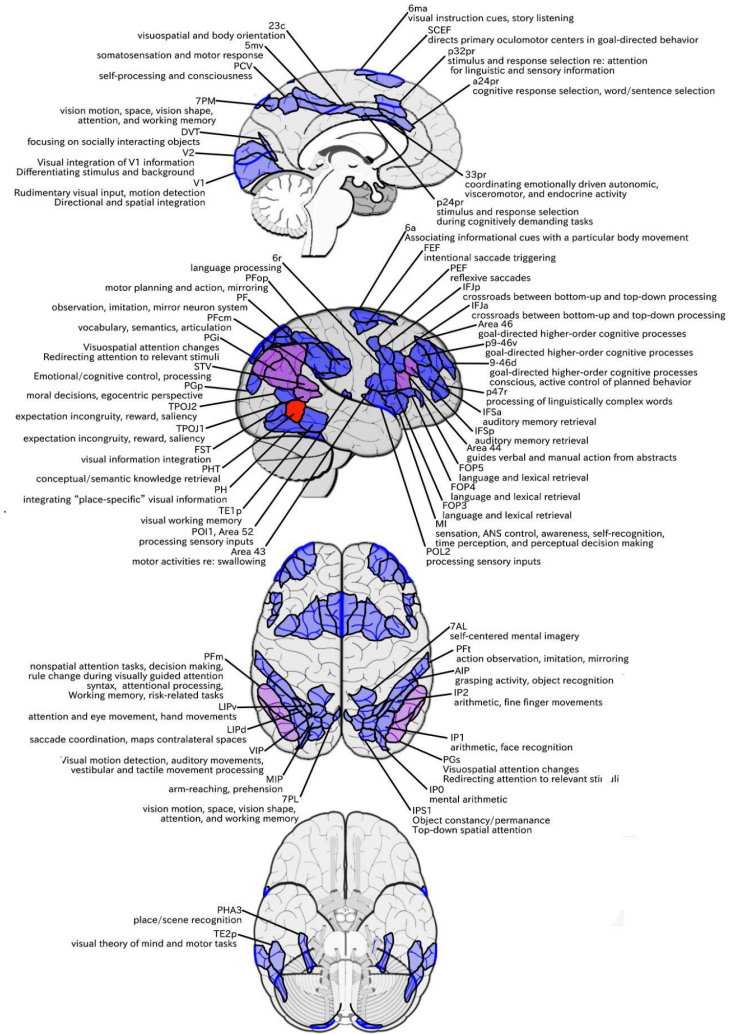
Traditional Acupoint Correlates:
GB8 and GB9

Functionally Connected Acupoints:

BL4 (9-46d/Area 46)	BL6 (6a)
BL7 (7AL)	BL8 (IP0/IP1IPS1)
GB4 (Area 43/6r)	GB5 (PoI2)
GB7 (TE1p/TE2p)	GB8 (TE1p)
GB9 (PH/FST)	GB13 (p9-46v)
GB15 (p9-46v/Area 46)	GB16 (FEF)
GB18 (AIP/LIPv/IP1)	TW20 (TE2p)
ST8 (6r/IFJp)	GV18 (V1/V2)
GV19 (7PM)	GV21 (SCEF)

Structurally Connected Acupoints:

GB18 (PFm)	ST8 (IFJp)

Area TE2a (Temporal Area 2 anterior)

Location:
On the anterior of the inferior temporal gyrus, the anterior half of the inferior sulcus, and the lateral bank of the occipitotemporal sulcus

Functions:
-Primarily related to visual pathways
-Similar functionally to TE1m including activation in the visual working memory secondary contrast and deactivation in language tasks
-Compared to TE1m: less activation in visual working memory tasks and less deactivation during language tasks.

Functional Connectivity:
Frontal lobe: 8AV, 8BL, 8C, a47r
Temporal lobe: STSvp, TE1m, TE1p
Parietal lobe: PGs, PGi, PFm

White matter connections:
Structurally connected to the arcuate/SLF and ILF. ILF projections are inconsistent across individuals. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe and turn medially to terminate at 6r, 6v, 8C, p9-46v, IFJa, IFJp, and IFSp. There are posterior projections from the arcuate/SLF that terminate at the inferior parietal lobule at PF and PFm. Local short association fibers connect to TE1p and TGd
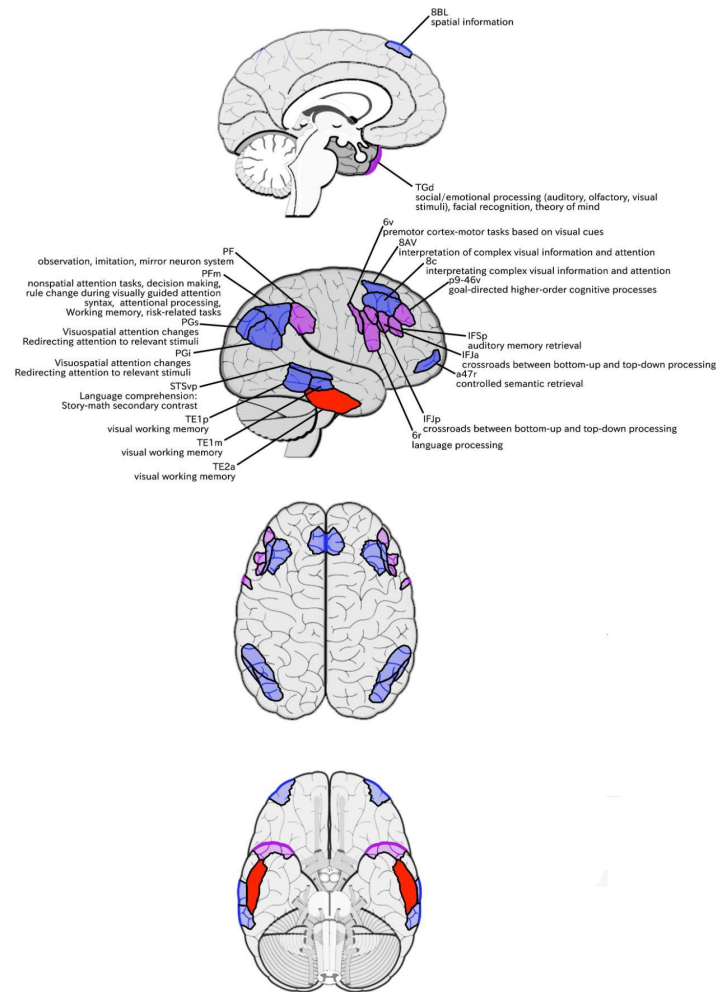
Traditional Acupoint Correlates:
GB7 and TW22

Functionally Connected Acupoints:
BL3 (8BL)	BL4 (8AV)
BL5 (8AV)	GB6 (STSvp/TE1m)
GB7 (TE1m/TE1p)	GB14 (a47r)
GB15 (8AV/8C)	GB18 (PFM/PGs)
GV22 (8BL)	

Structurally Connected Acupoints:
GB4 (6r)	GB7 (TE1p)
GB8 (TE1p)	GB15 (8C/p9-46v)
GB18 (PFm)	ST8 (6r/6v/IFJp)

Area TE2p (Temporal Area 2 posterior)

Location:
In the posterior part of the occipital temporal sulcus and the middle posterolateral portion of the fusiform gyrus

Functions:
-Primarily related to visual pathways
-Compared to TE2a: more active in theory of mind and motor tasks
-Compared to the other TE1 and TE2 regions: rather than deactivation in the TOOL-AVG contrast, TE2p is activated unilaterally on the left in TOOL-AVG, demonstrating a possible role in object recognition

Functional Connectivity:
Frontal lobe: FEF, PEF, IFSa, IFJa, IFJp, p9-46v, 6a, 6r
Insula: PoI2
Temporal lobe: PHT
Parietal lobe: PGp, AIP, MIP, LIPv, LIPd, IPS1, IP0, PFop, 7PC, 7PL, 7AL
Occipital lobe: PH, FFC, FST, TPOJ2, TPOJ3

White matter connections:
Structurally connected to the arcuate/SLF and local parcellations. White matter tracts of this parcellation are variable across individuals. Arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe. The termination of the arcuate/SLF is unable to be delineated, as the tracts cannot be traced to specific parcellations. Local short association fibers connect to FFC, PH, TE2p, TE1m, TF, and TE2a.
White matter tracts in the right hemisphere of TE2p have consistent occipital connections

Traditional Acupoint Correlates:
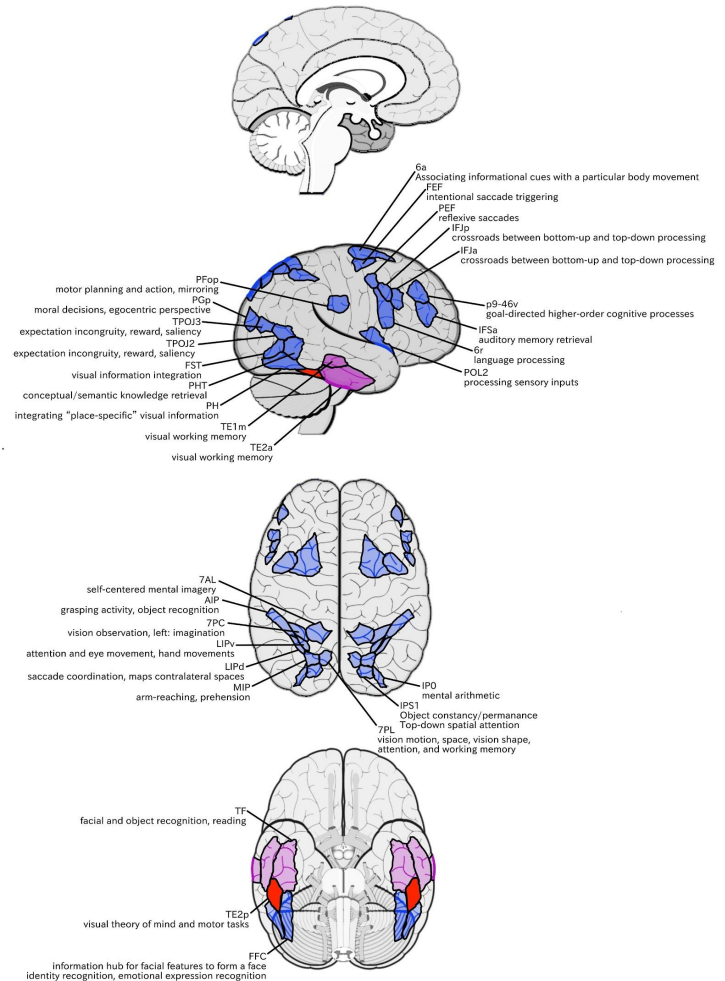TW20

Functionally Connected Acupoints:
BL6 (6a)   BL7 (7AL/7PC)
BL8 (IP0/IPS1)   GB4 (6r)
GB5 (PoI2)   GB8 (PHT)
GB9 (PHT/PH/FST)   GB13 (p9-46v)
GB15 (p9-46v)   GB16 (FEF)
GB18 (LIPv)   ST8 (6r/IFJp/PEF)

Structurally Connected Acupoints:
GB7 (TE1m/TE2a)   GB9 (PH)
TW22 (TE2a)

Area TF

Location:
On the anterior part of the fusiform gyrus and the occipitotemporal sulcus. It occupies part of the lateral bank of the collateral sulcus.

Functions:
-Single neuron primate studies suggest that area TF may be involved in the maintenance of working memory in conjunction with inferior temporal and prefrontal regions
-The fusiform gyrus is important for visual perception such as in facial recognition, object recognition, and reading
-Compared to TE2a: more activated in motor tasks, language recognition tasks, and theory of mind tasks
-Compared to TE2p: more activated in language recognition tasks and facial recognition tasks

Functional Connectivity:
Areas PeEC, TE2p

White matter connections:
Structurally connected to the arcuate/SLF and ILF. The arcuate/SLF tracts wrap around the Sylvian fissure projecting toward the frontal lobe and turn medially to terminate at IFSa and 46. ILF terminations course through the inferior temporal lobe to terminate at V2, V3, V4, V3A, and V3b. Local short association bundles connect to PeEc, VVC, TE2p, and TE2a
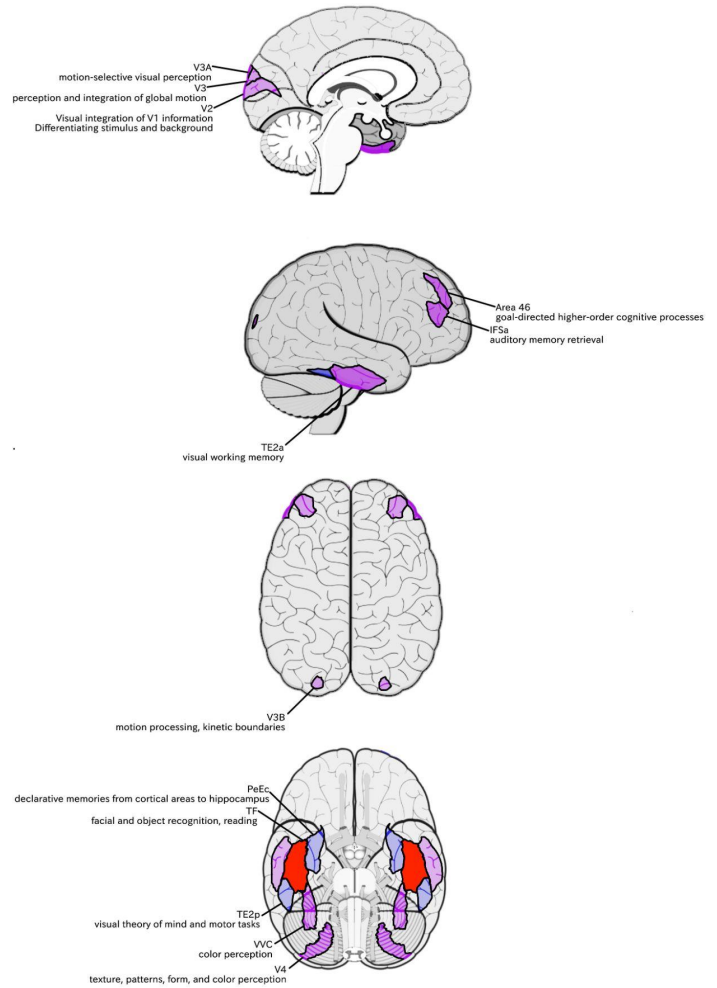
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
GB7 (TE2p)   TW20 (TE2p)

Structurally Connected Acupoints:
BL4 (Area 46)   BL8 (V3B)
GB15 (Area 46)

Area TGd (TG dorsal)

Location:
On the superior part of the temporopolar region. It is roughly anterior to the superior temporal gyrus and middle temporal gyrus, wrapping over the superior surface of the temporal planum polare just anterior to the limen insula

Functions:
-Areas TGd and TGv make up the temporal polar cortex, a paralimbic region important for social and emotional processing, auditory and visual aspects of facial recognition, emotional processing of auditory, olfactory and visual stimuli, and theory of mind
-Activated in the language-related task contrasts suggesting a role in ventral stream language processing along with its neighbors STGa, STSda, STSva, and TE1a
-Compared to TGv: deactivated vs activated in motor tasks in response to a visual cue and relational primary contrasts (ie, distinguishing objects based on feature dimensions)

Functional Connectivity:
Frontal lobe: 8AV, 8BL, 9a, 9p, 9m, 44, 45, 47s, 47L, 10v, 10r, SFL
Temporal lobe:STSva, STSvp, STSda, STSdp, TGv, STGa, PeEc, hippocampus, TE1a
Parietal lobe: PGs, PGi, 7m, d23ab, 31pv, 31pd

White matter connections:
Structurally connected to the uncinate fasciculus and ILF. Many individuals also have connections through the extreme/external capsule toward the parieto-occipital sulcus and occipital lobe. The uncinate fasciculus wraps medially around the fibers traveling toward the occipital lobe, these fibers course through the posterior temporal lobe to terminate at DVT, V1, V3, V2, V6, and 7PL. The uncinate fasciculus projects to the frontal lobe through the insula to terminate at FOP4, FOP5, 44, and 45. ILF fibers course through the inferior temporal lobe to terminate at V1 and V2
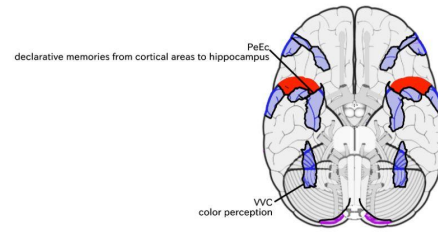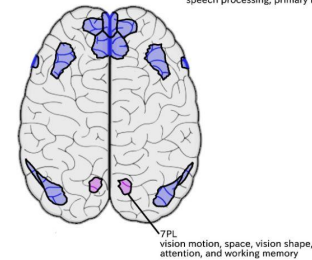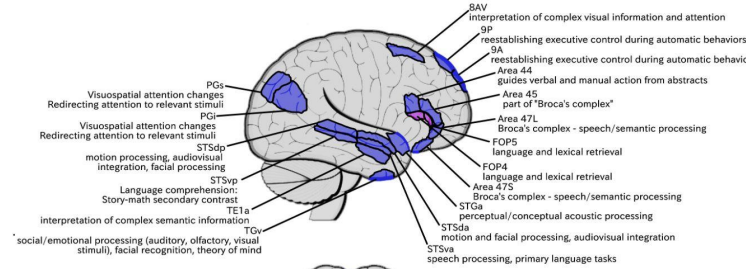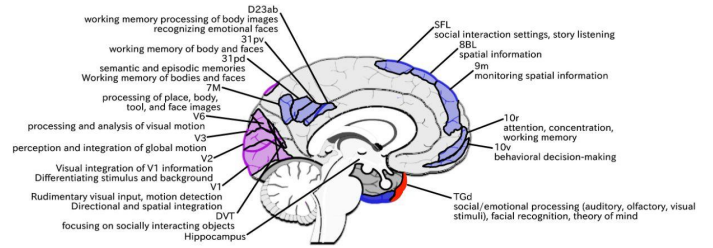
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8BL, 9P)   BL4 (8AV)
BL5 (8AV)   GB6 (STSda, STSdp, STSva, STSvp, TE1a)
GB15 (8AV)   GB18 (PGs)
GV22 (8BL)   GV23 (9m)
Yintang (10v)

Structurally Connected Acupoints:
GV18 (V1/V2)

Area TGv (TG ventral)

Location:
On the inferior temporal polar region just anterior to the inferior temporal gyrus and fusifom gyrus

Functions:
-Areas TGd and TGv make up the temporal polar cortex, a paralimbic region important for social and emotional processing, auditory and visual aspects of facial recognition, emotional processing of auditory, olfactory and visual stimuli, and theory of mind
-Like TGd, is activated in language-related task contrasts suggesting a role in ventral stream language processing
-Compared to TGd: activated vs deactivated in motor tasks in response to a visual cue and relational primary contrasts (ie, distinguishing objects based on feature dimensions)

Functional Connectivity:
Area 44, TGd

White matter connections:
Structurally connected to the ILF. ILF projections travel through the inferior temporal lobe to terminate at V1, V2, V3, and V4
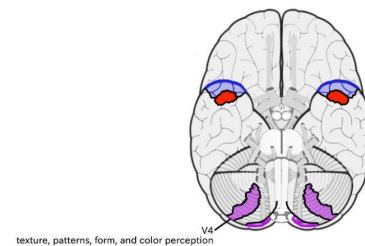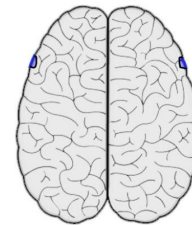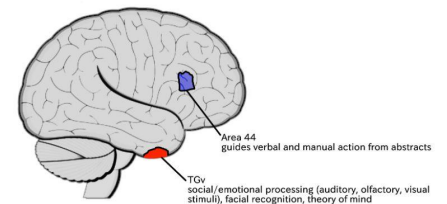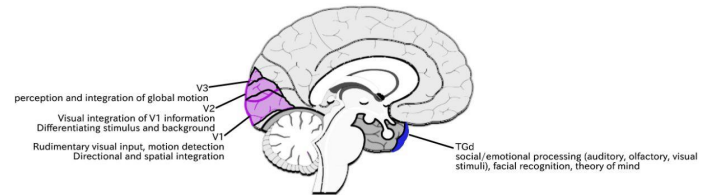
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
N/A

Structurally Connected Acupoints:
GV18 (V1/V2)

V3
perception and integration of global motion
V2
Visual integration of V1 information
Differentiating stimulus and background
V1
Rudimentary visual input, motion detection
Directional and spatial integration

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

Area 44
guides verbal and manual action from abstracts

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

V4
texture, patterns, form, and color perception

Medial Temporal Areas

Area PreS (Presubiculum)

Location:
On the posterior superior surface of the parahippocampal gyrus

Functions:
-Processing spatial information
-Contains more myelin than the nearby hippocampal cortex, and relative to PHA1 inferiorly, contains more myelin, is thinner, and demonstrates less activity during tasks related to working memory, language processing, and theory of mind
-Compared to PHA1: greater activity during motor tasks

Functional Connectivity:
Frontal lobe: 8AD, i6-8
Temporal lobe: PHA1, PHA2, hippocampus
Parietal lobe: RSC, ProS, d23ab, v23ab, 31a, 31pv, 7m, 7pm, POS1, POS2, IP1, PGs
Occipital lobe:V1

White matter connections:
Structurally connected to the cingulum, precuneus and occipital lobe. Cingulum projections run superior to the corpus callosum to end at anterior cingulate cortex and frontal lobe parcellations a24, 9m, 10d, and p32. There are PreS fibers that project posteriorly to end at occipital and precuneus areas V1, V2, V6, POS1, POS2, and 7m. Local short association fibers are connected to EC and PeEc
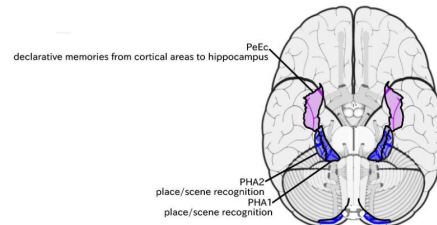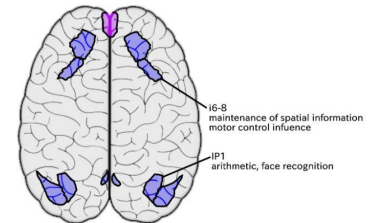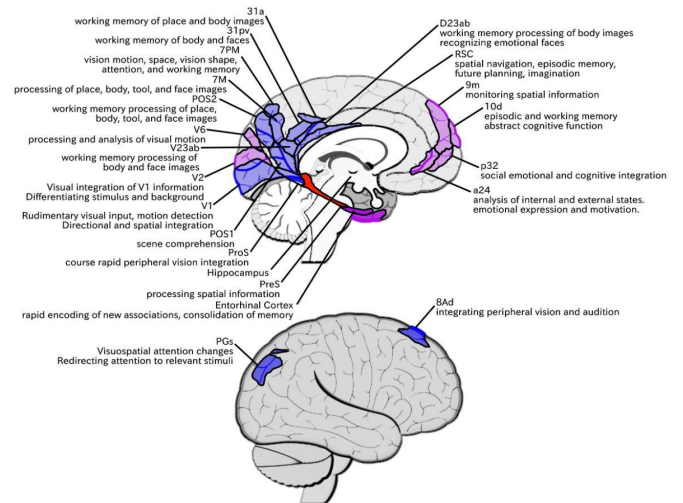
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL3 (8AD)	BL4 (8AD
BL5 (8AD/i6-8)	BL8 (IP1)
GB15 (8AD)	GB18 (PGs/IP1)
GV18 (V1)	GV19 (7PM)

Structurally Connected Acupoints:
GV18 (V2)	GV23 (9m/10d)

Area EC (Entorhinal Cortex)

Location:
On the medial posterior surface of the uncus

Functions:
-Rapid encoding of new associations and consolidation of memory in connection with the medial prefrontal cortex
-Compared to PeEC: contains more myelin, is thinner, and has different functional connectivity. It is less activated in primary task contrasts, ie completed tasks vs baseline fixation, and activated rather than deactivated in working memory of body images
-Compared to PHA: contains more myelin, is thinner, and is less activated during language tasks and theory of mind tasks

Functional Connectivity:
Frontal lobe: 8AD
Temporal lobe: TE1a, PeEc, hippocampus
Parietal lobe: PGs

White matter connections:
Structurally connected to the cingulum. Cingulum fibers span the entire cingulate cortex to terminate anteriorly at a24pr and p24. There are posterior projections from the cingulum that travel toward the parieto-occipital sulcus to terminate at DVT and POS2

Traditional Acupoint Correlates:
N/A

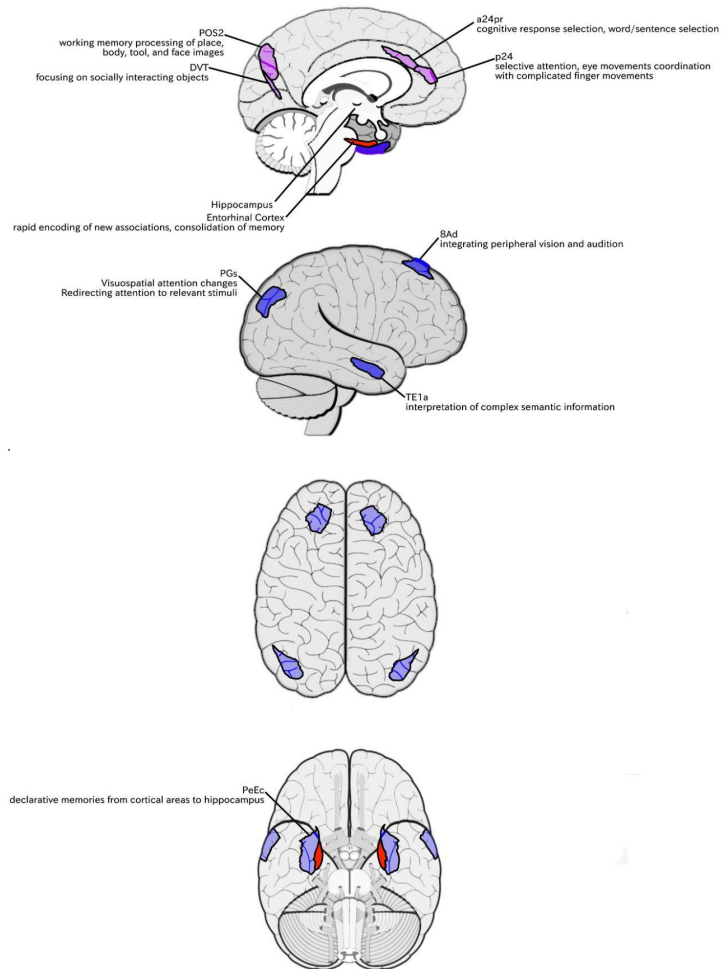Functionally Connected Acupoints:
BL3 (8AD)   BL4 (8AD)
BL5 (8AD)   GB15 (8AD)
GB18 (PGs)

Structurally Connected Acupoints:
N/A

Area PeEC (Perirhinal Ectorhinal Cortex)

Location:
On the anterior portions and inferior surface of the uncus extending to the collateral sulcus

Functions:
-Contributes to declarative memories transmitted between cortical areas and the hippocampus
-The perirhinal cortex region adds semantic knowledge to aid in item identification
-The perirhinal cortex integrates item information with spatio-temporal information and transmits this data to the hippocampus via the EC

-Distinguished from neighboring regions based on increased activation in working memory primary task contrasts and increased activation in selective recognition of faces
-Due to its particular affinity for facial recognition tasks compared to its neighbors, this may be the site of the anterior temporal face patch

Functional Connectivity:
Frontal lobe: IFSa
Temporal lobe: EC, TF, PHA2, PHA3
Parietal lobe: IP0
Occipital lobe: PH

White matter connections:
Structurally connected to the ILF. ILF projections travel through the inferior temporal lobe to end at PH, TPOJ3, and MT. In some individuals there are fibers that parallel the ILF to terminate at the medial occipital lobe at V1

Traditional Acupoint Correlates:
N/A

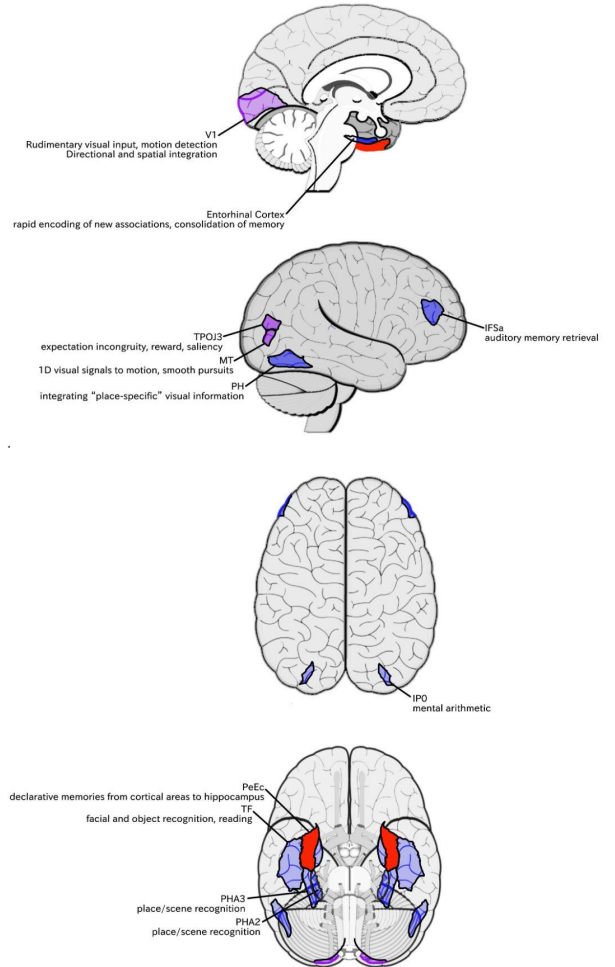Functionally Connected Acupoints:
BL8 (IP0)   GB9 (PH)

Structurally Connected Acupoints:
GB9 (PH)   GV18 (V1)

Area PHA1 (Parahippocampal Area 1)

Location:
A long thin area on the medial portion of the parahippocampal gyrus.

Functions:
-The parahippocampal cortex is involved in visuospatial processing and episodic memory by processing contextual information
-The anterior parahippocampal cortex is involved in encoding information without regard for stimulus category (scenes vs objects) or modality (word vs picture) and interfaces with the hippocampus, retrosplenial, and perirhinal memory systems, while the posterior parahippocampal cortex is involved with pictorial scene analysis, namely processing spatial features of visual scenes

-Activated in the PLACE-AVG contrast and deactivated in the FACE-AVG contrast (like PHA2 and PHA3), suggesting a role in place/scene recognition rather than face recognition
Compared to PHA2 and PHA3: less deactivated in face recognition

Functional Connectivity:
Frontal lobe: 10r, 8AD
Temporal lobe: PHA2, PHA3, VMV1, PreS, hippocampus
Parietal lobe: ProS, POS1, PGp, PGs
Occipital lobe: PH

White matter connections:
Connected to local parcellations. Local anterior fibers connect to PeEC. Local posterior fibers connect to PH. The exact terminations of the local connections are inconsistent across individuals
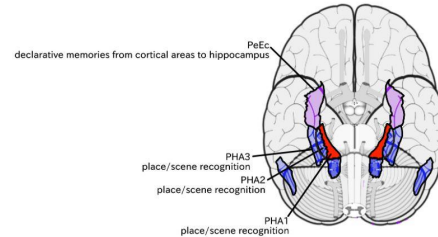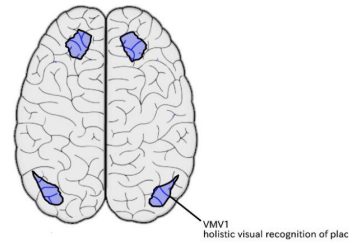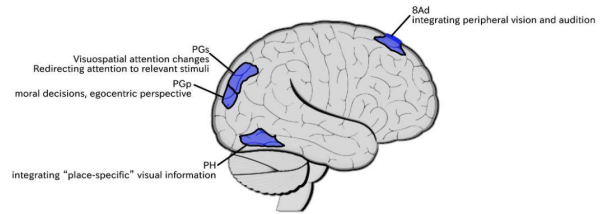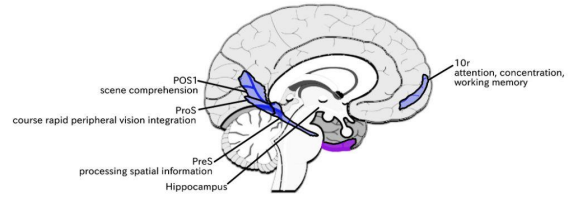
Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:

BL3 (8AD)	BL4 (8AD)
BL5 (8AD)	GB9 (PH)
GB15 (8AD)	
GB18 (PGs)	

Structurally Connected Acupoints:
GB9 (PH)

Area PHA2 (Parahippocampal Area 2)

Location:
On parahippocampal gyrus, primarily on its inferior surface, just adjacent to the collateral sulcus.

Functions:
-The parahippocampal cortex is involved in visuospatial processing and episodic memory by processing contextual information
-The anterior parahippocampal cortex is involved in encoding information without regard for stimulus category (scenes vs objects) or modality (word vs picture) and interfaces with the hippocampus, retrosplenial, and perirhinal memory systems, while the posterior parahippocampal cortex is involved with pictorial scene analysis, namely processing spatial features of visual scenes

-Activated in the PLACE-AVG contrast and deactivated in the FACE-AVG contrast (like PHA1 and PHA3), suggesting a role in place/scene recognition rather than face recognition
-Compared to PHA1: more deactivated in facial recognition tasks

Functional Connectivity:
Frontal lobe: 8AD, 47m, i6-8
Temporal lobe: PHA1, PHA3, PreS, hippocampus
Parietal lobe: ProS, 7pm, PCV, DVT, POS1, IP0, PGp, PGs
Occipital lobe: TPOJ3

White matter connections:
Structurally connected to the ILF. There are anterior projections from the ILF that terminate at PeEc. The posterior terminations of the ILF terminate at V1, V2, and V3. The exact terminations of the local connections are inconsistent across individuals

Traditional Acupoint Correlates:
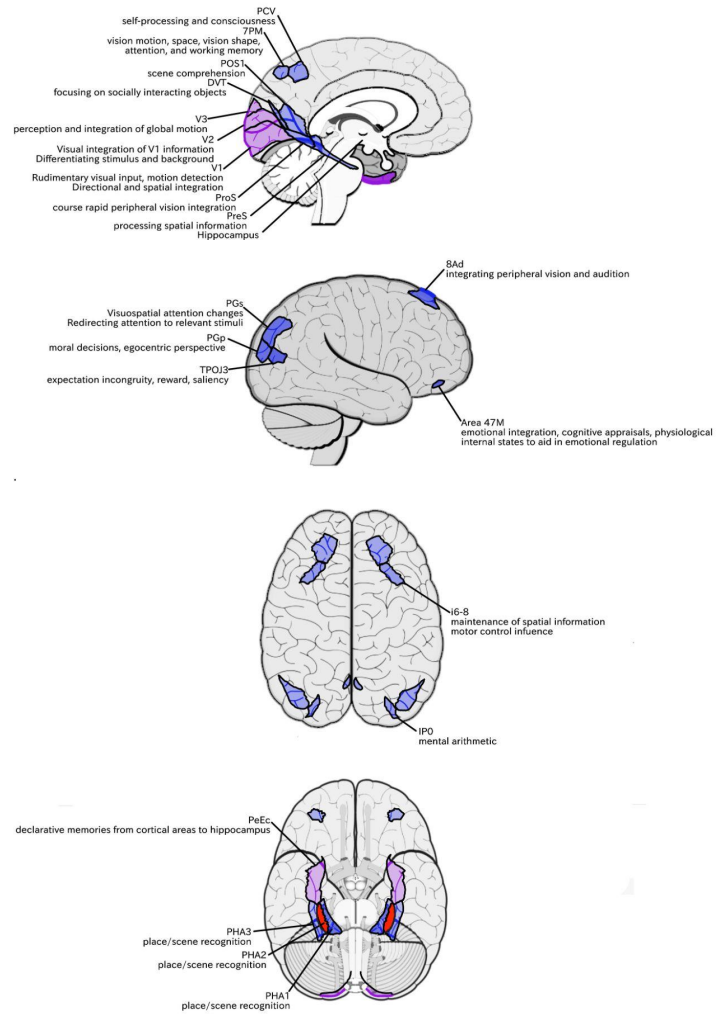N/A

Functionally Connected Acupoints:
BL3 (8AD)   BL4 (8AD)
BL5 (8AD/16-8)   BL8 (IP0)
GB15 (8AD)   GB18 (PGs)
GV19 (7PM)

Structurally Connected Acupoints:
GV18 (V1/V2)

Area PHA3 (Parahippocampal Area 3)

Location:
In the parahippocampal gyrus, primarily inside the collateral sulcus.

Functions:
-The parahippocampal cortex is involved in visuospatial processing and episodic memory by processing contextual information
-The anterior parahippocampal cortex is involved in encoding information without regard for stimulus category (scenes vs objects) or modality (word vs picture) and interfaces with the hippocampus, retrosplenial, and perirhinal memory systems, while the posterior parahippocampal cortex is involved with pictorial scene analysis, namely processing spatial features of visual scenes

-Compared to PHA2: greater activity in tool-related recognition tasks

Functional Connectivity:
Frontal lobe: 6a, IFSa
Temporal lobe: PHT, PHA1, PHA2, VMV2, PeEC
Parietal lobe: 23c, 7PL, 7AM, 7PM, PCV, DVT, POS1, MIP, LIPd, AIP, PGp, PFt
Occipital lobe: TPOJ3, VVC

White matter connections:
Structurally connected to the ILF. There are anterior projections from the ILF that terminate at TGd. The posterior terminations of the ILF terminate at VVC and FFC. There are fibers that run parallel to the ILF and terminate at the occipital lobe at V1, V2, and V6. The exact terminations of the local connections are inconsistent across individuals

Traditional Acupoint Correlates:
N/A

Functionally Connected Acupoints:
BL6 (6a)   GB8 (PHT)
GB9 (PHT)   GB18 (AIV)
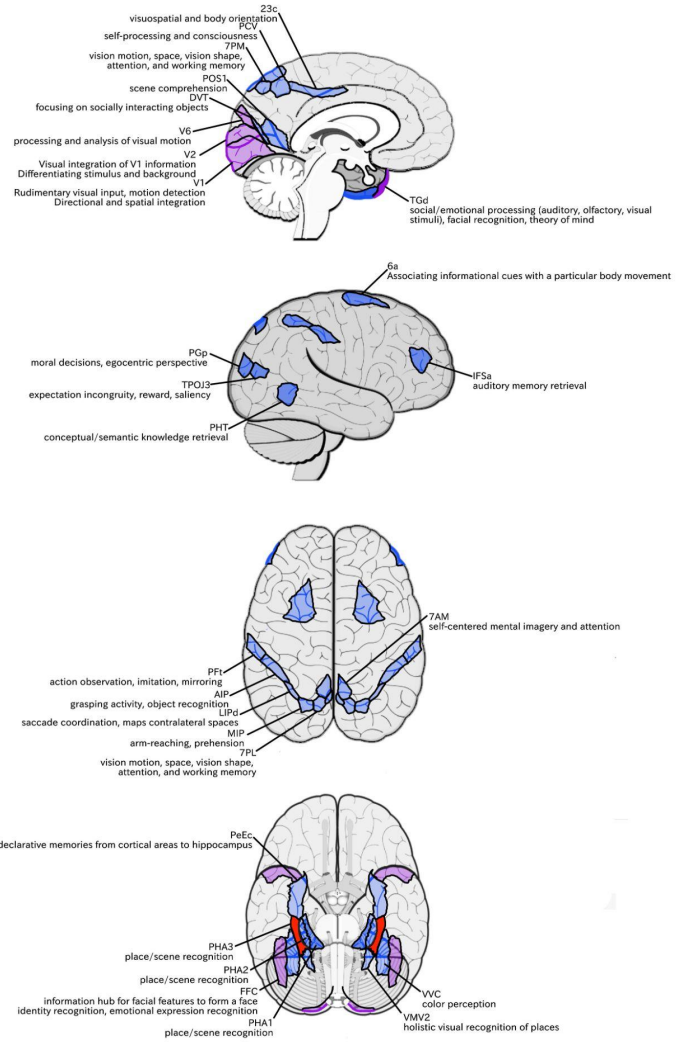GV19 (7PM)

Structurally Connected Acupoints:
GV18 (V1/V2)

Table 1 Traditional Acupuncture Point Associations With The Temporal Lobe

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, A5, POL2, TA2
GB6	STSda, STSdp, STSva, STSvp, TE1a, TE1m
GB7	TE1m, TE1p, TE2a, TE2p
GB8	PHT, TE1p
GB9	PH, PHT, FST
GB13	p9-46v
GB14	a10p, a47r, p10p
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

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.