

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

## **Section 9 - Large Scale Brain Networks**

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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 an evaluation of known major large scale brain networks 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, brain networks, default mode network, central executive network, sensorimotor network, visual network, limbic network, salience network, dorsal attention network, language subnetwork, ventral activating network

# Sensorimotor Network

"The transducer"

Responsible for sensing physical inputs, converting them to electrical signals, then initiating a physical response

- Processing external physical stimuli
- Feeling internal sensations, evaluating senses
- Producing a motor response

## Brain Regions

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

Motor strip: area 4

Premotor regions: 6d, 6mp, 6v

Middle Cingulate regions: 5L, 5M, 24dd, 24dv

Superior insula opercular regions: IG, OP1, OP2-3, OP4, Pir

Lower opercula/Heschl's gyrus regions: 52, A1, A4, RI, LBelt, MBelt, PBelt

## Brain network interactions:

- Auditory subnetwork for hearing
- Visual system for sight
- Limbic system for sense of smell and taste
- Saliency network for behavior and reward processing
- Central executive network for task processing
- Dorsal attention network for planning and controlling complex motor functions
- Default mode network in physical or mental illness

## Dysfunction

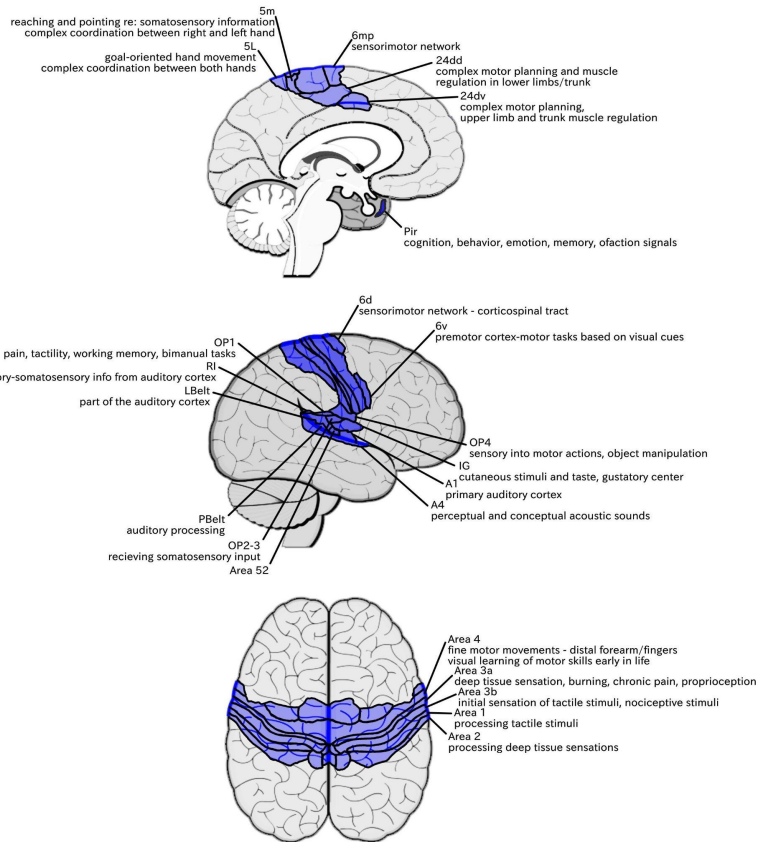
- Sensory and movement disorders: ALS, Parkinson's, Huntington's
- Degenerative diseases
- Developmental delays
- Mental health disorders: Autism spectrum disorder (ASD), bipolar (overactive in manic states)
- Auditory perception dysfunction
- Disturbances in perception-motor processing

## Traditional Acupoint Correlates:

BL6 (6d)	BL7 (Area 2)
GB5 (A1/A4)	GB17 (1/2/3a/3b/4)
ST8 (6v)	GV20 (1/3a/3b/4/5m)

## Additional Information:

- The primary motor cortex, somatosensory cortex, auditory, and visual cortices have been shown to demonstrate plasticity during learning exercises with behavior validation.
- Motor learning exercises, such as skilled finger movements, can lead to cortical reorganization in areas of the sensorimotor network responsible for motor learning
- Repetitive rTMS has been shown to induce changes in sensory perception and motor performance in key areas of the sensorimotor network



# Visual Network

“The observer”

Controls sight and visual processing to:

- Engage in visual processing
- Analyze motion
- Recognize patterns, textures, and faces
- Identify the location of objects in space
- Determine the function and permanence of objects
- Aid in problem solving
- Reinforce visually learned behaviors

## Brain Regions

Parietal lobe: DVT, IP0, IPS1, MIP, PGp, ProS

Medial occipital lobe: V1, V2, V3, V4

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

Ventral visual stream: FFC, VVC, V8, PIT, VMV1, VMV2, VMV3

Lateral occipital lobe: TPOJ3, MT, MST, V3cd, V4t, FST, LO1, LO2, LO3

## Brain network interactions:

- Dorsal attention network for reading and general visual processing
- Sensorimotor network for early development and imitation learning
- Limbic system for visual memory and processing threat-based stimuli in peripheral vision
- Salience network for self-control when presented with tempting imagery and emotional empathy

## Dysfunction

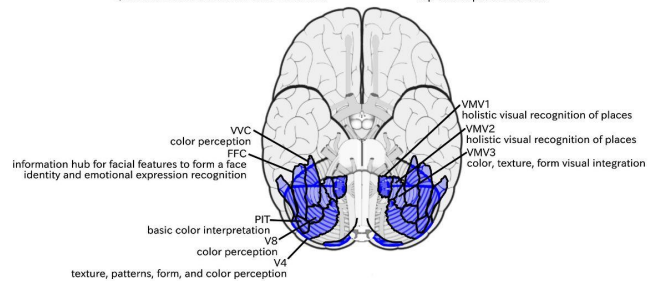
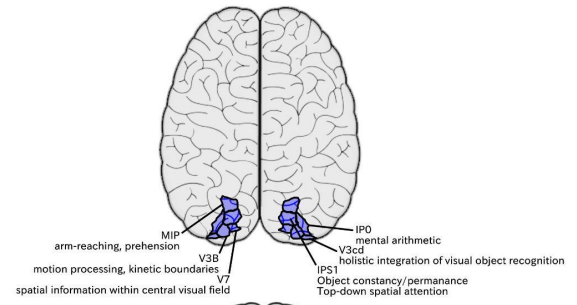
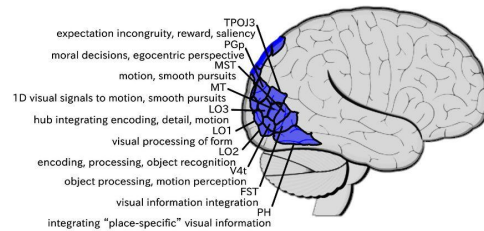
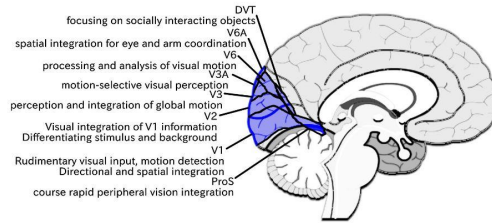
- Visual disturbances
- Difficulty focusing on reading: may be decoupling of visual network and default mode network
- Mild to severe impairment in children with autism spectrum disorder may be correlated with increased asynchrony with the sensorimotor network
- Decreased connectivity in the visual network may be present in schizophrenia and correlated with the severity of psychotic symptoms

## Traditional Acupoint Correlates:

BL8 (IP0/IPS1/V3b/V7)

GB9 (PH/FST)

GV18 (V1/V2)



# Limbic Network

"The regulator"

Regulates many core brain functions including response, reaction, behavior, emotion, memory, and learning

- Response to a stimulus, such as a new smell, sound, or sight
- Level of reaction or motivation: self-protection or reward-seeking
- The behavior that ensues
- The emotion associated with that response or behavior
- The memories formed based on the experience
- Any learning or takeaways from the experience

## Brain Regions

Frontal lobe: 10pp

Orbitofrontal regions: 11L, 13L, 47s, OFC, pOFC

Middle cingulate regions: Area 25

Temporal lobe: Amygdala, EC, Hippocampus, Parahippocampal cortex, PeEc, PreS, TE2a, TE2p, TF, TGd, TGv

## Brain network interactions:

- Sensorimotor network for sensory perception, spatial reasoning, and motor commands
- Language subnetwork for language processing
- Olfactory network for analyzing smells
- Central gustatory system for the sense of taste
- Default mode network for memory, self-referential processing, and behavioral decision-making

## Dysfunction

- Intensification or reduction of core brain activity
- Dementia, Alzheimer's, memory disorders, confusion
- Neuropsychiatric disorders: anxiety, bipolar disorder, schizophrenia, autism, etc
- Psychopathic disorders that exhibit aggressive or impulsive behavior

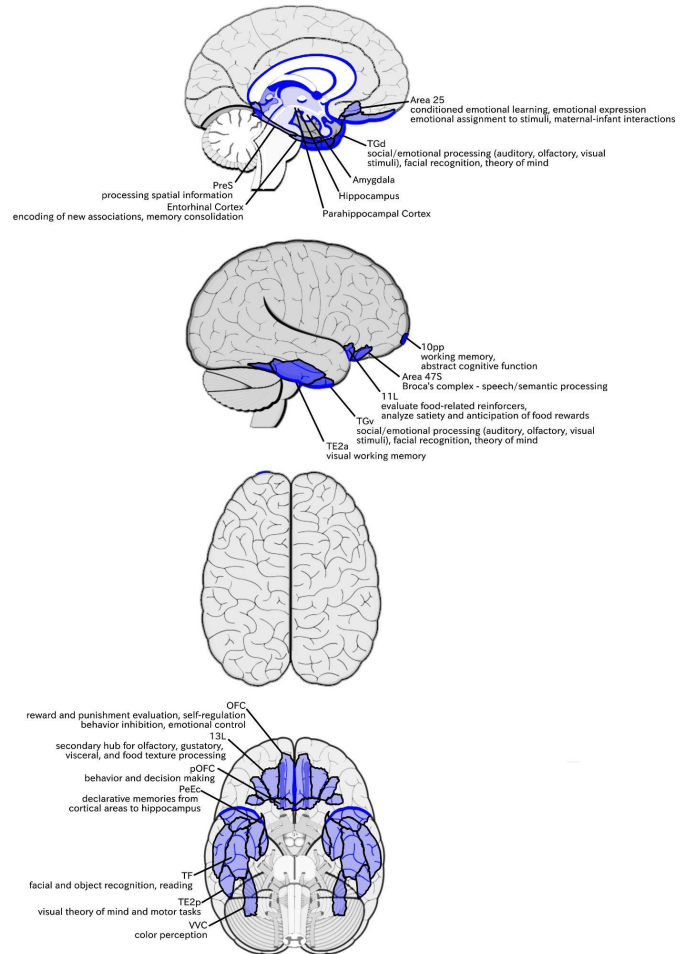
## Traditional Acupoint Correlates:

BL2 (10pp)

GB7 (TE2a/TE2p)

TW20 (TE2p)

TW22 (TE2a)



# Central Executive Network (Fronto-Parietal Network)

"The external mind"

Performs high-level cognitive tasks working alongside or anticorrelation with the other networks. Processes a varied set of information, such as flexibility, working memory, initiation, and inhibition

- Active tasks and external thinking involving working memory
- Controlled processing of information
- Integration of information from the other brain networks
- Rule-based problem solving and decision making
- Consideration of multiple, independent stimuli and factors
- Organizing behavior based on internal drives, subjective preferences, and choices
- Reinforce visually learned behaviors

## Brain Regions

Dorsolateral frontal lobe: 8AV, 8C, a10p, a9-46v, i6-8, IFJa, IFJp, IFSp, p10p, p9-46v, s6-8  
 Medial frontal lobe: 33pr, a32pr, p24  
 Inferior frontal lobe: 44, 8BM, a47r, p47r  
 Superior insular opercular regions: 43, AAIC, AVI  
 Temporal lobe: TE1m, TE1p, TE2a  
 Posterior cingulate: 31a, POS2, RSC  
 Parietal lobe: 7PM, 23d, IP1, IP2, PCV, PFM

## Brain network interactions:

- DAN to correlate attention processing and visual spatial processing
- DMN anticorrelation: CEN and DMN alternate activity when healthy
- Salience network acts to switch between the CEN and DMN
- Receives visual inputs from the visual network
- Evaluates auditory inputs from the auditory network
- Sensory input from sensorimotor network; returns task directives
- Processes stimuli and motivational signals from the limbic system

## Dysfunction

- Schizophrenia, PTSD: aberrant switching between CEN and DMN due to hyper or hypoactive salient network
- Bipolar II depression: impaired functional connectivity between the cerebellum and CEN. Loss of cognitive and emotional control
- OCD: overactive CEN not adequately controlling response inhibition or planning
- Generalized anxiety, cognitive control of social anxiety: reduced functional connectivity with amygdala
- ADHD: may be weaker connectivity between networks and less persistent cross-network interaction

## Traditional Acupoint Correlates:

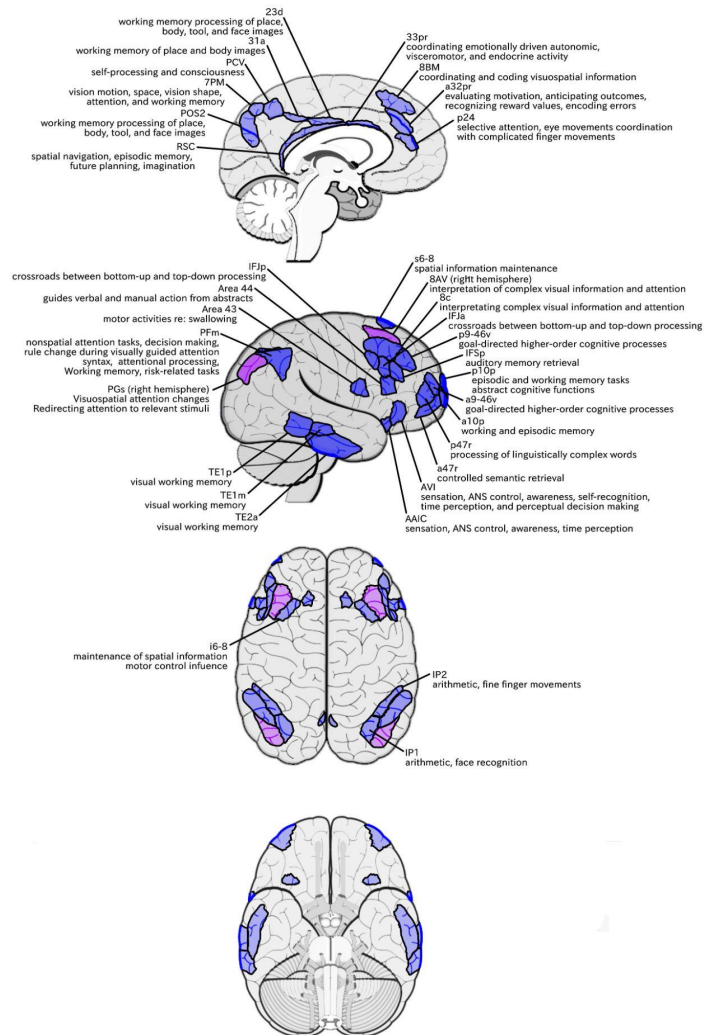
BL4 (8AV right)  
 GB4 (43)  
 GB13 (p9-46v)  
 GB18 (PGs right/PFM/IP1)

BL5 (8AV right/i6-8)  
 GB7 (TE1m/TE1p/TE2a)  
 GB14 (a10p/a47r/p10p)  
 GV19 (7PM)

BL8 (IP1)  
 GB8 (TE1p)  
 GB15 (8AD right/8C/p9-46v)

## Additional Information:

- The CEN contains one of the few network asymmetries. Functional areas 8AV in the frontal lobe and PGs in the parietal lobe are only present in the right hemisphere of the CEN. In the left hemisphere, these are connected to the default mode network (DMN).
- Meditation / mindfulness may correlate with an increase or strengthening in CEN functional connectivity



# Default Mode Network

"The internal mind"

Plays an integral role in coordinating with other networks for passive sensory processing.

- Visual processing when the mind subconsciously appreciates aesthetic beauty
- Introspective thoughts, daydreaming
- Semantic processing when encoding or translating meaning into written or spoken words
- Processing or evaluating personal emotions or the emotions of others

## Brain Regions

Premotor regions: 55b

Dorsolateral frontal lobe: 8AD, 8AV, 8BL, 9a, 9p, 10d

Medial frontal lobe: 9m, 10r, 10v, a24, d32, p32, s32, SFL

Inferior frontal lobe: 44, 45, 47L, 47m, 47s, IFSp

Insular opercular regions: A5, PSL, STGa, STV, TA2

Temporal lobe: PHA1, PHA2, PHA3, STSda, STSdp, STSva, STSvp, TE1a, TGd, TGv

Posterior cingulate: 7m, 31pd, 31pv, d23ab, v23ab, PRsPOS1

Parietal lobe: PGI, PGs

Occipital lobe: TPOJ1, TPOJ2

Other structures in the network include the precuneus, the lateral temporal cortex, and the hippocampal formation

## Brain network interactions:

- CEN anticorrelation. in healthy brains the CEN and DMN alternate activity
- Salience network acts to switch between the CEN and DMN for internal and external processing

## Dysfunction

- Schizophrenia: Overactivity can lead to intensified, self-referential thought symptomology
- Depression and PTSD: overactivity can lead to negative and disruptive thoughts
- Autism spectrum disorder: Implicated in difficulty processing emotions and feelings of others in relation to oneself. DMN dysfunction may contribute to difficulty processing social situations and information
- ADHD: higher functional connectivity between DMN and other networks may be linked to mind wandering and wavering attention
- Alzheimer's: correlated with degradation of the posterior cingulate gyrus responsible for memory formation and retrieval

## Traditional Acupoint Correlates:

BL3 (8AD/8BL/9P)

GB5 (A4/TA2)

GB18 (PGs left)

GV24 (10d)

BL4 (8AV left/8AD)

GB6 (STSda/STSdp/STSva/STSvp/TE1a)

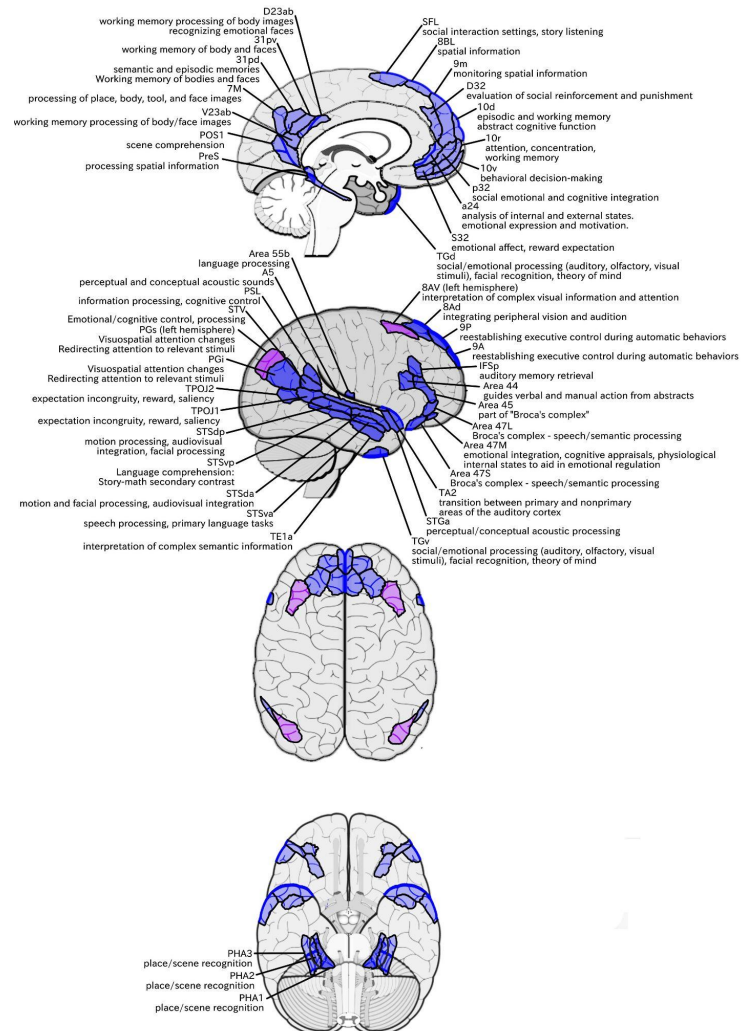
GV22 (8BL)

Yintang (10v)

BL5 (8AV left/8AD)

GB15 (8AV left)

GV23 (9m/10d)





# Saliency Network

"The moderator"

Moderates switching between internal processing of the DMN and external processing of the CEN. The saliency network is integral for sensorimotor processing, general cognition, and coordinating between emotion, pain, and physical action

- Visual processing when the mind subconsciously appreciates aesthetic beauty
- Daydreaming
- Processing/evaluating personal emotions or emotions of others
- Semantic processing when encoding or translating meaning into written or spoken words

## Brain Regions

Premotor region: 6ma, 6r, 55b, FEF, SCEF

Lateral frontal lobe: 9-46d, 46

Medial frontal lobe: 5mv, 23c, a24pr, p24pr, p32pr

Insula opercular areas: FOP1, FOP2, FOP3, FOP4, FOP5, MI, PFcm, PI, Pol1, Pol2, PSL

Parietal lobe: 7AL, PFop

The saliency network also includes nodes in the amygdala, hypothalamus, ventral striatum, thalamus, anterior cingulate cortex (ACC), medial temporal network, parahippocampal gyrus, olfactory bulb, ventral tegmental area (VTA) and specific brainstem nuclei

## Brain network interactions:

- Acts to switch between the CEN and DMN for internal and external processing
- Limbic network for processing pain, emotion, reward, and motivation

## Dysfunction

-If becomes hyper or hypoactive it can mishandle network switching and emotional regulation which can be a feature of anxiety, depression, PTSD, and schizophrenia

## Traditional Acupoint Correlates:

BL4 (9-46d/46)

GB5 (Pol2)

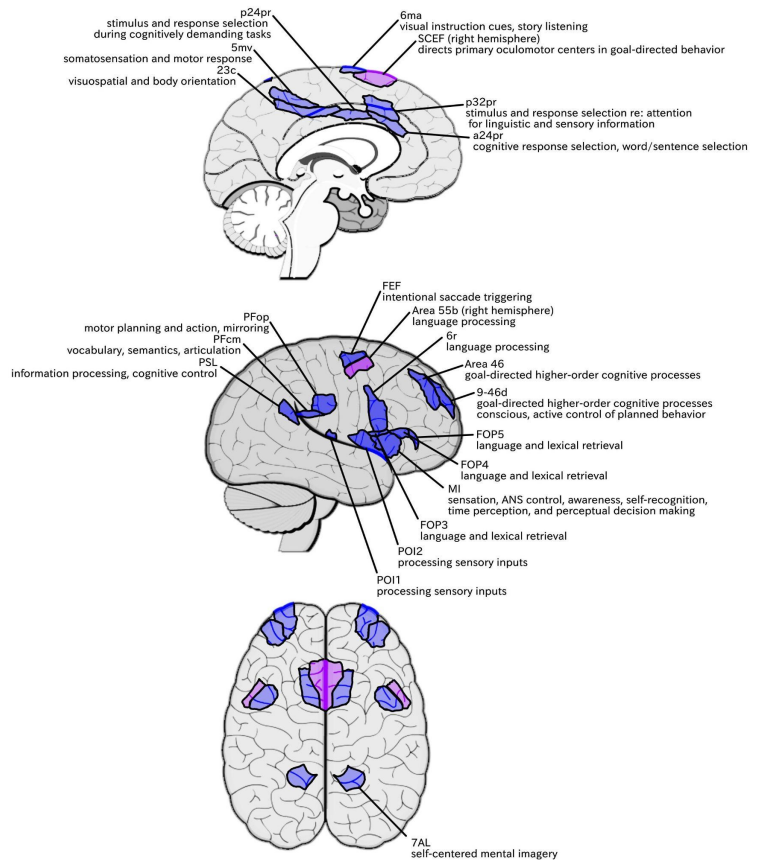
GV21 (SCEF right)

BL7 (7AL)

GB15 (46)

GB4 (6r)

GB16 (55b right/FEF)



# Dorsal Attention Network

"The aperature"

Steady holding of attention and guiding attention to other networks that are most prominent and active at any given time

- Alertness
- Selectivity
- Processing capacity
- Uses preconceived notions of visual features, scenes, etc as it processes each new idea

## Brain Regions

Premotor regions: 6a, FEF, PEF

Lateral frontal lobe: IFSa

Temporal lobe: PH, PHT, TE2p

Parietal lobe: 7AM, 7PC, 7PL, AIP, LIPd, LIPv, PF, PFT, VIP

Occipital lobe: MST, MT, V4t

## Brain network interactions:

- Correlated with CEN in deciding what the DAN will focus on next

## Dysfunction

- Neurodegenerative diseases and stroke can impair top-down processing and spatial neglect
- Schizophrenia/ADHD: attention and sensory disruption
- Children with autism spectrum disorder: often increased hyperconnectivity between functional attention areas. Adults however show hypoactivity in these regions

## Traditional Acupoint Correlates:

BL6 (6a)

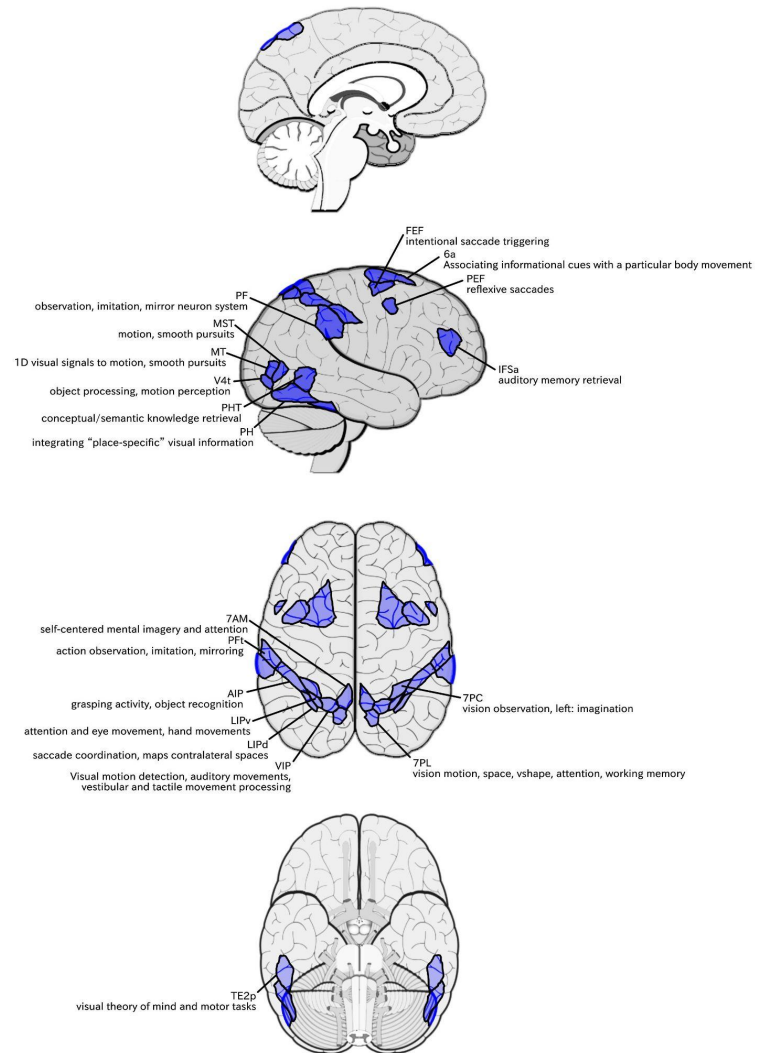
GB8 (PHT)

GB16 (FEF)

BL7 (7PC)

GB9 (PH/PHT)

GB18 (AIP/LIPv)





# Language Subnetwork

Activates functional areas in major brain networks to determine:

- What sounds were heard
- What words were read
- The meaning of these sounds and words
- What should be made in response
- Muscles needed to produce these sounds
- The order of sounds required to produce words
- How words should be organized to convey meaning through sentences

## Brain Regions

Premotor areas: 55b

Dorsolateral frontal lobe: 8C, 44, 45, IFJa

Medial frontal lobe: 8BM, SCEF, SFL

Lower opercula/Heschl's gyrus regions: PBelt

Temporal lobe: PHT, STSdp, STSvp, TE1p

Parietal lobe: AIP, PFm

## Brain Network Involvement

Default Mode Network:: translating information, language production, and semantic processing

Central Executive Network: language processing involving working memory. In the frontal lobe, key areas are involved in the interpretation of complex visual information, attention, and auditory memories.

Dorsal Attention Network: contributes to object recognition, controlled retrieval of conceptual knowledge, and the automatic retrieval of semantic information

Sensorimotor Network: the auditory cortex in the temporal lobe contributes during auditory story, arithmetic, and motor cue tasks

## Dysfunction

- Impacted language, aphasia, alexia, agraphia
- Impacted speech
- Impacted word association
- Impacted word recognition and familiarity

## Traditional Acupoint Correlates:

GB6 (STSdp/STSvp)

GB9 (PHT)

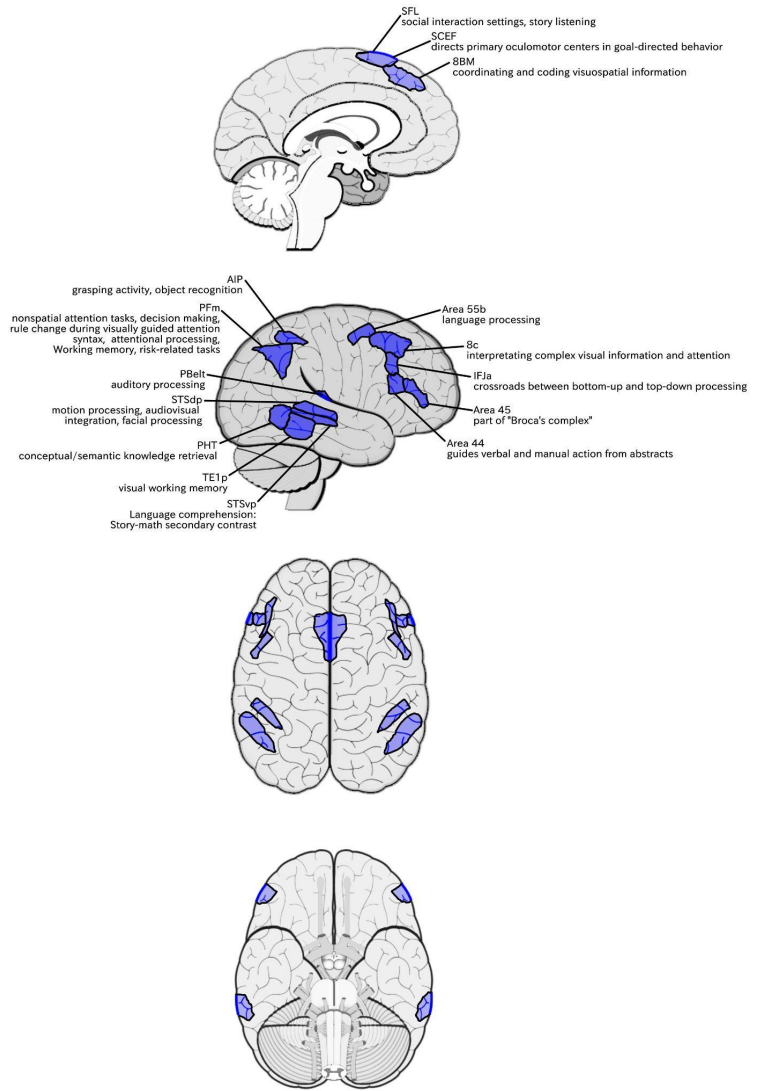
GB18 (AIP/PFm)

GB7 (TE1p)

GB15 (8C)

GB8 (PHT/TE1p)

GB16 (55b left)



# Ventral Activating Network (VAN)

Right hemispheric lateralization.

Reorients attention toward salient stimuli. Considered to be involved mostly, if not entirely, in involuntary actions

- Detection of salient targets, especially in unexpected locations
- Detection of abrupt changes in sensory stimuli
- Onset and offset of task blocks

## Brain Regions

Premotor regions: 6r

Dorsolateral frontal lobe: 8C, p9-46v

Superior insula opercular regions: AVI, FOP3, FOP4

Parietal lobe: LIPd, PFm, PGI, PGp

## Brain Network Involvement

Dorsal Attentional Network (DAN):

## Dysfunction

- Attentional disturbances
- Unilateral neglect
- ADHD: hypoconnectivity between fronto-parietal network, DAN, sensorimotor, and VAN

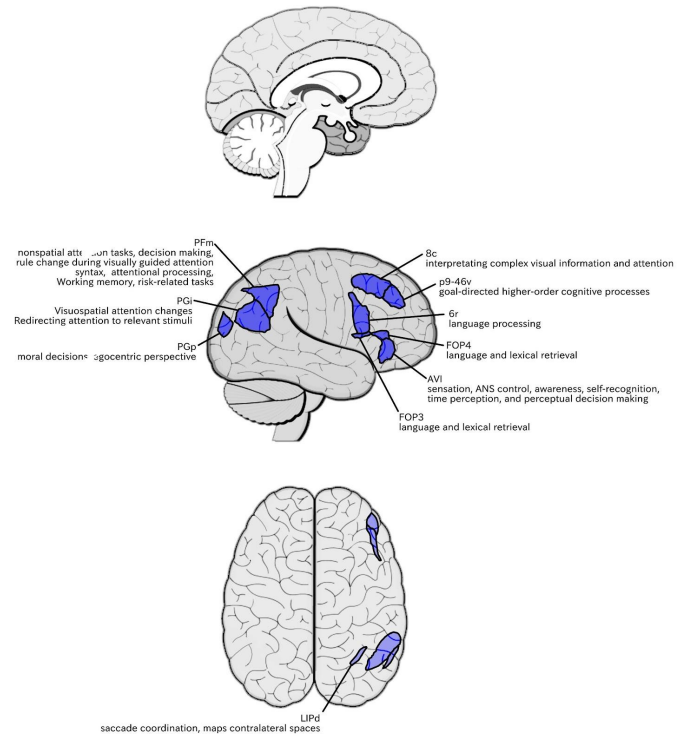
## Traditional Acupoint Correlates:

GB4 (6r)

GB15 (p9-46v/8C)

GB13 (p9-46v)

GB18 (PFm)



# Auditory Network

The associated areas of the cortex are activated bilaterally but seem to be left hemisphere dominant

Plays a role in the convergence and integration of various sensory modalities>

Allows interaction with the environment that ranges from processing auditory information to other sensory and cognitive tasks including processing:

- tone
- pitch
- speech
- language

## Brain Regions

Premotor regions: SCEF

Dorsolateral frontal lobe: 8C

Inferior frontal lobe: Area 44

Superior insula opercular regions: FOP4, PSL, PFcm

Lower opercula/Heschl's gyrus regions: A1, A4, A5, LBelt,

MBelt, PBelt, RI

Temporal lobe: STSdp

Lateral occipital lobe: TPOJ1

## Brain network interactions:

-Sensorimotor network: the auditory cortex in the temporal lobe contributes during auditory story, arithmetic, and motor cue tasks

-Visual network

-Central executive network

## Dysfunction:

-Auditory perception dysfunction

-Cortical deafness

-Tinnitus

-Speech comprehension impairment

-Auditory spatial attention impairment

-Impairment in context-dependent semantic predictions

-Auditory hallucinations

## Traditional Acupoint Correlates:

GB5 (A1/A4/A5)

GB15 (8C)

GB6 (STSdp)

GV21 (SCEF)

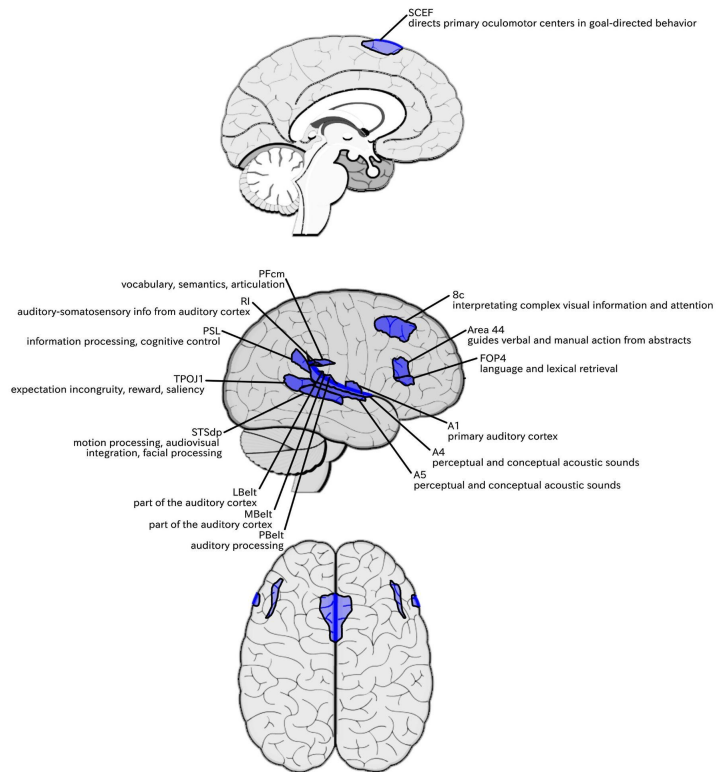


Table 1 Traditional Acupuncture Point Associations With The Medial Parietal Lobe

Acupoint	Cortical Parcellation Correlation
BL2	10pp
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, POI2, 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.

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