

## **Vision: Occipital Lobe (Calcarine Cortex)**

### **Anatomical-Physiological Background**

#### **Corollary Discharge**

The visual system has never been considered as a passive screen for light stimulation. Its interactive, constructive role is long recognized. Von Holst, Sperry, and Teuber have all emphasized the Test-Retest aspects of the system. Teuber suggested "corollary discharge" as a self-biasing system used to prepare the visual system for changes in the visual field. If you passively press against your eye the world will appear to jiggle. However directing your eye to move in a similar manner will not result in any instability in the perceived outer world. This is because, in the latter case, the motor commands to move the eyes are accompanied by a simultaneous, or "corollary discharge," a correlated neural message to the receptive areas negating the sensation of movement.

#### **Held and Hein**

Held and Hein, in a long series of studies, have demonstrated that the visual system alters its biasing weights with even short periods of environmental rearrangement. They demonstrated this artificially shifting the world with the use of adapting prisms results, when motor feedback was provided to the visual system of the mismatch between expected visual perception and perceived position in space, that the visual system readjusted itself. Over time the displaced world appeared normal and mot

actions were directly correct. Removal of the prisms resulted in a corresponding period of readjustment (shorter). Neural activity can be measured in the frontal eye fields during eye movements. But there is no means of determining causal sequences of neural events at this molecular level.

## **Feature Detection**

Barlow, Hubel & Wiesel, what the frog's eye tells the frog's brain  
Role of the Optic Tectum

X-Y cells

Visual Scotoma ( Central Cortical Blindness)

Reciprocal role of contralateral visual fields.

Visual Illusions and Hallucinations

Visual Illusions (Metamorphosias)

1. Elementary

change in object size

change in the size of objects in a single direction

obliquity

inversion

blurring & irradiation of outlines

changes in color

fragmentation of contours

illusion of movement

2. Complex

In three dimensions

telescoping (of objects)

pelopsia (closer) objects appear to approach and become larger

loss of stereoscopic vision

visual perseveration (palinopsia)

optic displacement (alloesthesia)

metamorphosis

Heise (1963) identified 4 groups out of 83 patients with visual disorders:

deformations

illusory movements

polyopsia

macropsia & micropsia

An additional 12 patients showed:

4 cases of splitting & separation of objects

1 case of reversed image of objects

1 illusion

6 cases limited to human faces

Anatomical

lesions at any level

more right than left (10%-5% more)

on the right occipital-temporal-parietal

on the left occipital

movement disorders related to temporal lobe

polyopsia associated with the occipital lobe

perseveration associated with right occipital or right parietal-occipital

Theoretical considerations

Vestibular stimulation will produce visual illusions in subjects with parietal-occipital lesions, often associated with vertigo.

There is a vestibular projection to the parietal lobes.

Visual Hallucinations (right hemisphere associated by more than 10%)

Occipital: Elementary, simple visual illusions, phosphenes

Occipital & Temporal; Complex Hallucinations:

Esthetic: catch a butterfly, whole field

Associated with a dreamy state: unreal or prior experience

Oneirism: Confusions, wandering attention, complex hallucinations with delirium & dreams

Associated ophthalmological lesions

### Visual Agnosias

Finkelburg (1870): asymbolia

Meynert (1900): sensory and motor (know and use)

Munk (1890): psychic blindness

Freud (1891): visual agnosia

Hughlings Jackson: "imperception"

Can walk without bumping into things but finds no meaning in objects.

Wernicke...considered primary and secondary identification..association

Lissauer (1908)..dissolutional agnosia..disruption of representational complexes.

Reaction: Von Monakow..rejects centers and Gestalters argue perceptual versus ideational

Gelb & Goldstein..the dedifferentiation of figure from background

Heenan & Albert discuss Poppleweaters classifications of the development of an image.

According to Hececian & Angelergues there are three separate but related aspects of visual agnosias.

1. Selectivity:

a) disturbed recognition of objects, colors, letters

b) disturbed recognition of spatial aspects and faces

2. Defect of language versus somatosensory

3. Left versus right hemisphere

Also, lesions producing agnosias in the right hemisphere tend to be more widespread, more diffusely organized (Semmes)

Teuber discovered, in both Korean War veterans, that agnosia was a poor term..they also had difficulty manipulating topographic information, both tactile and spatial (visual)

Milner found right sided lesions associated with complex spatial forms, and left sided for verbal, and for recognition, recall, and learning, regardless of sensory modality.

De Renzi argued that a distinction had to be made between perceptual discriminative versus semantic association

Visual Agnosias in Humans

visual object agnosia; bilateral diffuse and extensive lesions

Recognition deficits for drawn stimuli: usually accompanied by visual field defects, and general intellectual deterioration, simultagnosia

Prosopagnosia: bilateral lesions, other types of agnosia associated negative with aphasia and arithmetic

Color agnosia

Spatial agnosia

Unilateral spatial agnosia: loss of topographic concepts, loss of topographic memory

Balint's syndrome: disturbance of gaze, optic ataxia, impaired visual attention, cannot shift gaze to other items.

### Benton's Categorization of Visual Disorders

1. Visuo-Perceptual
  - a. Visual object agnosia
  - b. Impairment in facial recognition
    1. facial agnosia (prospagnosia)
    2. defective facial discrimination (unfamiliar faces)
  - c. Impairment in color recognition
2. Visuo-Spatial
  - a. Defect in localization of points in space
  - b. Defective judgement of direction & distance
  - c. Unilateral visual neglect
3. Visuo-Constructive
  - a. Defective assembling performance
  - b. Defective Graphomotor performance

### Spatial Perception

Investigation in clinical cases largely limited to visual processing or visual neglect.

Single Point Localization of objects in space

Spatial

Localization of single points in space

almost always visual domain

it produces visual disorientation...a blind person with vision.

In classic case, described by Holmes distance of objects was impaired.

Opposite syndrome also reported: depth okay but objects location left-right impaired.

**DOES THIS SUGGEST TWO MECHANISMS**

may also differ by close versus far reaching space

**DIFFERENT CUES?**

May be specific to visuo-motor coordination **IF SO WOULD A CLICK LOCALIZATION PARADIGM WORK?**

Theoretical considerations:

point in space: retinotopic impairment contralateral to side of lesion:

a failure to use local retinal cues for localization. As our eyes move and as the external map shifts we must maintain an internal stable map. requires that the retinal stimulation be coordinated with the shifting mind's eye. This in turn, must be coordinated with the head, eye, body, arms, etc. position.

movement detection separable from point

visuomotor coordination...letting patient see hand before movement improves performance.

Spatial Analysis:

poor drawing, poor "articulation" of parts, poor 3x3x3 block of cube counting - but no recognition of complex picture problem counting scattered objects, map deficits,

visuo-spatial agnosia

misalignment of words,.

left side neglect

Line bisection, usually unilateral, cues may help shorter lines easier

Position discrimination:

gaps in two contours - same position.

indicate on a numbered card where a dot had been on a flashed screen.

Orientation

Line orientation matching

Spatial search: cancellation tasks almost a criteria

Search Tasks: Poppelreuter

Kimura dot enumeration

Lesion:

point localization = occipital-parietal juncture

line orientation, gaps = right hemisphere. rpar > rtemp

Spatial Neglect

Hecaen & Angelergues:

413 cases, 59 with neglect, 51 of these with right hemi lesion, 4 left, 4 both.

ARGUMENT: OGDEN: She said severity important, if any neglect is used then 50% left and 44% right.

target search within - left or right

search for animal within animals left or right

search for object in overlapping pictures more right

if the patient has a particular difficulty (e.g., numbers) they will show worse search.

inattention or sensory neglect

extinction to simultaneous stimuli

motor neglect

spatial neglect

personal neglect (not my arm)

allesthesia and allokinesia (report touch on wrong side (ipsilateral lesions))

anosognosia (illness denial)

### Spatial analysis:

generally focused on neglect

disordered central representations of space

yet the disorders may be separable...tactile, visual, auditory - implying not damage to single central representation.

also some indication that bias may be either egocentric or environmentally centered.

Theories of Spatial Neglect:

attentional or representational

#### **ATTENTIONAL:**

inattention or unawareness

ipsilateral attentional bias

inability to disengage from right side stimuli

reduced sequential attentional capacity or early habituation

inattention or unawareness

novel items on neglected side reduced neglect

Heilman & Valenstein: right hemisphere has functions more related to arousal and its an arousal deficit.

Kinsbourne's: activation model with both hemispheres competing, with disrupted gradient of attention. hypoactive hypothesis (underactive right side, eg.)

EEG and PET slowing in non-lesioned hemisphere.???

Posner; Proved cue as to where in visual field an event might occur. catch trials is a false cue. difficulty shifting attentional spotlight away from the normal to the affected side. By cueing the patient to shift the spotlight to the affected side the deficit was overcome.

Representational theory:

the deficits occur depending upon the patient's imagined point of view (OF A PLACE).

Consider the cross-handed response data. If you focus on the center and have your left & right hand to either side and are to respond as fast as possible to a stimulus presented to the right or left - the same sided hand responds faster (shorter tracks?). THE RVF STIMULUS GOES TO THE LEFT HEMISPHERE < BUT THE RIGHT (CONTRALATERAL) HAND RESPONDS FASTER.

NOW, if you cross the arms the hand on the same side of the stimulus responds faster. (cognitive "natural" tendency to respond with hand in same side of space)

SO THE CONTRALATERAL CONTROL OF SPACE IS NOT PATHWAY OR BODY SIDE ORIENTED.

Memory theory

extinction: interference, limited capacity, reciprocal inhibition, Mesencephalic reticular formation lesions lead to sensory neglect. Stimulation = behavioral arousal and desynchronization of EEG.

Comparator cells: cause desynchronization:

the right parietal lobe desynchronized to both left and right stimuli

the left parietal only to right-sided stimuli = backed by pet data

The mesencephalic : locus coeruleus: norepinephrine projects diffusely. But destruction of locus coeruleus does not effect behavioral arousal or the EEG patterns.

Dopamine: blockade of dopamine does not effect desynchronization.

Heilman, Kenneth & Van Den Abell, Thomas. (1980). Right hemisphere dominance for attention: The mechanism underlying hemispheric asymmetries of attention (neglect). Neurology, 30, 327-330.

THERE IS A SIMILARITY BETWEEN THIS ARGUMENT AND NAUTA'S REGARDING THE FUNCTION OF THE LIMBIC-FRONTAL LOBE CONNECTIONS.

THIS SUPPORTS SEMMES POSITION.

Note that in the Heilman (1972) frontal lobe neglect paper they suggested, after Sokolov's suggestion that attention is related to reticular-arousal system, that neglect is an attention-arousal-intention deficit resulting from lesions of a cortico-limbic-reticular loop. They think each hemisphere has its own loop but that the right hemisphere dominates attention.

Alpha desynchronization results from attention or orientation to a stimulus.

If "comparator neurons" induce desynchronization then more should show in the right hemisphere.

12 right-handed college students. Presented a warning signal at a light diode to the left or right visual field while recording EEG. Right parietal lobe desynchronized equally to right or left warning signals.

Left parietal lobe desynchronized mainly to right signals.

SO: Right hemisphere dominates comparator or attentional processes.

Why left side neglect?

Because the left parietal does not attend to left field - damage to the right hemisphere results in left side neglect.

Notes parietal lobe has cells that react to fixation on an object. Contrasts the galin left & right cognitive activity stuff with the Pribram & McGuinness retort.

[WHY & AND WHAT IS THERE ATTENTION?]

Mesulam, M-M. (1981). A cortical network for directed attention and unilateral neglect. Ann. Neurol., 10, 309-325.

". . at least one plausible interpretation [for parietal lobe neglect has been to assume that the unilateral neglect reflects an underlying attentional deficit for segments of extrapersonal space." P. 309.

Unilateral, extensive, posterior ablations of parietal lobe in macaque monkeys results in contralateral attention hemianopia and sensory extinction. Neurons in this area increase when the animal reaches for an object - but not when the arm is passively moved [similar to the eye fields]. Neurons in this area would also respond to rewarded stimuli.

---

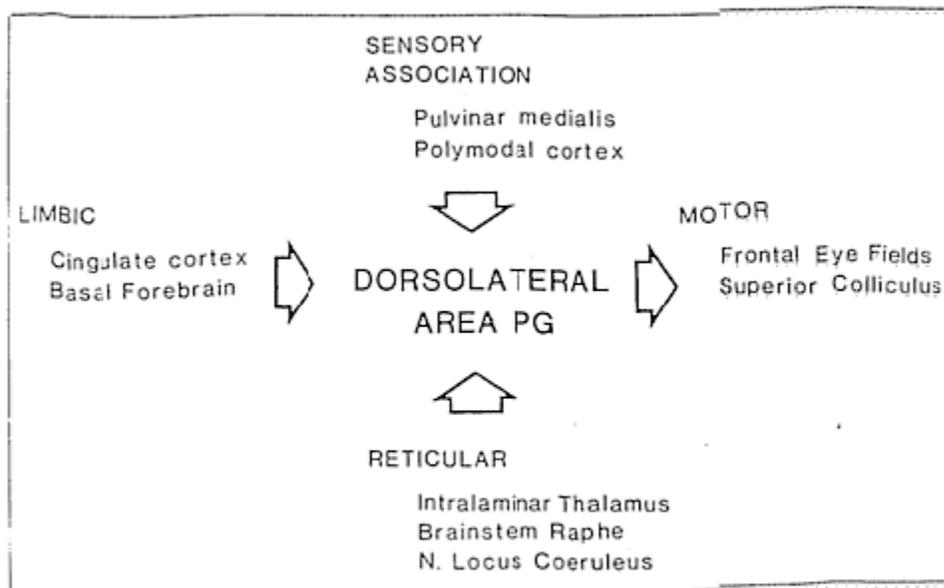
*"These neurons respond to stimuli with motivational value and with a likelihood of becoming an immediate target of visual or manual grasp."*

The focus of attention here is on neurons in the dorsolateral parietal gyrus.

It receives input from:

1. limbic system: motivational
2. Sensory association areas
3. Reticular system

This is illustrated below from page 313.



*Fig 2. The organization of input and output that is relevant to directed attention.*

These areas are assumed to function as follows:

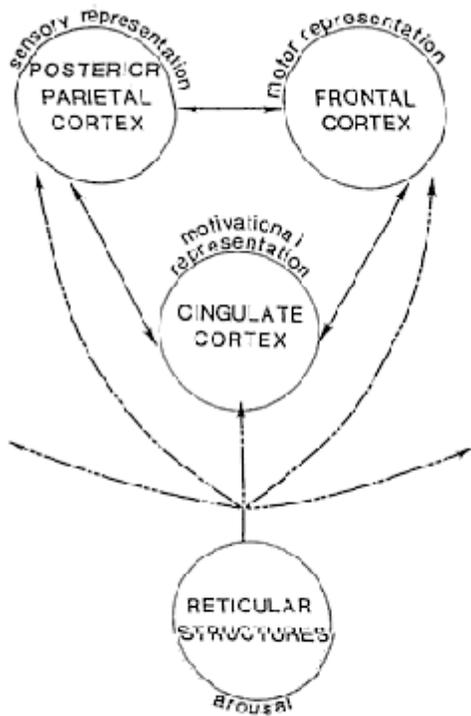


Fig 3. The components of a neural network involved in modulating directed attention.

Mesulam assumes that this PG area provides an area of afferent integration where "extrapersonal space becomes transformed into a sensory representational template." It is further assumed that this representation "transcends a composite reproduction of actual sensory events and that it contains additional mechanism for providing an interaction between space and relevance. It is conceivable that area PG contains a fluid template where the transformation of external events into synaptic activity reflects not only the physical properties of the stimulus field but also the distribution of relevance within segments of extrapersonal space." P. 313.

Unilateral damage would bias the representation in favor of the hemisphere

Notes that posterior parietal damage = neglect best elicited by simultaneous stimulation.

Frontal neglect elicited by stimuli to either side.(predominance of motor over sensory).

[BUT WHY IS NEGLECT LEFT-SIDED?]

sites Bisiach et al. (1979). Presented left sided neglect patients two geometric designs to say if they were the same or different. They viewed the stimuli through a slit. They neglected the left side of the design whether it passed from left to right or right to left. Thus, they concluded, it is the internal representation that is disrupted. [THIS IS EXPERIMENTALLY USEFUL TASK]

Notes Battersby et al.: demonstrated that the right sided lesions are larger...that left would elicit right-sided neglect if the left lesions were large enough - but equivalently large lesions generally make the patient untestable.

BUT: evoked potentials larger in right hemisphere.

When matched for lesions eye scan favors more neglect in right hemisphere lesions.

Their model:

1. Right hemisphere attends to both sides of space, with preference for contralateral
2. Left hemisphere concerned with right space
3. more synaptic space in right hemisphere devoted to attentional functions

WHY??? And is this premise not the same as Heilmans (1980), one year before and cited in this article, as well as Heilman's frontal lobe neglect paper.

WHY: The emergence of language skills in the left hemisphere (pushes the argument to why language skills emerge in the left hemisphere) -- these skills do not depend upon participation of right side neural functions.