Cognitive Neuroscience
9/14/21

Hemispatial Neglect

1. Clinical picture

2. Posner task: Results and interpretation

3. Reference frames: Egocentric and allocentric

4. Neglect for mental representations

Right parietal damage

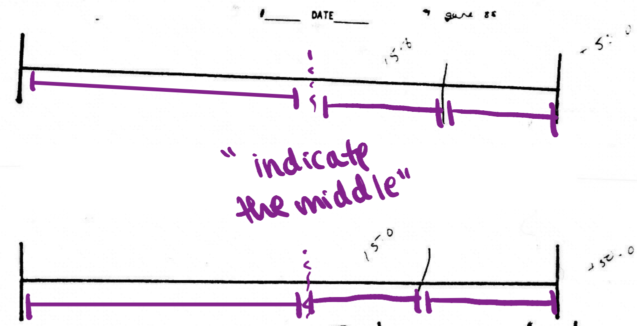
Unawareness of one half of space

Self-portraits painted by Anton Raderschaft during recovery from a right hemisphere stroke producing left hemispatial neglect. The earliest portrait is at top left. The latest is at bottom right.

Food left uneaten on the left side of a plate by a patient with left hemispatial neglect.

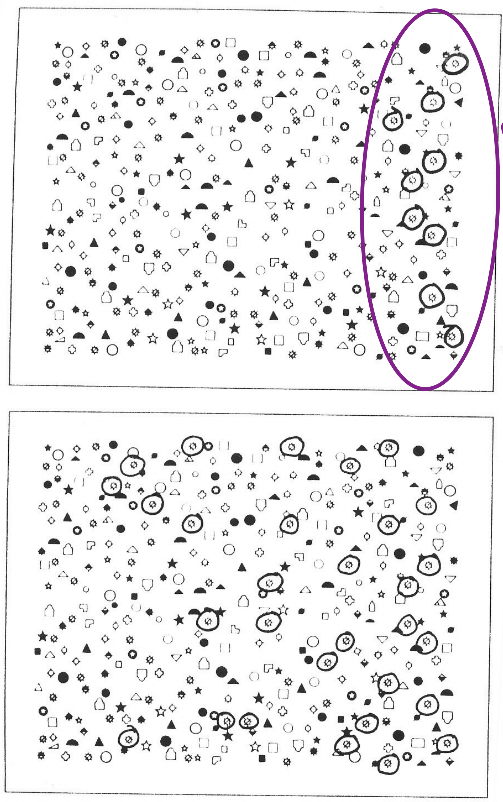
Three standard clinical tests for neglect

Line Bisection



Behrmann lab

Cancellation

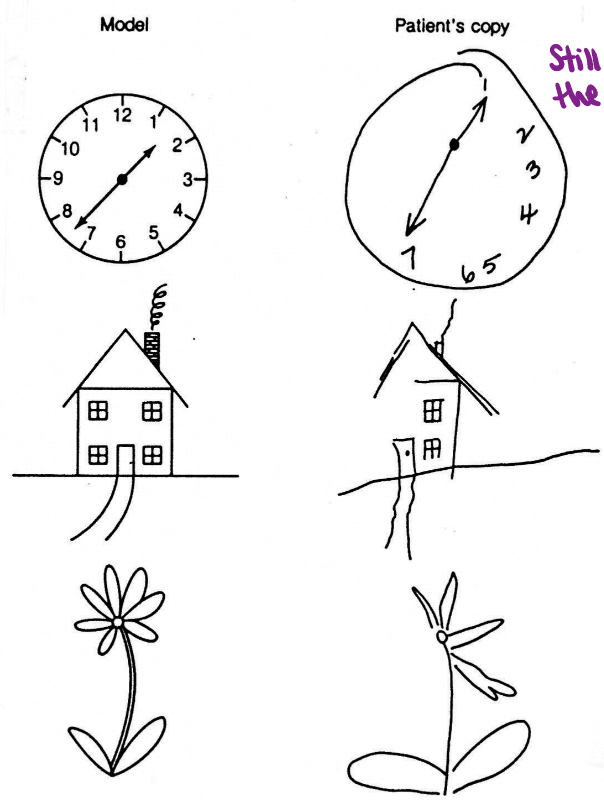


only detected on the right

Weintraub & Mesulam
Arch. Neurol. 44: 621 (1987)

Fig 1.—Two samples of shape cancellation task taken from two patients with right-sided cerebral lesions in study 1. Sample at top reveals dramatic neglect of left side of page. Sample at bottom demonstrates less severe contralateral neglect and degree of neglect in ipsilateral right hemispace.

Copying



Still drew the circle?

FIGURE 17-6. Drawings copied by a patient with contralateral neglect. From F. E. Bloom and A. Lazerson *Brain, Mind, and Behavior*, 2nd ed. New York: W. H. Freeman and Co., p. 300. Copyright © 1988. Reprinted with permission of W. H. Freeman and Co.)

Parietal → Common site of neglect

The locus most often associated with neglect in humans is the inferior parietal cortex (BA 39, 40) of the right hemisphere. Neglect can also arise from injury to other frontal & anterior cingulate areas to which parietal cortex is linked.

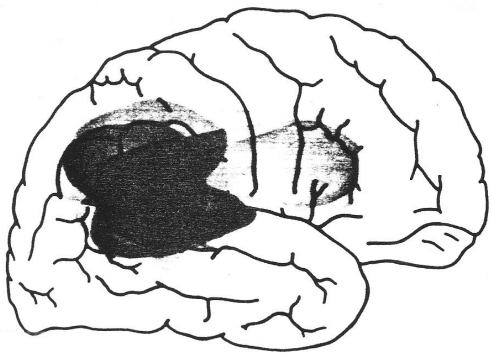
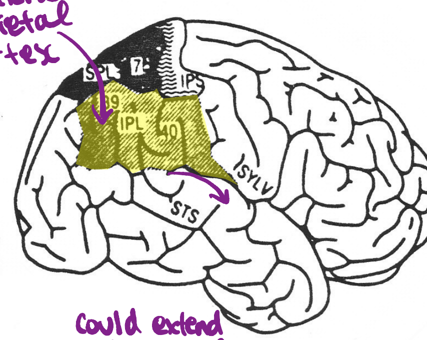


Figure 4. Lateral view of right hemisphere where we have projected and superimposed the CT scans of 10 patients with the neglect syndrome.

Heilman, 1983
In: Localization in Neuropsychology

lateral parietal cortex



could extend to temporal parietal junction

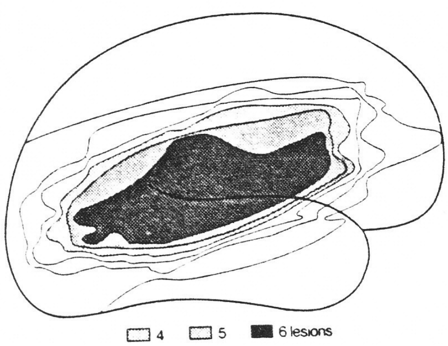


FIG. 1. Composite contour map of the antero-posterior superficial-and-deep lesions of seven severe N+ patients. The contours drawn on the standard lateral diagram of the brain represent the degree of overlap of the lesions: the outer line indicates the area affected by one lesion only, the next by two and so forth.

Vallar & Perani
Neuropsychologia 24: 609 (1986)

P(Left deficit | Right lesion) is ↑ than P(right deficit | Left lesion)

The common pattern (66%): Right more common
Right-sided lesion → left-sided neglect.

The exceptional pattern (34%):
Left-sided lesion → right-sided neglect.

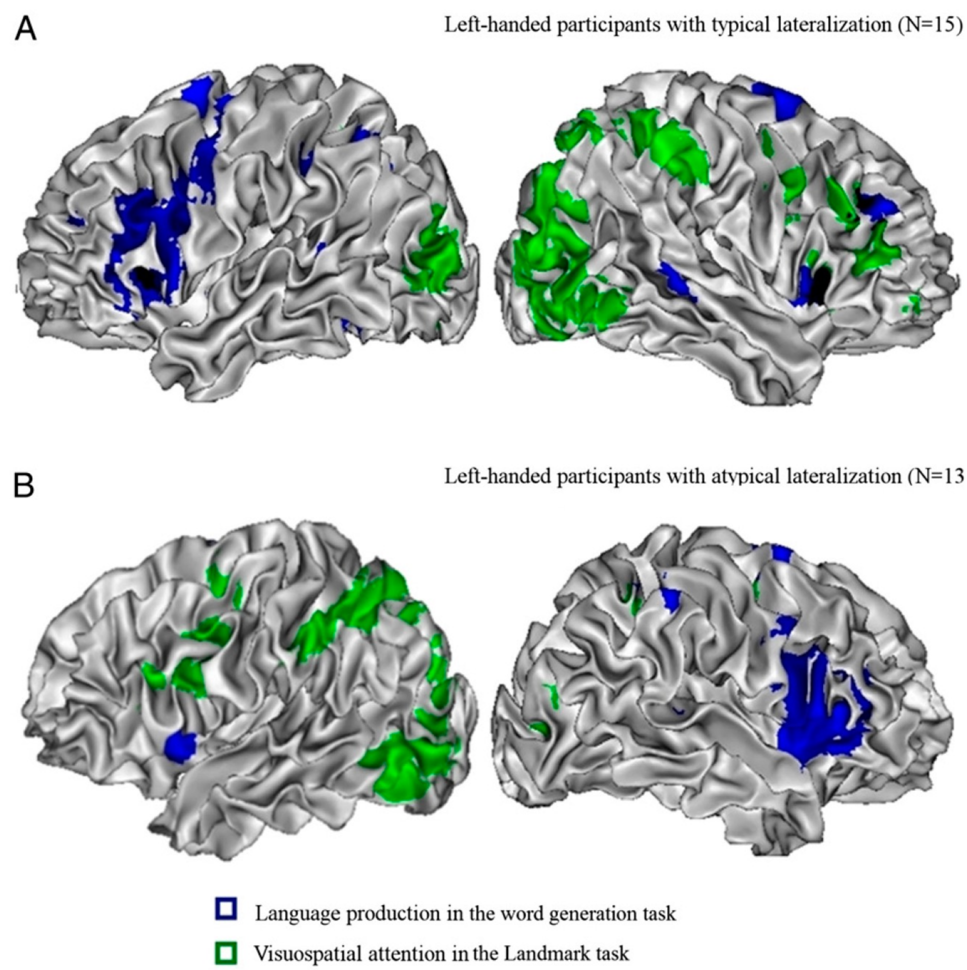


Fig. 1. Language production and visuospatial attention lateralize to different hemispheres, independent of the side of lateralization. Results for participants with (A) typical lateralization or (B) atypical lateralization, for word generation (in blue, word generation against repetition) and for the Landmark task (in green, Landmark against control task). In each panel the left picture shows activation in the left hemisphere, and the right picture shows activation in the right hemisphere.

Cai et al. (2013) Complementary hemispheric specialization for language production and visuospatial attention. Proc. Natl. Acad. Sci. 110(4):E322-30.

Observations suggesting that attention-related functions are pushed into the hemisphere opposite the hemisphere specialized for language

Left-handers were subdivided by whether they exhibited left-hemisphere (A) or right-hemisphere (B) specialization for language, as indicated by frontal-lobe activation (blue) in a word generation task. In each group, parietal and occipital activation during a covert attention task (green) was strongest in the non-language hemisphere. The word generation task required silent listing of words beginning with an instructed letter. The attention task required making fine visual discriminations on peripheral images while maintaining central fixation.

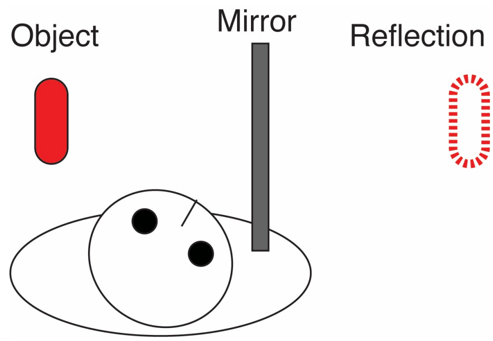
HEMISPATIAL NEGLECT

Related symptoms:

Allesthesia
Asomatognosia
Anosognosia
Extinction → Weak form of neglect
Competition, bias to thing on right

Non-visual expressions:

Auditory
Tactile
olfactory
Motor exploration
Directional hypokinesia



We conducted this experiment on twelve patients with visual hemineglect caused by right cerebrovascular accident (CVA). After chatting with the patients informally, we propped a mirror up vertically on the right side of the bed or wheelchair with one experimenter standing behind it. The mirror was 2 feet tall and held parallel to the sagittal plane so that its right edge was close to her right shoulder. She was asked to turn her head and eyes rightwards to look into the center of the mirror so she could clearly see the mirror reflection of the people and objects that were on the left side of the bed or wheelchair. It was quite clear that it was a mirror since it had a wooden frame and dust on its surface. To ensure that the patient knew she was looking in the mirror, one investigator stood on the patient's right behind the mirror and asked: 'What is this I am holding?' to which each patient replied 'a mirror'. Upon receiving a cue, a second investigator standing on the patient's left side held out a pen or candy bar toward her so that it was well within the reach of the patient's nonparalyzed (right) hand but entirely within the neglected (left) visual field – about 8 inches below and to the left of the patient's nose. The experimenter then asked the patient, 'Do you see the pen?' and when she nodded or said yes, the experimenter added, 'Okay, reach out and grab the pen please.'

Ramachandran et al. (1999) Can Mirrors Alleviate Visual Hemineglect? Medical Hypotheses 52(4): 303-305.

The patients fell into two groups:

A. In some of the patients, the presence of the mirror actually seemed to help them overcome the neglect, i.e. when they were asked to retrieve the object, after some initial hesitation they reached correctly for the object into the left visual field. This observation raises an interesting clinical question: Can the mirror be used as a therapeutic device to increase the patient's awareness of the left side of the world so that he is permanently cured of neglect? Will repeated practice with this technique accelerate recovery of function? And, if so, would the 'cure' be task-specific or would it generalize to other day-to-day activities?

B. In the second subgroup of patients we found, remarkably, that even though the patient knew she was looking into a mirror, she kept reaching for the mirror reflection of the object – apparently confusing the mirror reflection of the object for the real object! We have dubbed this syndrome 'mirror agnosia' or the 'looking-glass syndrome'. It is as though the patient is saying to himself: 'Since the reflection of the pen is on my right the object must be on my left, but since left does not exist on my planet the object is inside the mirror.' Intriguingly, when the patients were asked to describe where the object was, they often made absurd remarks such as: 'It's not in my reach', or 'It's behind the mirror'. Patient MR also tried groping behind the mirror on several trials claiming that 'the object is behind the mirror' or 'inside the mirror'. On some occasions, she tried to grope VSR's tie or belt-buckle while he stood behind the mirror. This happened continuously for about 20 seconds on any given trial. This syndrome was not seen in 6 control patients of comparable mental status with a left CVA, which suggests that the syndrome is probably a consequence of right hemisphere pathology.

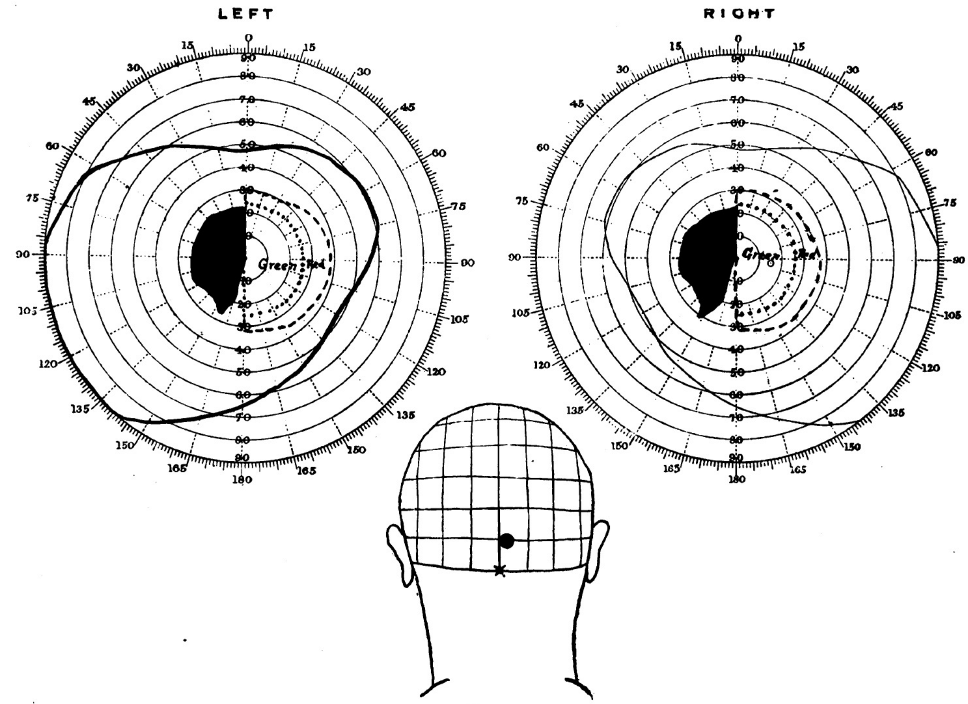


FIG. 1.

In this and the following figures the position of the wound of the skull is represented in a diagram of the head, and when missiles were retained in the brain their positions as seen in radiographic plates are also indicated. The vertical and horizontal lines in the diagrams represent distances in inches (2.5 cm.) from the inion as measured on a normal head.

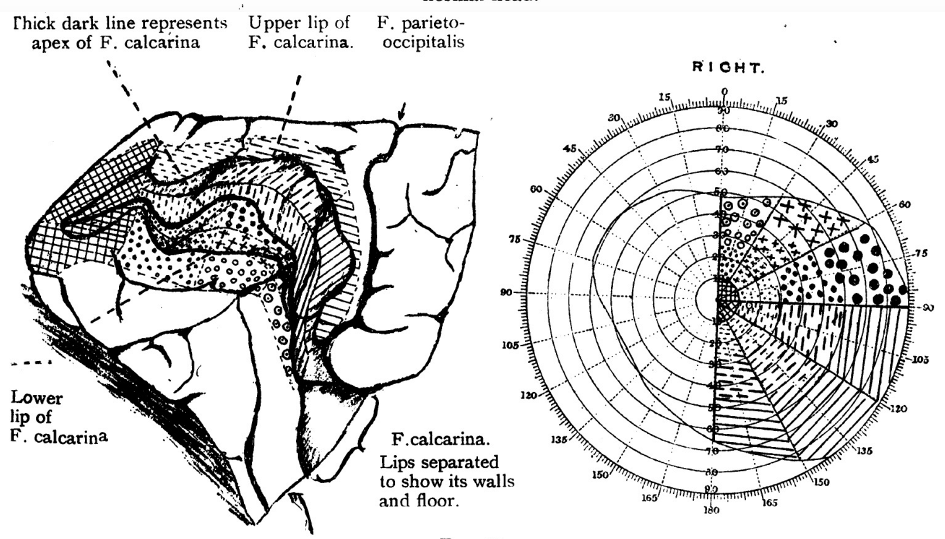
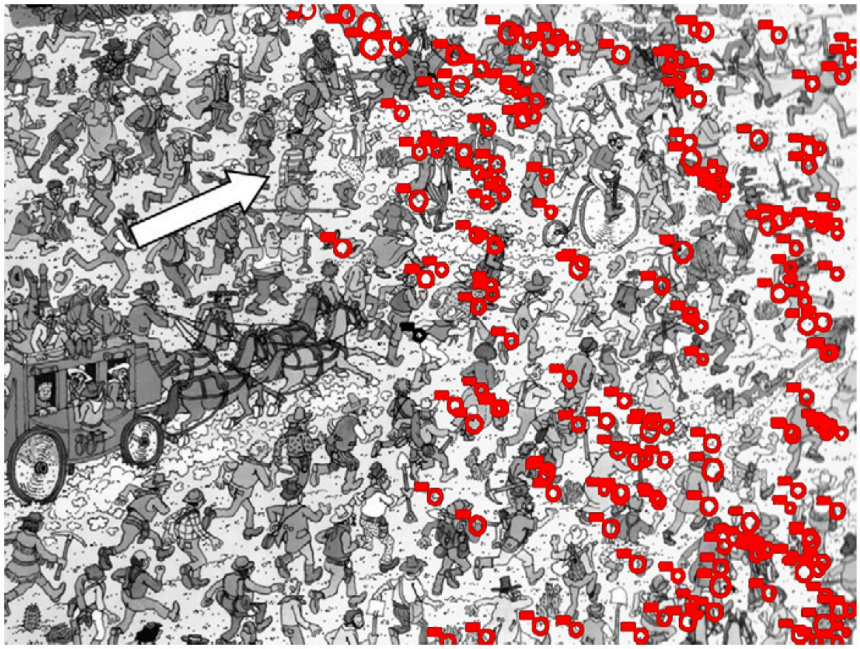


FIG. 16.

A diagram of the probable representation of the different portions of. the visual fields in the calcarine cortex. On the left is a drawing of the mesial surface of the left occipital lobe with the lips of the calcarine fissure separated so that its walls and floor are visible. The markings on the various portions of the visual cortex which is thus exposed correspond with those shown on the chart of the right half of the field of vision. This diagram does not claim to be in any respect accurate; it is merely a schema.

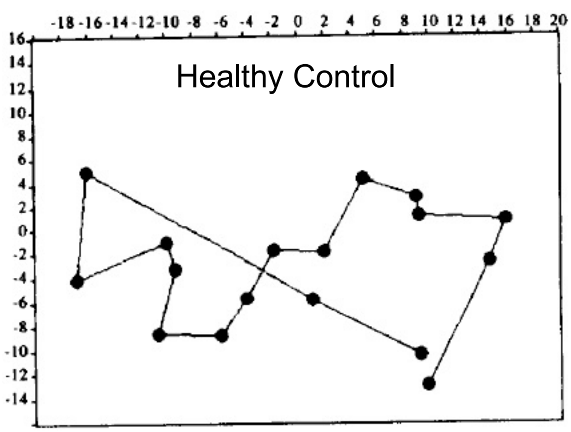
In a classic study, Gordon Holmes established that primary visual cortex contains a systematic map of the visual field. His subjects were soldiers who had suffered penetrating missile wounds while fighting in World War I. His method was to analyze the relation between the cranial location of the wound and the location in the visual field of the corresponding scotoma. This method hinged on the fact that damage to primary visual cortex produces so-called cortical blindness. Patients report virtually no visual sensation in the affected part of the visual field. The condition is homonymous in the sense that the same part of the visual field is affected regardless of whether the left or right eye is tested. It is of interest to ask whether cortical blindness in one hemifield (due to destruction of primary visual cortex in the opposite hemisphere) is experienced differently from neglect in one hemifield (due to destruction of parietal cortex in the opposite hemisphere).

Holmes (1918) The British Journal of Ophthalmology 7: 353-384.



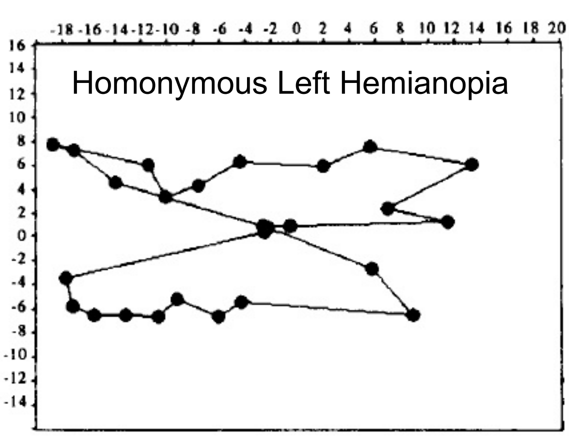
Neglect is reflected in oculomotor scanning behavior. Here, a patient with left hemispatial neglect, unsuccessfully scanning a scene in search of Waldo, rests his gaze almost exclusively on points in the right half of the display (red symbols). Waldo is at the location indicated by the arrow.

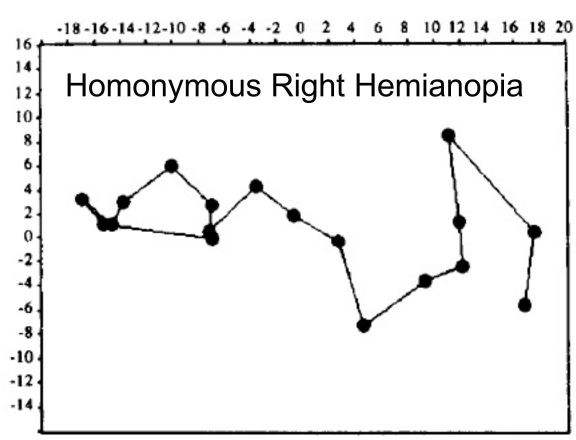
Vangkilde and Habekost (2010) Neuropsychologia 48: 1994-2004.



In contrast, in homonymous hemianopia, oculomotor scanning is intact. Indeed, patients compensate for their blindness in one visual hemifield by spending more time fixating items on the affected side of the display. Data here are from subjects scanning a display of dots in order to count them. The display is not shown. Dots indicate points at which gaze paused and lines indicate saccades.

Zihl (1995) Neuropsychologia 33: 287-303.





On the basis of the observation that neglect patients are particularly slow to respond to a contralesional target preceded by an ipsilesional cue, Posner and colleagues (J. Neurosci. 4: 1863-1874, 1984) argued that a mechanism for disengaging attention from the ipsilesional cue is impaired.

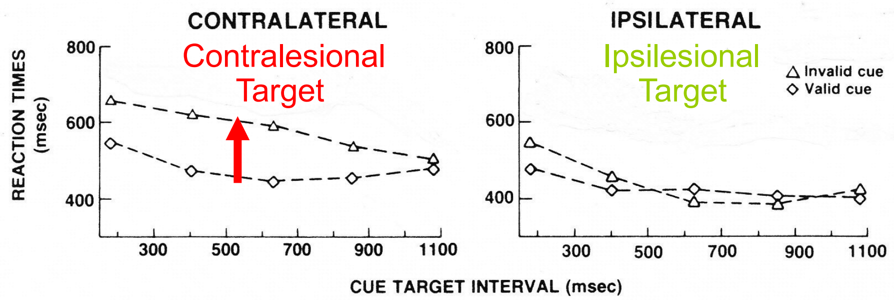


Fig. 5. Influence of cue-target intervals on performance of five patients with parietal damage. Data on the left come from trials where the targets are in the visual field contralateral to the lesion; data on the right are for targets ipsilateral to the lesion. The vertical axis represents reaction times and the horizontal axis corresponds to the interval between cue onset and target onset. The format is the same as Fig. 3, and the patients and data collection conditions are the same as Fig. 4

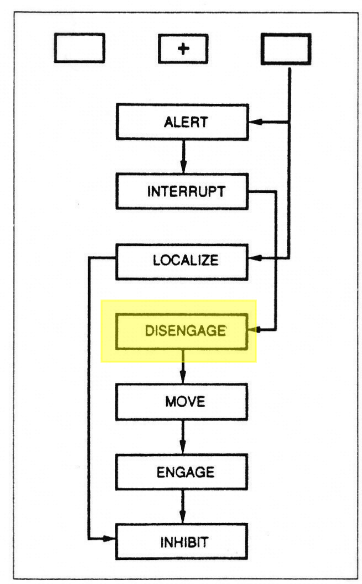
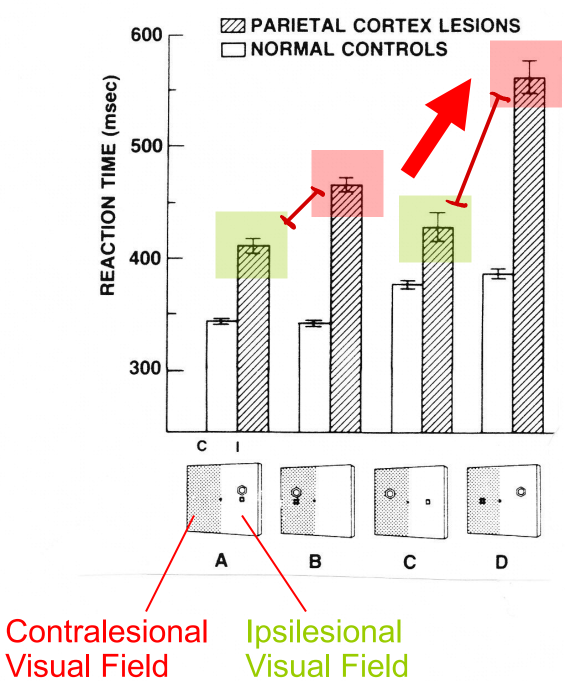


Figure 1. The theory of attentional selection proposed by Posner, Walker, Friedrich, and Rafal (1984).



Data shown here are from:

Petersen et al.
Exp. Brain Res.
76: 267-280 (1989)

Using a simple neural net model, Cohen et al. showed that it was possible to account for Posner's results without positing a special "disengage" mechanism. The model incorporates cross-inhibition between right and left hemispheres in accordance with Kinsbourne's "opponent processor" model of neglect.

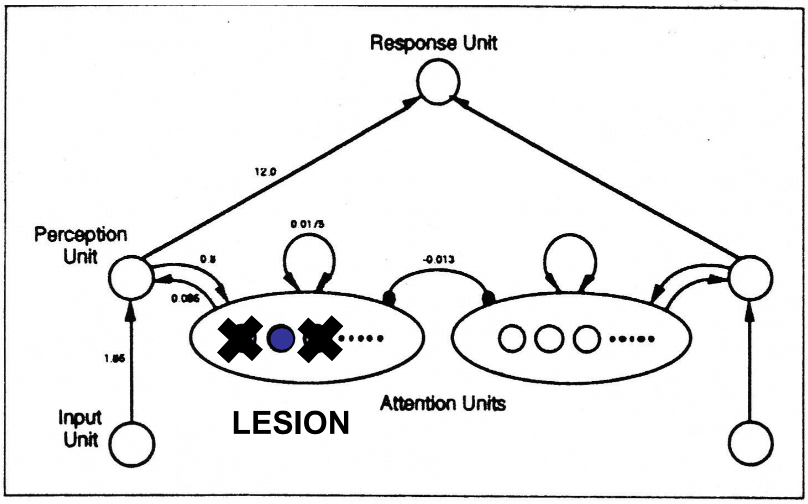
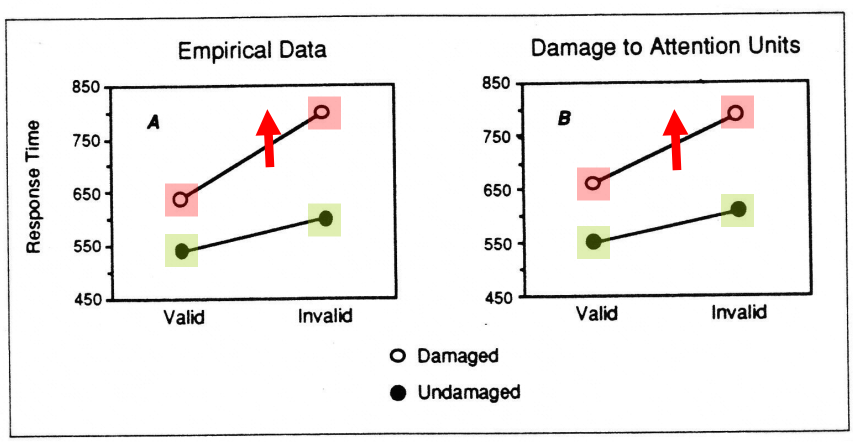


Figure 3. The network used to simulate performance in the spatial cueing task. Numbers are the weights on the connections between units. All attention units were connected with excitatory weights to all other units within the same pool, and with inhibitory weights to all units in the competing pool.

Figure 5. Performance data for the spatial cueing task. (A) Data from an empirical study (after Posner et al., 1984). (B) The results of the model's simulation of this data (response time = 0.99 × cycles + 107).



Cohen et al.

J. Cog. Neurosci. 6: 377-387 (1994)

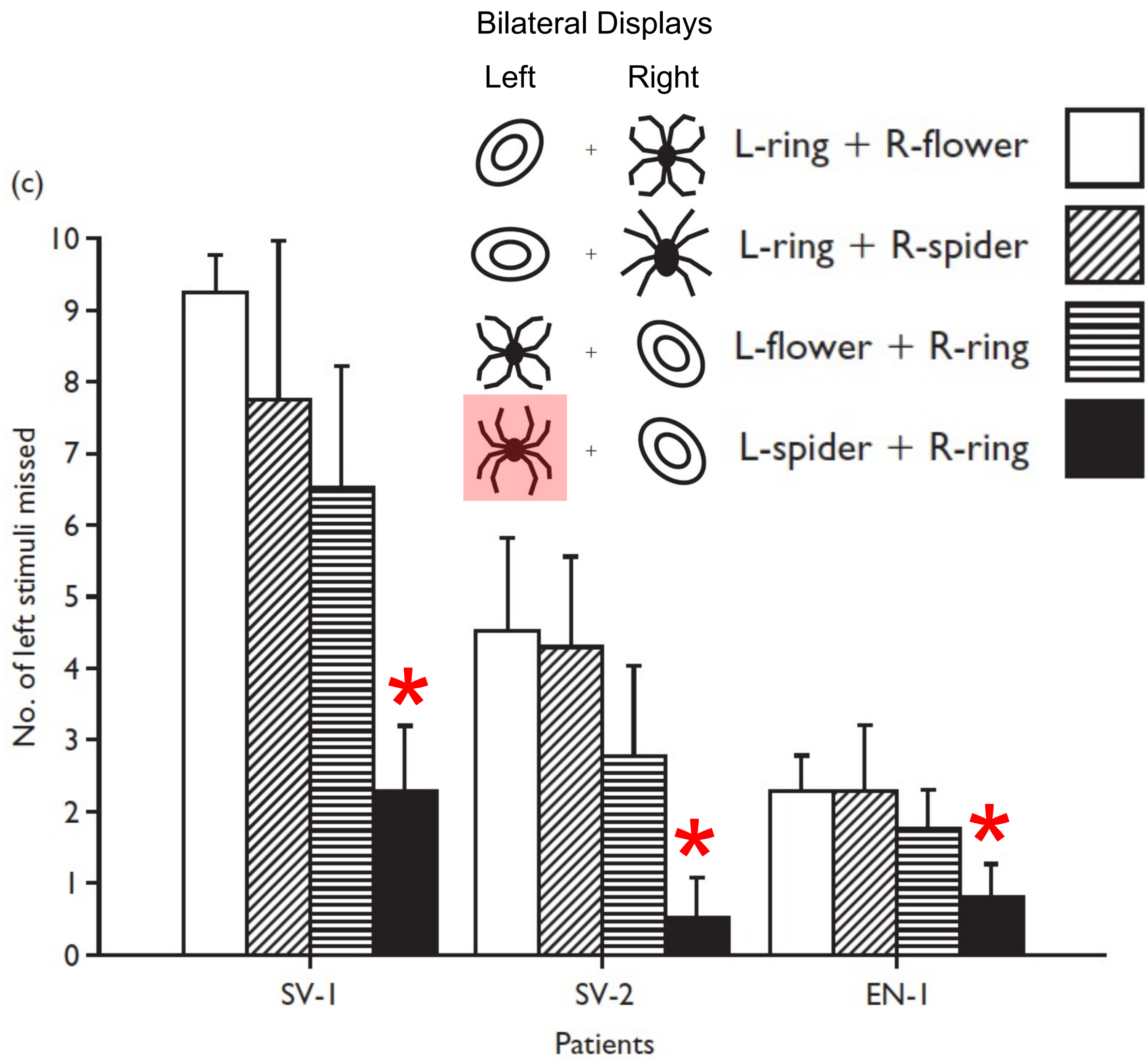
Step 1: the examiner indicated that he had a set of cards. P.S. was then shown individually two (otherwise matched) cards, one of which had flames on the left and one which did not. Upon each presentation, she was asked to describe the drawing. This was repeated twice, and each time, P.S. responded "A house".

Step 2: the two cards (vertically aligned) were placed on the desk top in front of the patient in free vision, and P.S. was asked if the two houses were "the same or different". She replied that they were the same. She was then asked if there was "anything wrong" with either card. She replied "no" and repeated that "they are the same".

Step 3: the cards were again presented together on the desk top, one above the other and centred on the midsagittal plane of the patient's head and trunk. The viewing distance was approximately 16 inches, although body, head and eye movements were in no way constrained. This was repeated 11 times, with alternate vertical ordering. On each trial, P.S. was asked which house she would prefer to live in. She thought this a silly question ("because they're the same"), but when forced to make a response, chose the non-burning house on 9/11 trials ($P = 0.033$, binomial test).

J.C. Marshall and P.W. Halligan (1988) Nature 336(6201):766-7.

Potent image content, although neglected, may be processed to a stage at which it elicits an appropriate emotional response.



Patients with left hemispatial neglect arising from right parietal damage were required to report, in response to each visual display, whether it contained an item on the right, an item on the left or items on both sides and to name each present item (ring, flower or spider). In bilateral displays, an emotional stimulus (spider) on the left robustly escaped extinction. This outcome suggests that visual pathways unaffected by neglect, possibly traversing the amygdala and temporal lobe, mediate the identification of and capture of attention by emotional stimuli.

P. Vuilleumier & S. Schwartz, NeuroReport 12(6): 1119-1122 (2001).

Potent image content, although neglected, may be processed to a stage at which it acquires salience sufficient to counteract extinction.

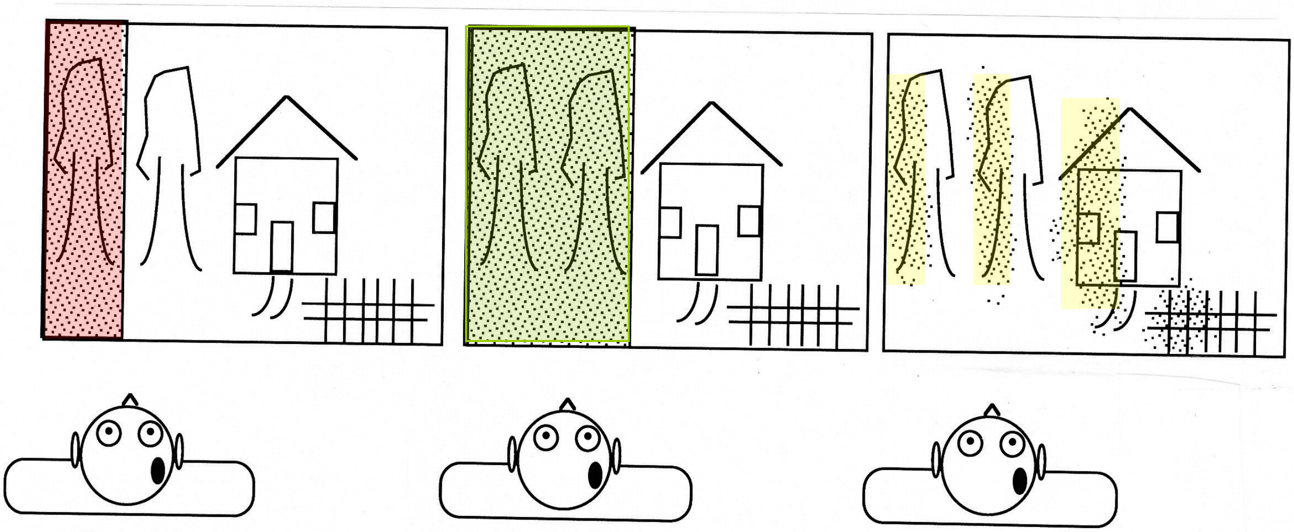
Egocentric

Retina
Head
Trunk

other
Allocentric

Environment
Scene

Object

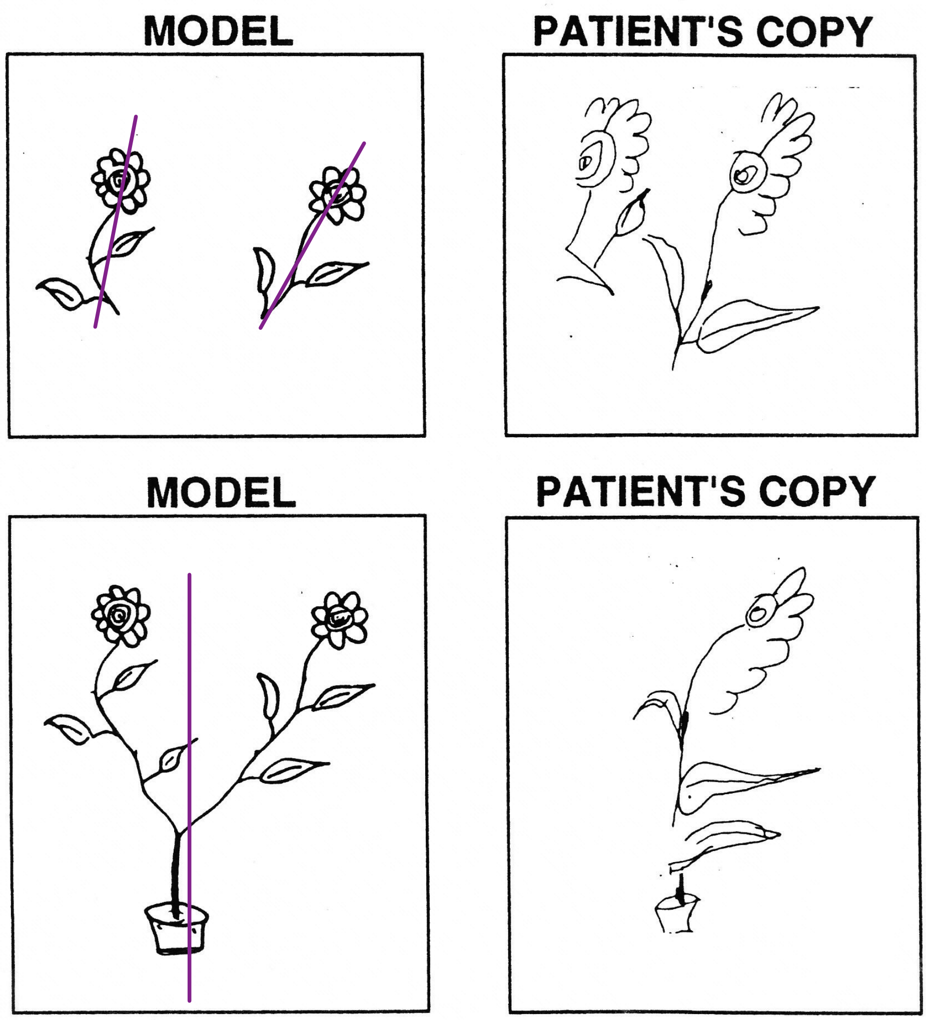


There are various spatial reference frames with respect to which neglect might be defined.

all of the above!

Some neglect patients, in copying, make object-centered left-sided omissions.

object-centered



J.C. Marshall and P.W. Halligan, J. Neurol. 240: 37-40 (1993)

Arguin and Bub (Cortex 29:349-357, 1993) measured the RT for a patient with left-sided neglect to name a letter presented in an array in which the other 3 elements were just filled circles. They found that the neglect was partly array-centered.

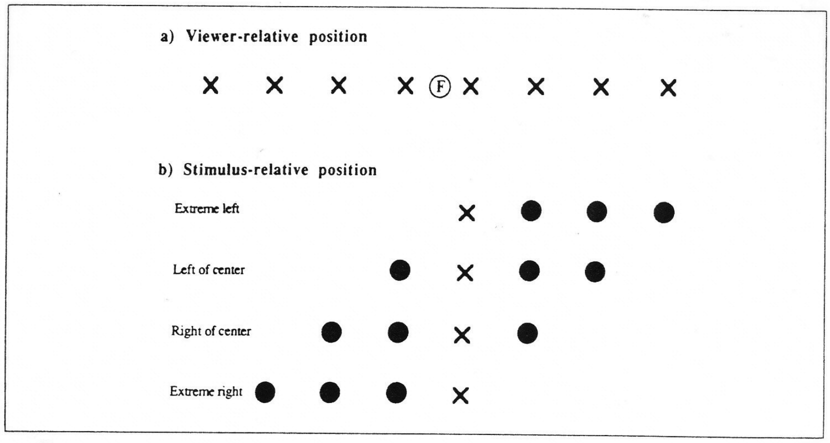


Fig. 1 – *(a) Set of possible locations (X) occupied by the target relative to the central fixation point (F). (b) Set of possible locations occupied by the target within the stimulus array. All these within-array locations were tested at each possible target location relative to the fixation point.*

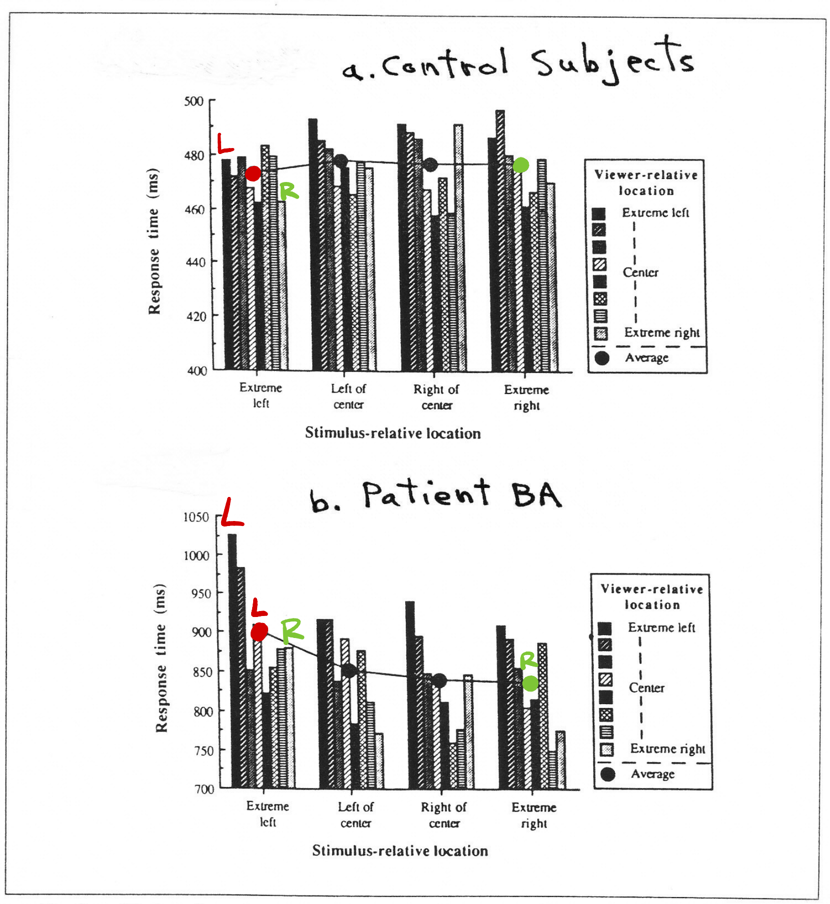
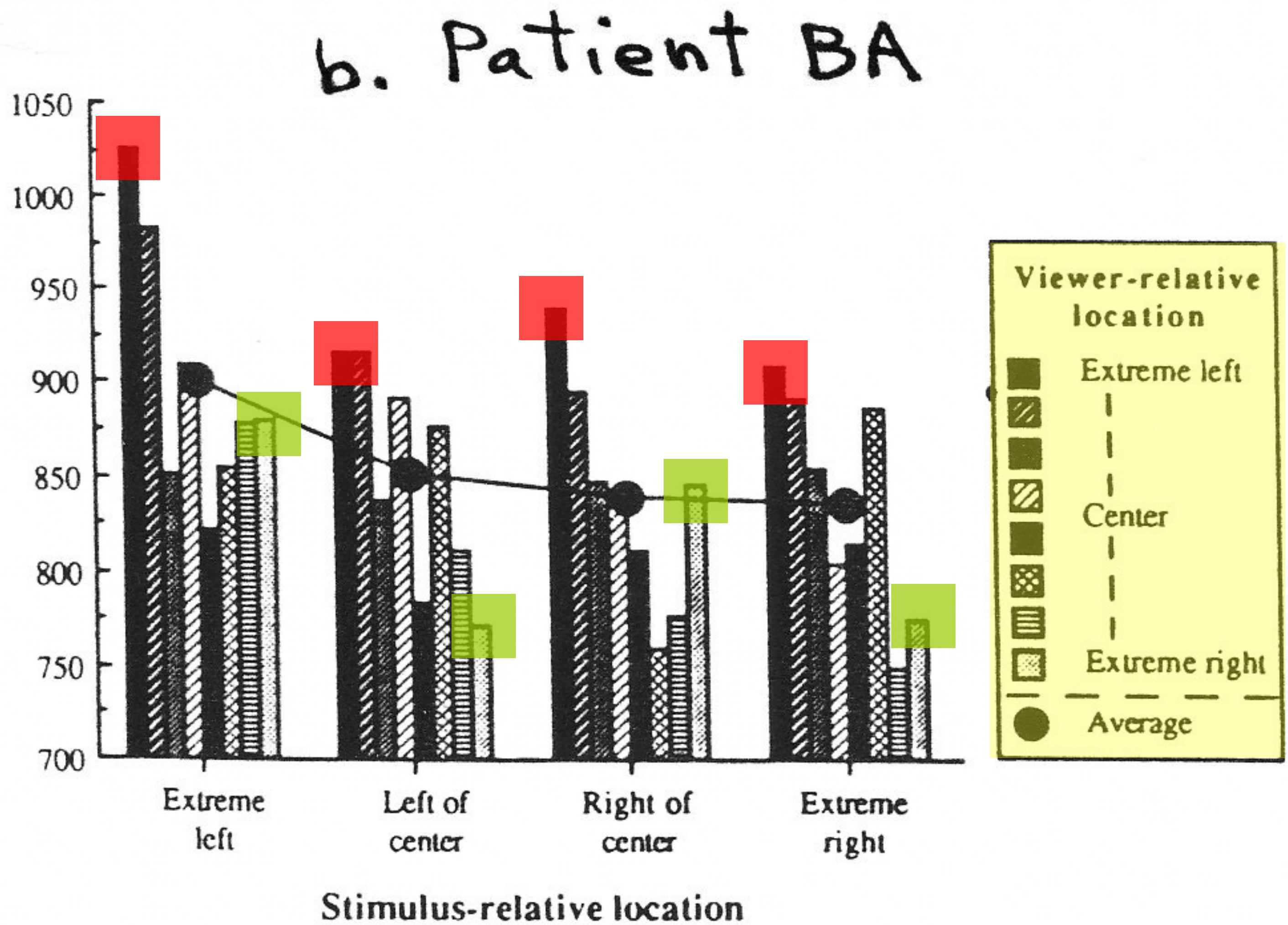
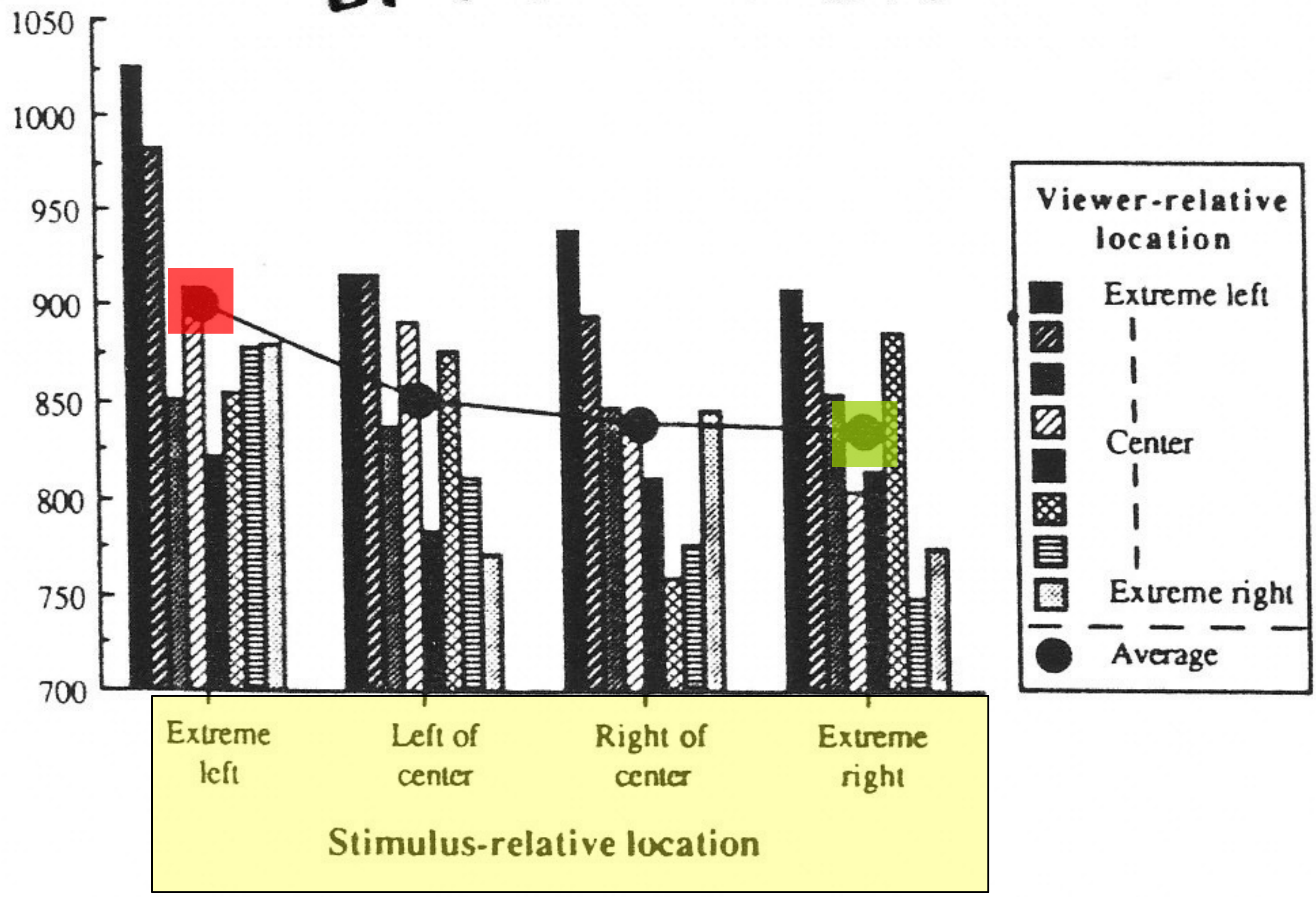


Fig. 2 – *RT data from the present experiment. The histograms represent the average RTs observed in the normal controls (a) and in B.A. (b) in each of the conditions. Superimposed over the histograms is a line graph illustrating the RTs, averaged over the different levels of the viewer-centered factor, for each level of the stimulus-centered target location factor. Note that the scale of the vertical axis is markedly different in these two graphs.*


b. Patient BA
1050
1000
950
900
850
800
750
700
Extreme left
Left of center
Right of center
Extreme right
Stimulus-relative location
Viewer-relative location
Extreme left
Center
Extreme right
Average

b. Patient BA



1050
1000
950
900
850
800
750
700
Extreme left
Left of center
Right of center
Extreme right
Stimulus-relative location
Viewer-relative location
Extreme left
Center
Extreme right
Average

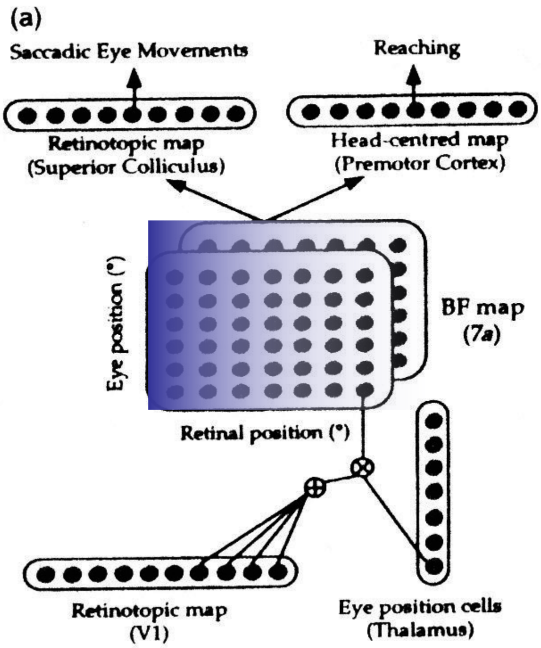
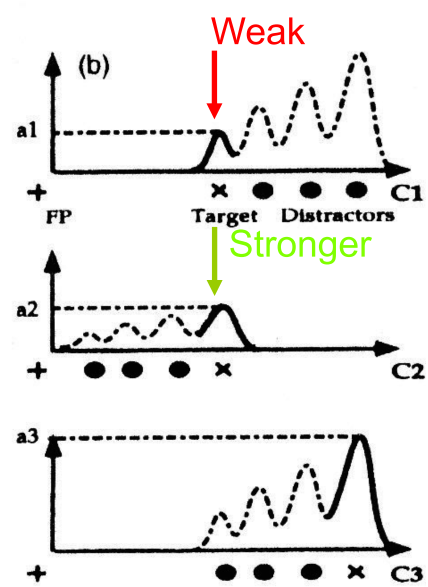


Fig. 7.3 (a) Network architecture. Each unit in the intermediate layers is a basis-function unit with a Gaussian retinal receptive field modulated by a sigmoid function of eye position. This type of modulation is characteristic of the response of parietal neurones.

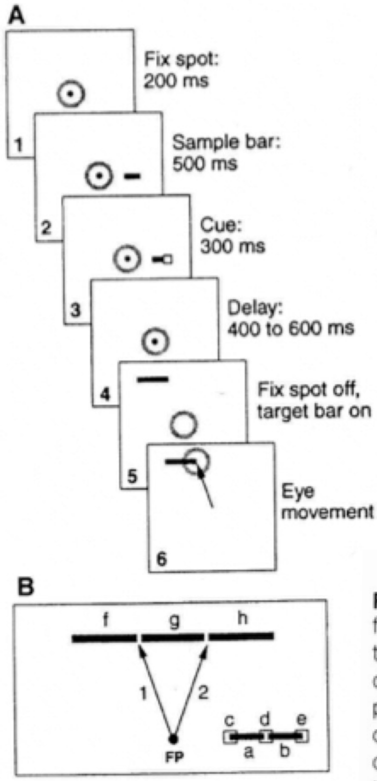


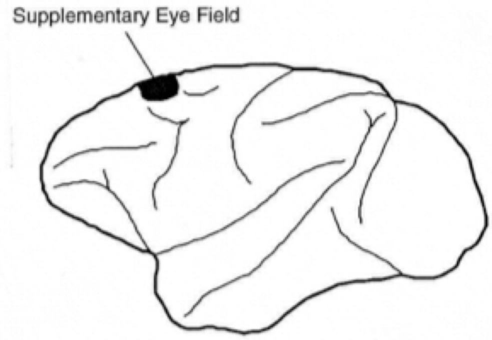
The occurrence of array-centered neglect as described by Arguin and Bub in the previous study, seems to imply that there must have been a loss of neurons representing the halves of arrays or objects rather than simply the left half of the visual field. However…

Fig. 7.7 Activity patterns in the retinotopic output layer when simulating the experiments by Arguin & Bub (1993). Reaction time between conditions 1 and 2 decreased, owing to the change in the relative saliency of the target

Alex Pouget claimed that the result obtained by Arguin and Bub could arise from damage to a network in which all neurons have retina-centered receptive fields organized into a map of the visual field. One must assume only (1) that neurons progressively farther to the left give progressively weaker visual responses and (2) that neighboring neurons inhibit each other. Neurons responding to an element at a given retinal location will fire more strongly when it is the leftmost item in an array than when it is the rightmost item.

Poget and Sejnowsli in The Hippocampal and Parietal Foundations of Spatial Cognition.





Robust encoding of object-centered processing

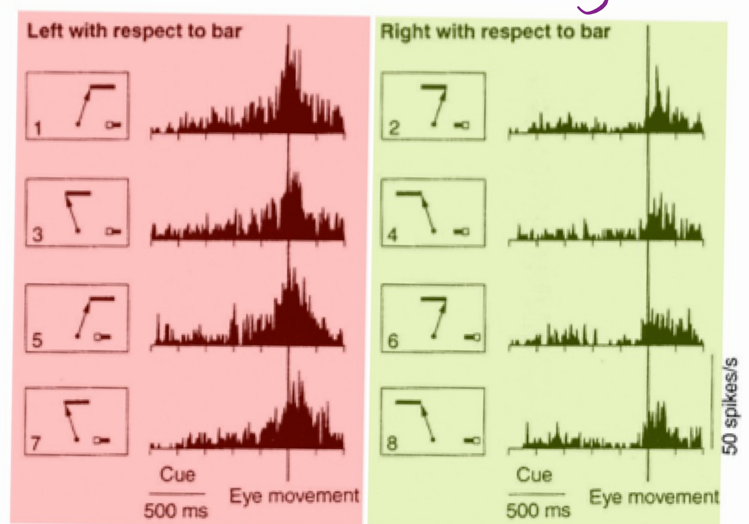


Fig. 2. Data collected from a neuron during the test for object-centered direction selectivity. Each panel represents the location of sample bar, location of cue, location of target bar, and direction of the eye movement for one condition. Panels are numbered according to the conditions listed in Fig. 1C. Each histogram represents neuronal firing rate as a function of time during successfully completed trials for the condition indicated to its left. Data from successive trials are aligned on the time of onset of the eye movement (vertical line). The time of onset of the cue (vertical shaded bar) varied across trials because of randomization of the interval between cue onset and target onset. Firing depended primarily on the direction of the eye movement relative to the bar (leftward in the left column; rightward in the right column) and not on its direction relative to the orbit (rightward in rows 1 and 3; leftward in rows 2 and 4). Note that conditions 1 and 2 are matched for both the retinal location of the cue and the orbital direction of the eye movement, as are conditions 3 and 4.

Olson & Gettner, pp. 985-988

SCIENCE • VOL. 269 • 18 AUGUST 1995

While Pouget was technically correct in saying that object-centered neglect need not arise from damage to neurons with object-centered spatial selectivity, he did not at all rule out this mechanism as a possibility. Indeed, we now know that neurons with object-centered spatial selectivity exist in the cerebral cortex of the monkey.

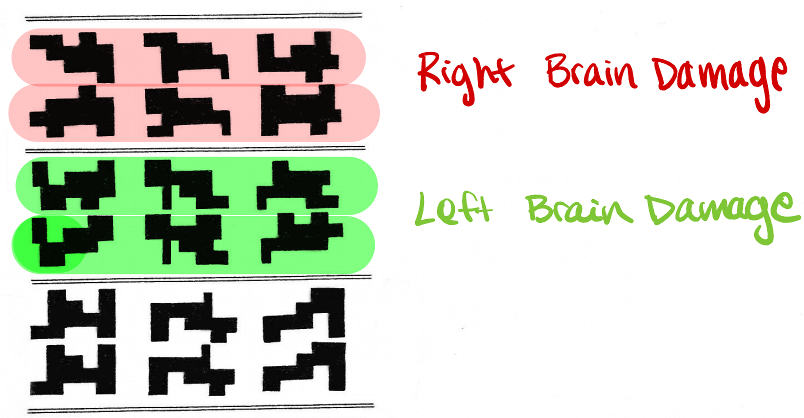


FIG. 1. Drawings of the nine pairs of shapes used in both the "static" and "dynamic" conditions. The top three pairs differ on the left, the middle three pairs differ on the right, and the bottom three pairs are identical. The mirror images of these nine pairs were also used.

Table 1. Group means for correct responses in the "static" and "dynamic" conditions

	Mean number of correct responses											
	"Static" condition*						"Dynamic" condition†					
	Same	S.D.	Different on left	S.D.	Different on right	S.D.	Same	S.D.	Different on left	S.D.	Different on right	S.D.
LBD	4.1	0.9	5.0	1.1	3.6	1.6	9.5	1.7	7.8	1.5	5.3	2.3
RBD	4.1	1.9	4.4	1.0	4.8	1.2	9.4	1.6	5.4	2.9	7.8	2.5
Controls	4.9	1.1	4.9	1.3	4.8	1.1	10.4	1.7	8.3	2.1	7.9	2.5

*Maximum possible correct for each pair type = 6.
†Maximum possible correct for each pair type = 12.

Ogden, Neuropsychologia 23:273-277 (1985)

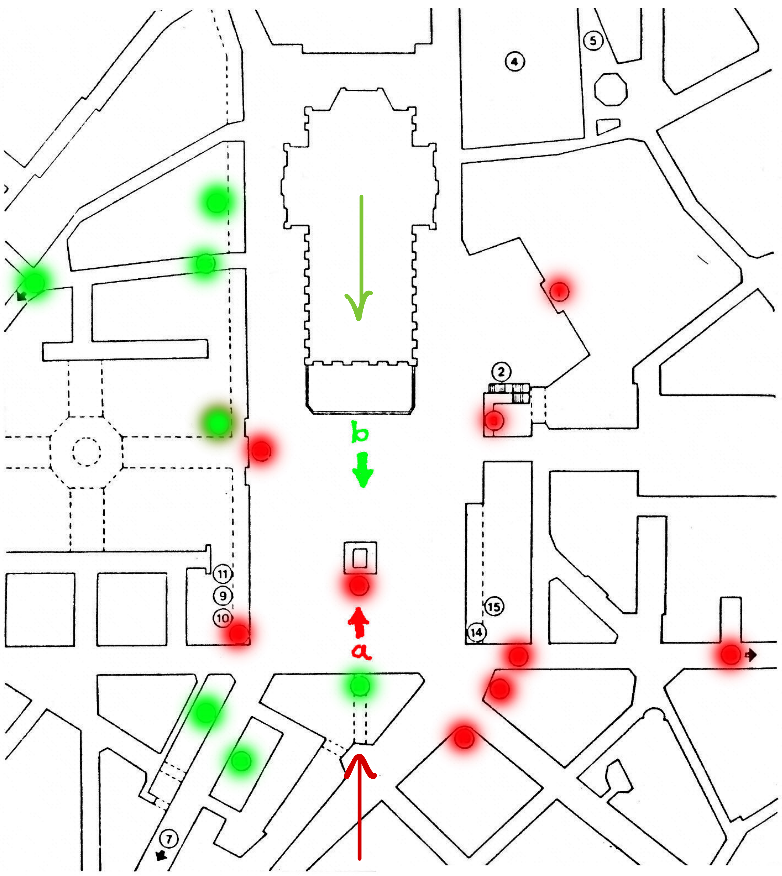
Ogden used a technique developed by Bisiach to test the notion that is a "representational" impairment. Subjects made same-different judgments on a pair of arbitrary shapes viewed as they slid sideways successively behind a narrow vertical slit. The objects in a pair could differ with regard to their left side (top row), their right side (middle row) or neither side (bottom row). Left (LBD) and right (RBD) brain-damaged patients made more errors when the differentiating detail was on the right or left respectively – i.e., when it was on the contralesional side.

Figure 1.5
Two views of the Piazza del Duomo in Milan, Italy.

Bisiach & Luzzatti's famous demonstration, based on having neglect patients describe the Piazza del Duomo in Milan from various remembered perspectives, that neglect can affect even mental representations of scenes.

Case 2

N.V., a lawyer of 72, had a stroke on December 2nd, 1977. Neurological examination revealed a very slight left hemiparesis with left hemianopia and severe left hemihypesthesia. He was completely anosognosic for the above-mentioned deficits. The tests were begun on the same evening. The scanning task elicited complete neglect of the left half of the pattern, which could not be overcome in spite of the examiner's remarks.



Has perfectly good memory

Neglects things on bad side

Description of the square. Perspective *a.* "The cathedral; the corner of the Royal Palace (1); the Arengario (3); the Vittorio Emanuele II monument (13); the northern (6) and southern (14) arcades; the lamps; Galtrucco (15); Piazza Missori (16) at the end of Via Mazzini (17); Al Duomo stores (18), ... but they are no longer there; Alemagna (19)." After the examiner's invitation to continue his description, he added: "The front of the Galleria (20) with the terraces and Motta (12)."

Perspective *b.* "The palace with the arcade to Via Orefici (21); the Palazzo dei Giureconsulti (22); the Loggia dei Mercanti (23); Motta (12); Rinascente (8); Piazza San Fedele (24); Via San Raffaele (25)." The last 4 items were provided after the examiner's incitement to go on.

Note: Coslett (Brain 120:1163, 1997) reported that visual & imaginal neglect may occur independently.

Cortex 14: 129-133 (1978)