Behavioral Neuroscience A
12: “Attention”

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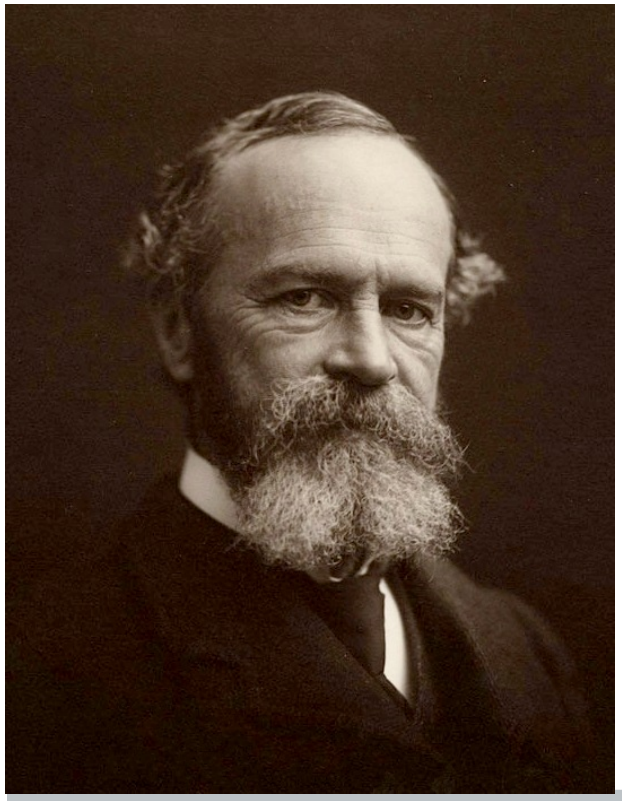
https://youtu.be/RnLUz1gtDJ8

Lecture Video at above link.

“Every one knows what attention is”

Every one knows what attention is. It is the taking possession by the mind, in clear and vivid form, of one out of what seem several simultaneously possible objects or trains of thought. Focalization, concentration, of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others, and is a condition which has a real opposite in the confused, dazed, scatterbrained state which in French is called *distraction*, and *Zerstreutheit* in German.



William James (1842-1910)

William James, The Principles of Psychology, 1890

Attention doesn’t exist

In everyday language, we use “Attention” to refer to many different phenomena, which share a common theme:

You must focus on one **behavior/stimulus/task** while not being distracted by other tasks or stimuli.

However, people use attention in so many different ways, it is confusing.

Attention doesn’t exist

Behavior / Stimulus / Task can take many forms:

-Riding a bicycle

-Counting backwards by 7s (100, 93, 86, 79, 72…)

-Pushing a button as soon as a red square appears on a screen

-Listening to someone you are having a conversation with

-Looking to different parts of a picture to understand its contents

Sometimes we use it as a noun:

-Divide your attention between talking on the phone and driving your car.

Today's topics

Attention

1) Attention: definitions
2) Attention tests
3) Selective attention / change blindness
4) Posner cue-paradigm: benefits of attention
5) Top-down attention and sensory cortex
6) Fronto-parietal attention networks
7) Bottom-up attention
8) Hemispatial neglect

History: Defining “Attention”

Strange to say, so patent a fact as the perpetual presence of selective attention has received hardly any notice from psychologists of the English empiricist school. The Germans have explicitly treated of it, either as a faculty or as a resultant, but in the pages of such writers as Locke, Hume, Hartley, the Mills, and Spencer the word hardly occurs, or if it does so, it is parenthetically and as if by inadvertence. The motive of this ignoring of the phenomenon of attention is obvious enough. These writers are bent on showing how the higher faculties of the mind are pure products of 'experience;' and experience is supposed to be of something simply *given*. Attention, implying a degree of reactive spontaneity, would seem to break through the circle of pure receptivity which constitutes 'experience,' and hence must not be spoken of under penalty of interfering with the smoothness of the tale.

William James (1842-1910)

William James, The Principles of Psychology, 1890

Historically studied properties of attention

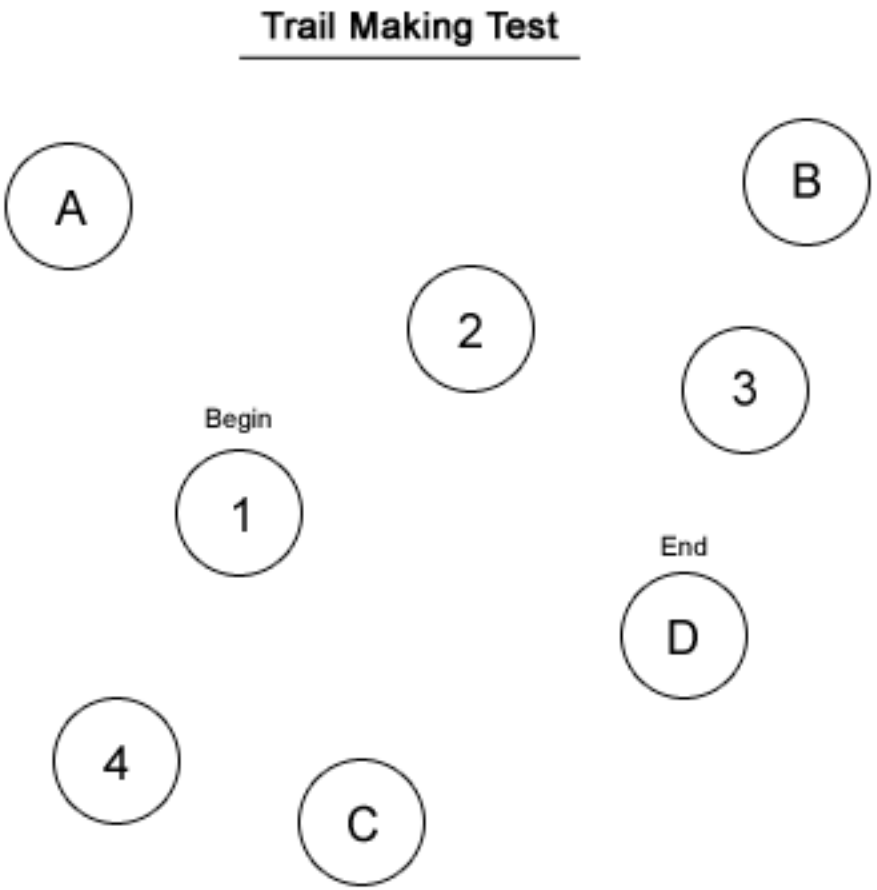
Selective attention:
occurs when we focus on one single entity (one single object, area in space, one stimulus feature) and suppress processing irrelevant stimuli (distractors).

Divided attention:
occurs when we are required to perform two (or more) tasks at once (like driving a car).

Sustained attention:
occurs when we are required to perform a task for an extended period of time (like monitoring a radar).

Example: test of attention

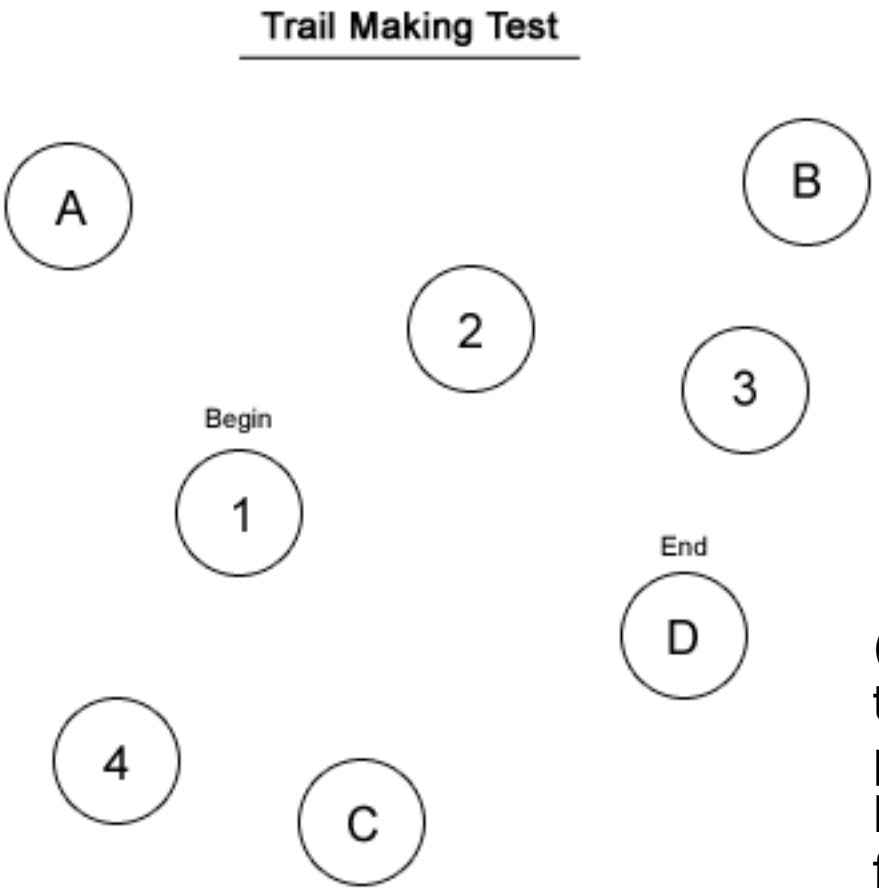
Trail making test (1944): divided attention (requires also visual scanning, visuomotor tracking)



Task: Connect discs: 1-A-2-B-3-C-4-D

Example: test of attention

Trail making test (1944): divided attention (requires also visual scanning, visuomotor tracking)



(You have to keep track of what your previous number or letter was, and search for next one...)

Task: Connect discs: 1-A-2-B-3-C-4-D

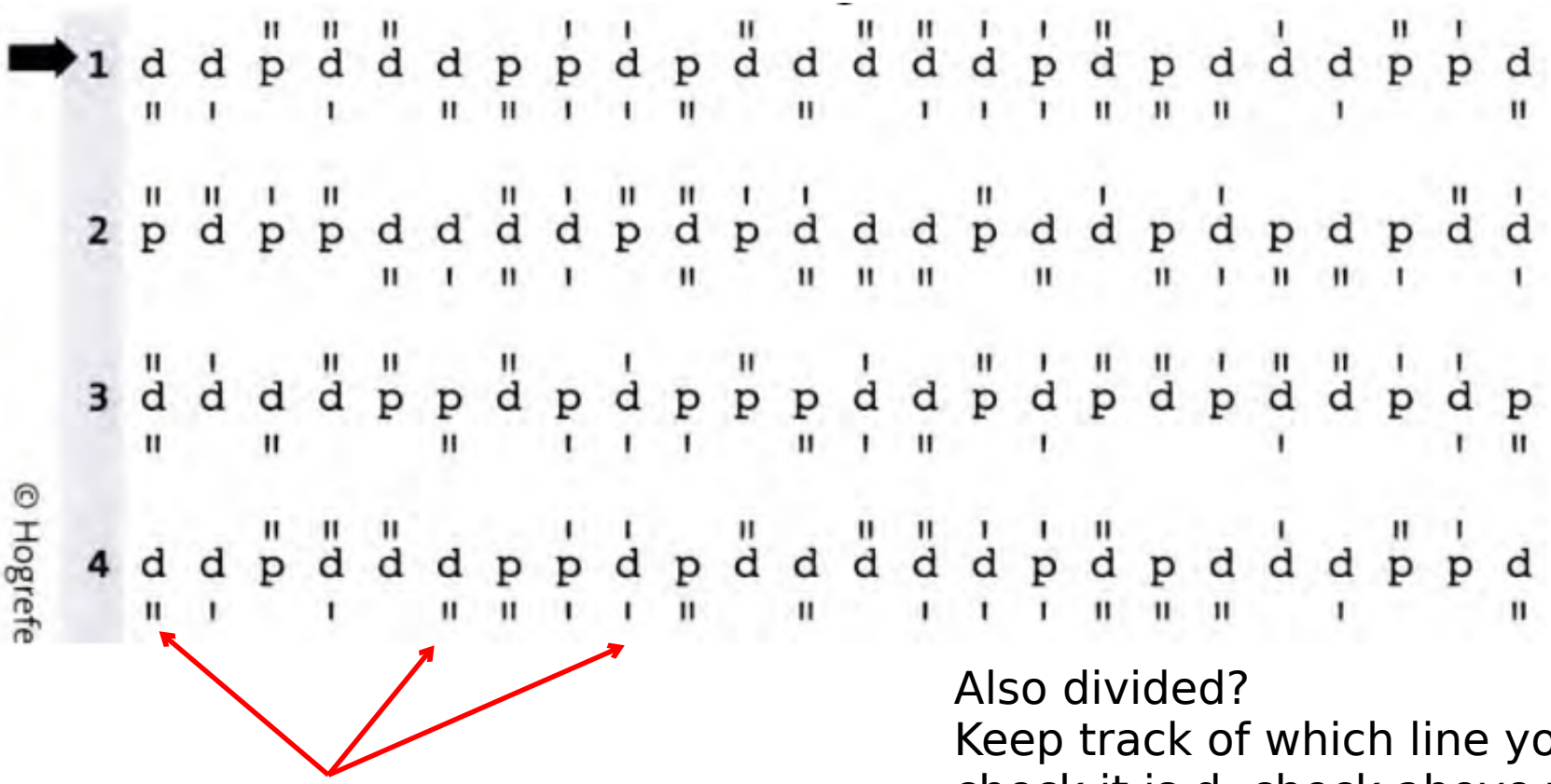
Tests of attention

d2: sustained attention/alertness

Find all ds with 2 lines!

Tests of attention

d2: sustained attention/alertness



Find all ds with 2 lines!

Also divided?
Keep track of which line you're on, check it is d, check above for lines, below for lines...do they add to 2?

Demonstrations: www.theinvisiblegorilla.com

the invisible gorilla

Christopher Chabris and Daniel Simons

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Demonstrations, videos from our research, videos of us speaking, etc. Dan's YouTube Channel includes most of these videos as well as favorites from around the web that are related to or mentioned in our book. You can view more videos on his personal website

The original selective attention task

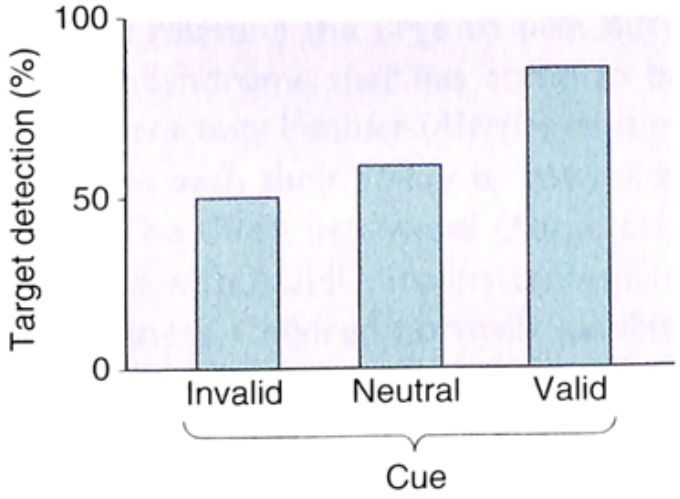
This video is the one that started our collaboration and inspired the book. You can read more about it here.

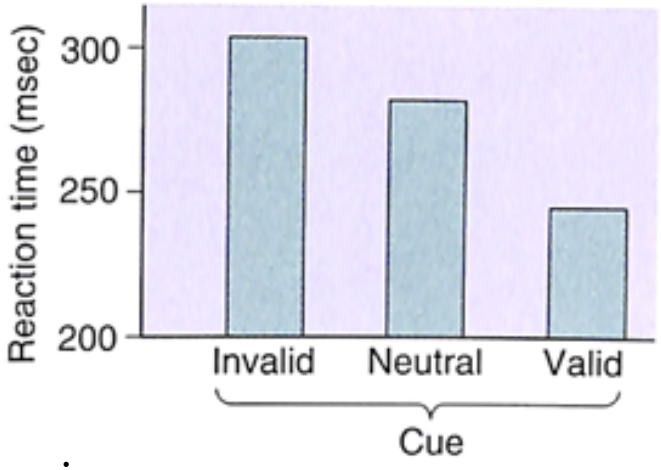
Selective attention can lead to "missing" unattended information.

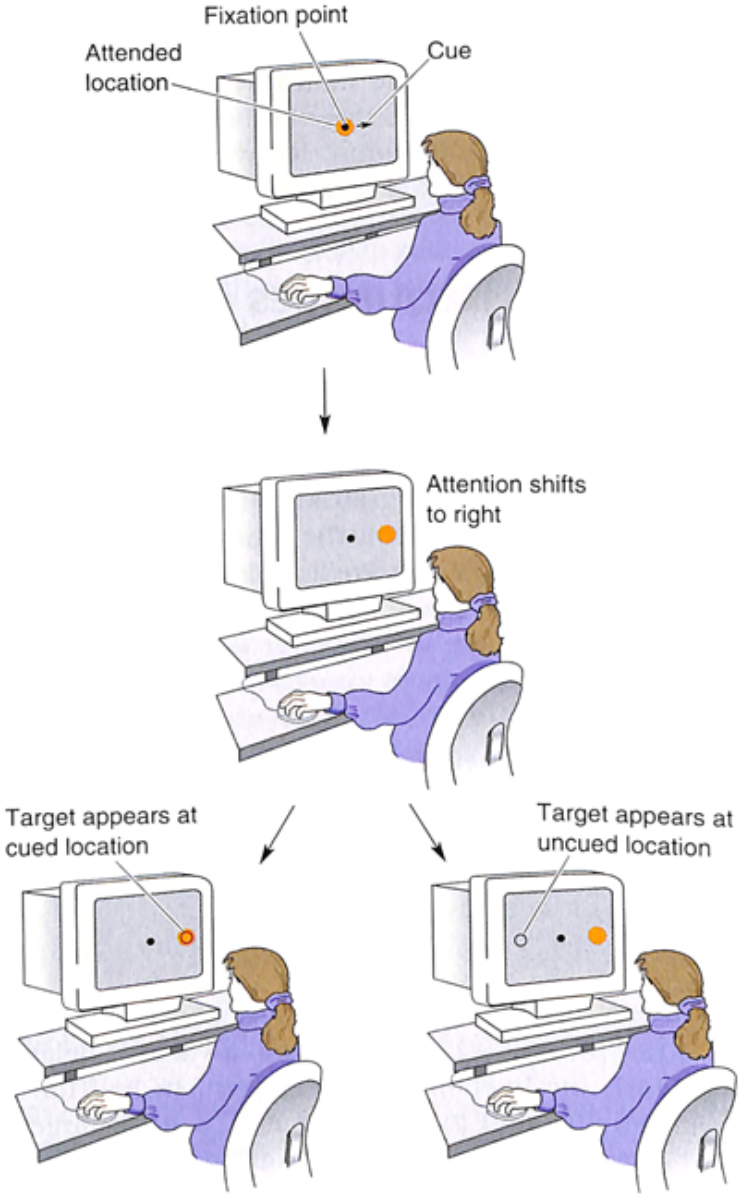
Change blindness refers to the situation that we are often "blind" to unattended but sometimes drastic changes.

Posner Paradigm: Your attention can be “cued”

Targets that appear in a position that has been “cued” (by an arrow) are detected with higher accuracy and speed (behavioral benefit).







Bear, Neuroscience

Why do we need attention…?

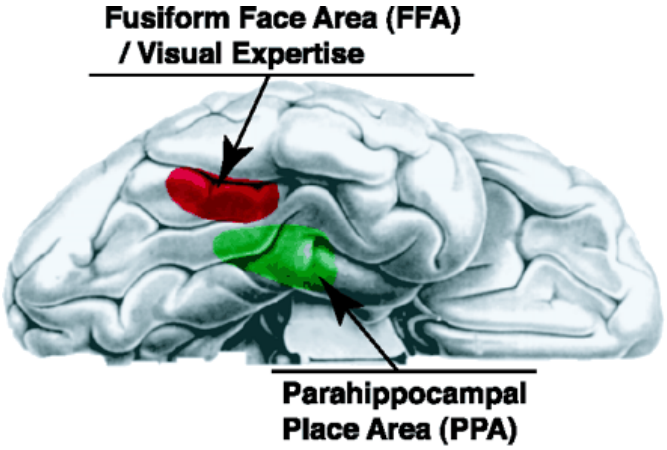
Attention allows us to focus on a few sensory elements that are important for our current task and to suppress irrelevant elements.

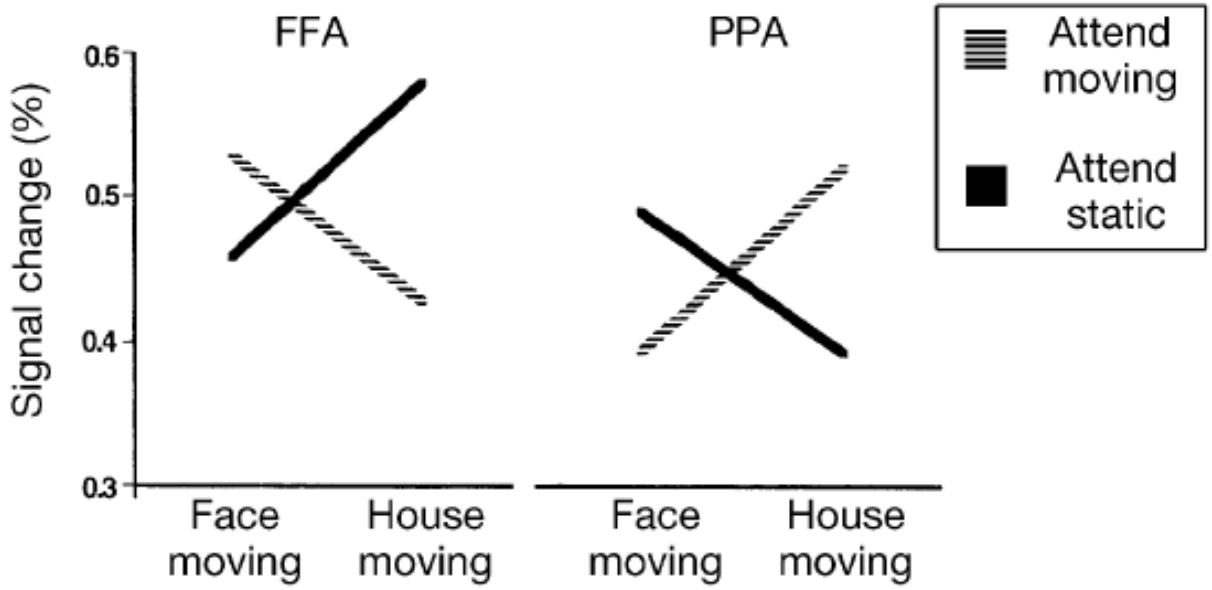
This helps to overcome limits:

- sensory processing limits (our sensory system can only process a limited amount of entities at a time – eyes can only point one direction at a time, etc.)
- response limits (we can only prepare a limited set of motor responses at a time)

FMRI shows neural modulation related to behavioral attention

Brain activity in areas related to faces or houses is increased when the respective object (face or house) is attended.





O'Craven et al., Nature, 1999

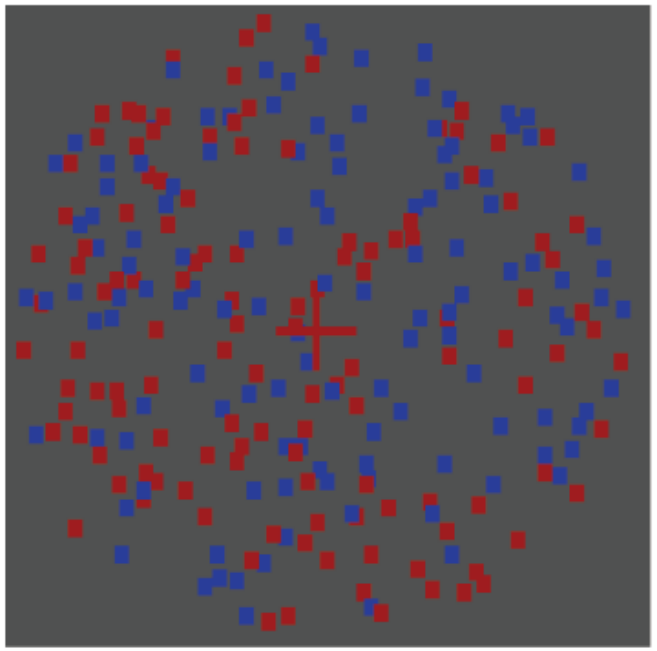
Fusiform face area: FFA, responds stronger to faces.

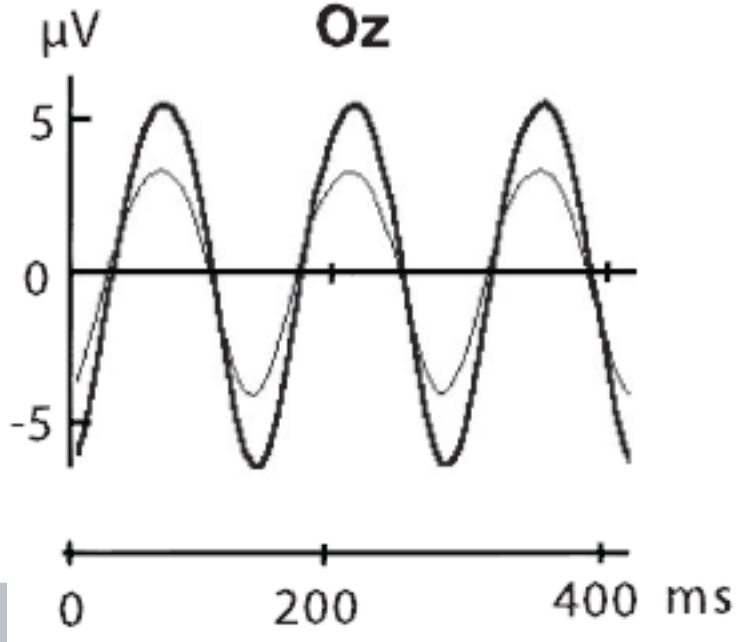
Parahippocampal place area (PPA), responds stronger to houses.

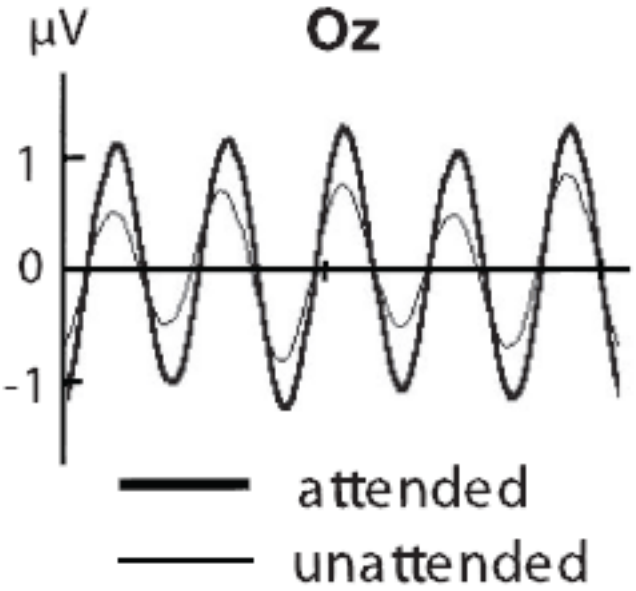
Attention: EEG

Blue and red dots flicker at different frequencies (7 and 11.67Hz) and elicit a visual steady-state response (vSSR, below) at these frequencies.

The amplitude of the vSSR is modulated by attention (compare attended and unattended below).

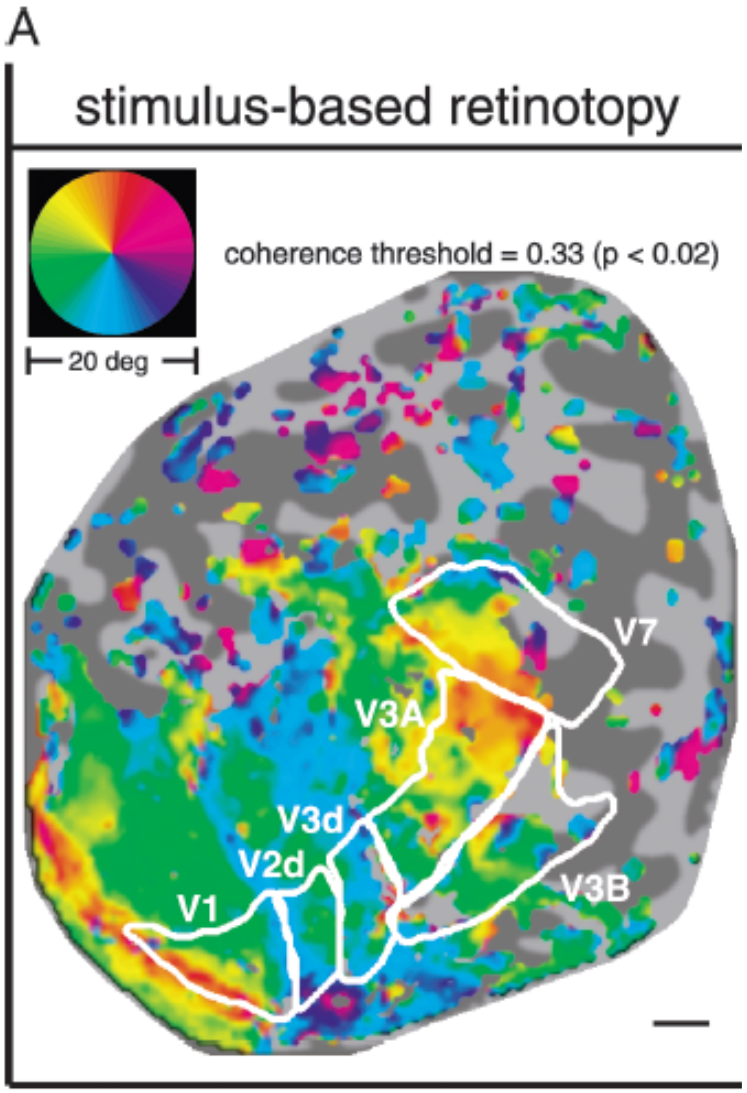






Müller et al., PNAS, 2006

FMRI: V1 activity changes with attention?



Graph A) shows the correlation of stimulated position in the visual field and the brain activated in visual cortex.

V1: primary visual cortex

This is NORMAL SITUATION (no attention)

Silver et al., Journal of Neurophysiology, 2005

Spoken command indicates where subject should attend

Attention-mapping:

In this experiment, the participants had to pay attention to the quadrant cued by a voice. Functional magnetic resonance images were acquired during this task.

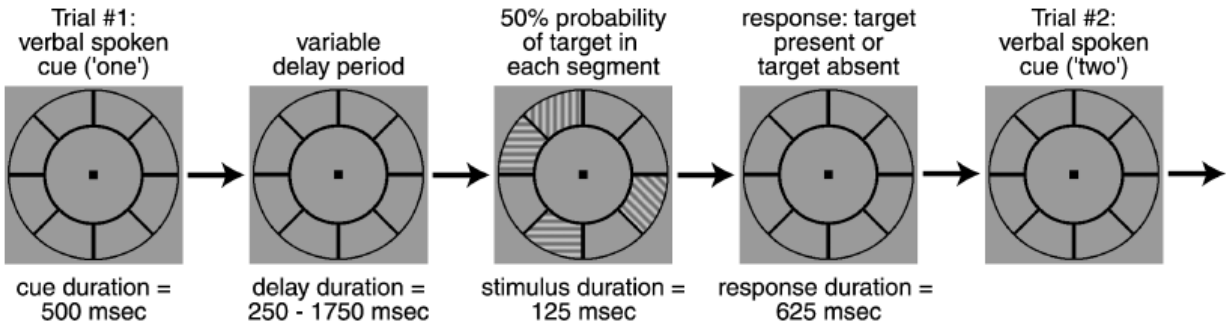
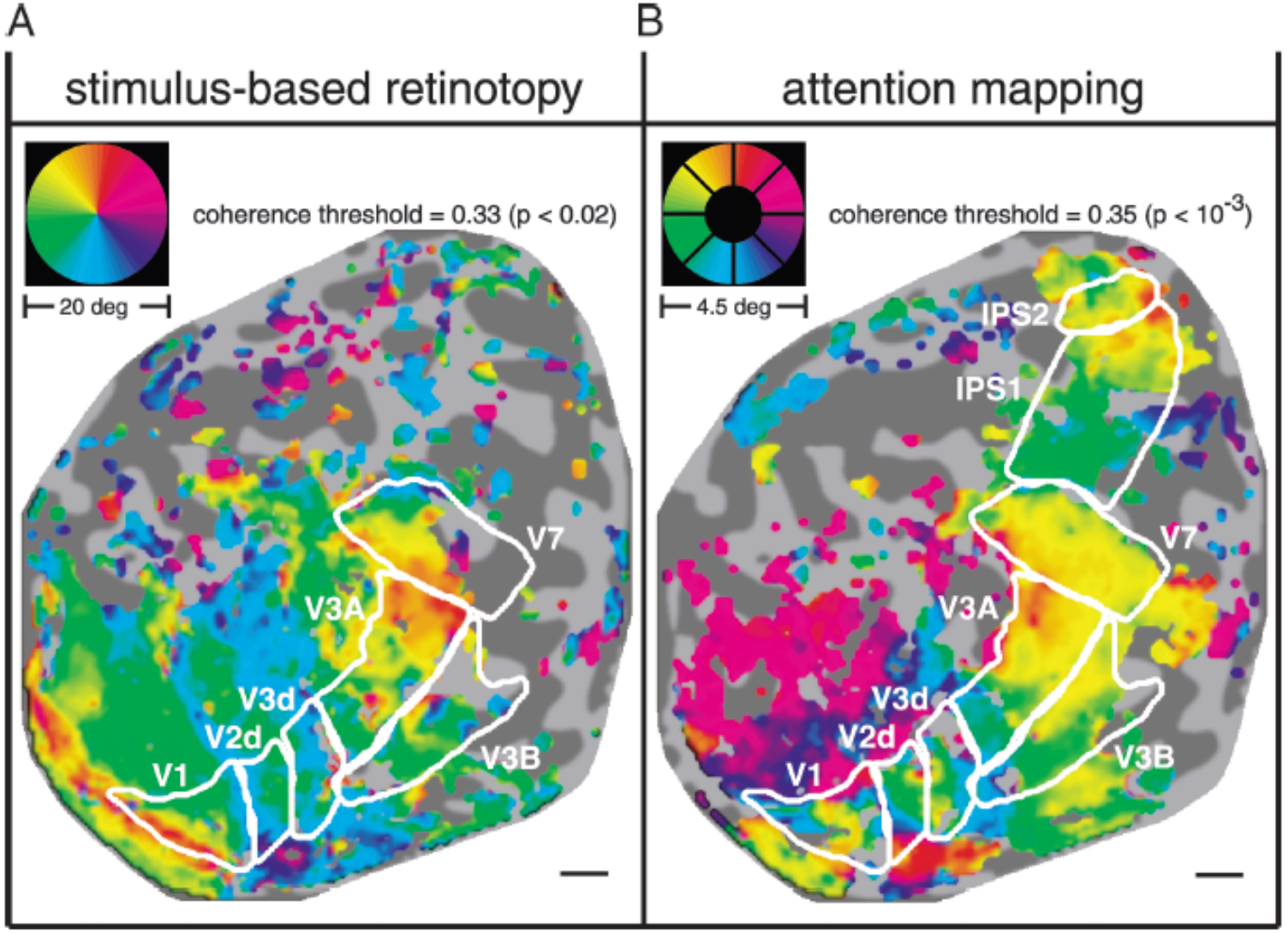


FIG. 1. Covert attention-mapping task used to generate maps of attention-related activity. Each trial began with an electronically synthesized spoken cue that corresponded to one of the segments in the annulus. After a variable delay period, a grating was presented with 50% probability, independently in each segment. An auditory click then signaled subjects to respond with a button press indicating whether a target was present or absent in the cued segment. After the response, the next trial began with another verbal cue that directed attention to one of the adjacent segments, either ascending in number (clockwise scans) or descending (counterclockwise scans). Total trial duration was 3 s. Subjects were instructed to maintain fixation throughout each scan and responded only to the cued segment on each trial. Only the cued segment varied systematically over time. Although there were visual stimuli presented on every trial, there was no systematic pattern of visual stimulation.

Silver et al., Journal of Neurophysiology, 2005

Normal situation ↔ Attended situation

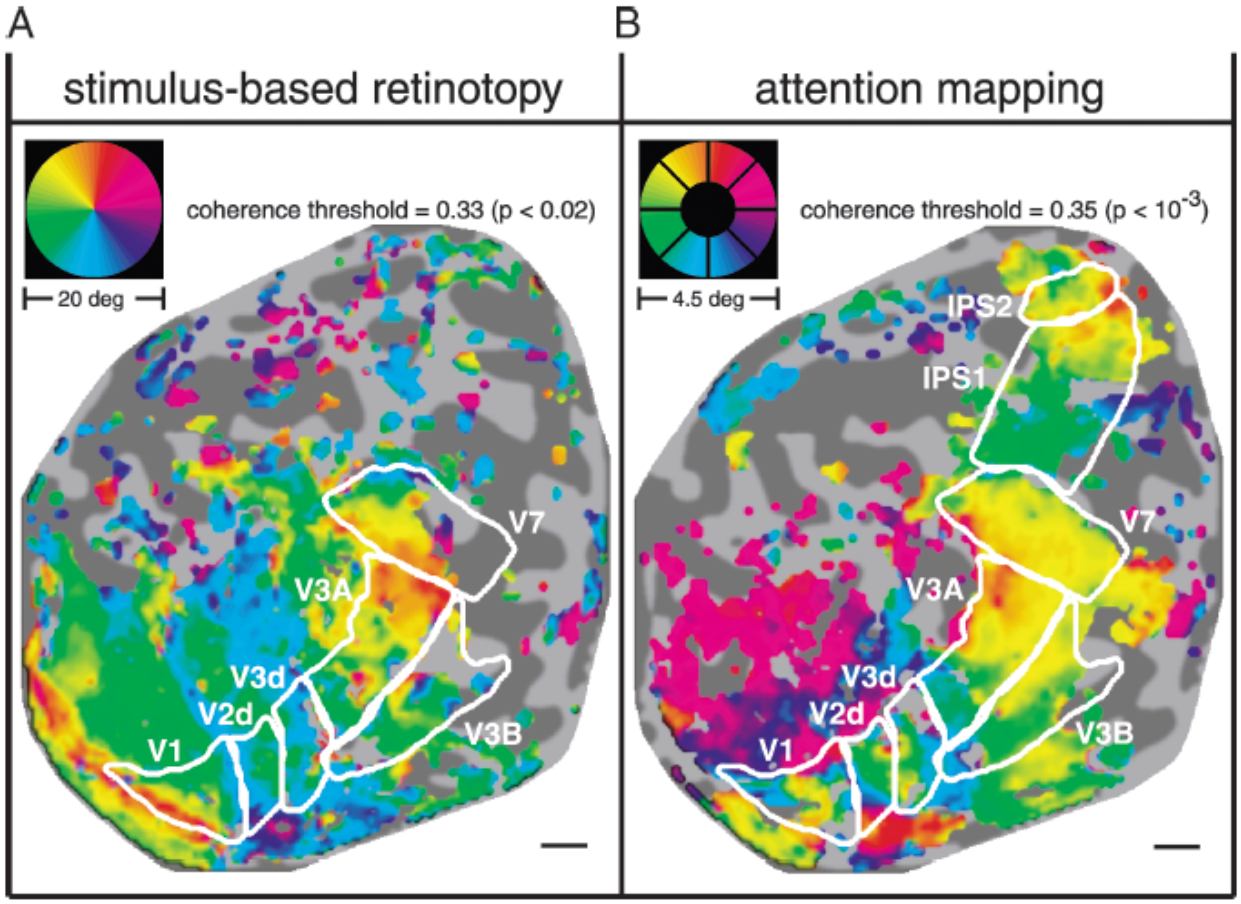
In graph B), we see the areas in visual cortex and intraparietal sulcus that show high correlation of fMRI activity with the attended quadrant (e.g., yellow: left upper).



Silver et al., Journal of Neurophysiology, 2005

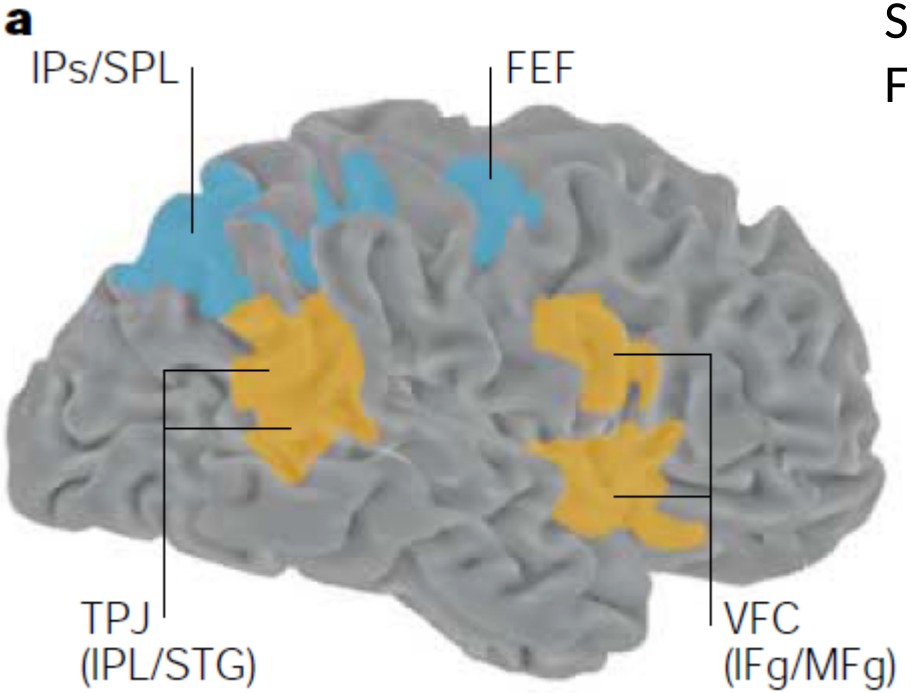
Parietal lobe has “spatial attention” map?

Parietal lobe has “attention map” that encodes position of attended visual field



Silver et al., Journal of Neurophysiology, 2005

Brain networks related to different types of attention



Dorsal fronto-parietal network:
IPs=intraparietal sulcus
SPL=superior parietal lobule
FEF=frontal eye field

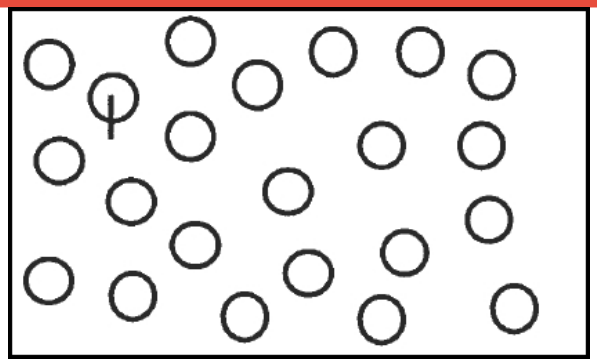
Top-down attentional control and selection. Both IPS and FEF are also involved in generating saccades (eye movements).

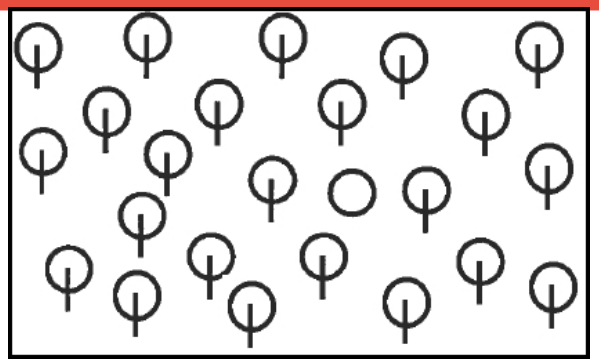
Ventral fronto-parietal network:
(right-lateralized)
TPJ=temporo-parietal junction
IPL=inferior parietal lobule
STG=superior temporal gyrus
VFC=ventral frontal cortex
IFg=inferior frontal gyrus
MFg=middle frontal gyrus

Bottom-up attention, stimulus-driven (unexpected stimuli)

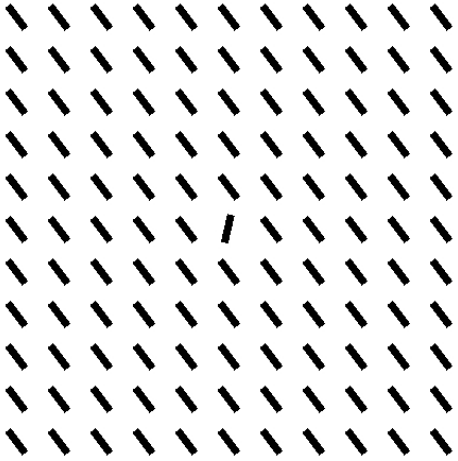
Corbetta, Nature Reviews Neuroscience, 2002

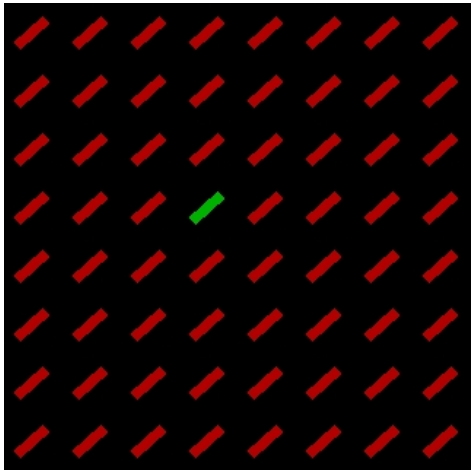
Bottom-up visual attention “pop-out”

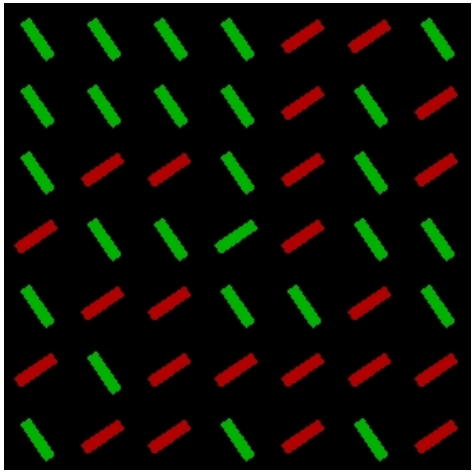




Vasconcelos, UCSD







The ventral fronto-parietal attention network is involved in bottom-up driven attention such as pop-out effects. These occur when objects with particular features within a set of distracters “pop out” or grab attention.

Bottom-up (Auditory)
“Cocktail Party” effect

You can focus your attention to follow a single conversation and suppress other, irrelevant, distracting conversations.

-> Cocktail-party effect

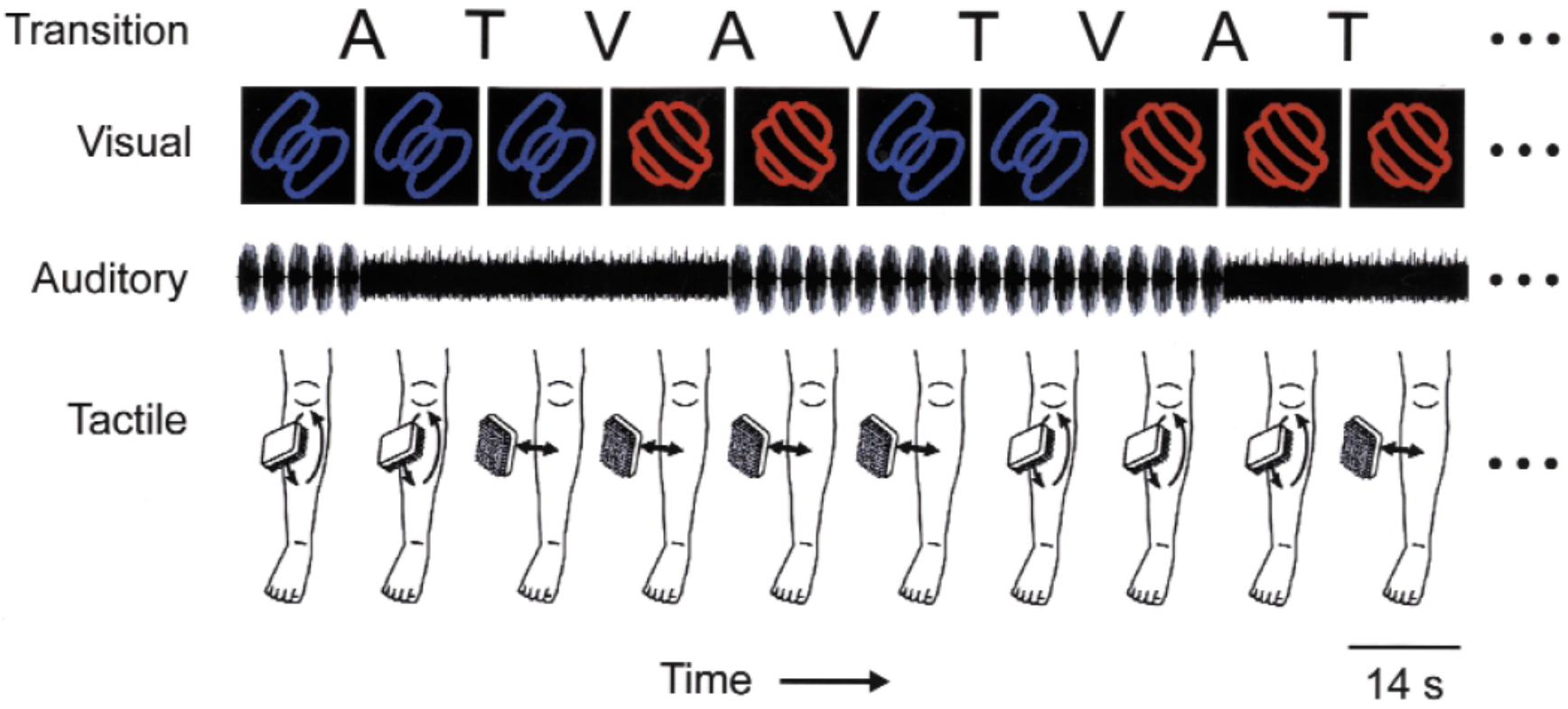
Sound source localization and separation support this effect.

However, a salient sound (your name, your cell phone) will still be processed even if it was unattended.

-> Bottom-up attention

Attending to different sensory modalities (sight vs sound vs touch)

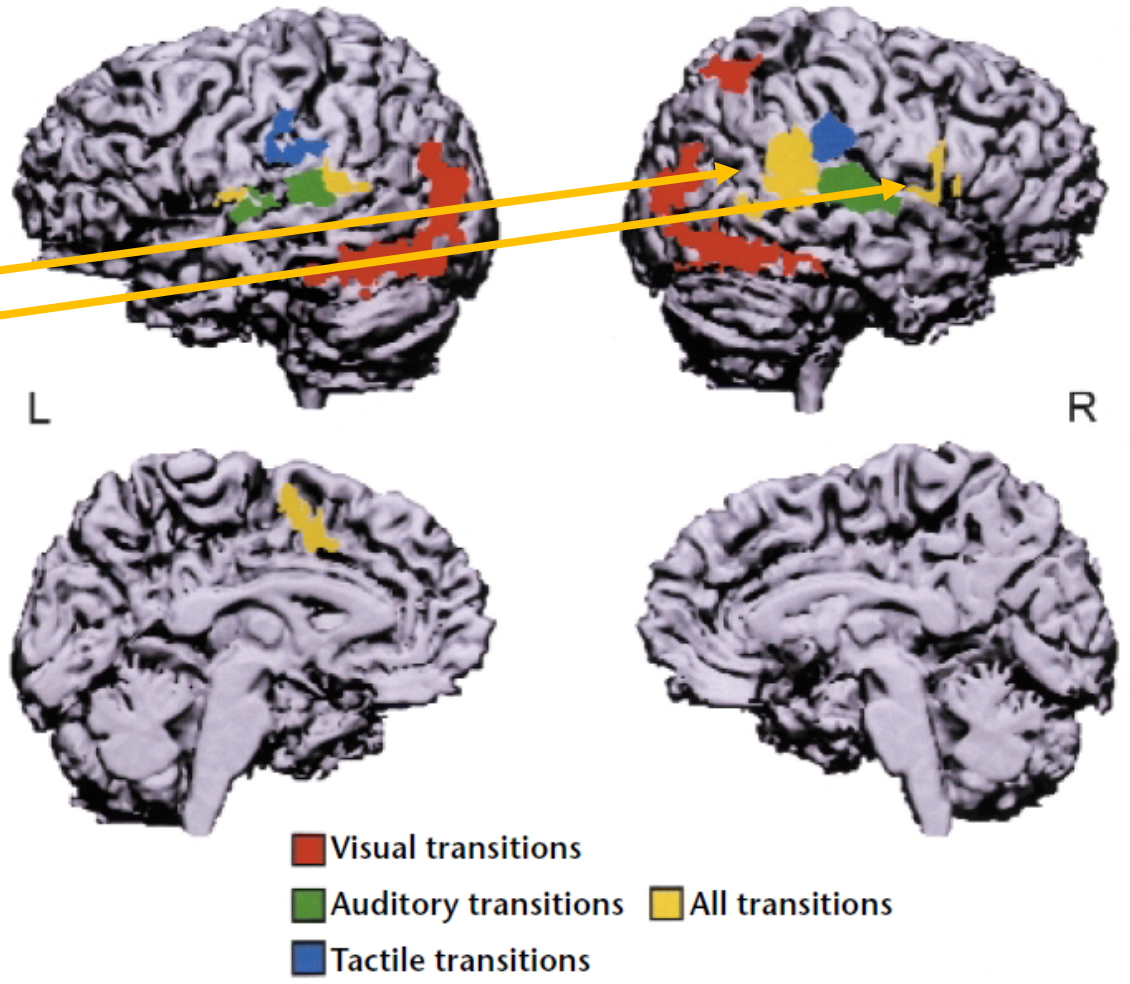
In this functional magnetic resonance imaging experiment, subjects were constantly stimulated in three different modalities: visual (red/blue shapes), auditory (water running, frog), and tactile (brushing/tapping on leg). Brain activity in response to the changes was measured.



Downar et al., Nature Neuroscience, 2000

Ventral fronto-parietal network

Change-related activity that occurred across all three modalities was observed mainly in the right hemisphere, in the temporoparietal junction (TPJ), Inferior frontal gyrus, Insula, left cingulate/supplementary motor area.



Downar et al., Nature Neuroscience, 2000

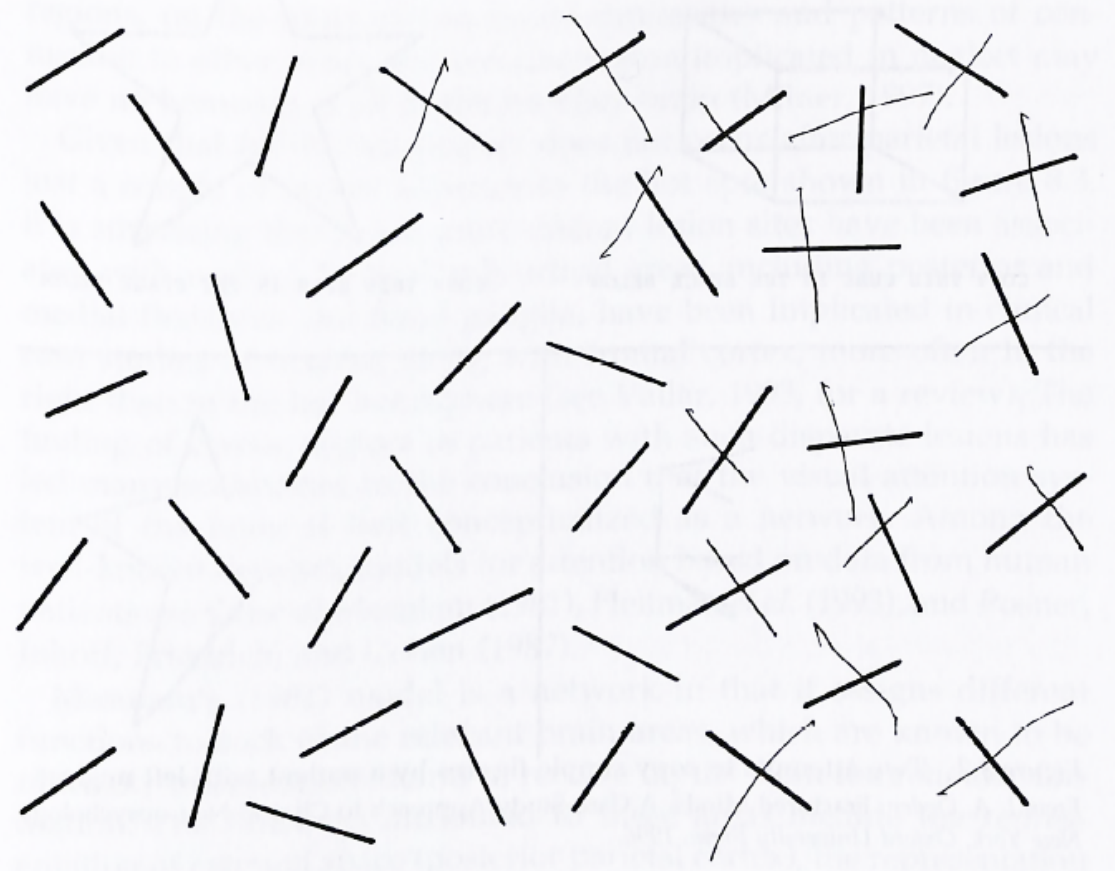
Hemispatial Neglect

Neglect patients “neglect” (do not process) contralesional stimulation.

For example, neglect patients search for objects only in the “good” hemisphere.

Neglect patients neglect one half of their own body (e.g., when using make-up or shaving).

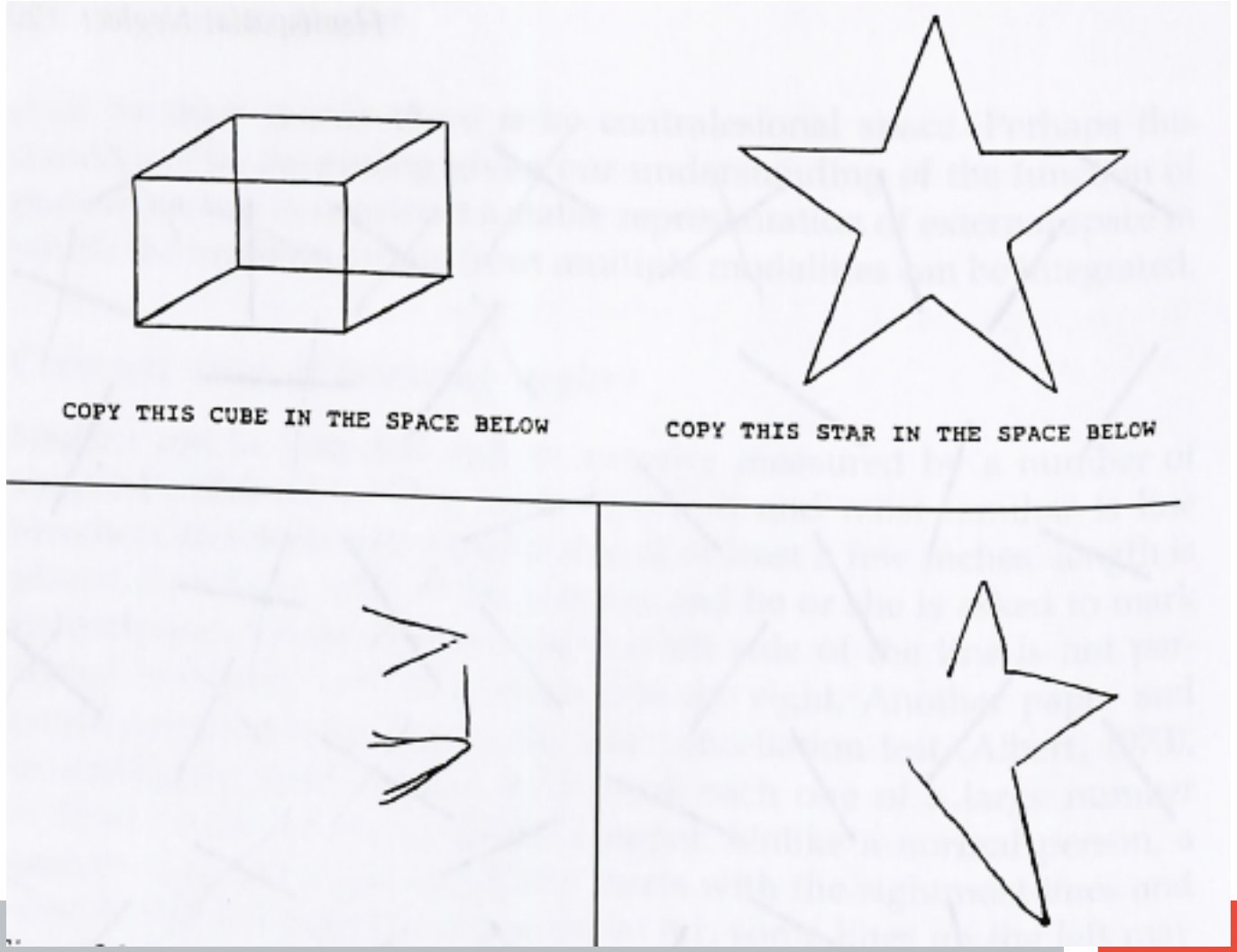
Neglect patients may eat only half of their plate.



Line-bisection test: patients with left hemispatial neglect cross only the right lines.

Hemispatial Neglect

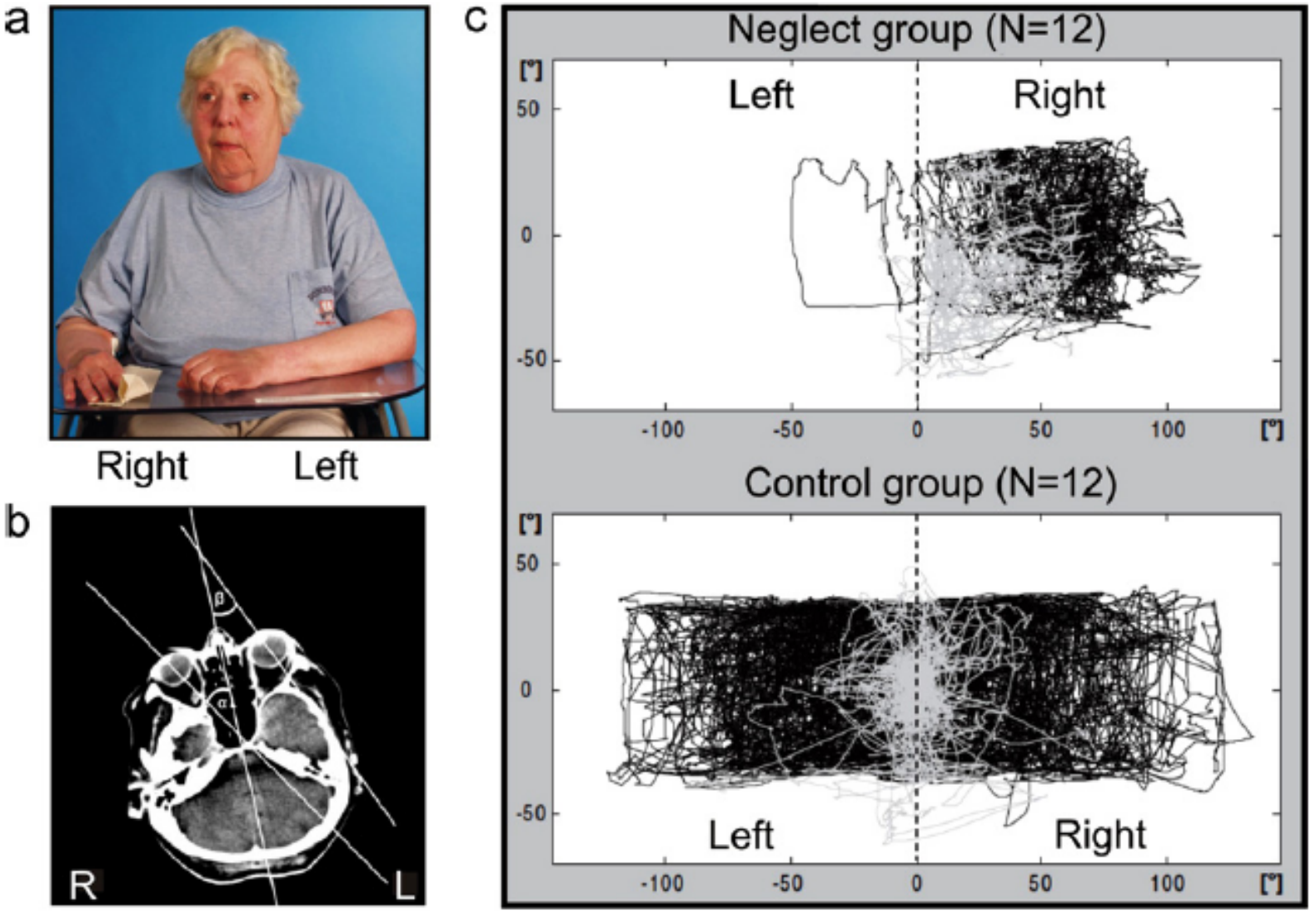
Test for neglect: copying line drawings



Farah, Cognitive Neuroscience of Vision

Looking behavior of Hemispatial Neglect Patient

Patient (left hemispatial neglect) looks to right when doing nothing.



Karnath and Rorden, Neuropsychologia, 2012

Representational Neglect in Hemispatial Neglect

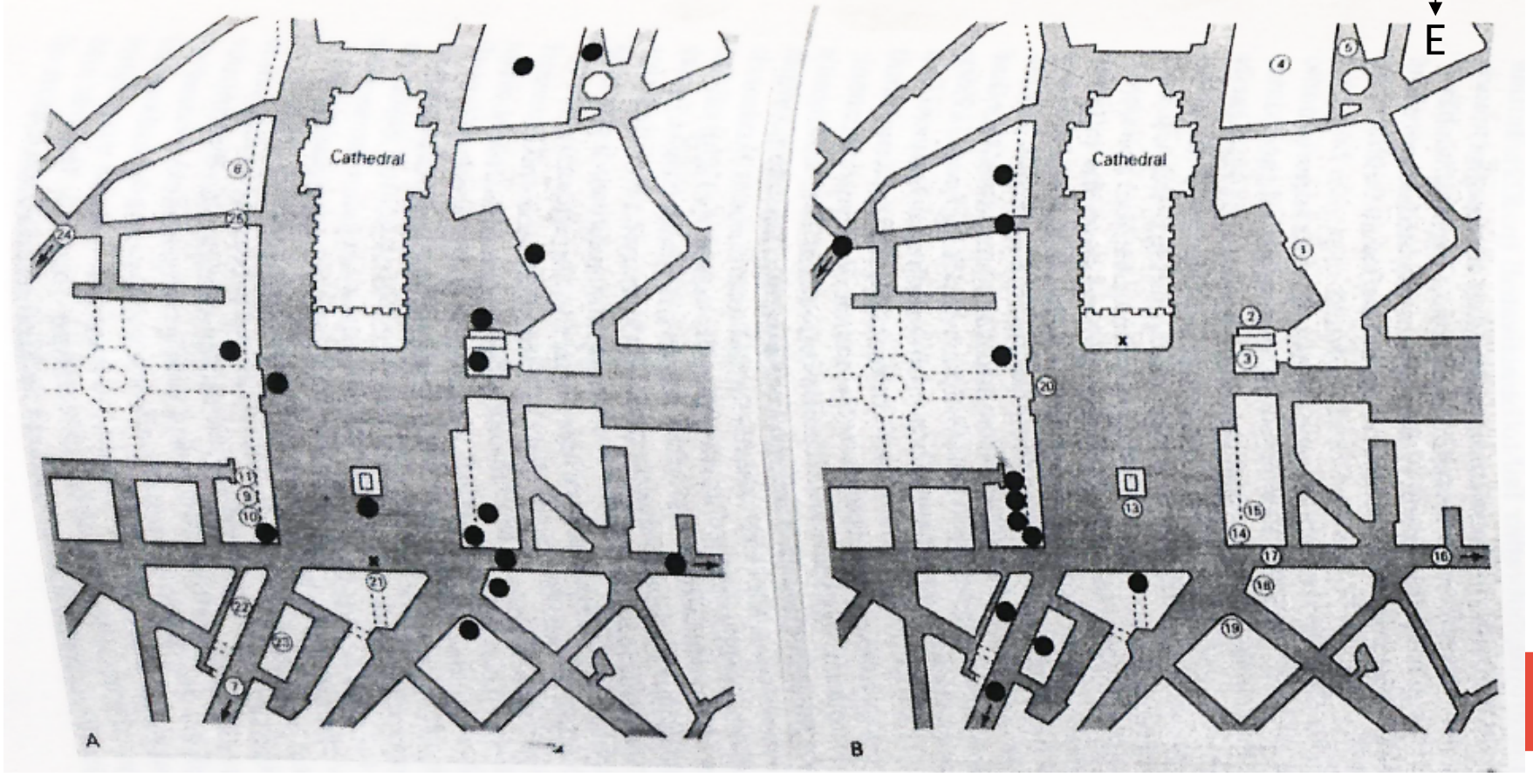
Piazza del Duomo, Milano

Hemispatial Neglect even affects "imagination"

A patient with left hemispatial neglect reported more landmarks on the south side (A) of the Piazza del Duomo in Milan when told to imagine facing from east to west.

This patient reported more landmarks on the north side when told to imagine facing from west to east.

From Bisiach and Luzzatti, Cortex, 1978



Traditional view: left hemispatial neglect is caused by a lesion to right inferior posterior parietal cortex.

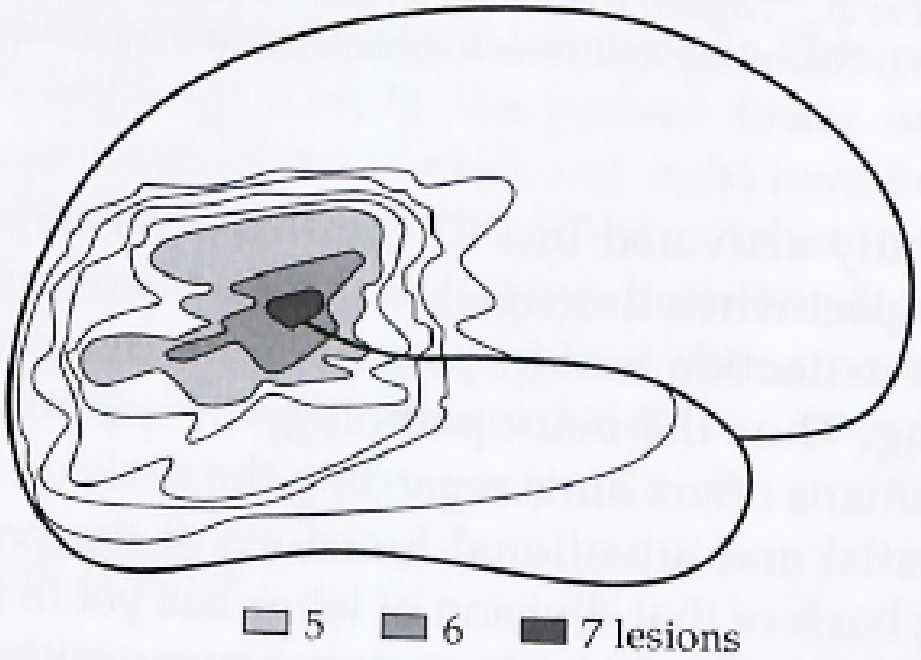


Figure 8.3 Reconstructed lesions of eight patients with severe neglect, showing the location of maximal overlap in the inferior posterior parietal region.
From G. Vallar and D. Perani, "The anatomy of unilateral neglect after right hemisphere stroke lesions: a clinical CT scan correlation study in man," Neuropsychologia, 24, 1986, with permission of Elsevier Science.

Hemispatial Neglect: Not just parietal lobe…?

New research stresses the role of the temporal lobe in hemispatial neglect.

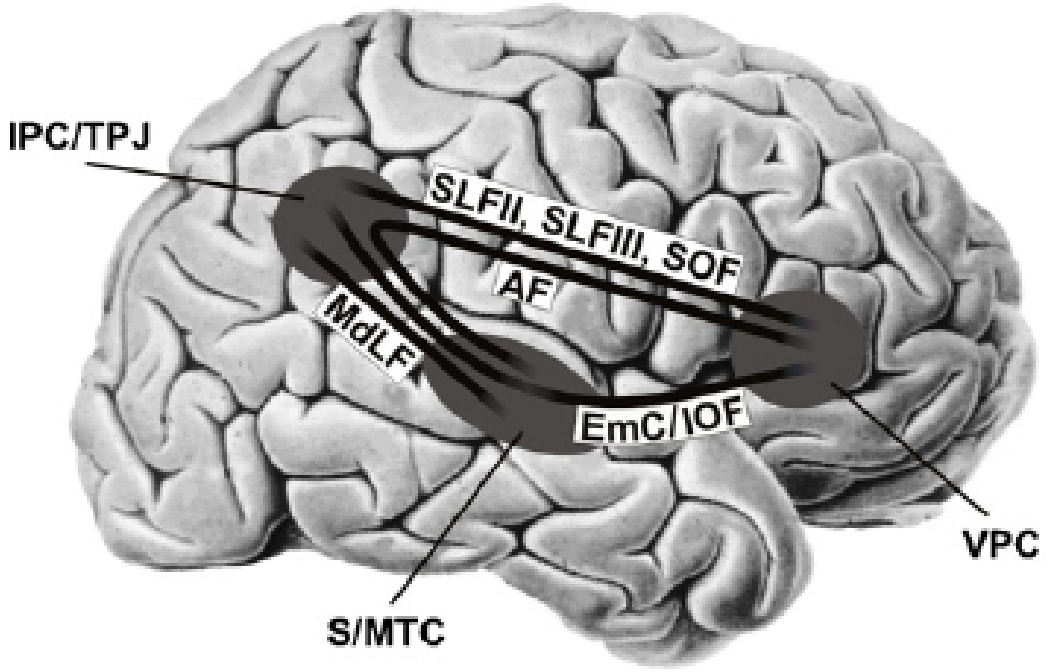
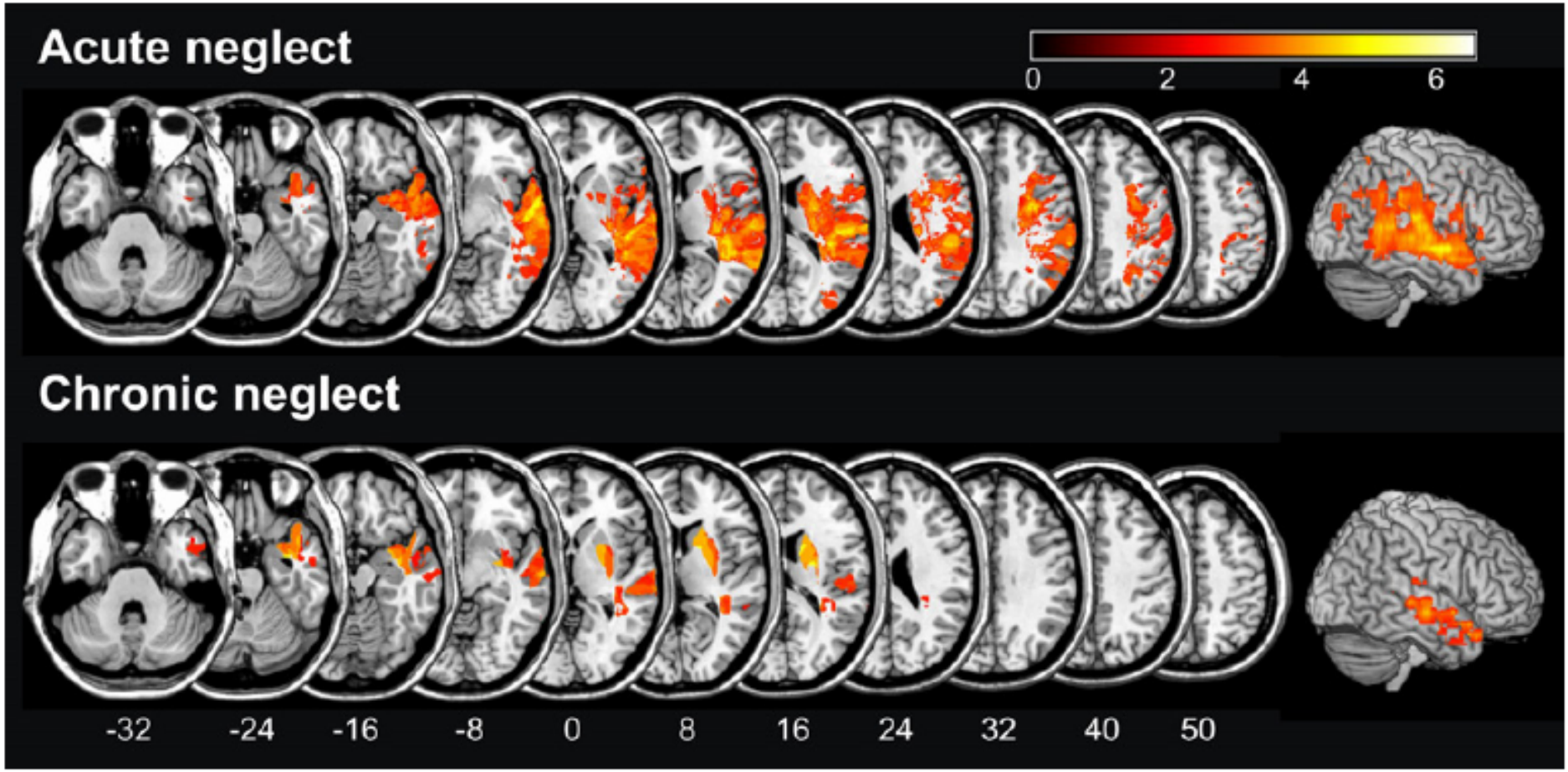


Fig. 2. Sketch of the perisylvian neural network linking the inferior parietal lobule with the ventrolateral frontal cortex (via SLF II, SLF III, SOF), ventrolateral frontal cortex with superior/middle temporal cortex and insula (via AF, EmC/IOF), and superior temporal cortex with the inferior parietal lobule (via MdLF, EmC/IOF). SLF II/III, subcomponents II/III of the superior longitudinal fasciculus; SOF, superior occipitofrontal fasciculus; AF, arcuate fasciculus; EmC, extreme capsule; IOF, inferior occipitofrontal fasciculus; MdLF, middle longitudinal fasciculus; IPC, inferior parietal cortex; TPJ, temporo-parietal junction; S/MTC, superior/middle temporal cortex; VPC, ventrolateral prefrontal cortex (Modified from Karnath, 2009).

Karnath and Rorden, Neuropsychologia, 2012

Hemispatial neglect

Shown in red/yellow are those areas of the brain that significantly predicted neglect severity (either acute or chronic) of 54 patients. Neglect severity was measured with a Letter Cancellation Task, Bells Test, and Copying Task.



Karnath and Rorden, Neuropsychologia, 2012

Summary – Attention

- Several forms of attention can be distinguished: selective attention, divided attention, and sustained attention.
- Selective attention can improve target detection.
- Attention (focusing on one object, feature, location) can modulate activity in sensory cortex related to the processing of the attended entity.
- A dorsal fronto-parietal network is more involved in top-down attention, while a right-lateralized, ventral fronto-parietal network is more involved in bottom-up attention.

Extra Slides

Levels of attention: Attention doesn't exist

Unconscious: Some aspects of attention you do "automatically":

Looking at different parts of the picture – you don't have to think about where your eyes go next – your brain naturally drives it based on visual input and other things.

But, if you have to move your eyes in a specific pattern like a maze, it is not automatic.

Conscious: Some aspects of attention take a lot of focus and are *not* automatic:

You are searching a picture for a certain object.

You are doing very dangerous heart surgery.

Conscious attention is “checking”? Attention doesn’t exist

Constantly checking and re-checking before you make each action

Counting: Check that the next number calculation is correct before you say it: 100, 93, 86, 79…

Bicycle: Check you will not hit a walking person, check that the light is green, check that there are no cars coming, check that you are balanced, check that you are going straight….

Attention is limited: if you check less, mistake more

Counting 100, 93, 86, 79…while riding your bicycle, it is dangerous (you might have an accident). Cell phone on bicycle…