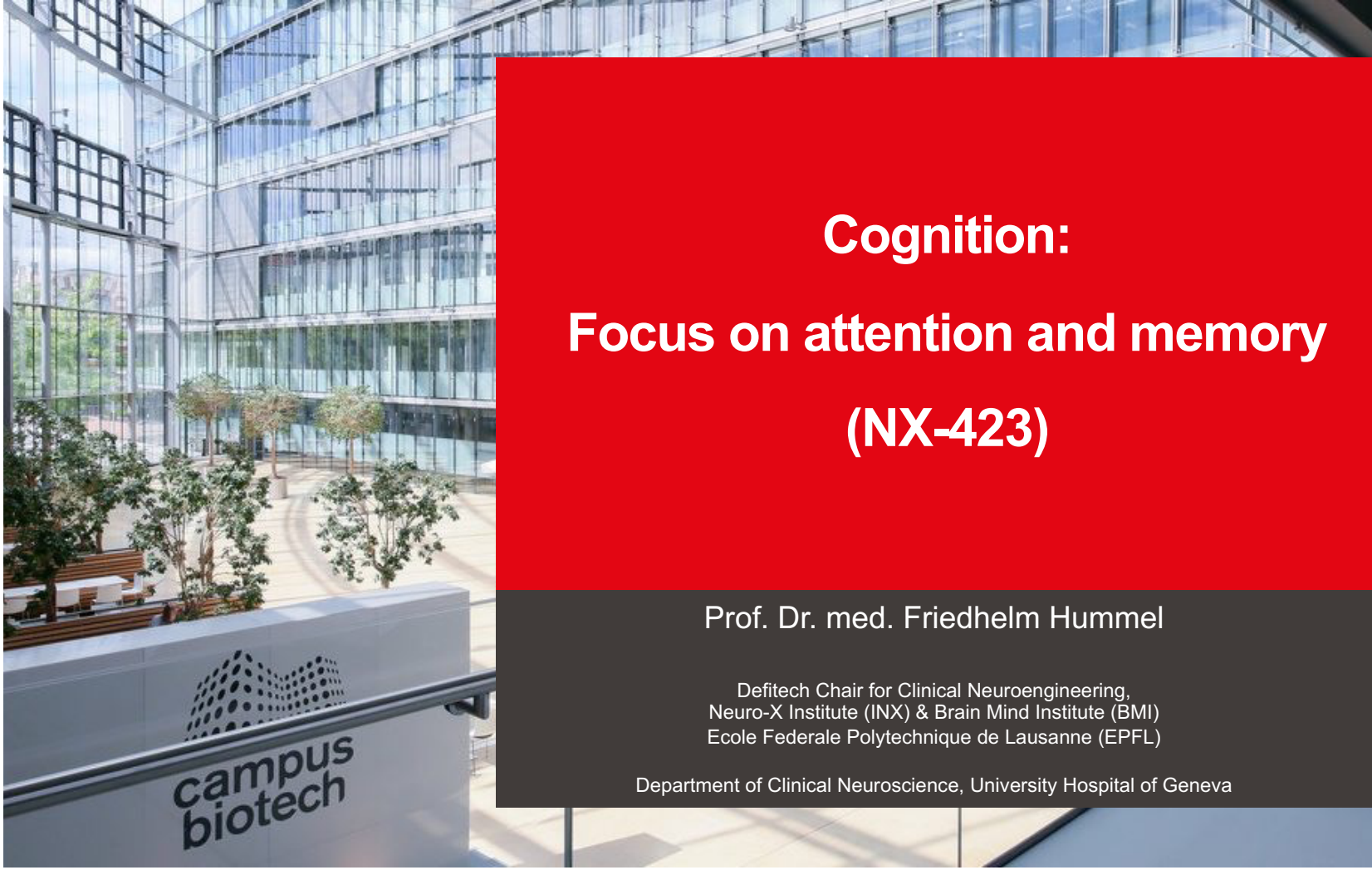
EPFL

Neuro X Institute

HUG Hôpitaux Universitaires Genève

Clinique romande de réadaptation



Cognition:

Focus on attention and memory

(NX-423)

Prof. Dr. med. Friedhelm Hummel

Defitech Chair for Clinical Neuroengineering,
Neuro-X Institute (INX) & Brain Mind Institute (BMI)
Ecole Federale Polytechnique de Lausanne (EPFL)

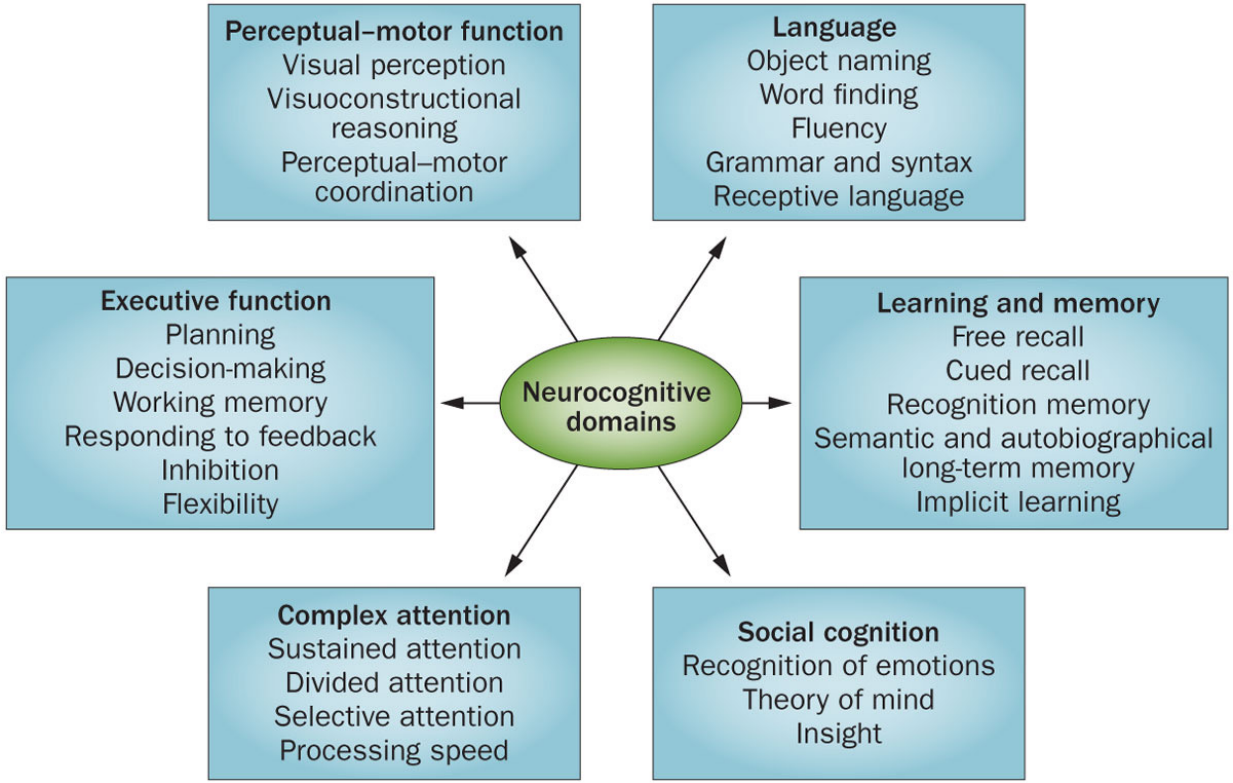
Department of Clinical Neuroscience, University Hospital of Geneva

Neuro-X Master:

NX-423
Translational neuroengineering

‘*Cognition Ecce Homo* by Lutz Baar

Diagnostic and Statistical Manual of Mental Disorders (DSM-V)



Sachdev, P. S. *et al.* (2014)

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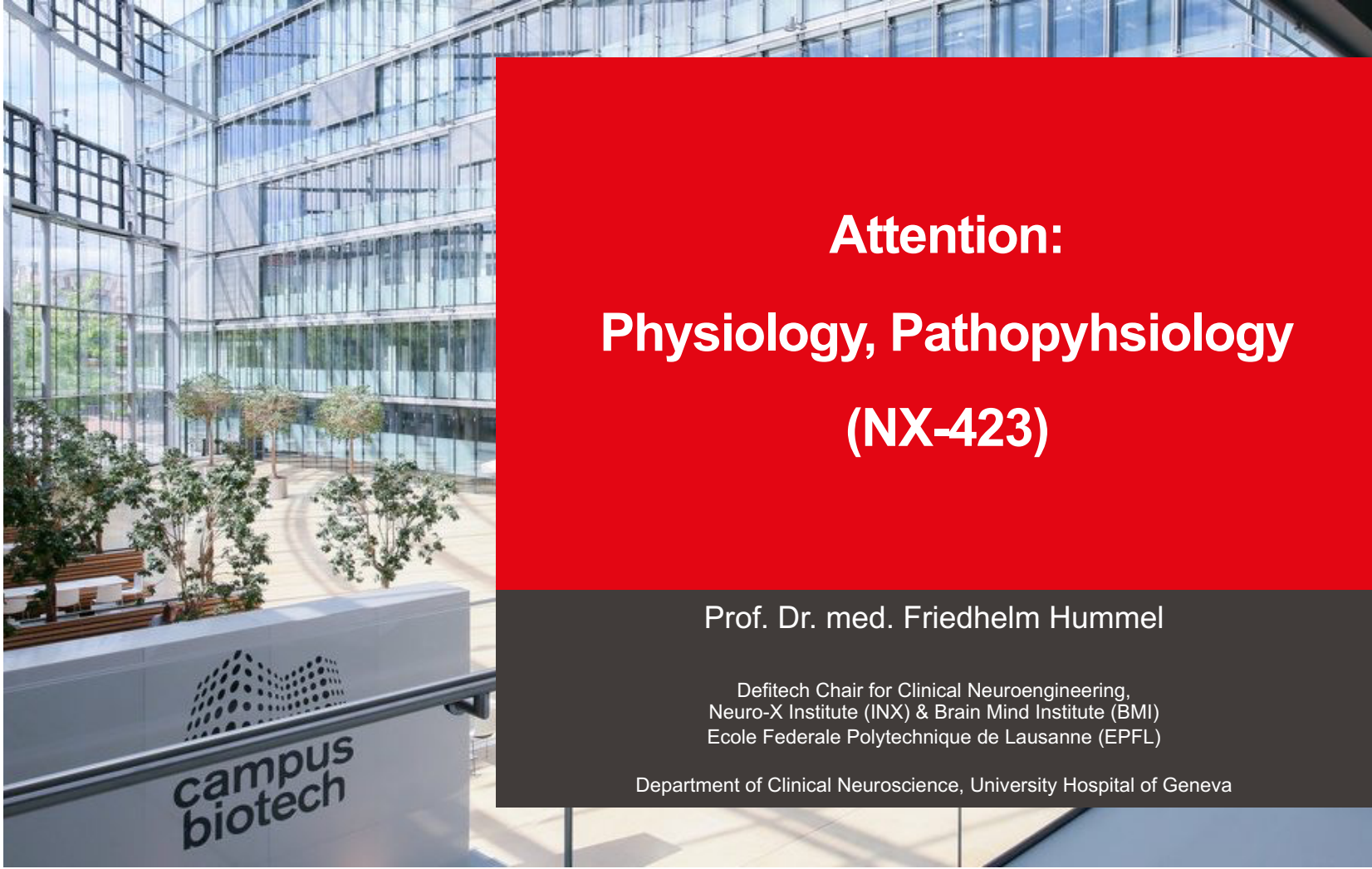
Clinique romande de réadaptation



Attention:

Physiology, Pathopyhsiology

(NX-423)

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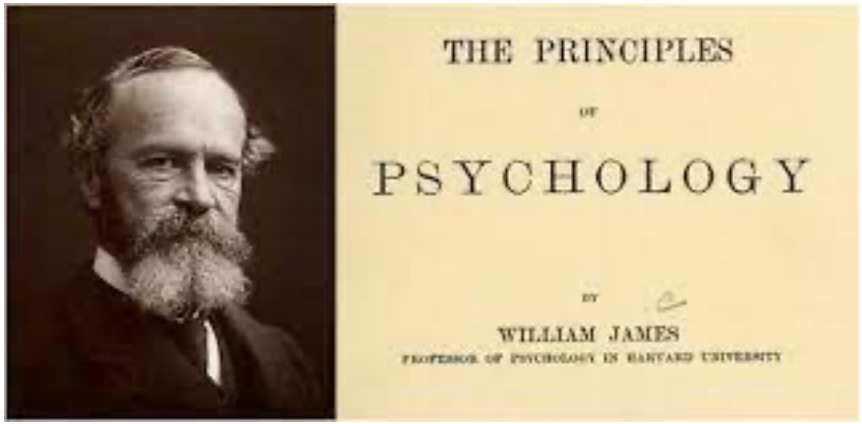
Translational neuroengineering

‘*L’attention*’ by Marion Brocarel

‘*Attention chantiers*’ by Bottichio Anik

William James (1890)

'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 [p. 404] of thought. Focalization, concentration, of consciousness are of its essence. It implies ***withdrawal from some things*** *in order* ***to deal effectively with others****'*



Examples how focussed attention works in daily life

https://youtu.be/vJG698U2Mvo

https://www.youtube.com/watch?v=CdCoWzB1iGA

Attention as Arousal, Alertness, or Vigilance

Sensory Attention (e.g., visual attention)
- Visual Spatial Attention
- Visual Feature Attention

Attention in Other Sensory Modalities

Attention and Executive Control

Attention and Memory

Lindsay, 2020

Attention as Arousal, Alertness, or Vigilance

most generic form of attention, could be described as merely an overall level of alertness or ability to engage with surroundings

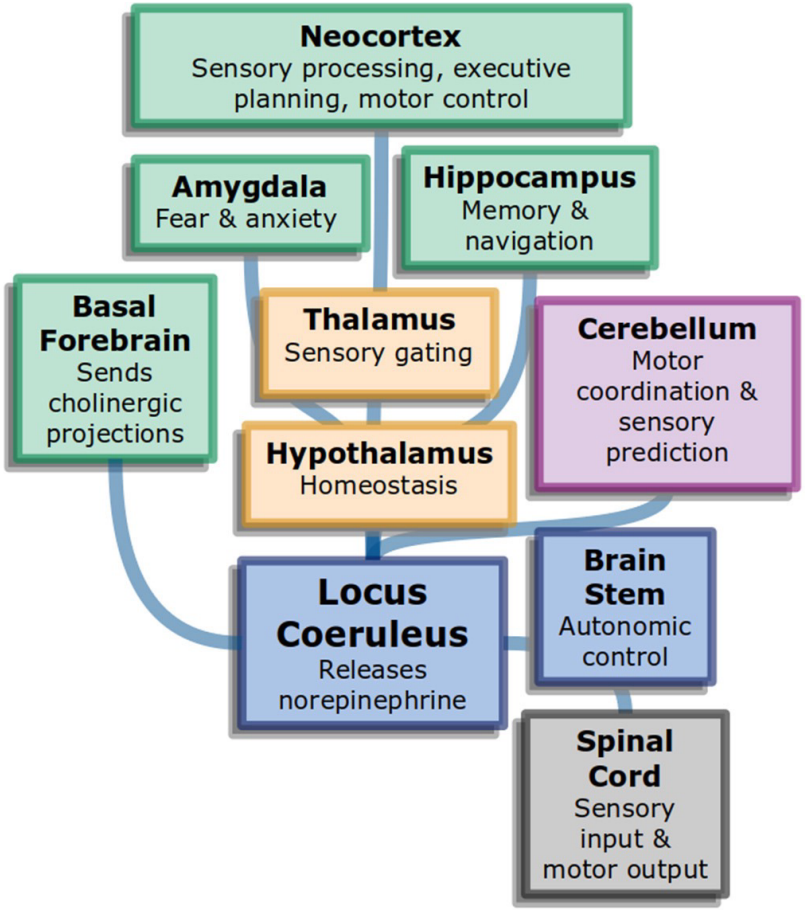
interacts with arousal and the sleep-wake spectrum

more arousal is not always beneficial

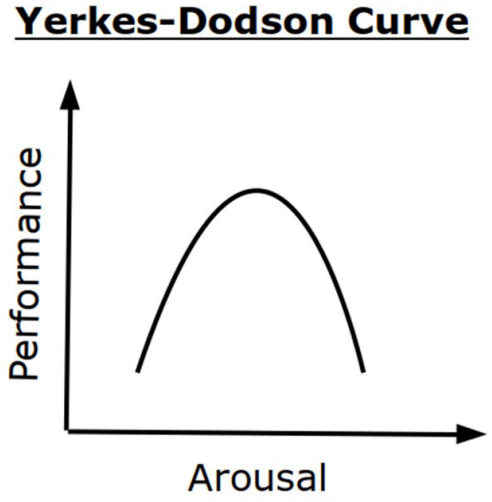
complex anatomical network involved in these aspects of attention

Lindsay, 2020

A



B

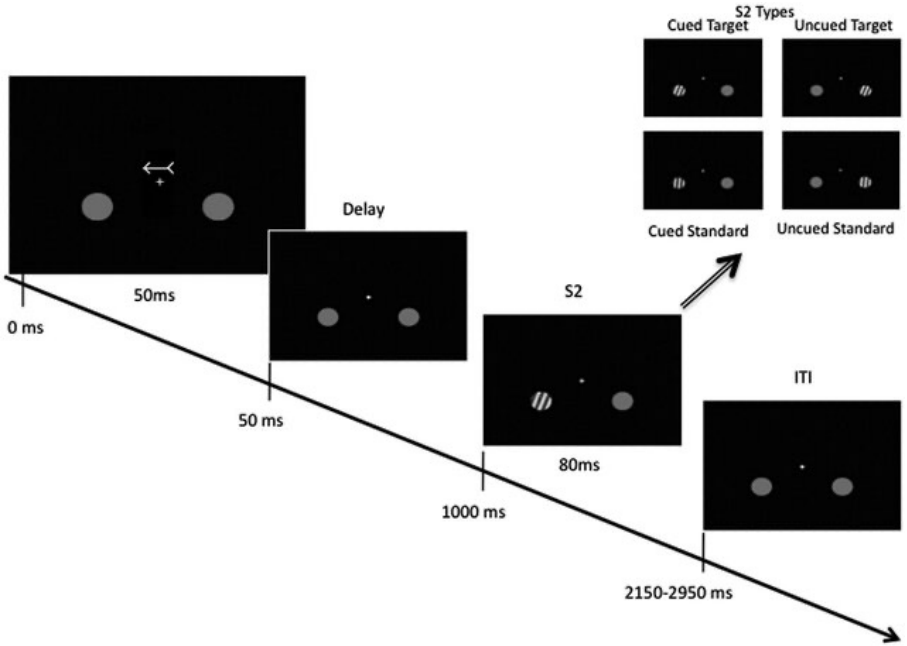


Lindsay, 2020

Sensory Attention (e.g., visual attention)

- Visual Spatial Attention

- Visual Feature Attention



Sensory Attention (e.g., visual attention)

- Visual Spatial Attention

- Visual Feature Attention

can be tracked by eye movements

this shift of attention is outwardly visible, it is known as overt visual attention

covert spatial attention (no eye movements, ‘spotlight’)

importantly, for covert—as opposed to overt—attention the input to the visual system can be identical while the processing of that input is flexibly selective.

Lindsay, 2020

Sensory Attention (e.g., visual attention)

- Visual Spatial Attention
- **Visual Feature Attention**

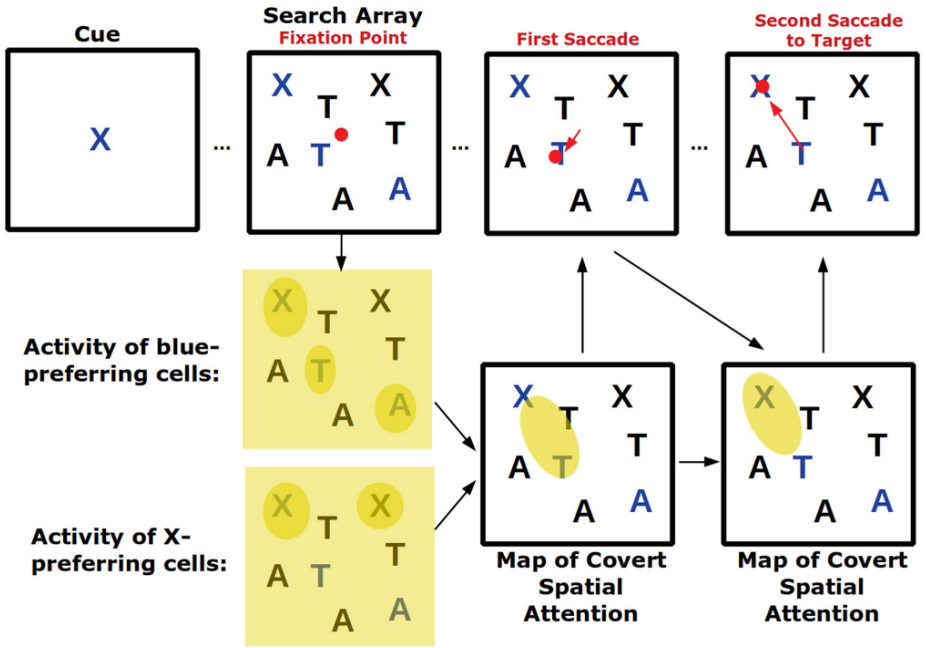
cued on each trial to attend to a particular visual feature such as a specific color, a particular shape, or a certain orientation

neural effects of feature-based attention in the visual system are generally similar to those of spatial attention

as opposed to spatial attention, however, feature-based attention is spatially global

Lindsay, 2020

Sensory Attention (e.g., visual attention)

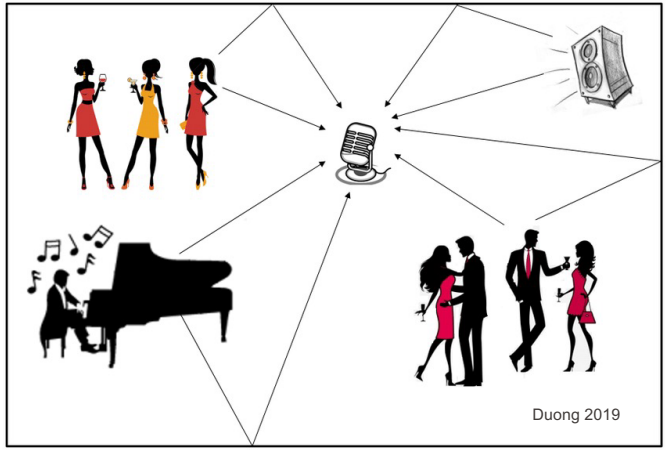


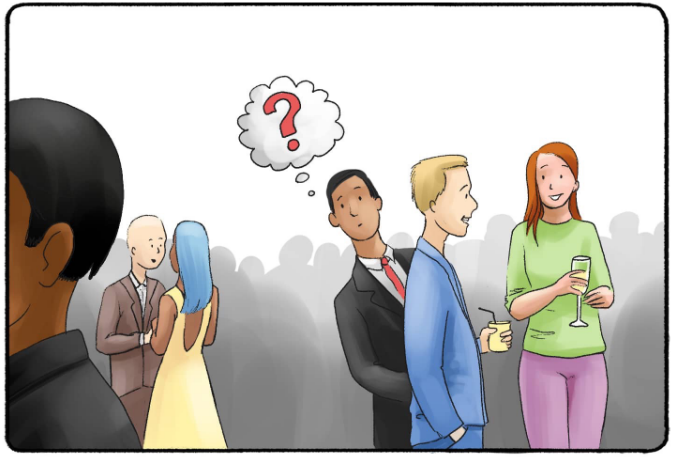
Lindsay, 2020

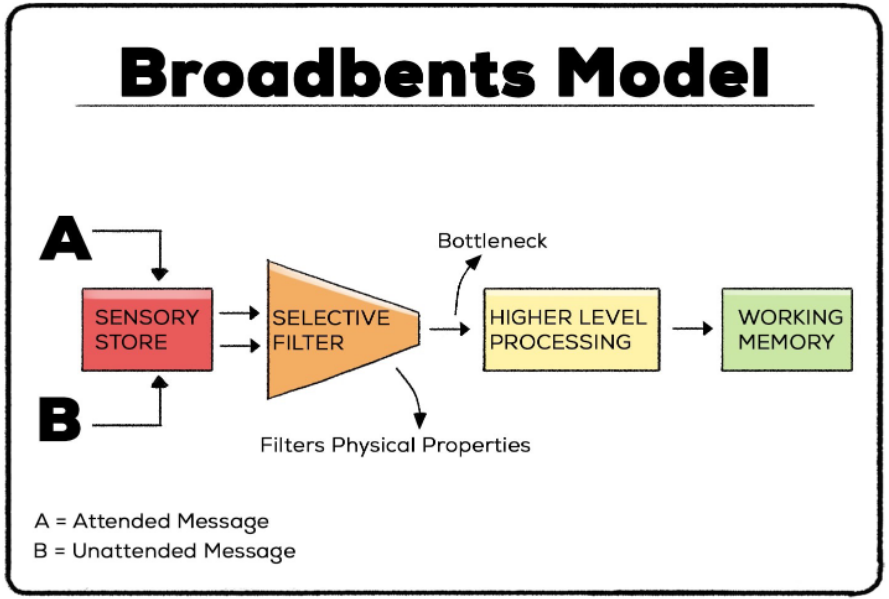
Attention in Other Sensory Modalities

selective attention in audition - the “cocktail party problem”

Lindsay, 2020







Adapted from https://practicalpie.com

Attention in Other Sensory Modalities

selective attention in audition - the “cocktail party problem”

interestingly, selective auditory attention has the ability to control neural activity at even the earliest level of auditory processing, the cochlea

somatosensory system

taste system

Lindsay, 2020

Attention and Executive Control

multiple simultaneous competing tasks, a central controller is needed to decide which to engage in and when

efficient task selection and execution

striker in football example

Lindsay, 2020

Attention and Memory

memory has a limited capacity, brain needs to select what enters memory

the ability of attention to dynamically select a subset of total information is well-matched to the needs of the memory system

deciding to recall a specific memory is a choice about how to deploy limited resources

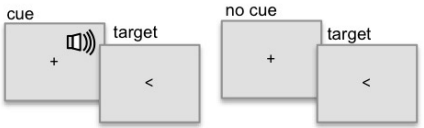
Both memory encoding and retrieval can rely on attention

Lindsay, 2020

Activation

Process **Preparation**

Tasks **Warning cues**: Responding to a target that is preceded by a warning cue (compared to when no cue is presented)



Sustained attention / Vigilance

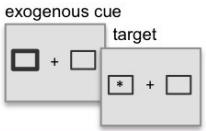
Clock task (Mackworth, 1948): Responding to infrequent targets, as detecting when double jumps of a clock hand occur

Selection

Process **Stimulus-driven (bottom-up) orienting**

Tasks **Pop-out**: Finding a target (o) that doesn't share basic features with distracting stimuli

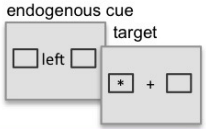
Exogenous orienting cues: Peripheral cues that consist on abrupt changes in stimulation



Goal-directed (top-down) orienting

Search: Finding a target (>) that does share one or more basic features with distracting stimuli

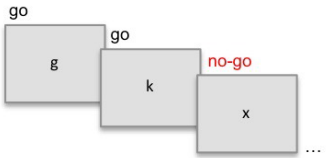
Endogenous orienting cues: Must be interpreted and (voluntarily) followed to orient attention



Control

Process **Inhibition**

Tasks **Go-NoGo**: Not responding to a particular stimulus (x) in a context of rapid responses to similar frequent stimuli



Conflict resolution

Stroop-like tasks: Responding to a non-dominant feature of a target (Stroop, 1935)

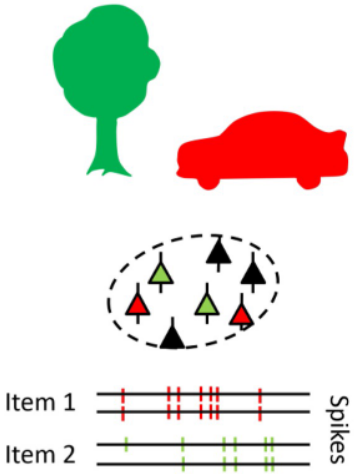
Flanker task: Responding to a central stimulus surrounded by distracters (Eriksen & Eriksen, 1974)

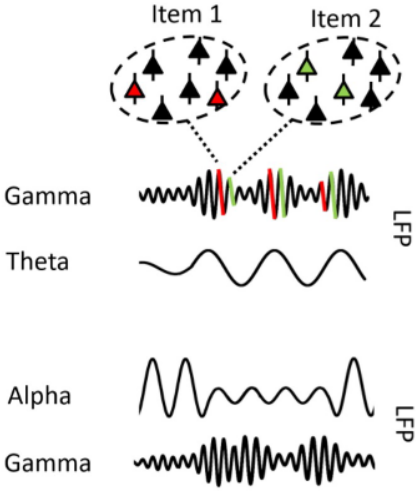
Rueda *et al.*, 2015

Friedhelm C. Hummel

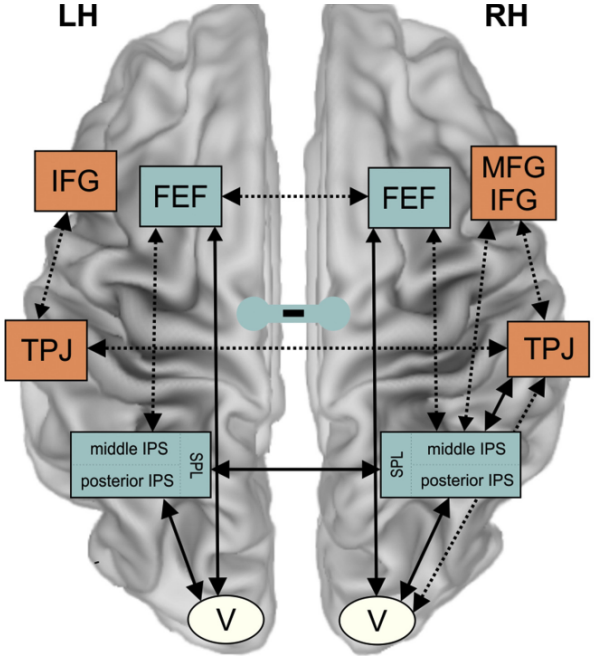
In humans addressed by multimodal systems neuroscience approaches

- Structural and functional MR imaging
- EEG/MEG based electrophysiology
- Virtual lesion approaches
- Neuromodulation





Ventral and dorsal attention systems



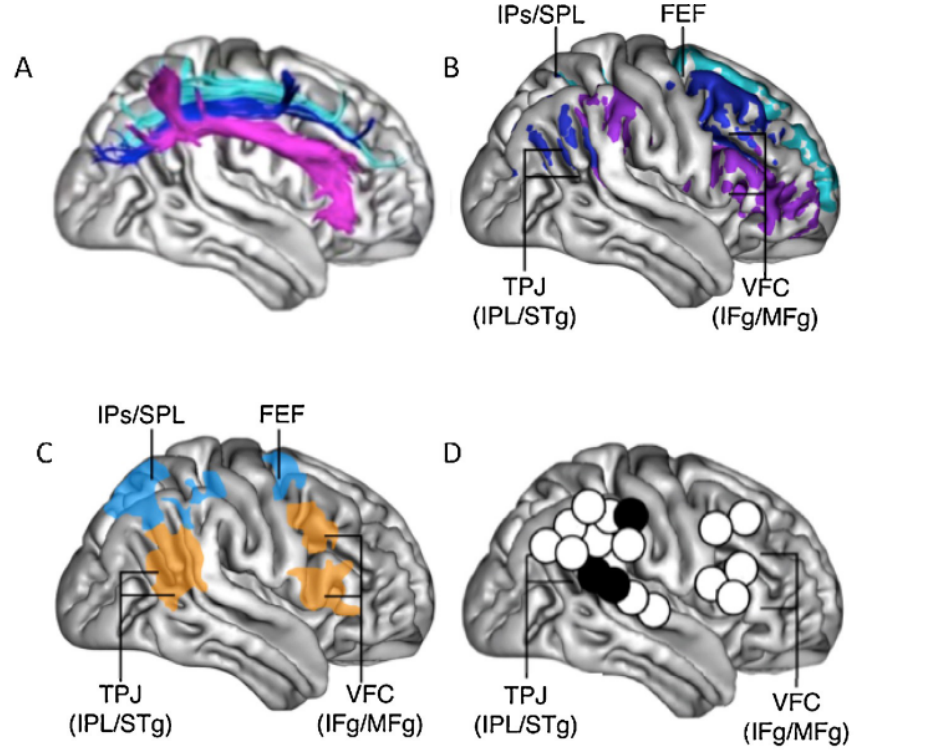
dorsal

- contralateral (LH) or bilateral (RH) allocation of attention
- calibration of attentional weights
- shifting of attention

ventral

- reorienting
- signalling expected (LH) and unexpected (RH) events
- updating

Mengotti et al. 2020



Structural Network

Superior longitudinal fascicle (SLF) connecting
- Temporo-parietal junction (TPJ)
- Parietal cortex (SPL, IPs)
- Frontal eye field (FEF)
- Ventro-frontal cortex (VFC)

Functional Networks

Goal directed attention
- Parietal cortex – FEF

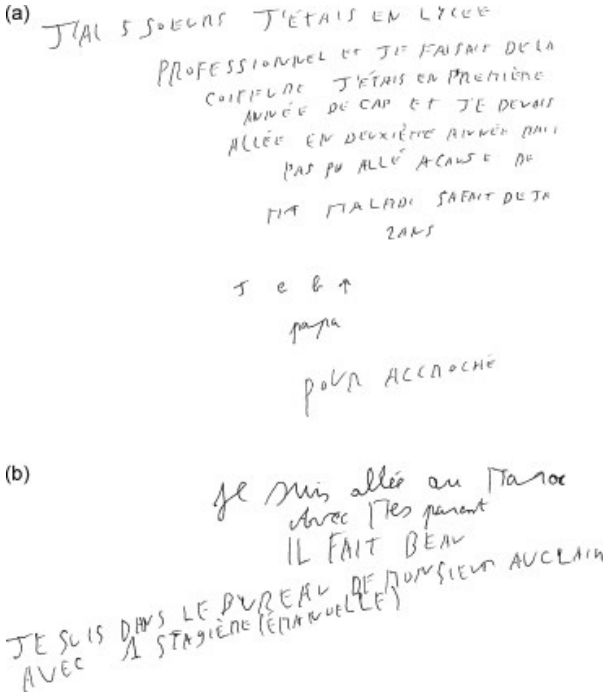
Stimulus-driven attention (unexpected)
- TPJ - VFC

Functional Localization

Lesions (white dots)
Electrical stimulation (black dots

Lunven & Bartolomeo 2017

Case of a patient



Adapted from Auclair et al. 2008

(a)

J'AI 5 SOEURS J'ÉTAIS EN LYCÉE PROFESSIONNEL ET JE FAISAIT DE LA COIFFEUSE J'ÉTAIS EN PREMIÈRE ANNÉE DE CAP ET JE DEVAIS ALLÉE EN DEUXIÈME ANNÉE MAIS PAS PU ALLÉ ACAUSE DE MA MALADIE SAFAIT DE 7A 2ANS

J e B ↑

papa

POUR ACCROCHÉ

(b)

je suis allée au Maroc avec mes parent IL FAIT BEAU

JE SUIS DANS LE BUREAU DE MONSIEUR AUCLAIR AVEC A STAGIÈRE (FEMME)

Adapted from Auclair et al. 2008

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je suis papa

POUR ACCROCHÉ

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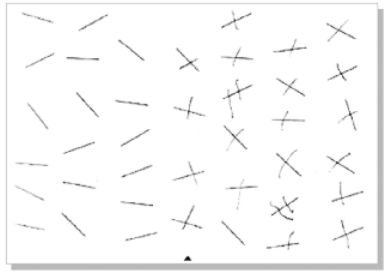
Adapted from Auclair et al. 2008

Adapted from https://sites.google.com/a/macalester.edu/hemispatial-neglect

Symptoms- Clinical testing

A



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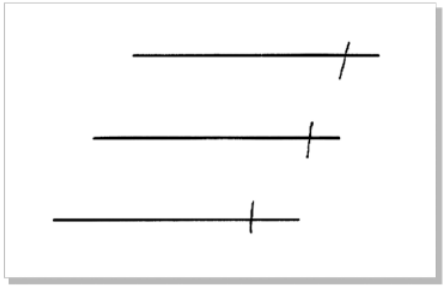
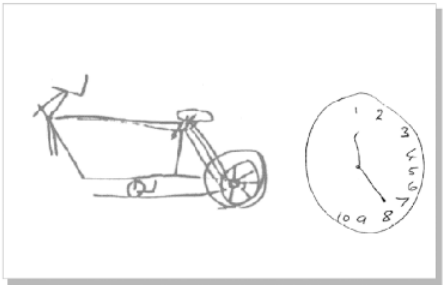
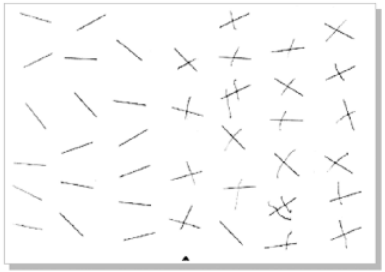


C



Vuilleumier & Saj 2013

A



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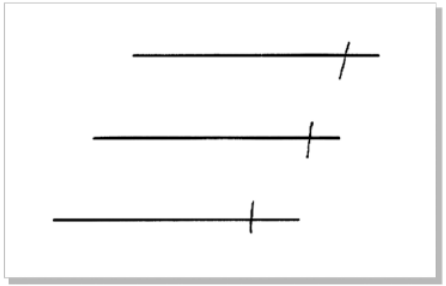

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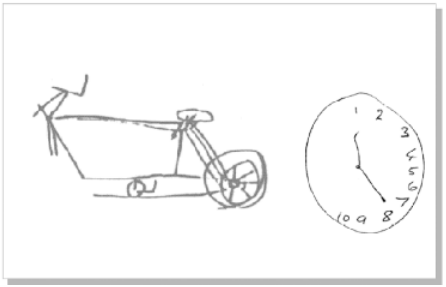
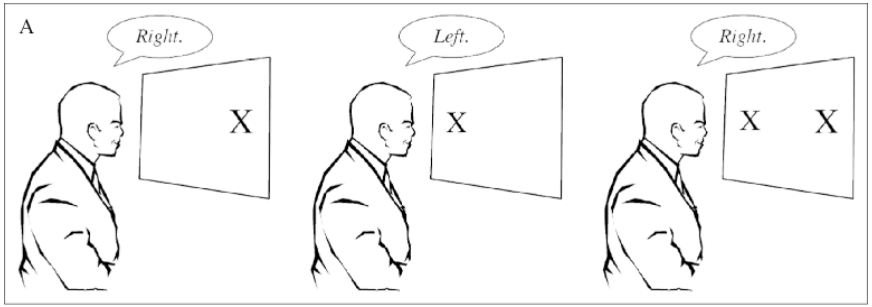
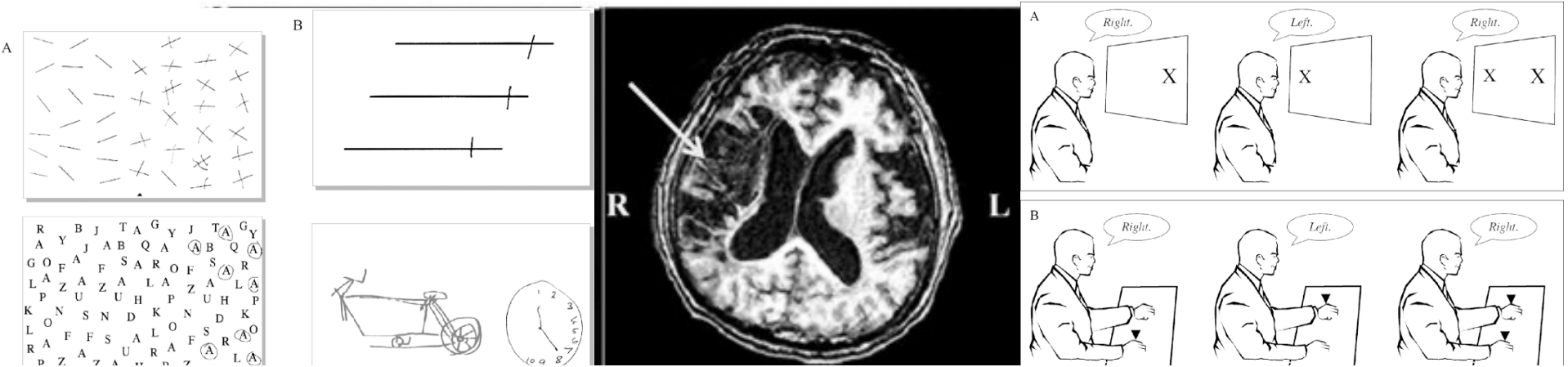




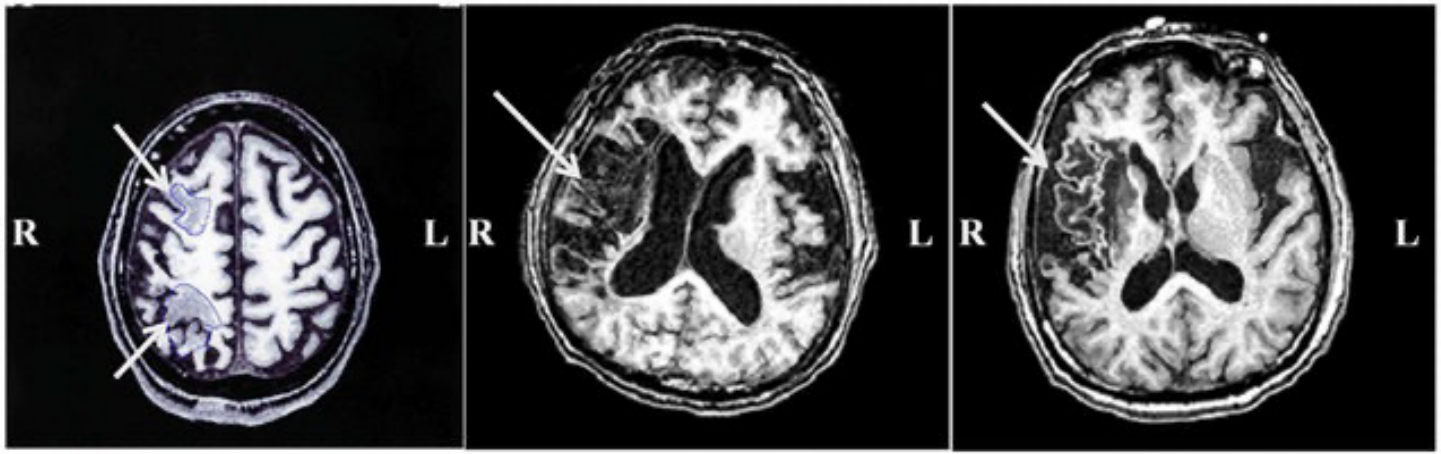
Vuilleumier & Saj 2013

Right hemispheric stroke



Adapted from Vuilleumier & Saj 2013; Mizuno et al. 2023

Right hemispheric stroke



Patient 1 Patient 2 Patient 3

Adapted from Mizuno et al. 2023

From what does the patient suffer from?

Neglect

Anton Räderscheidt

Neglect

Syndrome of visuospatial deficits

Disorder of attention

patients characteristically fail

to orientate, to report, to respond to

stimuli located on the contralesional side

Mainly unilateral right hemispheric lesion in the attentional network

Anton Räderscheidt

Spatial deficits

- A bias in the gradient of spatial attention towards the ipsilesional side of space
- Difficulty disengaging attention from ipsilesional (R) and shifting it to contralesional (L) locations
- A pathological spatial bias (contralesional items lose in competition for attention to ipsilesional)
- Directional motor deficits in which patients have difficulty directing movements into the contralesional side of space
- Problems with spatial working memory, i.e. keeping track of spatial locations over time
- A disordered egocentric representation of space

Anton Räderscheidt

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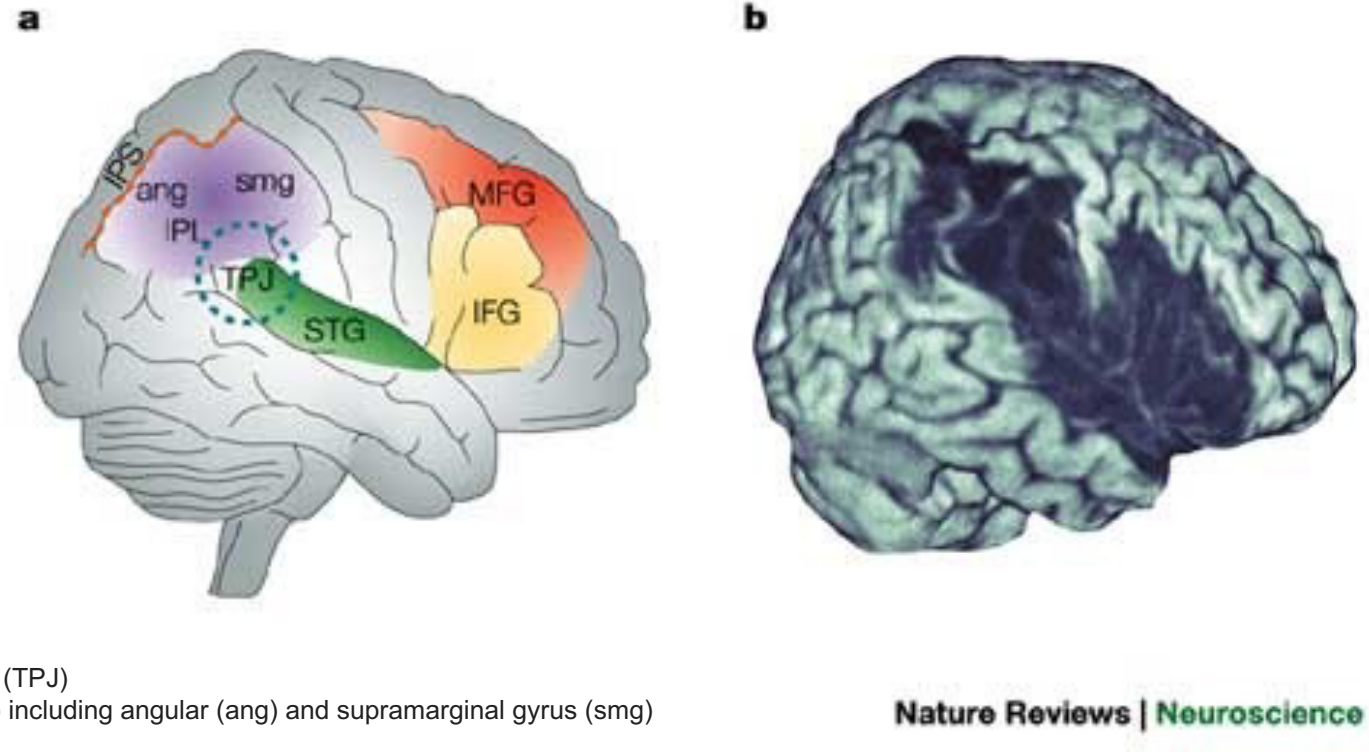
Non-spatial deficits

- Difficulties in sustaining attention over time
- Impairments in selective attention, which may occur in both left and right sides of space and at central locations.
- Neglect patients can demonstrate bilateral attentional impairments, even though the most obvious abnormality is a bias towards ipsilesional (usually right-sided) space

Anton Räderscheidt

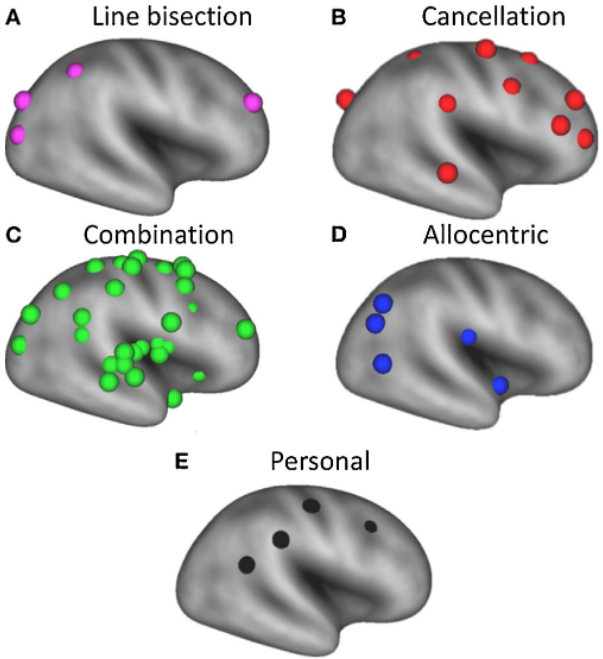
Right hemispheric lesions in the attentional network leading to neglect



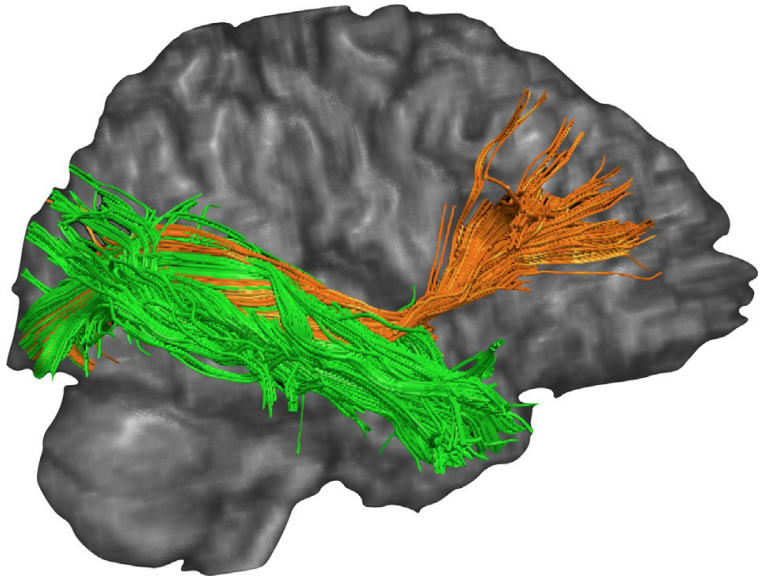
Temporo-pariatl Junction (TPJ)
Inferior parietal lobe (IPL) including angular (ang) and supramarginal gyrus (smg)
Intraparietal sulcus (ips)
Superior temporal gyrus (STG)
Inferior frontal gyrus (IFG)
Middle frontal gyrus (MFG).

Husain & Rorden 2003

Lesion sites assoicated with neglect syptoms



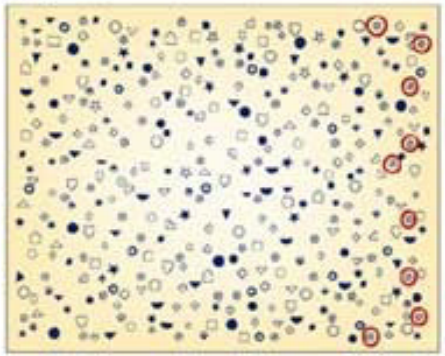
White matter tracts associated to neglect



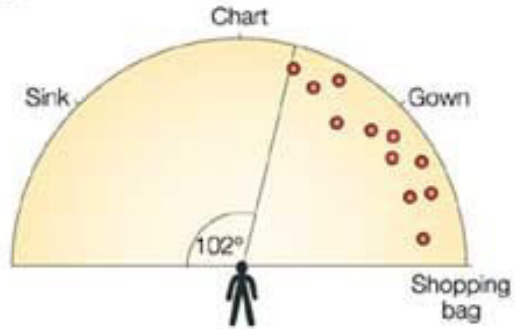
Lunven & Bartolomeo 2017

Neglect – Symptoms: how to evaluate

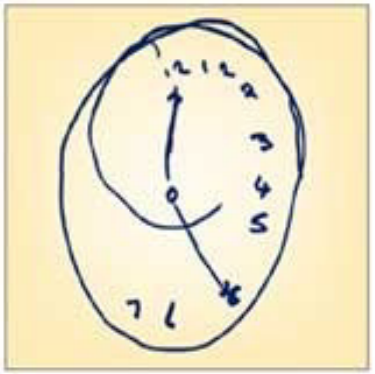
a Cancellation test



b Naming objects around a room



c Clock drawing

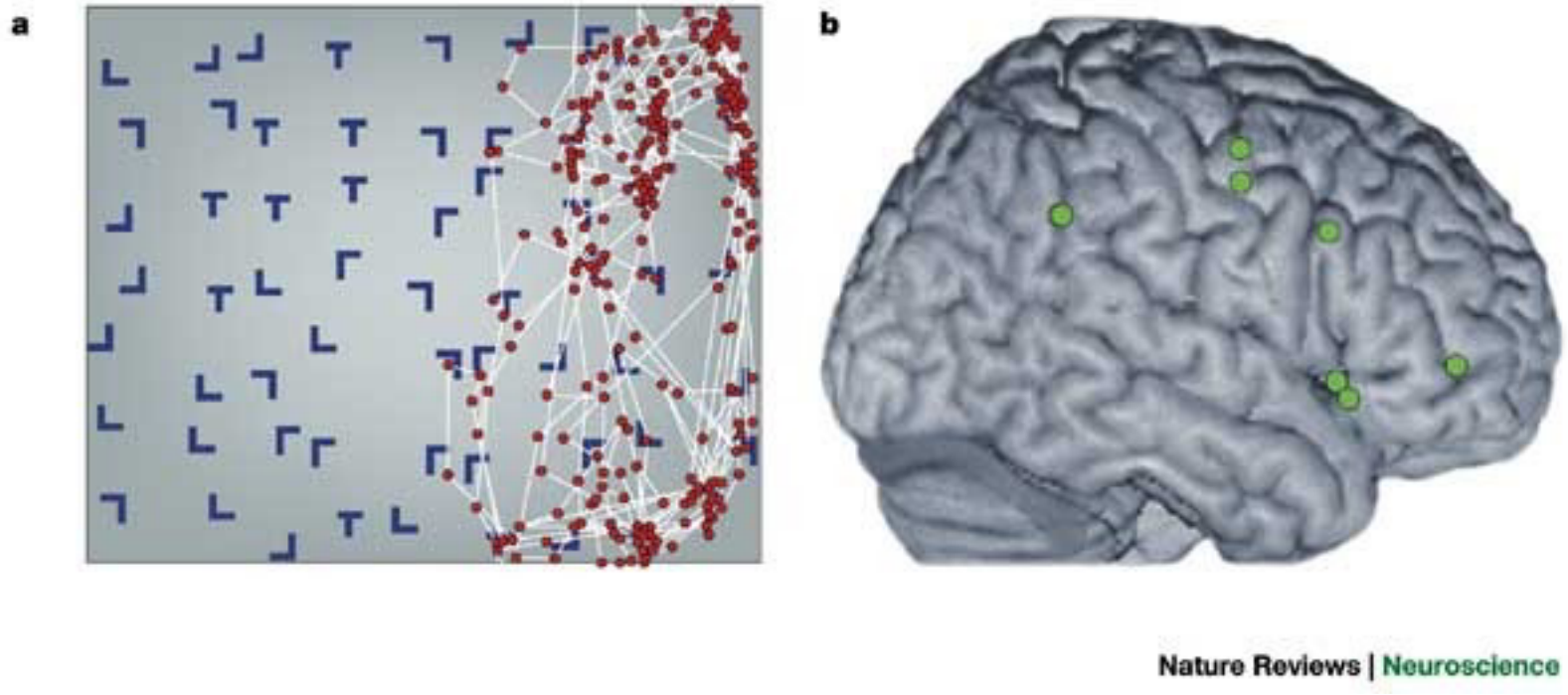


d Milan Square

Nature Reviews | Neuroscience

Husain & Rorden 2003

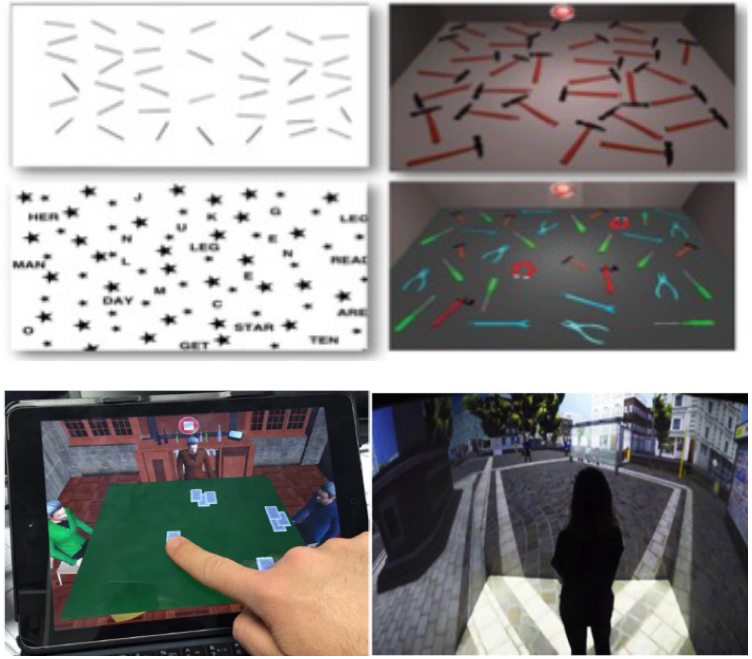
Visual exploration



Husain & Rorden 2003

Neurotechnology

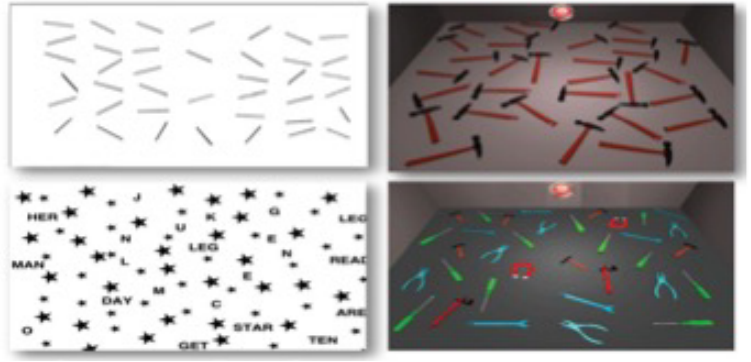
Paper-Pencil to computerized



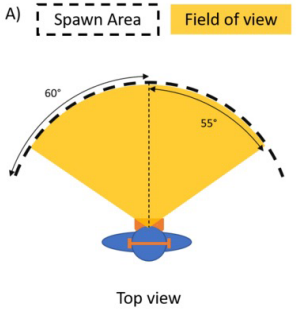
Knobel et al. 2021; for review Cavedoni et al. 2022

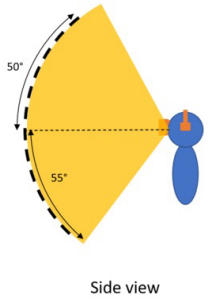
Neglect – Diagnostics

Paper-Pencil to computerized



Task Using Immersive Virtual Reality





Knobel et al. 2021; for review Cavedoni et al. 2022

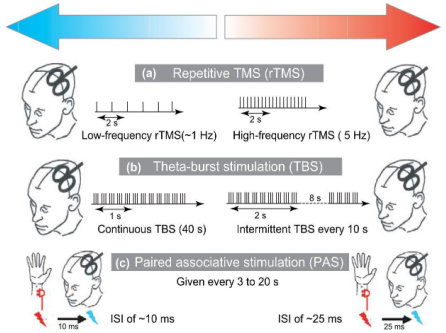
Sensory Stimulation

Eye Movement–Based Therapies
Auditory Spatial Cueing (VR)
Robot-Assisted Therapy and Sensory Feedback
Mirror and Prism Therapies

Rossetti et al. 2015

Non-invasive Brain Stimulation

rTMS
tDCS
tACS



Quartarone *et al.* 2006 TINS

Questions!