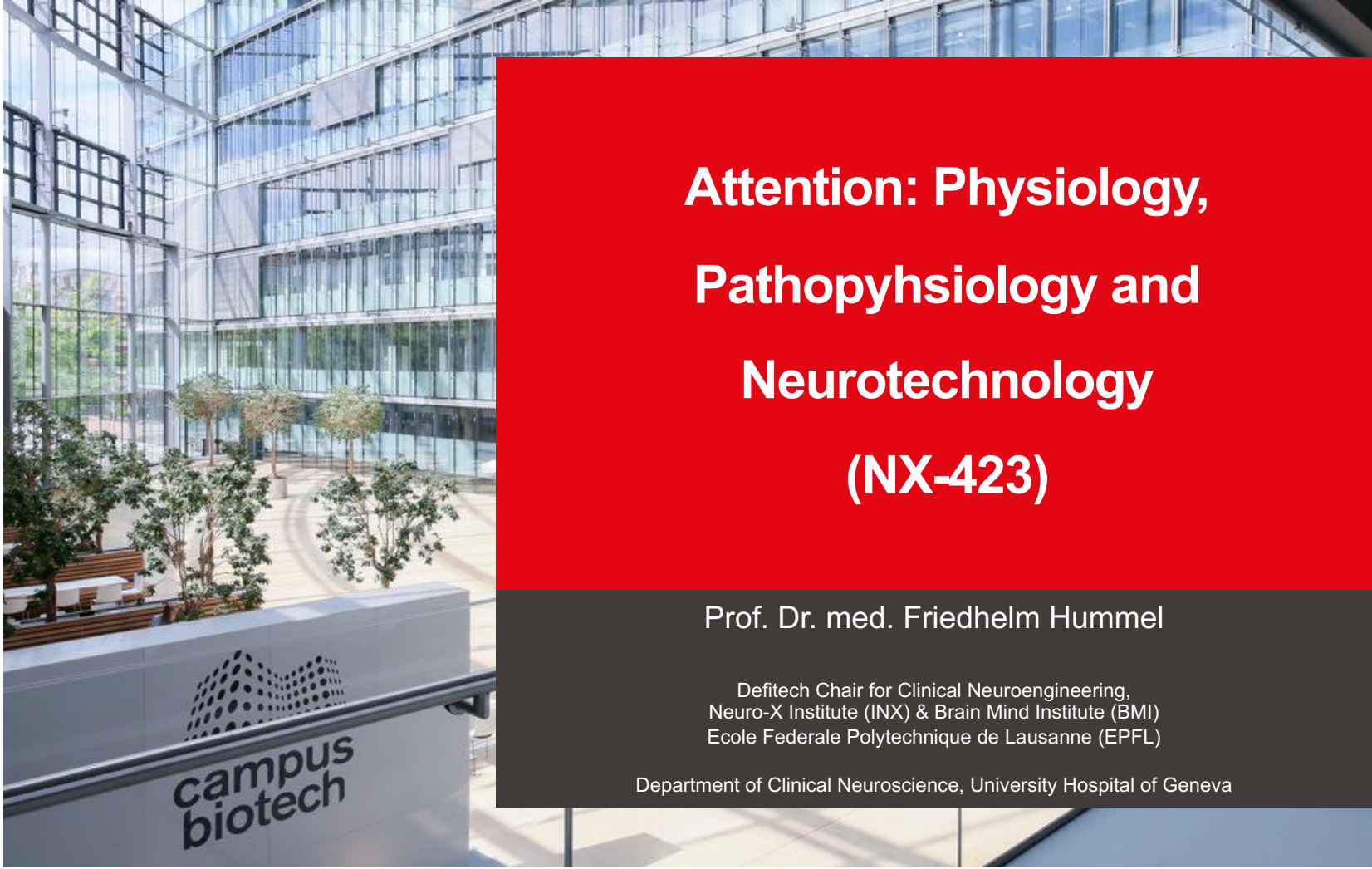
EPFL

Neuro X Institute

HUG Hôpitaux Universitaires Genève

Clinique romande de réadaptation



Attention: Physiology, Pathopyhsiology and Neurotechnology (NX-423)

Prof. Dr. med. Friedhelm Hummel

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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

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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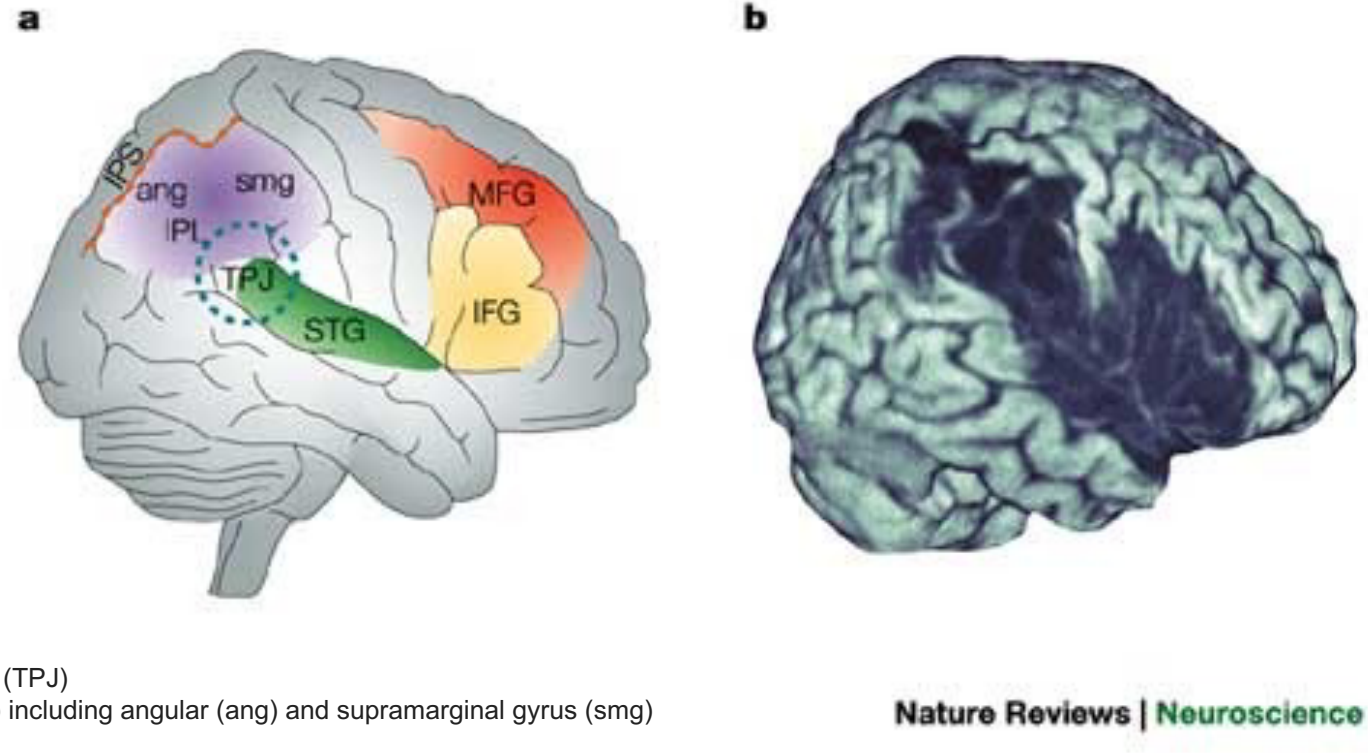
Non-spatial deficits

- 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

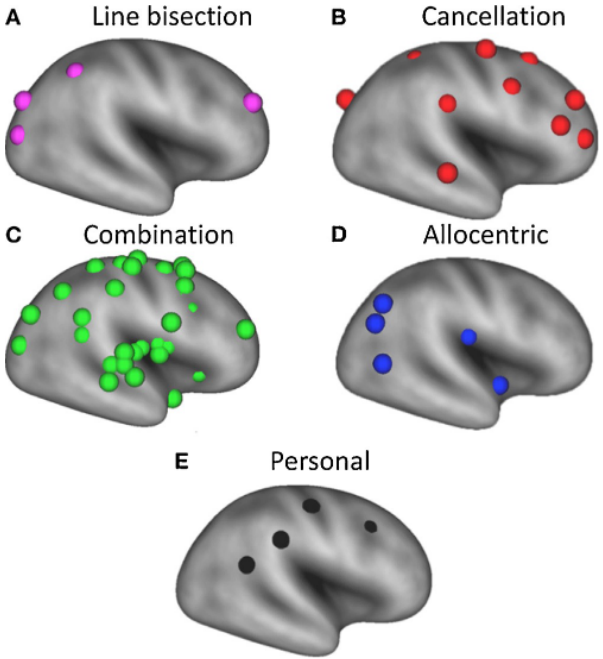
Right hemispheric lesions in the attentional network leading to neglect



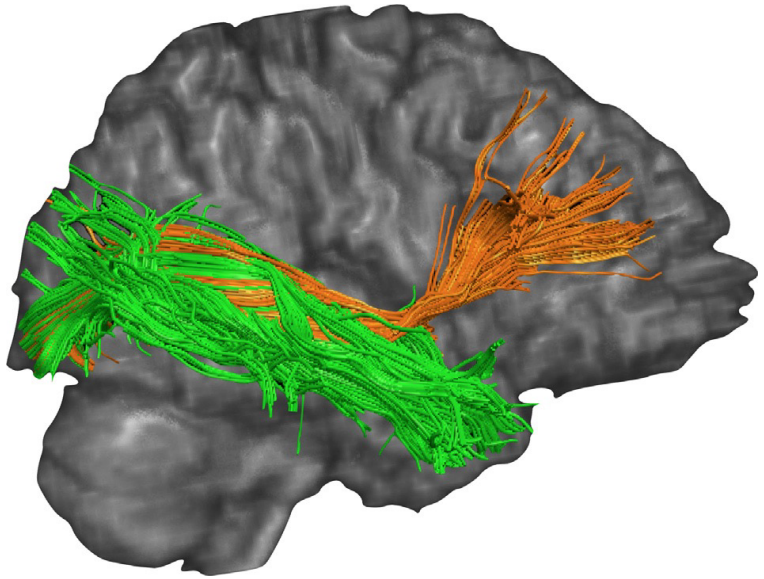
Temporo-pariatl Junction (TPJ)
Inferior parietal lobe (IPL) including angular (ang) and supramarginal gyrus (smg)
Intraparietal sulcus (ips)
Superior temporal gyrus (STG)
Inferior frontal gyrus (IFG)
Middle frontal gyrus (MFG).

Husain & Rorden 2003

Lesion sites assoicated with neglect syptoms

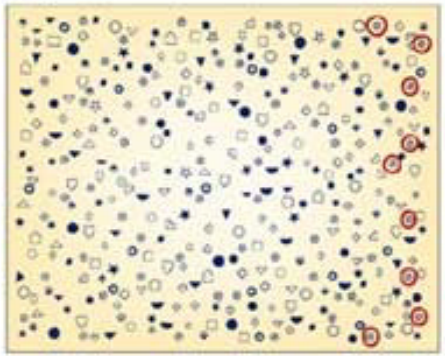


White matter tracts associated to neglect



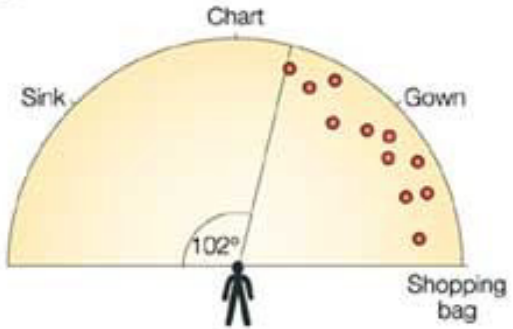
Lunven & Bartolomeo 2017

a **Cancellation test**

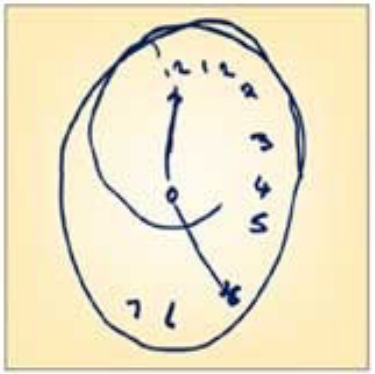


Naming objects around a room

b



c **Clock drawing**

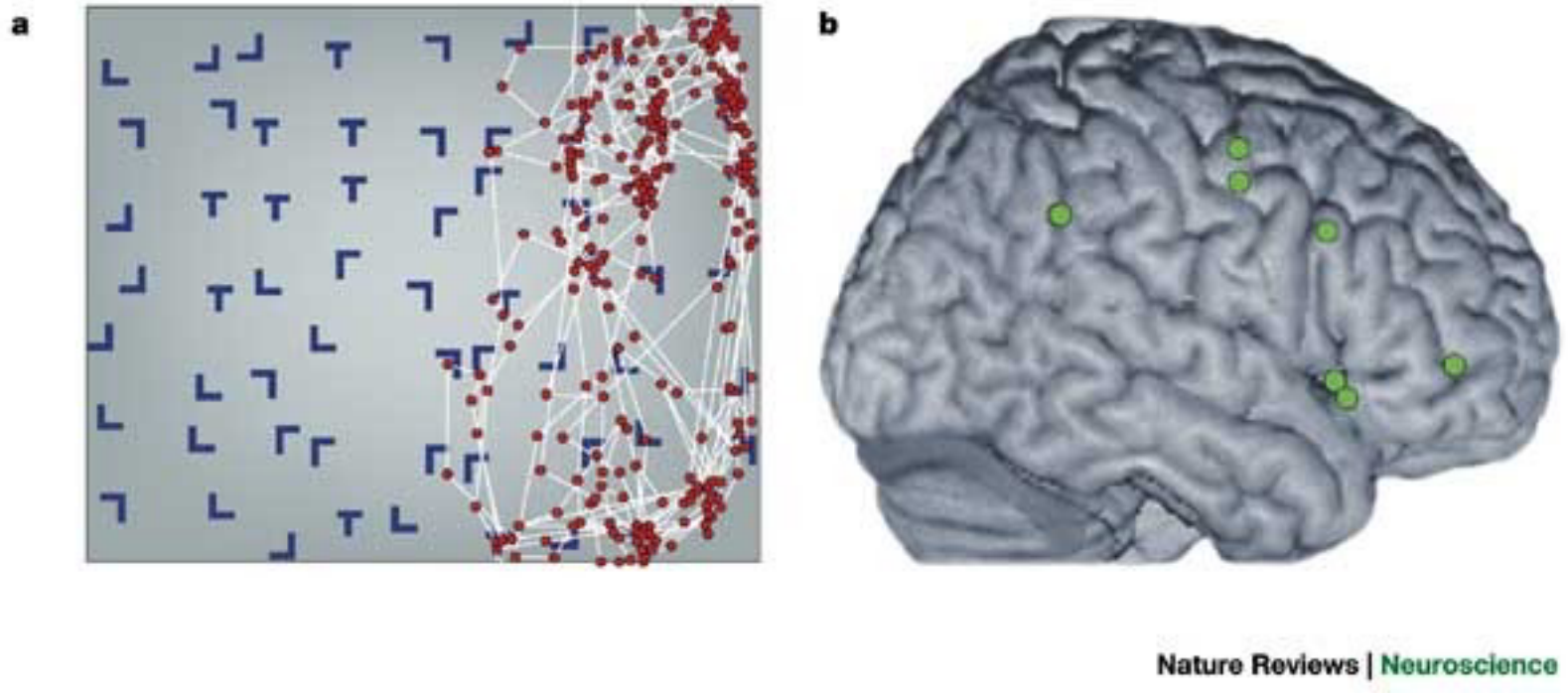


d **Milan Square**

Nature Reviews | Neuroscience

Husain & Rorden 2003

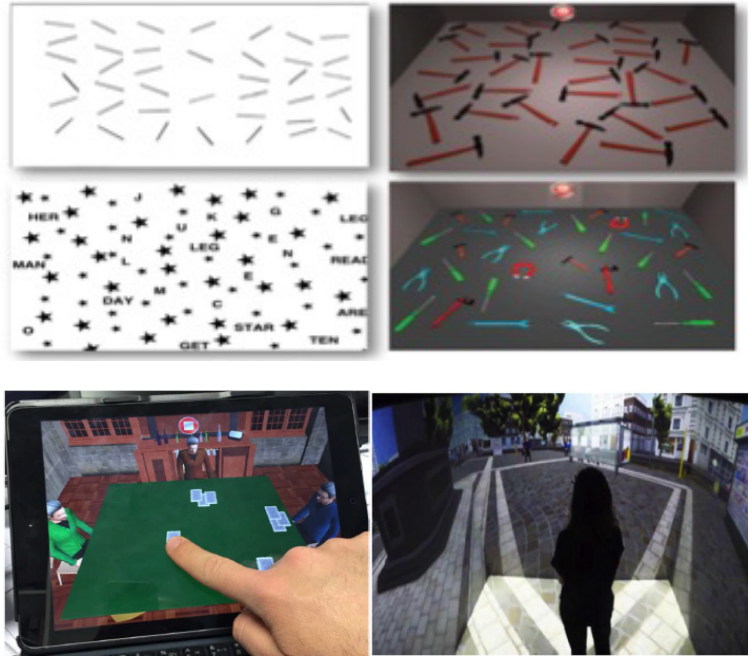
Visual exploration



Husain & Rorden 2003

Neurotechnology

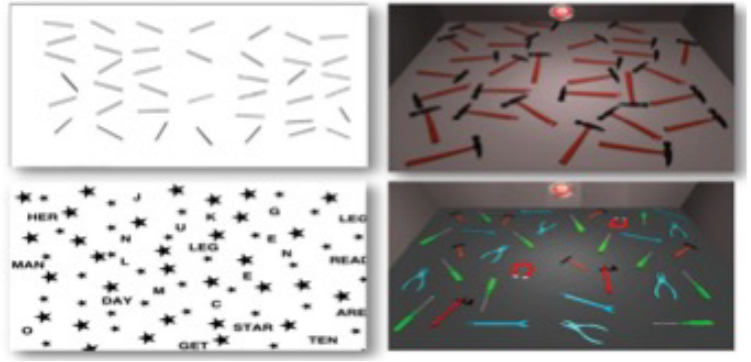
Paper-Pencil to computerized



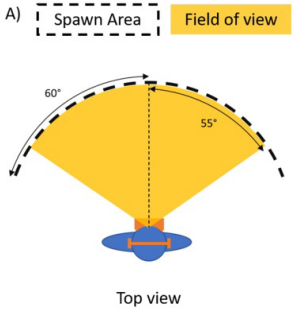
Knobel et al. 2021; for review Cavedoni et al. 2022

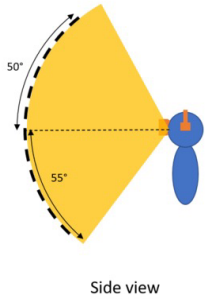
Neglect – Diagnostics

Paper-Pencil to computerized



Task Using Immersive Virtual Reality





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

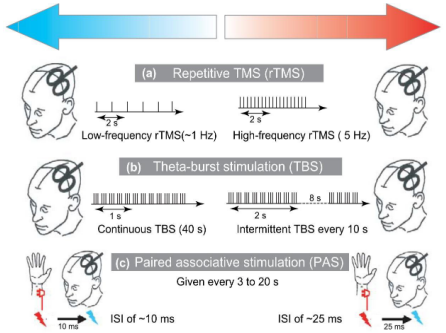
Sensory Stimulation

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

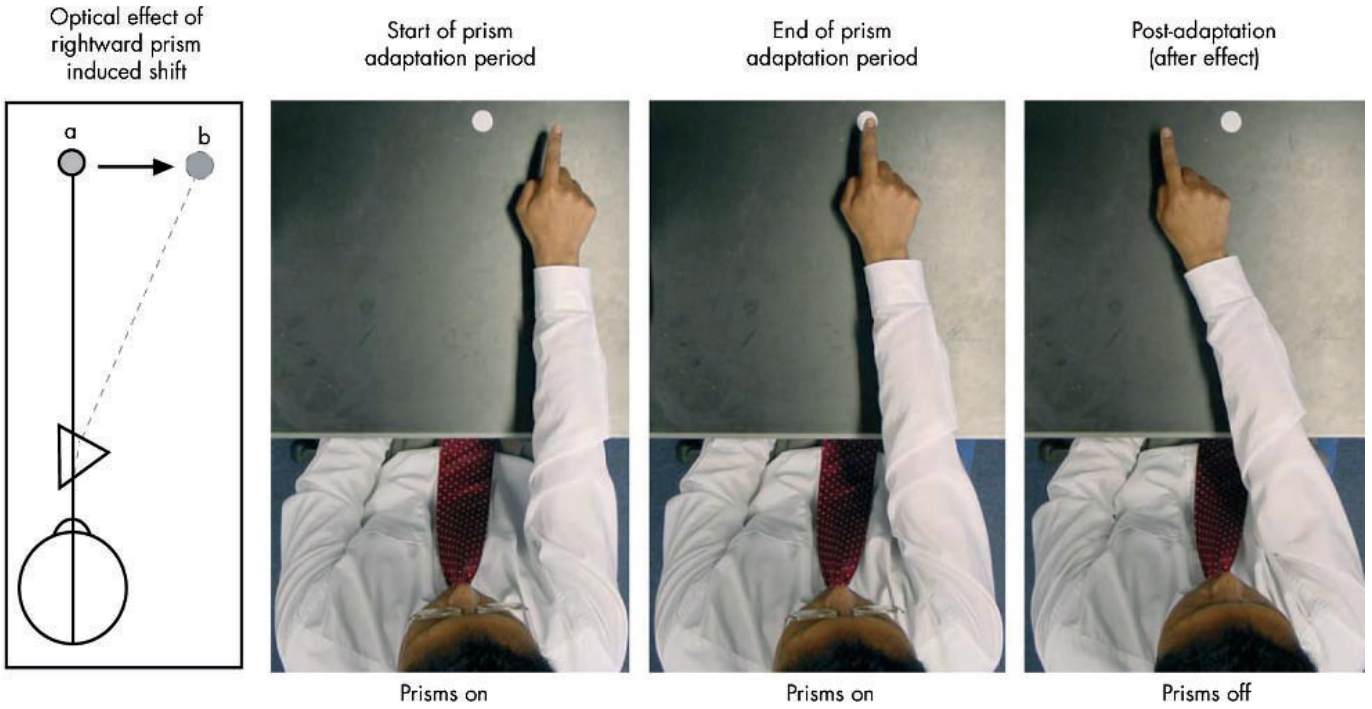


Quartarone *et al.* 2006 TINS

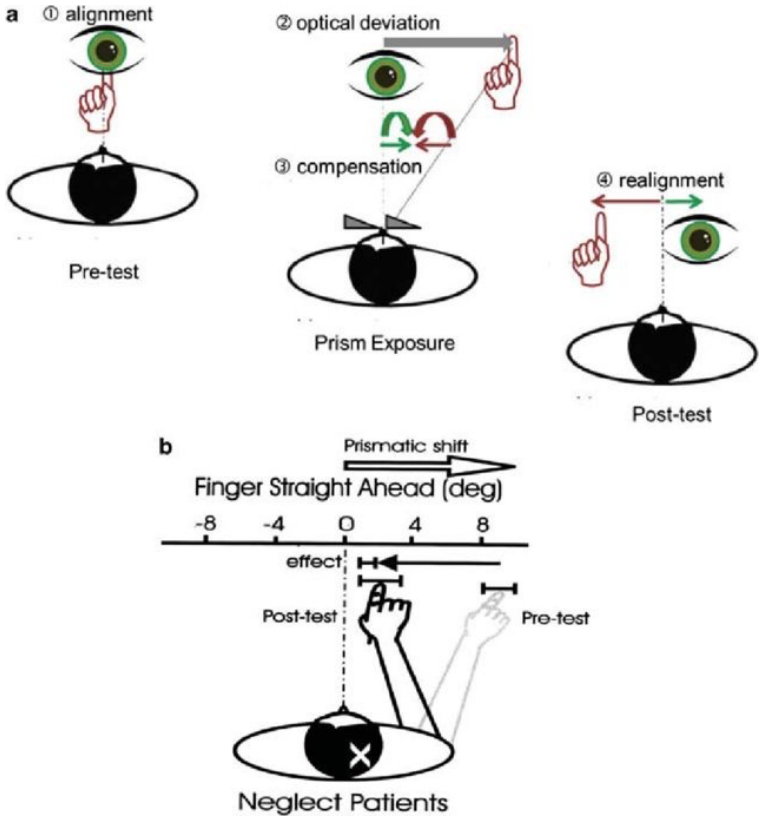
Friedhelm C. Hummel

Neglect – Prism adaptation

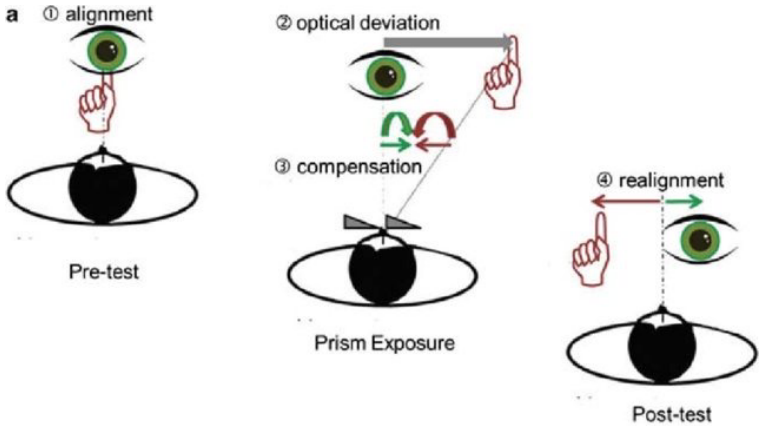
Prism adaptation-based therapy

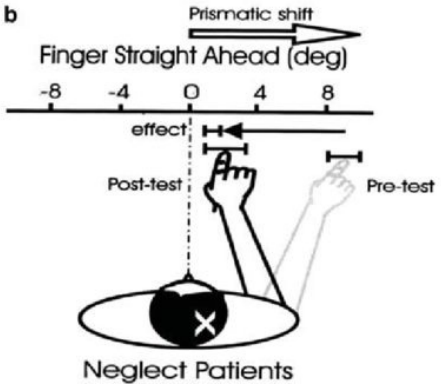


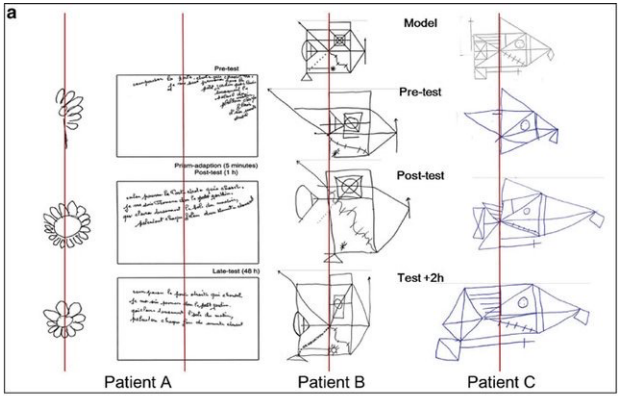
Adapted from Parton 2004

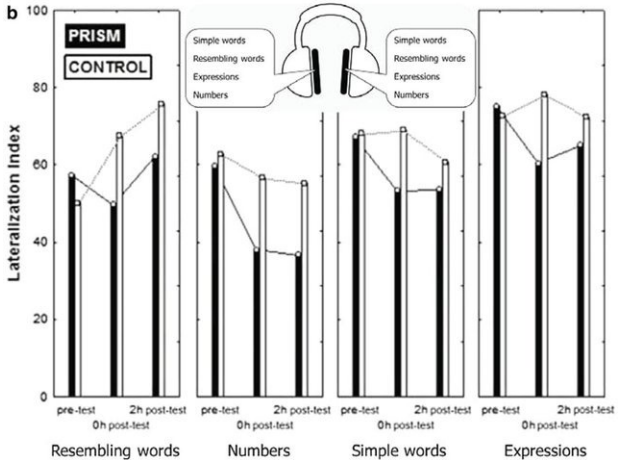


Rossetti et al. 2015



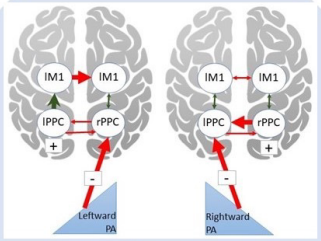




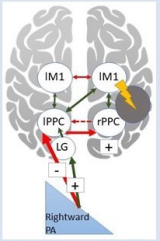


Rossetti et al. 2015

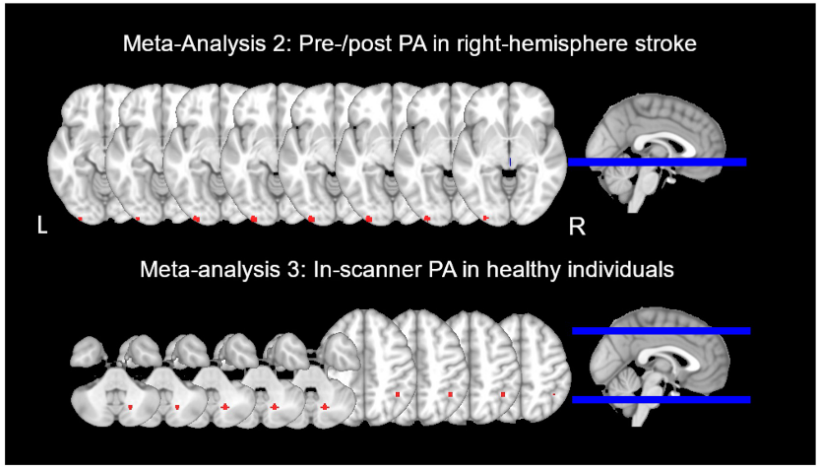
Neural Mechanisms of Prism Adaptation



Prism adaptation (PA) in healthy adults activates posterior parietal cortex and cerebellum, reduces bilateral parieto-frontal, and increases fronto-limbic and sensorimotor network connectivity.

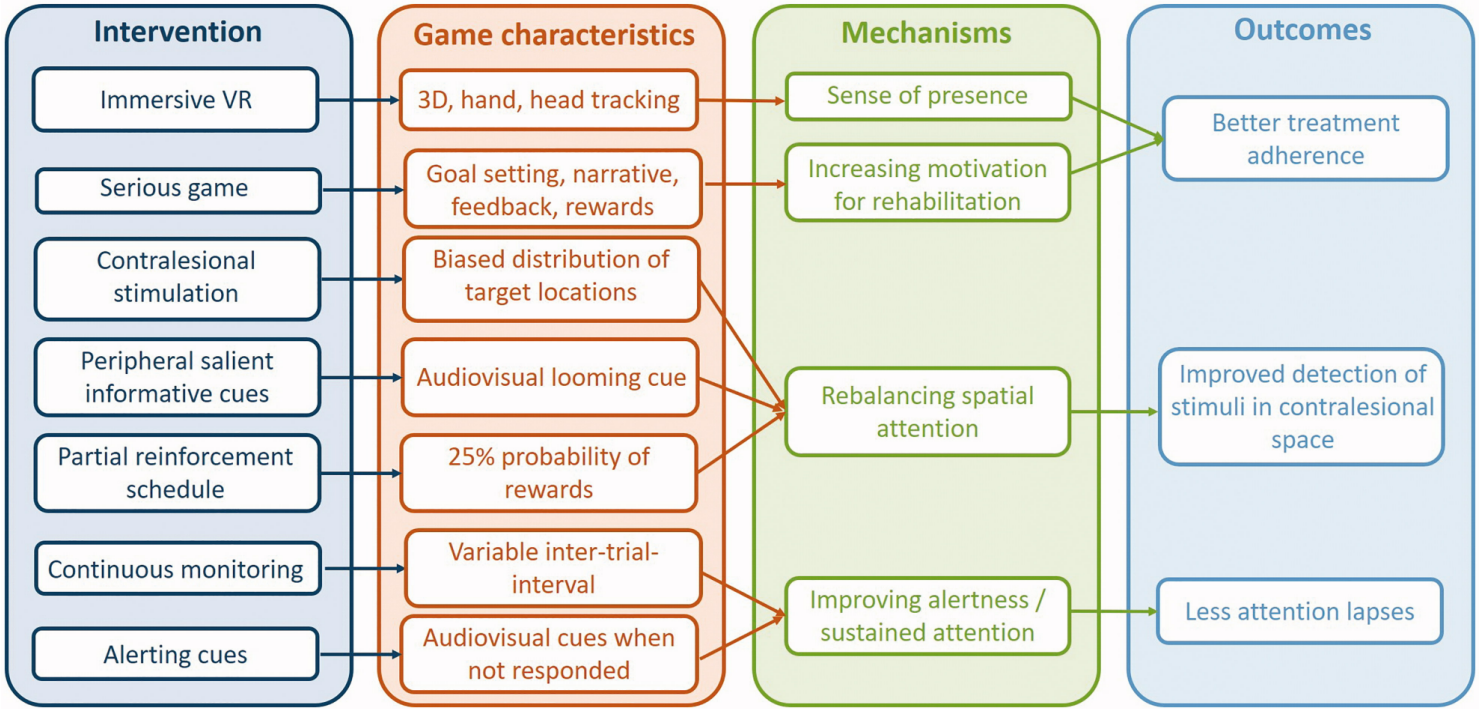


PA in right brain damaged individuals with spatial neglect relies on different circuits, such as, the intact left occipital cortex, indicating a hemispheric re-organization in spatial processing.

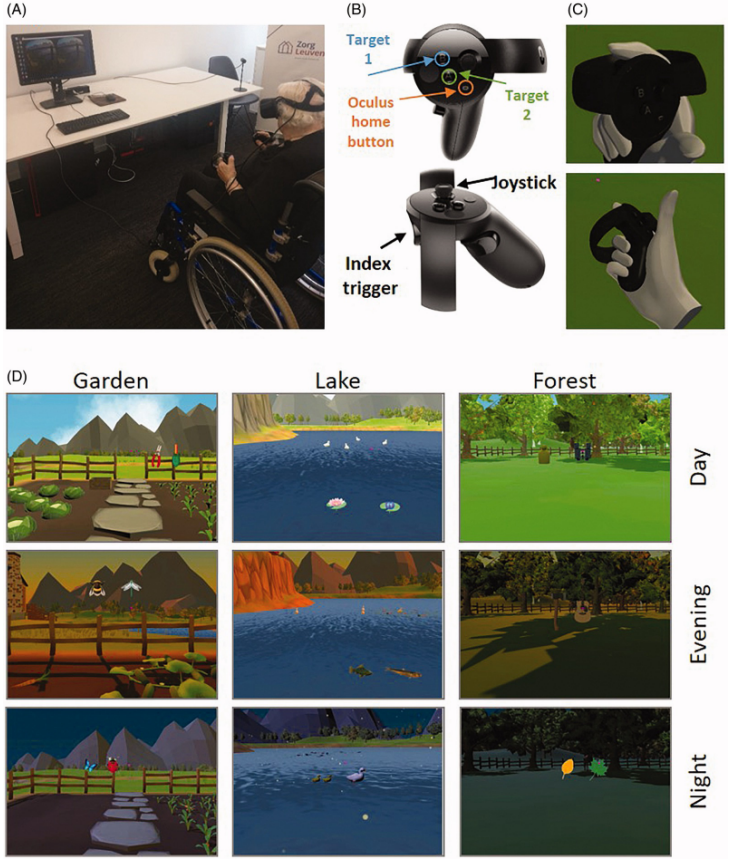


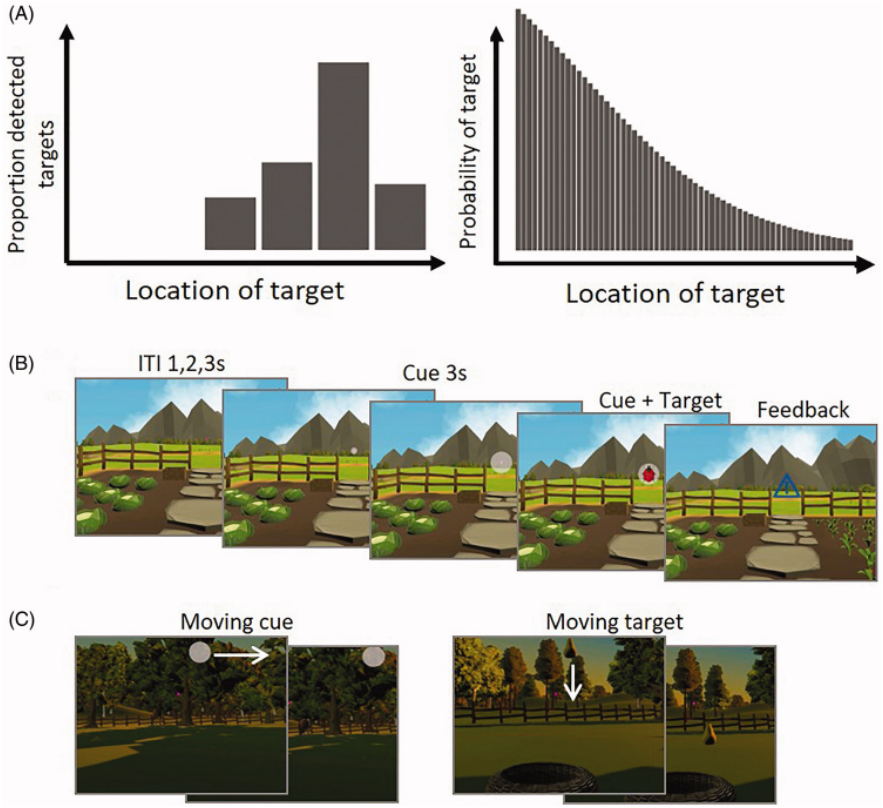
Boukrina 2021

Allows to address several mechanisms simultaneously



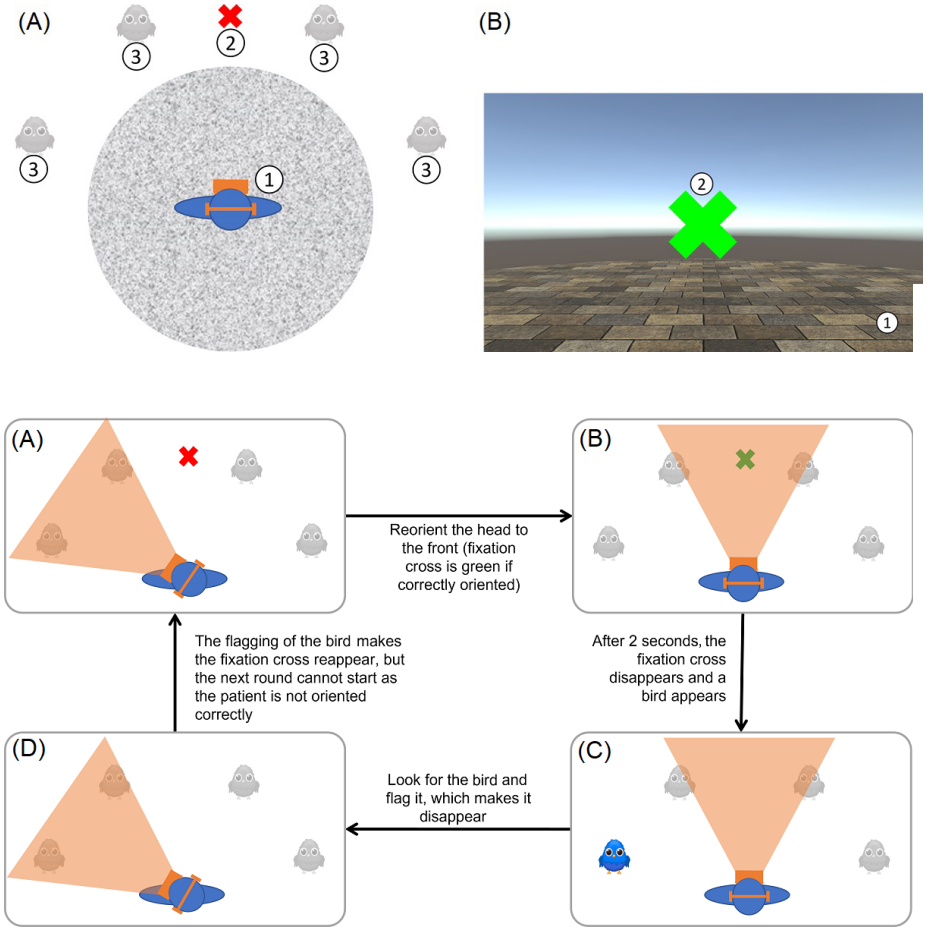
Huygelier et al. 2022

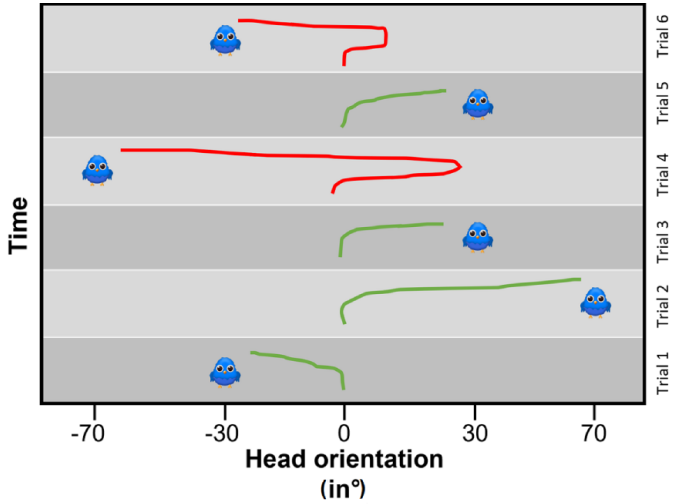




Huygelier et al. 2022

Neglect – VR for treatment

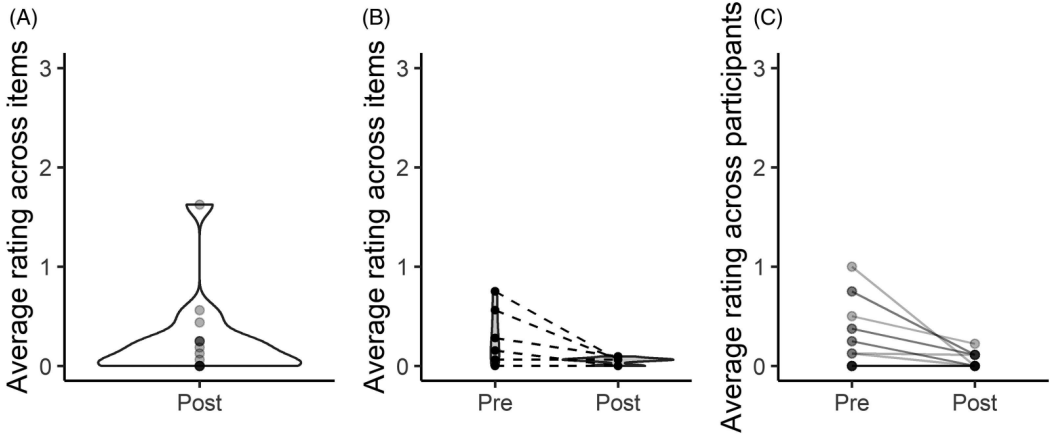


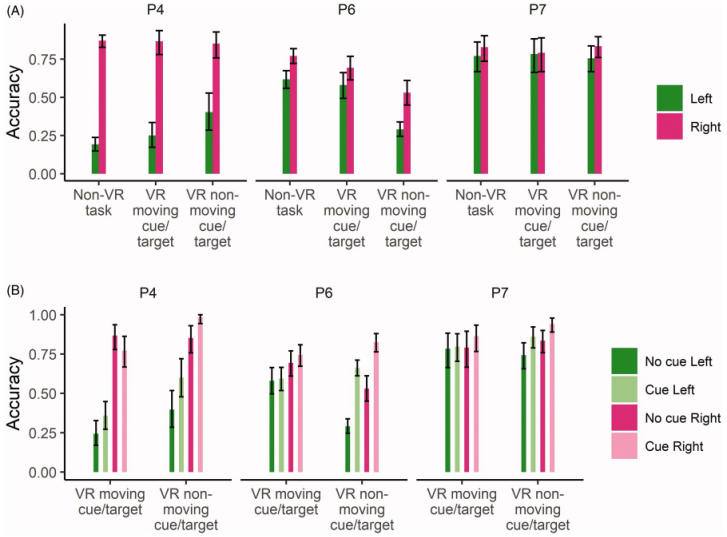


Knobel et al. 2022

Neglect – VR, gaming

Proof-of-concept in few patients

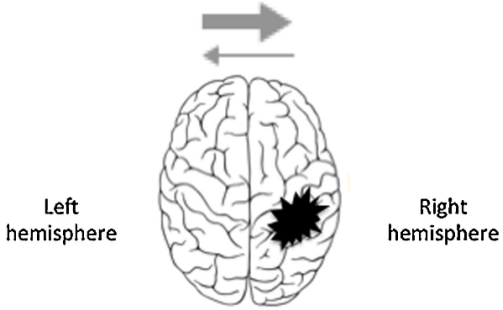




Huygelier et al. 2022

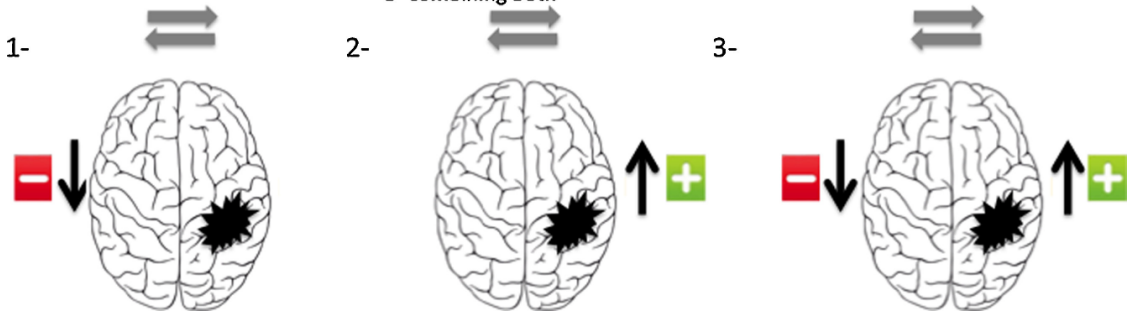
Neglect – Brain stimulation

Spatial neglect: interhemispheric imbalance
brain lesion and reciprocal inhibition imbalance

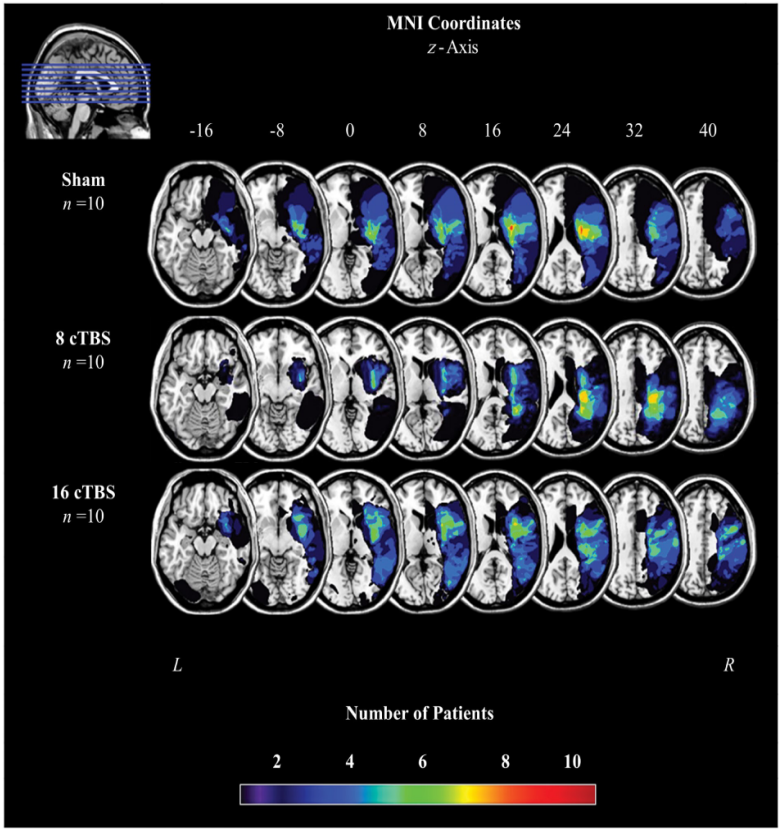


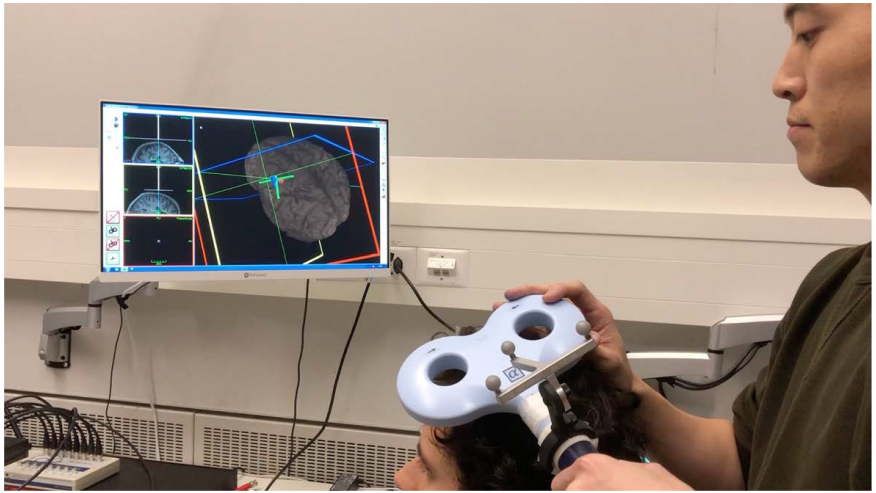
Rationale of non invasive brain stimulation
In neglect

1- reducing excitability of undamaged hemisphere
2- enhancing excitability of damaged hemisphere
3- combining both



Jacquin-Courtois 2015

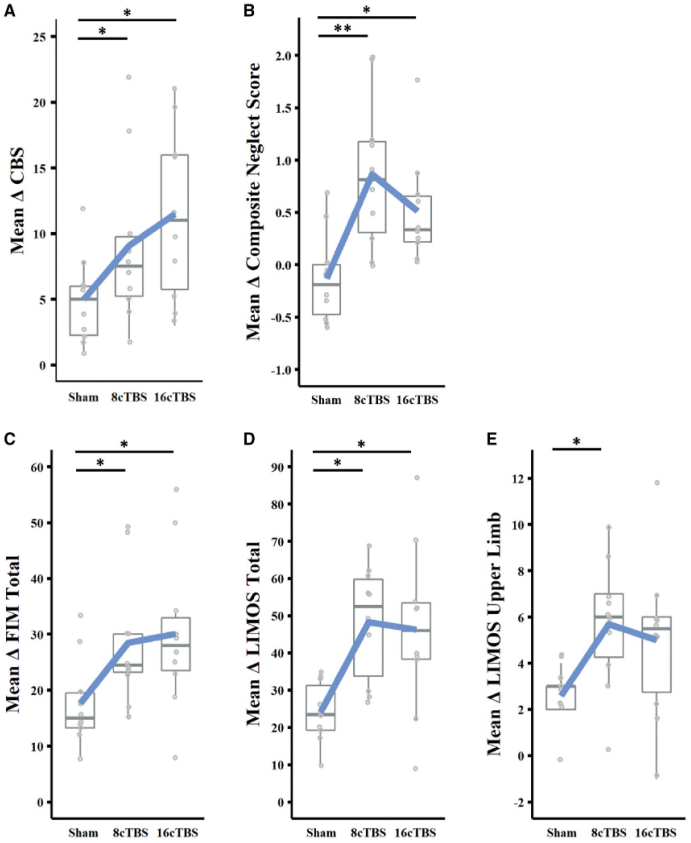




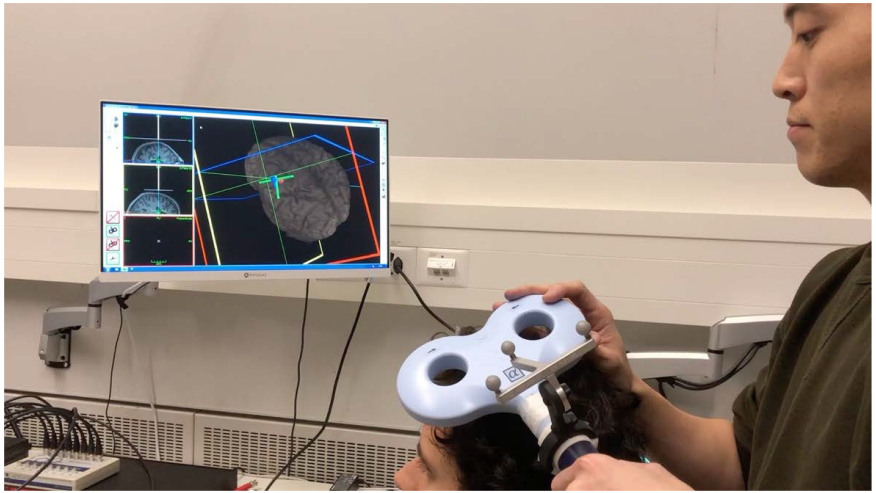
cTBS rTMS (inhibitory)
Applied to the left (non-lesioned) parietal cortex
2 different dosages
Placebo controlled
Subacute stroke patiens

Nyfeller *et al.* Brain 2019

Neglect – Brain stimulation



Significant improvement in clinical measures



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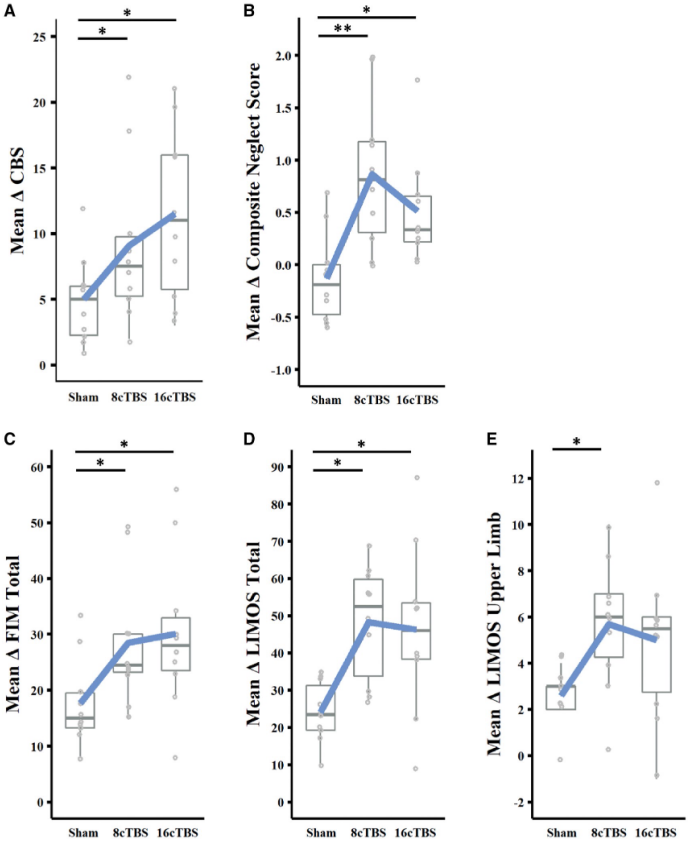

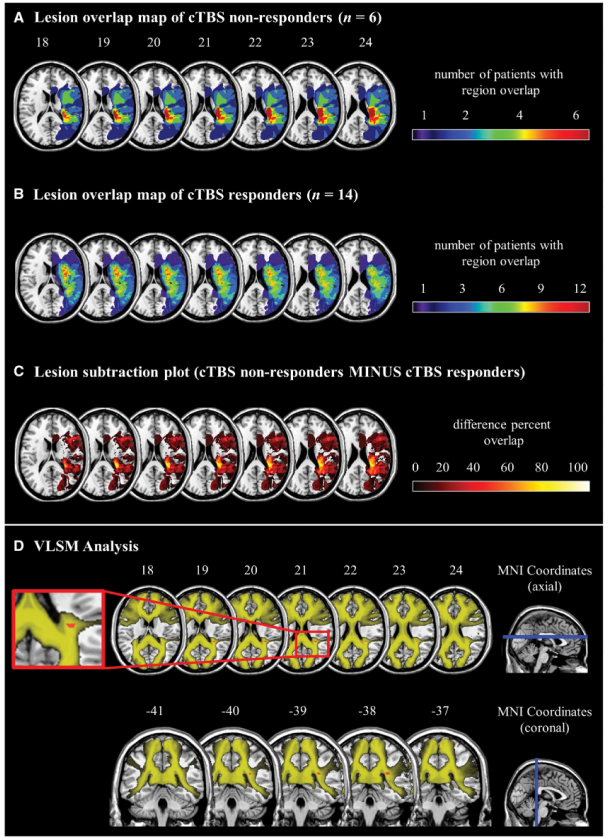

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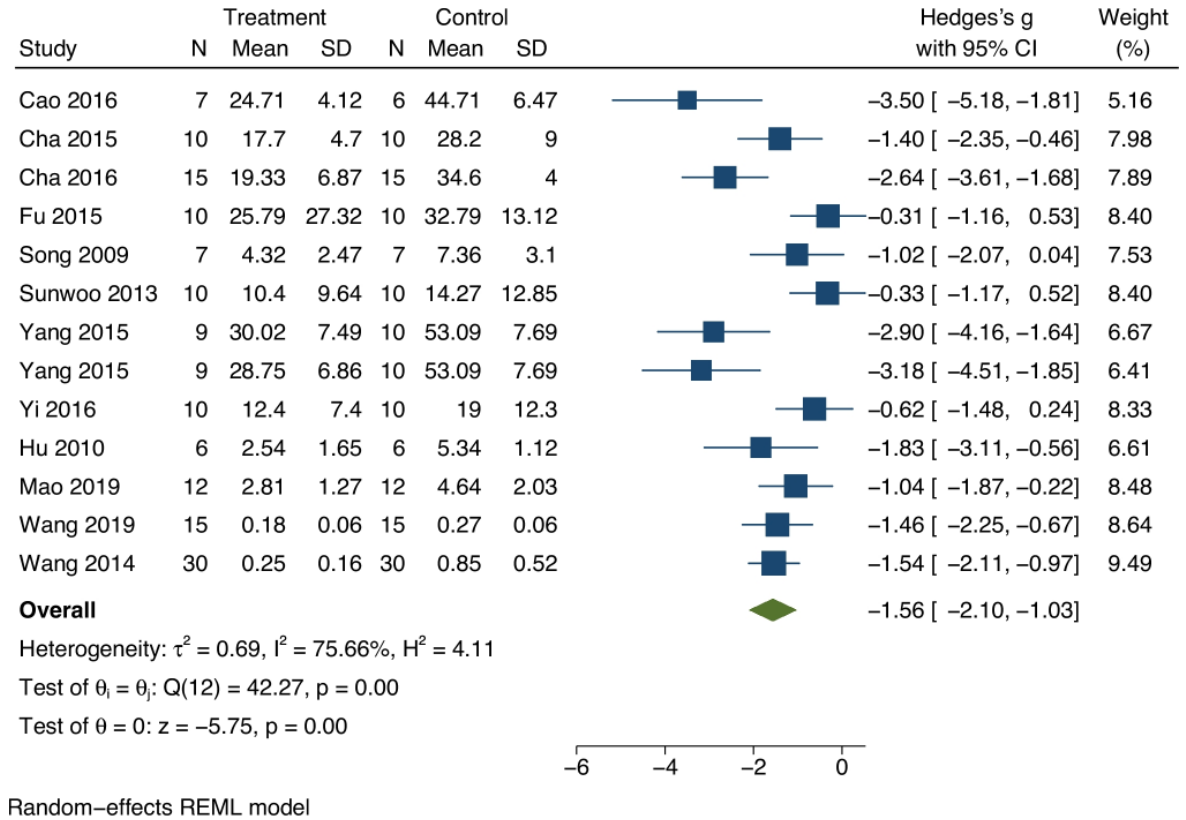
Neglect – Brain stimulation



Study	Treatment N	Treatment Mean	Treatment SD	Control N	Control Mean	Control SD	Hedges's g with 95% CI	Weight (%)
Cao 2016	7	24.71	4.12	6	44.71	6.47	−3.50 [−5.18, −1.81]	5.16
Cha 2015	10	17.7	4.7	10	28.2	9	−1.40 [−2.35, −0.46]	7.98
Cha 2016	15	19.33	6.87	15	34.6	4	−2.64 [−3.61, −1.68]	7.89
Fu 2015	10	25.79	27.32	10	32.79	13.12	−0.31 [−1.16, 0.53]	8.40
Song 2009	7	4.32	2.47	7	7.36	3.1	−1.02 [−2.07, 0.04]	7.53
Sunwoo 2013	10	10.4	9.64	10	14.27	12.85	−0.33 [−1.17, 0.52]	8.40
Yang 2015	9	30.02	7.49	10	53.09	7.69	−2.90 [−4.16, −1.64]	6.67
Yang 2015	9	28.75	6.86	10	53.09	7.69	−3.18 [−4.51, −1.85]	6.41
Yi 2016	10	12.4	7.4	10	19	12.3	−0.62 [−1.48, 0.24]	8.33
Hu 2010	6	2.54	1.65	6	5.34	1.12	−1.83 [−3.11, −0.56]	6.61
Mao 2019	12	2.81	1.27	12	4.64	2.03	−1.04 [−1.87, −0.22]	8.48
Wang 2019	15	0.18	0.06	15	0.27	0.06	−1.46 [−2.25, −0.67]	8.64
Wang 2014	30	0.25	0.16	30	0.85	0.52	−1.54 [−2.11, −0.97]	9.49
Overall							−1.56 [−2.10, −1.03]	

Heterogeneity: $\tau^2 = 0.69$, $I^2 = 75.66\%$, $H^2 = 4.11$

Test of $\theta_i = \theta_j$: Q(12) = 42.27, p = 0.00

Test of $\theta = 0$: z = −5.75, p = 0.00

Random−effects REML model

Li & Huang 2022

Take home message - Interventions

Neurotechnology offers treatment opportunities in neglect based on

- Prism adaptation
- VR-based cueing
- Non-invasive brain stimulation

Next steps

- Personalization
- Larger trials
- Development towards home-based, self-application

Questions?