

SPATIAL NEGLECT

(unilateral neglect, hemi-inattention)

DEFINITION

- failure to explore, orient or respond to contents of the contralesional side of somatic and extrasomatic space (Heilman, et al., 2000)
- Prevalence after stroke varies (Gammeri, et al., 2020; Ringman, et al., 2004)
 - RBD – 26-72%
 - LBD – 19-61%

WHY WORRY ABOUT NEGLECT?

- **Interferes with success during rehabilitation.** (Jehkonen, et al., 2006; Bosma, et al., 2020)
- **Reduced independence in daily activities** ((Kerkhoff & Schenk, 2012; Nijboer, et al., 2013; Czernuszenko, et al., 2009)
- **Reduces community re-integration**
- **Associated with falls** (Kortte & Hillis, 2009)

LONG TERM PREVALENCE

- **Long-term prevalence after stroke varies** (Gammeri, et al., 2020; Ringman, et al., 2004; Della Sala, et al., 2018) -
 - RBD – persistent in 17%
 - LBD –; persistent in 5%
- **Long-term interference in daily life tasks** (e.g., Della Sala, et al., 2018)
 - **daily life tasks are more cognitively complex than most neglect tests**

ASSESSMENT OF NEGLECT

- Clinical guidelines recommend screening of individuals with acute stroke for neglect and other cognitive deficits (Royal college of Physicians, 2004; VADOD, 2010; American Heart Association, 2016)



But neglect is not routinely assessed

- ▶ A recent study of 2018 and 2019 5% Medicare Limited Data Set data (Morrow, et al., 2024)
 - ▶ Only 4.9% had neglect formally diagnosed out of 9,076 participants

ARE PEOPLE WITH STROKE BEING SCREENED FOR NEGLECT?

- NIHSS has a, possibly 2, “neglect” items
 - Visual and tactile extinction item
 - VF item
- Most places routinely administer the NIHSS

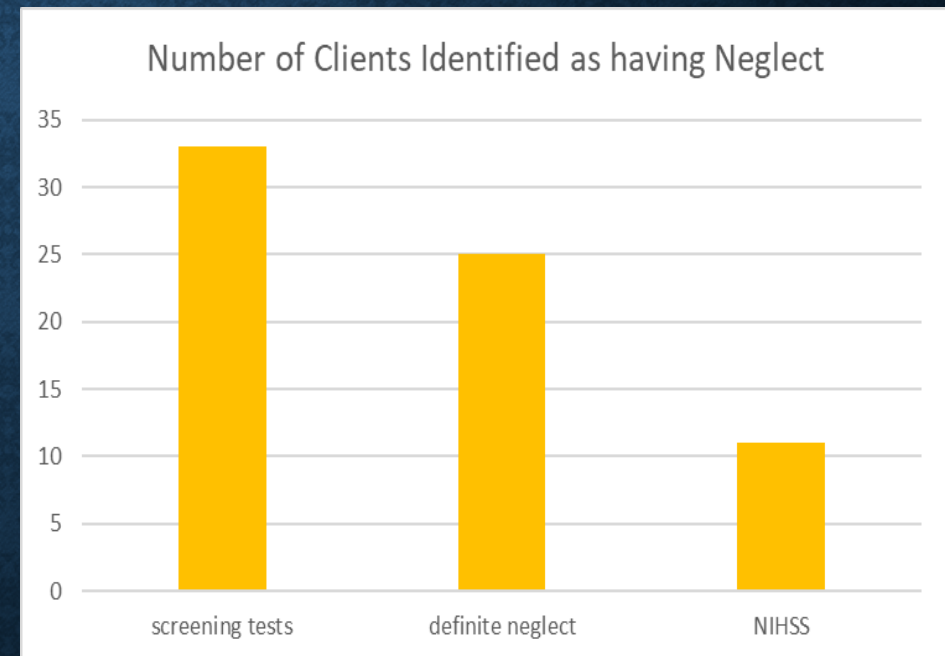
ARE PEOPLE WITH STROKE BEING SCREENED FOR NEGLECT?

- 428 clients within 7.3 days of stroke (Moore, et al., 2019)
 - Gave NIHSS and Oxford Cognitive Screen Cancellation Task
- 62 clients with (Pug-Pijoan, et al., 2018)
 - Line Bisection, Triangle Cancellation, Circle Gap Detection test
 - NIHSS given by vascular neurologists

ARE PEOPLE WITH STROKE BEING SCREENED FOR NEGLECT?

- Moore, et al (2019)
 - Specificity 91.2%
 - Sensitivity 31.6%
- Better for more severe – but still only 38.1% sensitivity
- Better for more subtypes

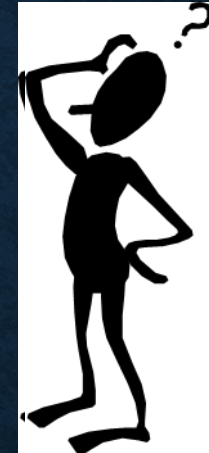
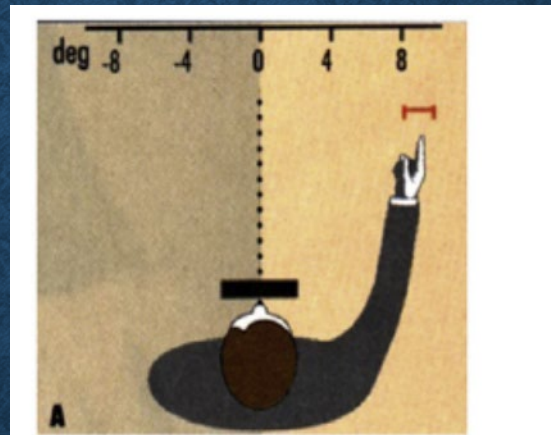
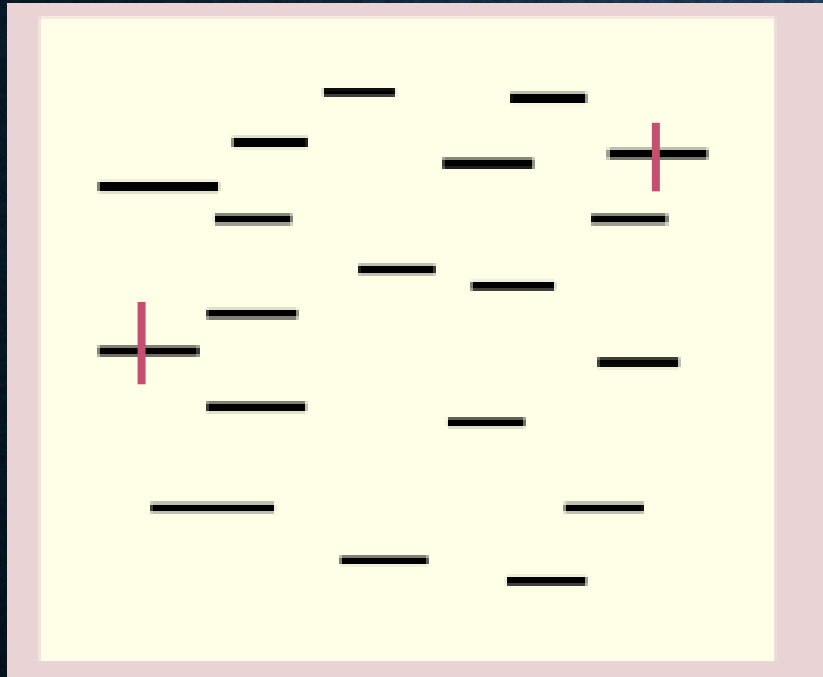
- Puig-Pijoan, et al. (2018)



EVALUATIONS FOR NEGLECT

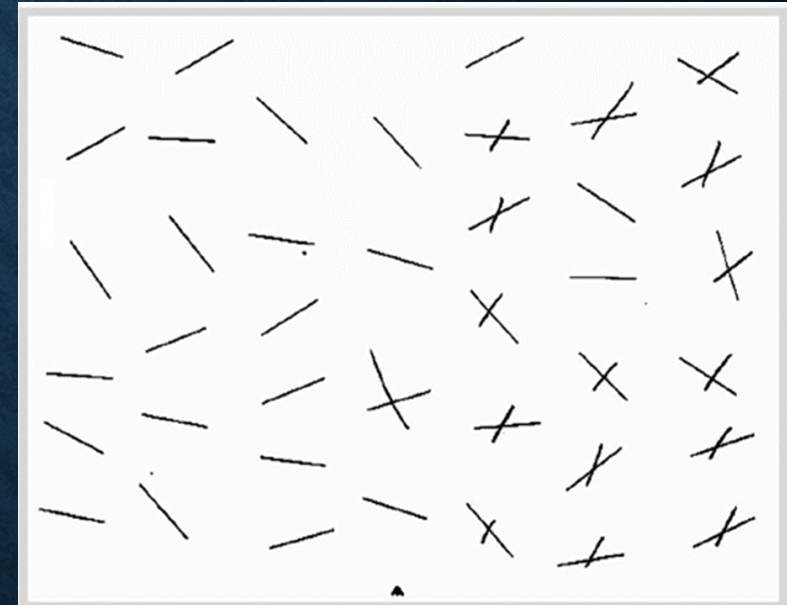
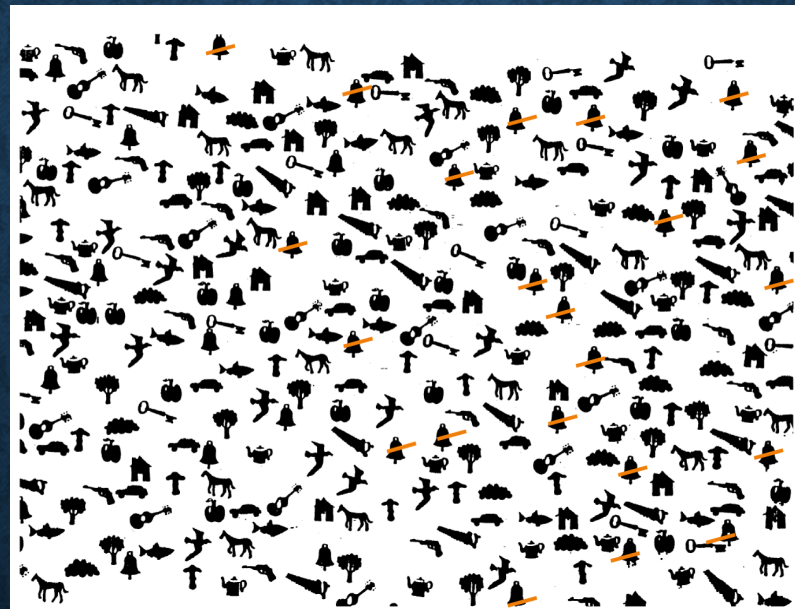
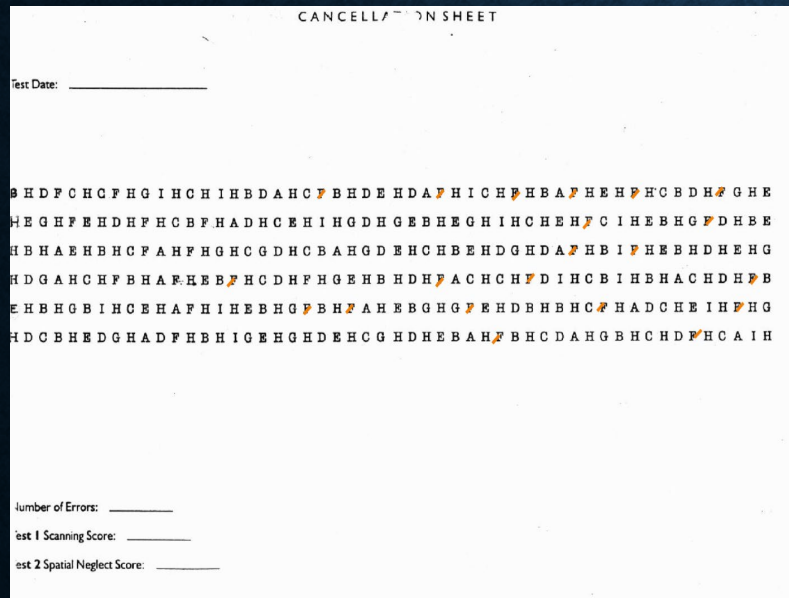
- “Find the midpoint” tests
- Search tests – usually visual
- Drawing/copying tests
- Perceptual judgment tests
- Reading Tests
- Extinction Tests
- Eye movements
- Posture tests
- Functional Tests

“FIND THE MIDPOINT” TESTS : LINE BISECTION



SEARCH TESTS

- Cancellation tests (letter, star, word, shape, Alberts, Bells)



SEARCH TESTS

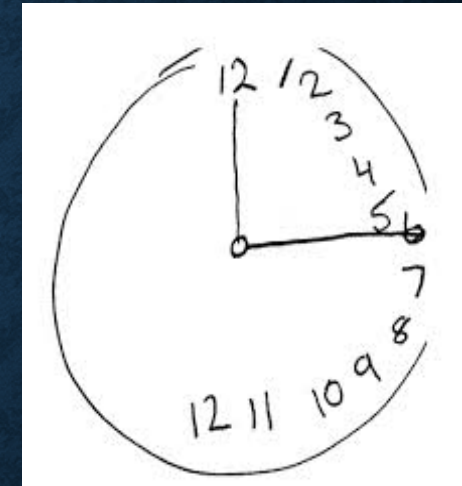
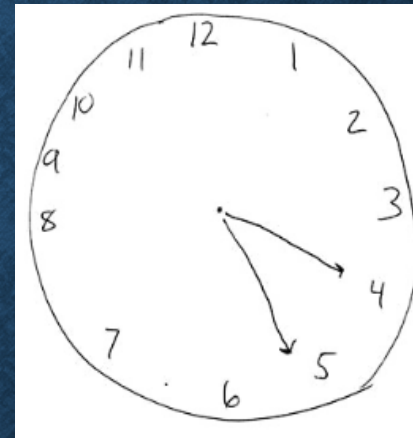
- Fluff Test (Cochini, et al., 2001)



DRAWING/COPYING TESTS

- **Clock drawing - Accuracy scoring** (Chen & Goedert, 2012)

- Hands present
- All # present
- No # repeated
- No substitution (e.g., tick marks)
- # orientation is normal
- # order is accurate (if there is a repetition, but otherwise normal, accept this item)
- All # are in the circle
- No empty quadrant (if only anchor # then don't get this item)
- No extra marks in circle
- No # > 12
- Hands are connected
- 2 hands present
- 1 hand is longer
- No # orientations are rotated
- Number -to-edge distance is constant
- Equal space between numbers
- No military time
- Anchoring # are present



Clock size – height and width

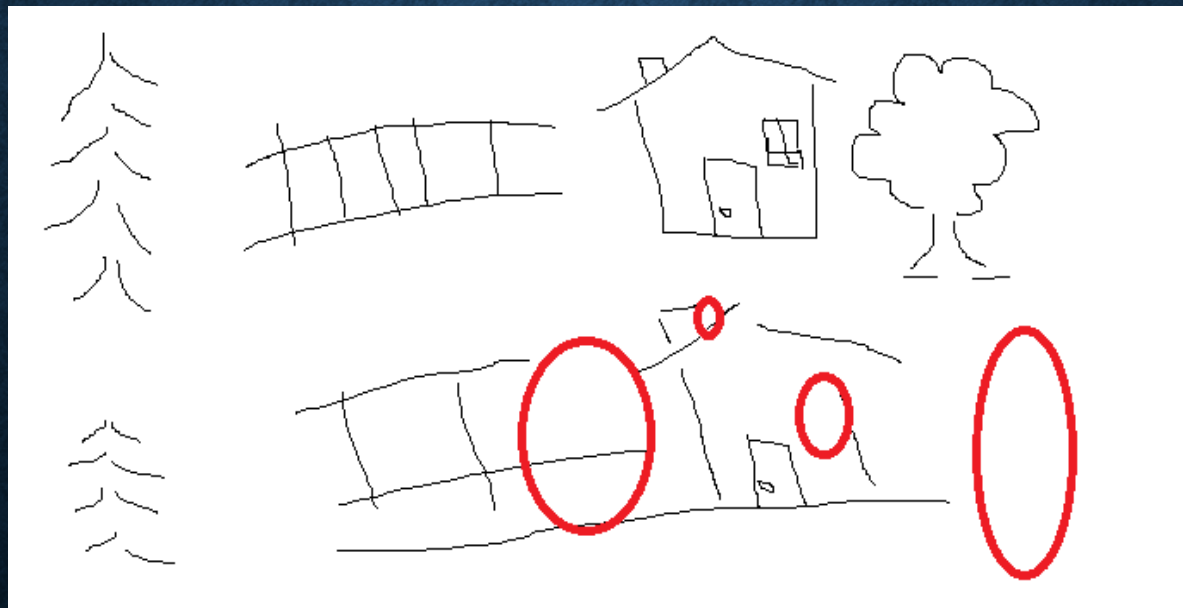
Clock shape – if a perfect circle = 1; oval

vertically = > 1; oval horizontally = < 1

Displacement from center of page = how much
L or R and towards top or bottom of page.

DRAWING/COPYING TESTS

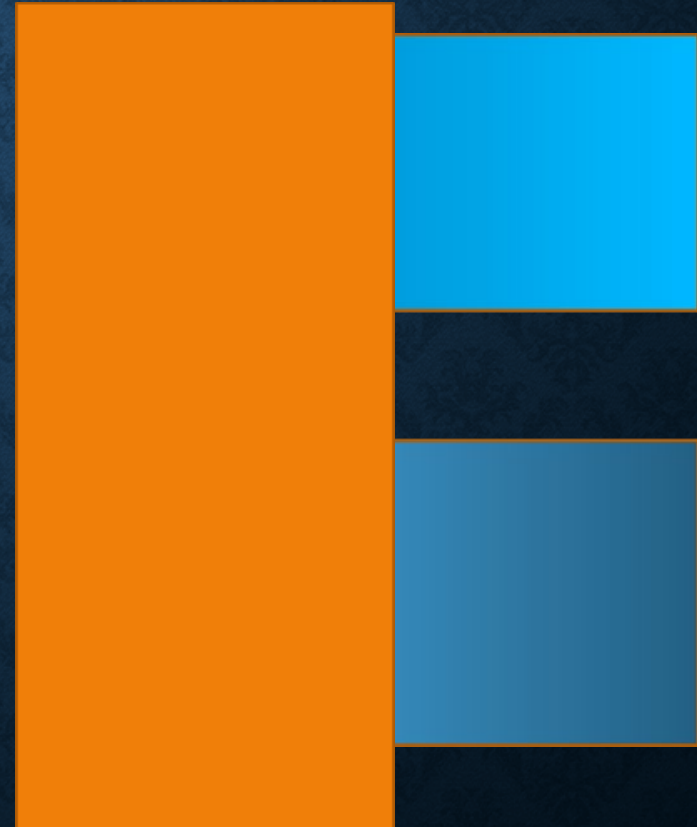
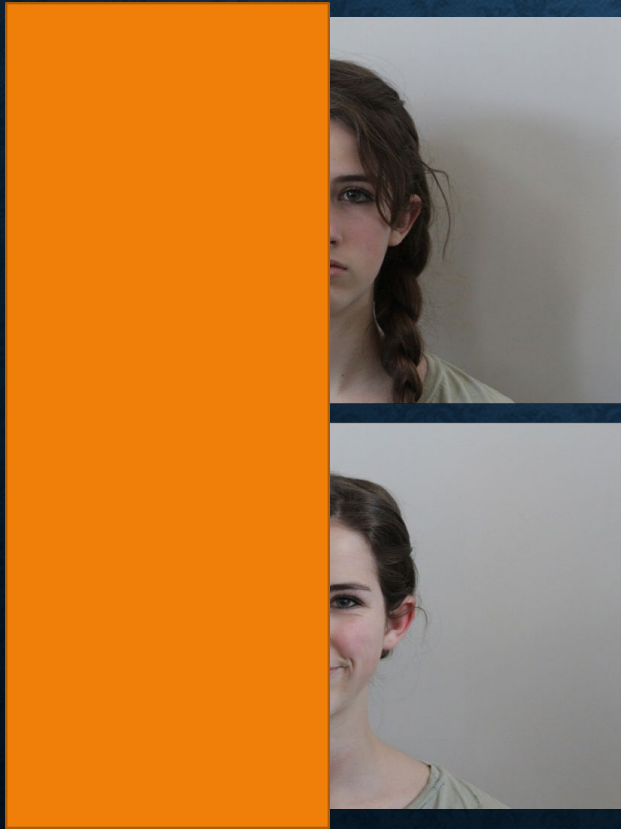
- Ogden Scene Drawing test (Ogden, 1985)



(Kleinman, et al., 2007)

PERCEPTUAL JUDGEMENT TASKS

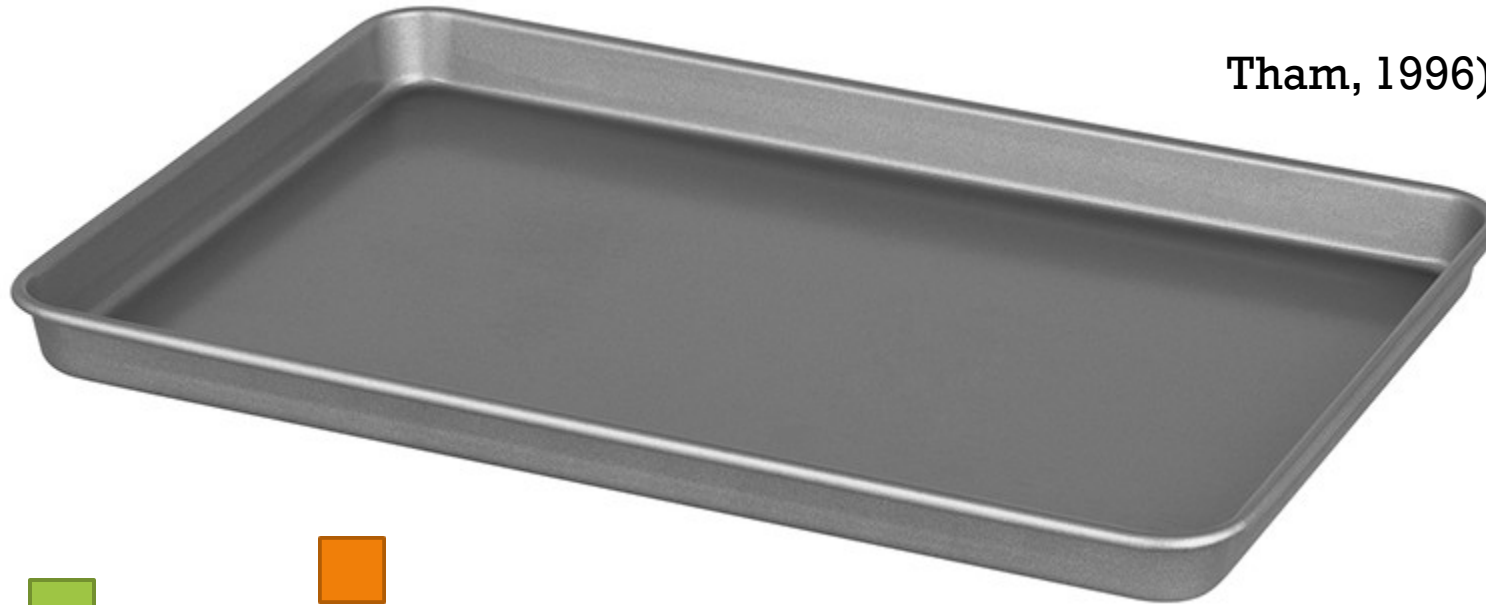
- Chimeric faces (Is it a real face?; Which is happier?)
- Grey Scales (Which is darker?)

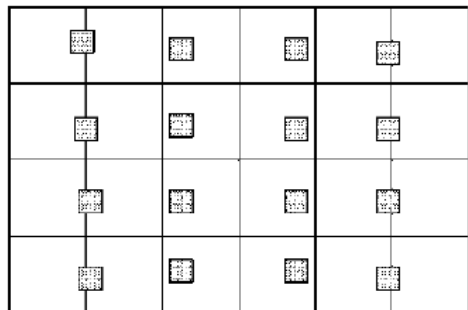


SIMULATED OR REAL FUNCTIONAL TASKS

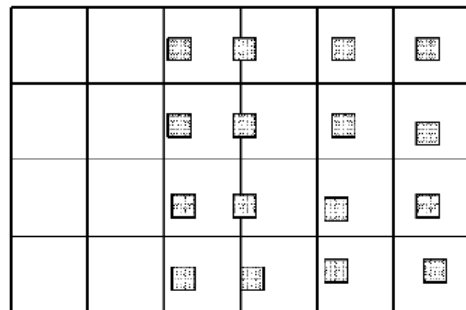
BAKING TRAY TASK

Tham, 1996)

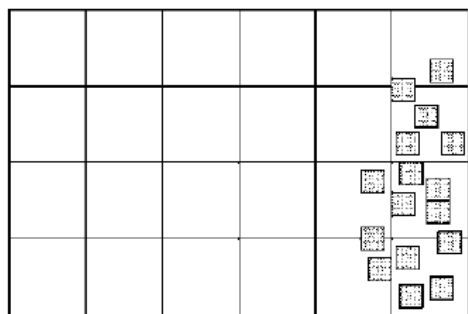




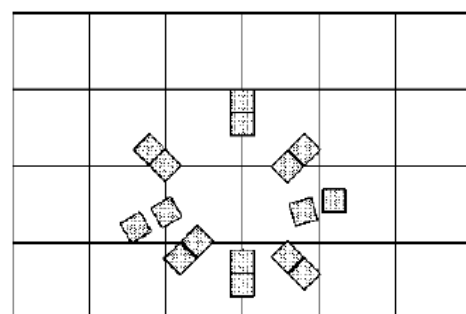
a. Normal



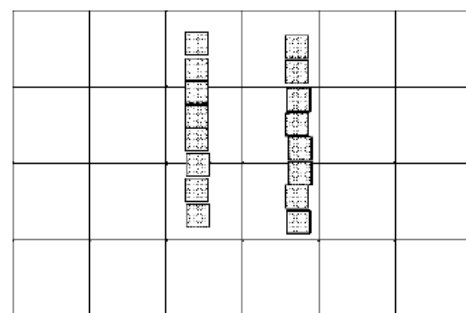
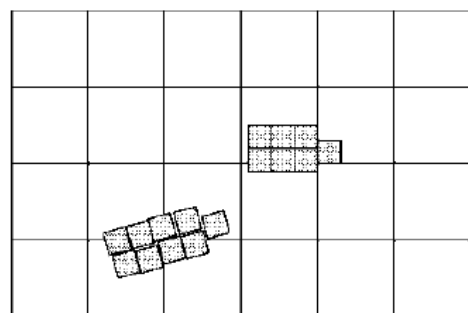
b. Rightward bias (unilateral neglect)



c. Rightward bias (unilateral neglect)



d. Figure formation (cognitive impairment)



NEGLECT ASSESSMENT

- No one assessment identifies all people with neglect
- Line bisection
 - doesn't always correlate with other neglect assessments (e.g., Sperber & Karnath, 2016)
 - Sperber & Karnath suggest it shouldn't be used at all in acute stroke to dx neglect.

A test battery should be used

TEST BATTERIES



- **(Rivermead) Behavioral Inattention Test**
 - Criterion-referenced test
 - Conventional subtests
 - Line crossing, letter cancellation, star cancellation, figure copying, line bisection, and representative drawing
 - Used most often
 - Behavioral subtests
 - Picture scanning, telephone dialing, menu reading, article reading, telling and setting the time, coin sorting, address and sentence copying, map navigation, and card sorting

TEST BATTERIES

- **Semi-Structured Scale for Functional Evaluation of Hemi-Inattention** (Zoccoloti, et al., 1992)
 - Personal neglect subscale
 - Show me how you comb your hair, use the razor/powder yourself, put your eyeglasses on?
 - Extrapersonal neglect subscale
 - Serving tea, card dealing, picture description, environment description

(Della Sala, et al., 2018)

Pt Code	Days from onset		Extra USN		Personal USN		RCPM	DT	Everyday USN		Gaze	Examples of USN in everyday life
	First	Last	First	Last	First	Last			Extra	Personal		
1	20	90	+	-	+	-	+	+	+	-	-	While working in the family repair shop, his nephews kept noticing that he would ignore the screws and bolts on his left.
2	30	110	+	-	+	-	-	+	+	-	+	When his flat's intercom rings, he would go downstairs to open the door, as he could not find the intercom on the left side of the wall.
3	180	270	+	-	+	-	-	+	+	-	+	She failed to notice the dosage of her pills even though the pharmacist kept telling her that they appeared on the left side of the box.
4	60	160	+	-	-	-	+	+	+	-	+	He was admitted more than once to the Accident & Emergency of the local hospital as he kept knocking objects on his left side.
5	40	100	+	-	-	-	-	+	+	-	-	Back to his work as Radiologist, he failed to scrutinize the left side of CT and MRI scans, returning repeatedly to inspect the right side.
6	20	90	+	-	-	-	+	+	+	+	-	He failed to locate his left slipper or left shoe to the point that he often gave up searching and started to walk wearing only the right shoe.
7	80	180	-	-	+	-	-	-	-	+	-	She would ignore her left arm. When her husband confronted her, forcing her to take notice, she would spend hours cuddling her left arm.
8	60	120	-	-	-	-	-	-	+	+	-	Her husband was concerned by the fact that she lays the table only on the right side.
9	180	240	-	-	-	-	-	+	-	+	-	In standing up, she would ignore her left side, as if it did not exist. She would not put any weight on her left leg (assuming a pink flamingo shape), and attempted walking as if she only had her right leg.
10	120	180	-	-	-	-	-	-	-	+	-	Careless towards his left side. This was a cause of great concern for him when walking for fear of falling. Notably, this left neglect and the accompanying concern were rather frequent at home yet never present in the gym with the physio.

Legenda: DT: Dual Task; Extra: Extrapersonal; RCPM: Raven Coloured Progressive Matrices; +: presence of USN; -: absence of USN.

SIMULATED OR REAL FUNCTIONAL TASKS

CATHERINE BERGEGO SCALE (KF-NAP VERSION)

- Observe client
 - grooming L side of face
 - adjusting left sleeve/slipper
 - eating food on L side of plate
 - knowledge of L limbs
 - collisions with objects on L
 - cleaning L side of mouth after eating
 - difficulty looking to L
 - finding personal belongings
 - auditory attention to L
 - difficulty traveling towards L on unit

(Chen & Hreha, 2015)

<https://kesslerfoundation.org/researchcenter/stroke/nsnapplication>

CATHERINE BERGEGO SCALE (KF-NAP™ VERSION)

- **Scoring of above items:**
 - 0=no neglect;
 - 1= mild neglect(always explores the R hemispace first and slowly/hesitantly explores the L side);
 - 2= moderate neglect (onstant and clear left-sided omissions or collisions);
 - 3 = severe neglect (only able to explore the right hemispace)
- **Total Score:**
 - 0 = No behavioral neglect
 - 1-10 = Mild behavioral neglect
 - 11-20 = Moderate behavioral neglect
 - 21-30 = Severe behavioral neglect

CATHERINE BERGEGO SCALE (KF-NAP™ VERSION)

- **Also can ask as a self-report questionnaire to assessment awareness - anosognosia**
 - 0 = no difficulty
 - 1 = mild difficulty
 - 2 = moderate difficulty
 - 3 = severe difficulty

DYNAMIC INTERACTIONAL TEST FOR NEGLECT (TOGLIA & CERMAK, 2009)

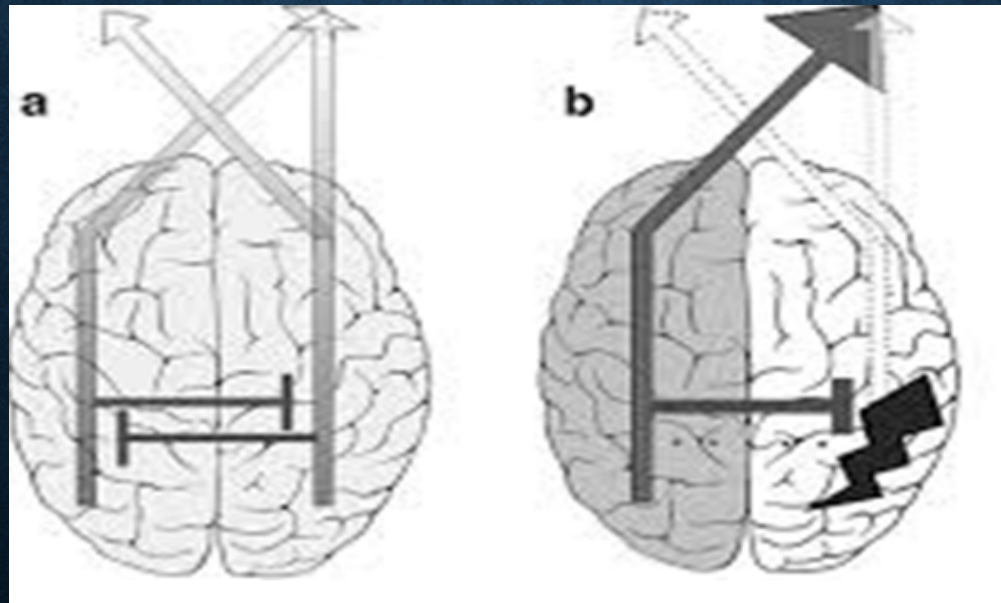
- Based on modern cognitive theories
 - Abilities are changeable and sensitive to instructive and context
- Purpose:
 - to assess learning potential for improving attention of Left space
 - To treatment plan

CUEING

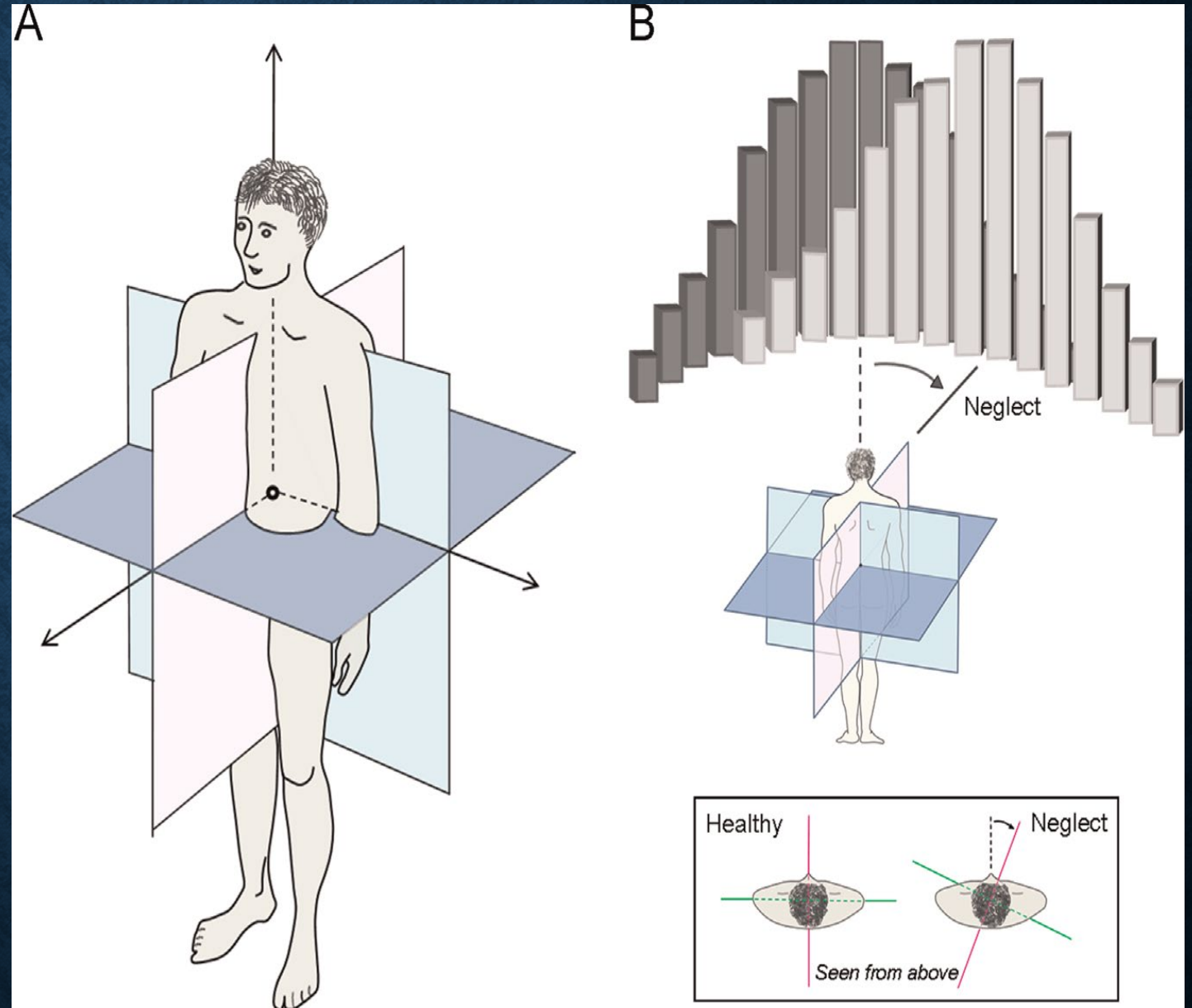
Cue or strategy	Sample Script
Verbal feedback	There are still some more on the left side. Remember to look to the left
Tactile, visual imagery strategy	Close your eyes. Feel and image the size of the space as I move your arm across across the page. Think of your eyes sweeping across the space like a beam of light. Imagine the size of the space in your mind as I move your arm. Now lets feel the edges around the table/page. Think about where your left edge of the page is and open your eyes to check.
Visual anchor strategy	Let's place your left hand/finger here (show left). If you see your hand, you know you are all the way at the left side. Always remember to put something on the left to help you know when you have reached the left side.
Stimuli reduction	When you cover what you are seeing on the page, it may make it easier for you check to see if there is anything else. Let's try it. I will leave this paper here for you.

HISTORIC MODELS

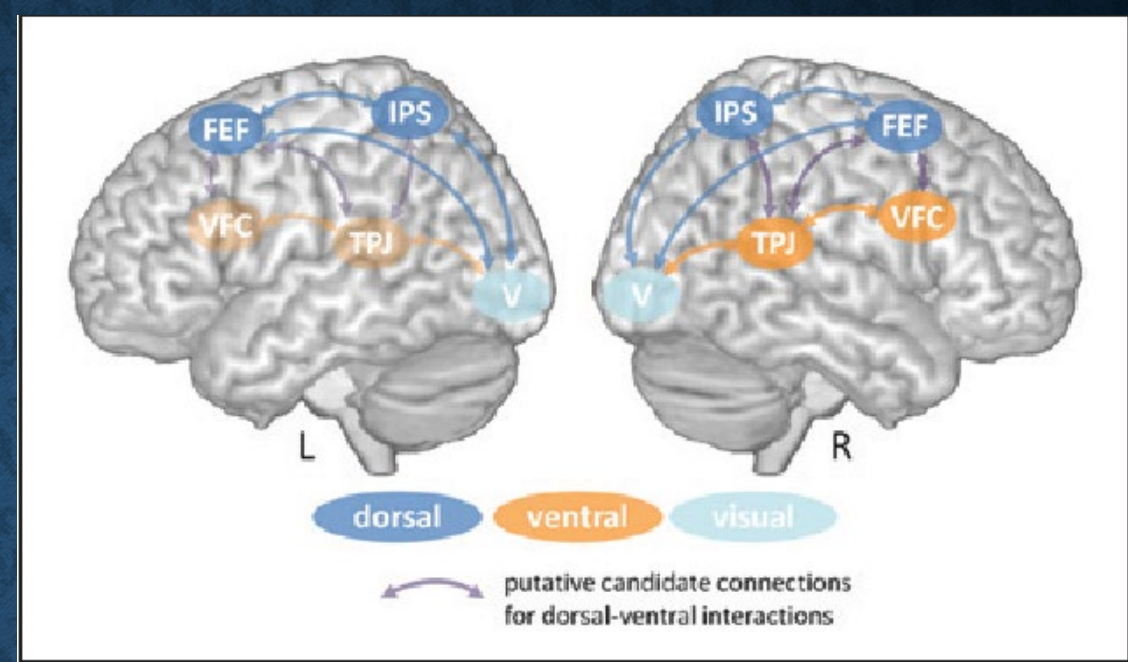
- Failure of disengagement (Posner, 1984)
- **Hemisphere imbalance** (Kinsbourne, 1987)
 - R-hem attends (uses the information to plan motor actions?) to both spaces; L-hem only to the right space (Mesulam, 1999; Heilman, et al., 2000)



- **Karnath (2015)**
- Disturbed stimulus-driven(ventral) but preserved goal-directed attention system (dorsal) in neglect
- An altered representation of own body position with respect to external objects –intact voluntary (top down) guidance of spatial attention itself – executed on top of this body-related matrix



MODELS

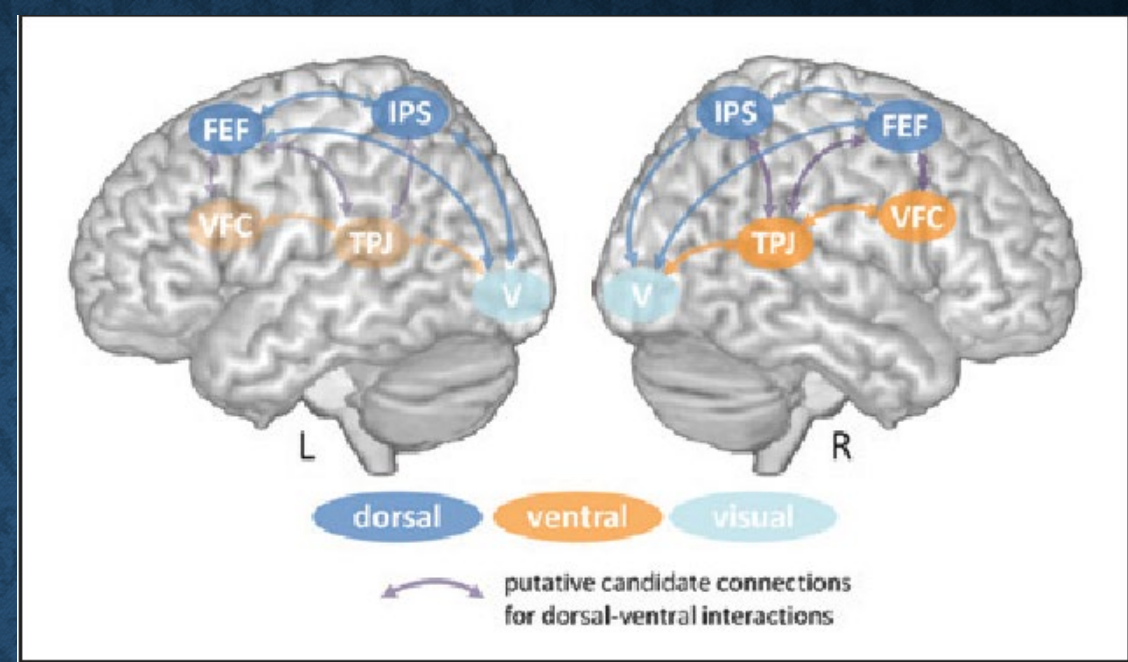


- **Aberrant interactions between the dorsal and ventral spatial attention networks**

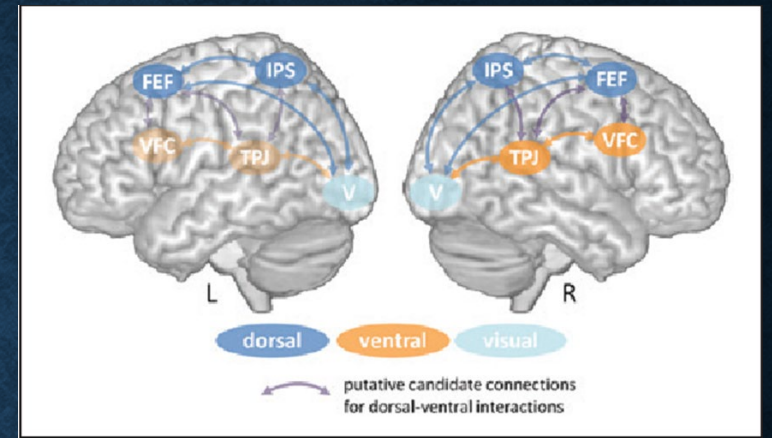
(Corbetta & Shulman, 2011; Tosoni, et al., 2023)

- There are 2 networks that control attention
 - Dorsal Attention Network (DAN) – IPS, SPL, FEF, IFJ, perhaps middle temporal – connect to visual cortex
 - Ventral Attention Network (VAN) – VFC, IFJ IFG, insula, STG, TPJ – also connect to visual cortex
- Only the VAN is lateralized
- Potential connections between DAN and VAN = Region near TPJ, SFL

MODELS



- **Aberrant interactions between the dorsal and ventral spatial attention networks** (Corbetta & Shulman, 2011; Tosoni, et al., 2023)
 - Core = non-spatial attention deficits due to damage in ventral system in vigilance and arousal = impairment in reorienting and detection of novel, behaviorally important stimulation
 - Causes hypoactivation of R hemisphere, decreasing interactions between VAN and DAN and between ipsilesional regions with DAN
 - Causes imbalanced interhemispheric activation in DAN at rest and during tasks, with higher LH activation
 - Locus of attention is coded through activation levels in both hemispheres so drives spatial attention and eye movements to RVF
 - So explore R first and likely to miss targets on L –
 - Abnormally high salience of ipsilesional stimuli – don't get filtered out or disengaged from



Take home: neglect emerges from the aberrant interactions between the damaged VAN, which is lateralized, and the non-damaged, but dysfunctional DAN

The network functioning is more important than where the anatomical damage is

Can also account for the inconsistent behaviors seen in neglect.

HETEROGENOUS CONDITION

- **By sensory system**
 - visual
 - Auditory
 - tactile
- **By space**
 - Personal
 - Peripersonal
 - extrapersonal
- **By coordinates**
 - Egocentric
 - allocentric
- **By function**
 - Aiming/motor intentional
 - Perceptual
 - representational

No one model of USN accounts for all these differences

WHY SHOULD WE CARE ABOUT THE TYPE OF USN?

- Bottom up
 - Stimulation – reduces neglect behavior
 - Caloric stimulation (Miller & Ngo, 2007) – cold water into the ear canal activates the RH more than the LH
 - Neck vibration (Schindler, et al., 2002) – to left posterior neck muscles reduces neglect behavior through altered proprioception
 - Galvanic vestibular stimulation (Wilkinson, et al., 2014, Lobel, et al., 1999) – anode left mastoid/cathode right mastoid – activates TPJ, premotor frontal lobe, anterior interparietal sulcus
 - Non-invasive Neuro stimulation (tDCS; rTMS; Theta burst) (Veldema, et al., 2020) –inhibitory over posterior parietal cortex or bilateral have best evidence - but lots of variety in protocols
 - Optokinetic stimulation (Kerkhoff, et al., 2013) –
 - moving stimuli in background moving to left causes adaptation in eye proprioception indicating estimate of gaze direction – foveated targets seem displaced to R – but have to reach left to reach actual target – so alters visuo-proprioception coordinate coordination
 - Limb activation (Robertson, et al., 2002) – activates ipsilesional hemisphere
 - Mirror therapy (Dohle, et al., 2009) – activates ipsilesional hemisphere
 - Prism Adaptation (Rossetti et al., 1998) – prisms shift visual info to R — but have to reach left to reach actual target – so alters visuo-proprioception coordinate coordination
 - May only work for those with aiming neglect (Goedert, et al., 2014)

WHY SHOULD WE CARE ABOUT THE TYPE OF USN?

- Top down
 - Visual scanning training (Antonucci, et al., 1995)



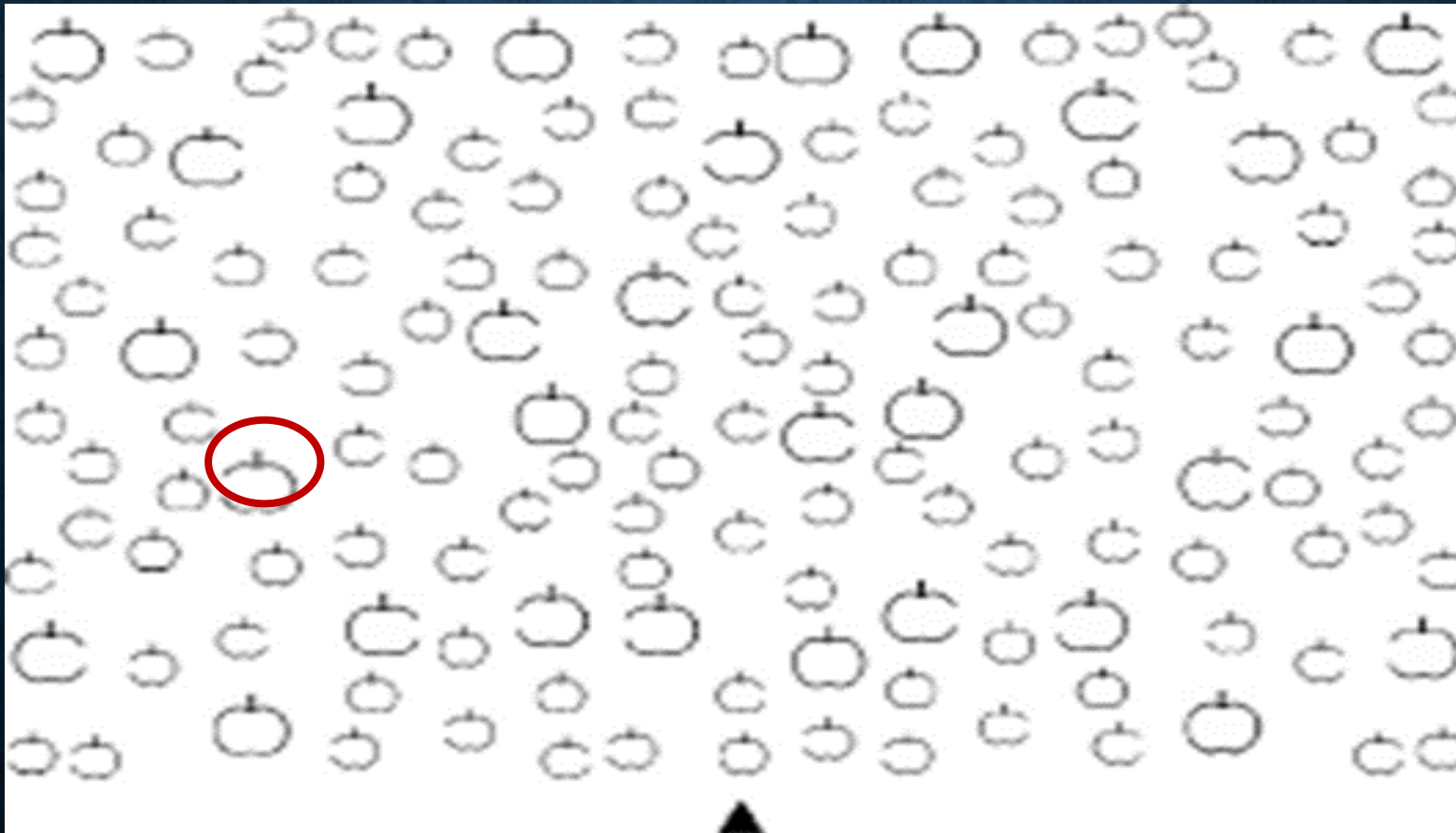
- Combination approaches

PROBLEM

- There is no one test that is the gold standard for neglect
 - NIHSS items are really a screen for the possibility of neglect
 - Not sufficient to dx neglect
 - Battery of tests is best practice (e.g., Behavioral Inattention Test)
 - However, the batteries are typically in peripersonal space and rely on egocentric neglect
- No one test provides discrimination between the different types of neglect – would take too long clinically to do all these tests
- No commercially available test discriminating aiming from perceptual neglect
- Current assessments are not sensitive - especially may not be sensitive enough to pick up subtle, but disabling-in-real-life, USN

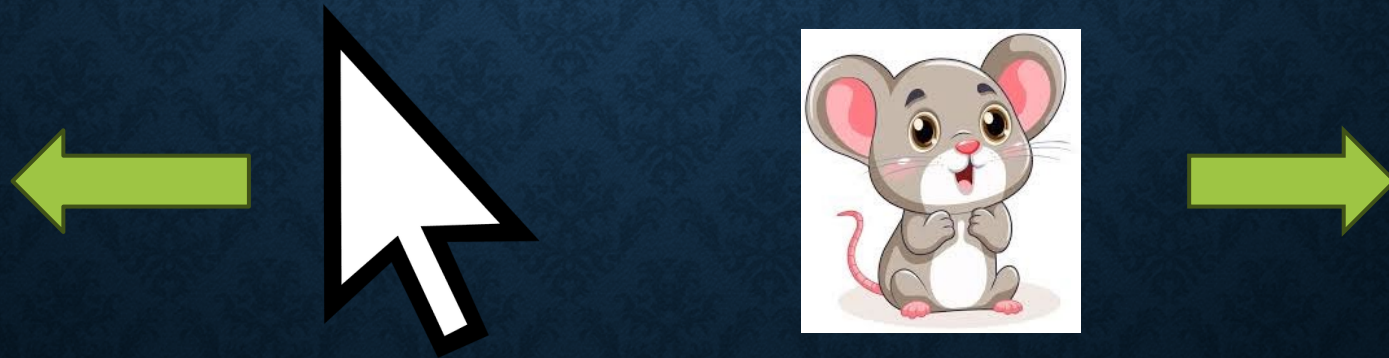
STRATEGY FOR DISCRIMINATING EGOCENTRIC FROM ALLOCENTRIC USN

- Detect object that have a feature on the right or the left side (Apples Test: Bickerton, et al., 2011)



HOW TO DISCRIMINATE AIMING FROM PERCEPTUAL NEGLECT

- Task that requires perception of left objects while not having to move into left space to do so.
- E.g. Computerized Line Bisection with reversed version that dissociates movement of mouse with movement of cursor



NEW STUDY (funded through VA RR&D)

(PI: Anna Barrett, U Mass and VA there)

- Determine if there is a neural biomarker of neglect detected from clinical imaging
- Determine if there is a neural biomarker of Aiming neglect
- Determine if this biomarker and Aiming neglect predicts response to PAT

NEW STUDY #2 (funded through a University of Utah Digital Health seed grant)

OUR TEAM: Rhonda Nelson, Lorie Richards, Mohammed Sbair, Andrew Moran, Sarah Creem-Regehr, Patrick Walker, Mozghan Vali Pour

- Develop a VR-based assessment that will
 - Detect the range of severity of USN
 - That will discriminate aiming from perceptual USN
 - That will discriminate allocentric from egocentric neglect
 - That will discriminate personal (?), peripersonal, and extrapersonal USN

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