The problem of reaching:

Where is the target of grasp? (integration of visual information on the retina with proprioceptive information from eye and head/neck muscles)

Where is the gripper? (alignment of proprioception with vision)

What are the task’s requirements (rewards and costs)?
When you point, you align your finger with the retinal location of the target.
Coding location of target with a retinocentric receptive field

- Fixation point
- Neural discharge
- Premotor ctx
- Motor ctx
- Somatosensory ctx
- Posterior parietal ctx
- Visual ctx
To reach a target, hand position is computed in fixation-centered coordinates.
Target in fixation-centered coordinates

Hand position in fixation-centered coordinates

\( x_t - x_h \)

Target position with respect to the hand

\( x_t \)

\( x_h \)

Premotor cortex

Post. Parietal Cortex

\( x_t \)

\( x_h \)

\( x_a \)

fixation point

\( q_1 \)

\( q_2 \)
Post. Parietal Cortex neurons code for hand and target position in eye-centered coordinates

Condition 1  

Condition 2  

1.0 sec

Reach onset

Buneo C et al. (2002) Nature
Reaching errors in parietal lobe damage suggest a coding of space with respect to eye position and not body position.

56 year old right handed male who suffered an infarct in the right hemisphere, frontal and parietal areas.

Fixation-centered location of target

Fixation-centered location of hand

Arm configuration in proprioceptive coordinates

Eye and head orientation in proprioceptive coordinates

Retinocentric location of target

Premotor cortex

Post. Parietal Cortex
Neurons in the PPC encode both image location and eye position

Andersen RA et al. (1985) Science
As eye position changes, the gain of the discharge on the receptive field changes.
PPC neurons are also sensitive to head position

Eyes are centered in their orbit

Brotchie et al. Science 1995
Summary

Target location and hand position are computed by posterior parietal cortex cells in terms of vectors with respect to fixation point.

Proprioceptive information from the arm, head, and eyes is used to estimate hand position with respect to fixation.

Proprioceptive information from the head and eyes is combined with information about retinal location of the target to estimate target position with respect to fixation.

Posterior parietal cortex neurons combine visual and proprioceptive information as a gain field.
PPC neurons encode target of intended movement during the delay period

Crammond and Kalaska 1989
PPC neurons encode target of intended movement even after it disappears
PPC neurons encode target location and not the forces necessary to reach that target

Kalaska et al. J Neurosci 1989
PPC neurons encode an internal value of the visual stimuli with respect to action.
Patients with lesion in the right hemisphere may exhibit neglect of the left visual space

Eye scan path to find target letters “T”

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M Husain et al. (2001) Brain 124:941
Neglect of the extra-personal and personal space

Test for neglect of extra-personal space: Line bisection test, figure copying, reading a sentence.

Test for neglect of personal space: use a comb, use a razor to shave the face, use a lipstick.

Neglect of extra-personal space: lesion of the right frontal lobe, ventral premotor cortex

Neglect of personal space: lesion of the right inferior parietal cortex

STG: superior temporal gyrus
MFG: medial frontal gyrus
WM: white mater
SMG: supramarginal gyrus
Prism glasses produce after affects that improves the sense of “straight ahead” in neglect patients

Prism glasses produce after affects that reduce the neglect observed in PPC lesions

Prisms

original

pre-

post-

late

Controls

Apraxia

Apraxia is an inability to perform skilled movements, particularly tool use, in the absence of elementary motor deficits (weakness, normal posture or tone).

It is most commonly associated with damage to the parietal cortical areas of the left hemisphere.
Understanding actions of others: the mirror neuron system

Social skills and theory of mind: the awareness that other people have beliefs and desires as we do, but different from our own, and that these beliefs and desires guides their actions. By observing their actions, we can guess their goals and intentions.
Summary of the posterior parietal cortex

Actions are planned in fixation centered coordinates:
   Position of the hand and the target are represented in terms of their location with respect to the fixation.

Neurons combine proprioceptive information with visual information using a gain field.

The visual scene is evaluated in the PPC in terms of relevance to action.

Lesion of the right parietal cortex can result in neglect. Lesion of the left parietal cortex can result in apraxia.

Mirror neurons might provide a mechanism through which we understand the intention of others.