PS3019
Cognitive and Clinical Neuropsychology
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Overview
Neuropsychology of visual processing
Neuropsychology of spatial processing
Milner and Goodale’s theory about the mechanisms of vision in detail
Neuropsychology of Memory

Reading list

Additional reading

Recap:

Recap and basic methodology and terminology
Methods
Patients with circumscribed brain damage
Localisation of function vs. mass action
Single-case vs. groups studies

Animal studies

Techniques for assessing brain anatomy
- Computed Axial Tomography (CAT of CT)
  - X-rays
  - High density appears light (e.g. blood)
  - Non-dense dark (e.g. cerebrospinal fluid)
- Magnetic Resonance Imaging (MRI)
  - Magnetic fields distort behaviour of protons
  - Protons in different substances revert to original state at different speed (relaxation time)
  - Analysis of relaxation time reveals brain structure

Techniques for assessing physiological function
- Positron emission tomography (PET)
  - Radioactive molecules introduced in blood flow
  - Accumulation of radioactive material in specific brain regions reveals active brain areas during specific tasks
  - Can be used with different substances (e.g. neurotransmitters)
- Functional magnetic resonance imaging (fMRI)
  - Typically measures blood flow and oxygenation during specific tasks
  - Oxygen rich blood has magnetic properties (dianimate)
  - When oxygen is extracted blood loses magnetic properties (paramagnetic)
  - As neuronal activity requires oxygen from blood, fMRI provides indirect information about its location and time-course

Electrophysiology
- Single cell recordings
  - Intracranial
  - Mainly animals
  - Humans before surgery for removal of epileptic tissue
- Electroencephalography (EEG)
  - Continuous measure of form and frequency of EEG
  - Signal as a function of state of consciousness
- Event Related Potentials (ERPs)
  - Measure of localised potential in response to specific stimuli, events or tasks
  - Well known specific components
    - Endogenous
    - Exogenous

Lectures 1 & 2
The neuropsychology of object recognition
and visual agnosia

Reading
Banich, chapter 6

Recap - Basic methodology and terminology
- Banich chapter 1 pp. 19-39
- Banich chapter 3

Recap - Visual systems
- Gazzaniga, I.V. and Mangun. Cognitive Neuroscience, Chapters 5 and 6
- Bruce, Green and Georgeson, Visual Perception, Chapter 3

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Techniques for modulating brain activity

**Transcranial magnetic stimulation (TMS)**
- Electrical fields induced on scalp
- Alteration of membrane potential of neurons
- Decreased probability that the neurons in the area where TMS is applied to fire
- Innocuous can be used with healthy volunteers

**Behavioural methods**
- Cognitive theories and experimental psychology
- Neuropsychological tests and test batteries

**Simulations and computational models**
- Artificial intelligence
- Connectionist networks

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**Recap visual systems**

**Primary visual pathways**
- To higher cortical visual areas

- **Retina**
- **Pulvinar**
- **Lateral Geniculate Nucleus**
- **Superior Colliculus**
- **Visual Cortex**

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**The organisation of the Lateral Geniculate Nucleus (LGN)**

- Parvocellular (P) system
- Magnocellular (M) system

From the visual cortex (occipital cortex) to other areas of the brain

- Dorsal system - Mostly Magnocellular
- Ventral system - Magnocellular and Parvocellular
Electrophysiological studies of the ventral stream in nonhuman primates

Single cell recordings
- Cells sensitive to colour
  - Help figure ground segregation
- Various electrode sites within the ventral stream
  - Individual cells in posterior areas (e.g., V2) activated by simple stimulus attributes (e.g., colour, texture, length, width, orientation, direction of motion, spatial frequency)
  - Cells in more anterior areas (e.g., inferotemporal cortex: PIT, AIT) are activated by more complex stimuli (hands, faces)

Progressive increase in size from posterior to anterior areas

- V1 small receptive field
  - Cell can only be sensitive to local features of objects
- V4 large receptive fields
  - Cell can be sensitive to spatial relationships among object parts
  - Cells’ visual field always includes midline of visual space
- Beyond V4
  - No retinotopic mapping of visual field
  - Form-cue invariance
    - Same response to different cues (e.g., photo, line drawing) of same object
  - Perceptual constancy
    - Response to same object irrespective of position, size, illumination, viewpoint etc.

Lateral Occipital Complex (LOC)
- Same pattern of activation for same object with different size, location, viewpoint, illumination (Grill-Spector et al., 1998)

Fusiform Face Area (FFA)
- Greater response to face than other objects (Kanwisher et al., 1997)

Parahippocampal Place Area (PPA)
- Greater response for places in local environment (Epstein et al., 1999)

Lateralized organisation of the ventral stream

Hierarchical stimuli (Navon, 1977)
- Global local processing

Global precedence in inconsistent stimuli

In healthy individuals (e.g., Martin, 1979)
- Left Visual Field advantage (Right Hemisphere) in global trials
- Right Visual Field Advantage (Left Hemisphere) in local trials

In patients with brain damage of temporal lobe (Delis et al., 1986; Doyon et al., 1991)
- Left lesions affect local processing
- Right lesions affect global processing

Temporal lobe specialised for object identification

Modular models
- Specialised areas for identification of specific objects

Distributed models
- Neural networks of neurons code specific objects (e.g., Haxby et al., 2001)

Hybrid models
- Patterns of activation across ventral stream code for classes of objects and specialised populations of neurons support the recognition of specific objects
Computational models of object recognition

Object centred models
- Marr (1982)
  - Primal Sketch
  - 2 ½ D representation
  - 3D object representation
  - Orientation invariant
- Biederman (1987)
  - Library of “Geons”
  - Structural descriptions of relationships between geons

Viewer centred models (e.g. Tarr & Buthoff, 1998)
- Series of viewer centred representations of same objects support object recognition
- Have some support in the observation that some cells in temporal cortex are view dependent

Visual Agnosia

Inability to recognise objects
Not due to basic visual problems
Not due to memory problems
Modality specific

Lissauers 1890s

Apperceptive agnosia
- Local features cannot be linked together to form meaningful whole objects

Associative agnosia
- Meaningful perceptual representations can be formed but meaning of objects cannot be accessed

Apperceptive agnosia

Often caused by carbon monoxide poisoning

Diffuse damage to occipital cortex and surrounding areas

Inability to discriminate or copy basic shapes or letters

Milder forms of apperceptive agnosia (but is it the same syndrome?) caused by damage to right parietal region (not strictly part of ventral stream) (Warrington, 1982).

Overall better visual abilities but:
- Inability to complete degraded stimuli
- Inability to process incomplete degraded stimuli

Associative agnosia

- Damage to occipito-temporal regions of both hemispheres
  - Unilateral damage at boundaries between temporal and occipital lobe (Farah, 1990)

- In contrast with apperceptive agnosia perceptual grouping is unimpaired
- Patients can extract information about general shape from vision (rather than from other modalities as in apperceptive agnosia) and if confusion occurs it is between items similar in shape
- Patient can provide verbal definition of object (so it is not a memory problem per se)
- Patient can match identical pictures
- Traditional interpretation: defective retrieval of semantics of object from visual form
- Preserved copying abilities of patients with associative agnosia

- Inability to draw the same object from memory

Recent approaches suggest more extensive visual problems (see Farah 2000)
- Vision not completely unimpaired and copying performed slowly and point by point
- Difficulty in matching novel or unfamiliar objects which cannot be explained solely in terms of defective retrieval of semantics of objects
- Best at recognising 3D objects, the photos, then line drawings

Faces are recognised configurationally (Thompson 1980)

When inverted the configurational properties of faces are lost and local processing prevails

Experimental behavioural studies
- Left Visual Field (LVF) advantage for face recognition (Geffen et al., 1971)
- LVF advantage reduced for inverted faces (Leehey et al., 1978)

Prosopagnosia following damage to right hemisphere (De Renzi et al., 1994)

Single dissociations
- Patients with left hemisphere lesions can recognise faces but not objects

In general a broad range of areas within occipital and ventral temporal regions are involved in face processing.

Prosopagnosia
- Special type of visual agnosia
- Selective inability to visually recognise specific faces (even when familiar)
- Other objects visually recognised (not a general visual problem)
- People recognised in other modalities (not memory deficit)

Higher level processing are intact
- Faces recognised as faces
- General attributes can be extracted (Tranel et al., 1988)
  - gender
  - age
  - expression of emotion

Brain regions involved in face processing in humans
Yin (1970)
- Posterior areas of right hemisphere
- Comparison of face and object processing in healthy and brain damaged individuals
- Faces and other stimuli normally seen in one orientation (e.g. houses) task: identification of stimuli in a previously studied list
  - upright stimuli
  - inverted stimuli (equal stimulus complexity but loss of configurational properties)

Healthy individuals show an inversion effect
- Upright stimuli are remembered better than inverted stimuli
- Larger inversion effect for faces than houses

Patients with right-posterior damage
- Reduced inversion effect for faces
- Performance similar to controls with inverted faces
- Recognition poorer than controls with upright faces
- Right-posterior areas specialised in configurational processing required for face recognition

Evidence from electrophysiology
Benton et al. (1996)
- N200 elicited specifically in response to faces
- Recorded over fusiform-gyrus
- Left hemisphere recording does not show difference between faces and inverted faces
Is face processing a general case of expertise in identifying specific members within a well-known class of objects?

Does the inversion effect found by Yin (1970) pertain to other classes of objects rather than faces?

Is configurational processing a strategy that develops with expertise with a particular class of objects?

Diamond and Carey (1986)
- University students show a larger inversion effect for faces rather than photos of individual dogs
- Show-dog judges show a similar effect for faces and dogs
- Expertise seems to play a role in the emergence of the inversion effect

Rhodes et al. (1989)
Greater inversion effect for same-race faces than for different-race faces

Rhodes at al. (1989)
Greater inversion effect for same-race faces than for different-race faces

- Individuals with over 20 years experience identifying cars or birds
- Selective activation of similar areas with presentation of faces and objects within the domain of expertise
- “Fusiform face area” could be activated whenever specific members of well-known category need to be identified.

Car expert
Bird expert
Faces Cars Birds

N.B. Brain slices in radiological convention with left hemisphere on right hand side and vice versa

Activation of “face” area following learning of artificial categories (Gauthier et al., 1999)

Individuals trained to recognise novel forms “greebles”

- Fusiform face area activated only in “greeble experts” when presented with “greebles”
- Activation of right fusiform area for upright compared to inverted “greebles” increased with learning
- Possibility that fusiform area reflects processing of subordinate levels of categories which becomes automatic with expertise

Are faces special?

Alternative 1
Fusiform area specialised for configural processing of individuals within a well-known category of objects
- It is active during the processing of faces as face recognition is as a privileged example of this process

Alternative 2
Fusiform area specialised for processing faces
- This special ability can be co-opted by other processes if individual acquires enough expertise with another category, thus requiring configural processing

Alternative 1 supported by
- Dissociation for recognition of faces in brain damaged patients
- Damage occurring early during development can be persistent for face recognition but not for other objects (Farah et al. 2000)

Implicit recognition of faces in patients with prosopagnosia

Electrodermal skin conductance response for familiar faces which cannot be explicitly identified (Tranel & Damasio, 1988)

Name-occupation interference (De Haan et al., 1987)
- As neurologically intact individuals, a patient with prosopagnosia showed delayed reading of celebrity name is next to person of different occupation even if the patient cannot recognise the people depicted

A subset of patients with prosopagnosia retain relevant information in memory and are able to process visual features at some level.
- This challenges the notion of a complete disruption of link between perceptual features and semantic (biographic) information in memory.

Summary
- Recap basic methodology and terminology
- Recap cortical visual pathways
- The ventral stream
- Lateralisation in the ventral stream
- Recap models of object recognition
- Visual agnosias
  Apperceptive
  Associative
  Prosopagnosia