PYB304 Final Exam

Item 1: Memory

Item 2: Research Methods

Item 3: Social Neuroscience

Item 4: Neuropharmacology

Item 5: Brain Imaging

Item 6: Language and the Brain

Item 6: Language and the Brain

Cerebral lateralization

Lateralize – to be largely under the control of one or other side of the brain.

Discovery of the specific contributions of left-hemisphere damage to aphasia and apraxia

Aphasia – a brain-damage-produced deficit in the ability to use or comprehend language (found by Broca).
Broca's area – the area of the inferior prefrontal cortex of the left hemisphere hypothesised by Broca to be the centre of speech production.
Apraxia – a disorder in which patients have great difficulty performing movements when asked to do so out of context by can readily perform them spontaneously in natural situations.

- Almost always associated with left-hemisphere damage, despite the fact that its symptoms are *bilateral*.

Theory of **cerebral dominance** – one hemisphere – usually the left – assumes the dominant role in the control of all complex behavioural and cognitive processes, and the other plays only a minor role.

- **Dominant hemisphere** – a term used in the past to refer to the left hemisphere, based on the incorrect assumption that the left hemisphere is dominant in all complex behavioural and cognitive activities.
- **Minor hemisphere** – a term used in the past to refer to the right hemisphere, based on the incorrect assumption that the left hemisphere is dominant.

Tests of cerebral lateralisation

Sodium amytal test

Sodium amytal test – a test involving the anesthetisation of first one cerebral hemisphere and then the other to determine which hemisphere plays the dominant role in language.

- Results are used to plan surgery of patient.
- When the hemisphere for speech, usually the left, is anesthetised, the patient is rendered completely mute for a minute or two. Once the ability to talk returns, there are errors of serial order and naming.
- In contrast, when the minor speech hemisphere, usually the right, in anesthetised, mutism often <u>does not occur</u> at all, and errors are few.

Dichotic listening test

Dichotic listening test – a test of language lateralisation in which two different sequences of three spoken digits are presented simultaneously, one to each ear, and the subject is asked to report all the digits heard.

- It is reported that more people report slightly more of the digits presented to the right ear than the left, which is indicative of left-hemisphere specialisation of language.
- In contrast, it was found that all the patients who had been identified by the sodium amytal test as having right-hemisphere specialisation for language performed better with the left ear than the right.

Discovery of the relation between speech laterality and handedness

- Relation between handedness and language lateralization. Found in:
    - Wounded soldiers (Russel & Espir, 1961).
        - **Right handed**: left hemisphere lesion show 60% more aphasia, right hemisphere 2% aphasic.
        - **Left handed**: left hemisphere lesion 30% aphasia, right hemisphere 24% aphasic.
    - Confirmed by Sodium Amytal (Wada) test:
        - 92% right handed – left hemisphere language dominant.
        - 69% left handed – left hemisphere language dominant.
    - General population = 90% right handed, 10% left handed.
    - Measured via:
        - Self-report.
        - Edinburgh Handedness Inventory.

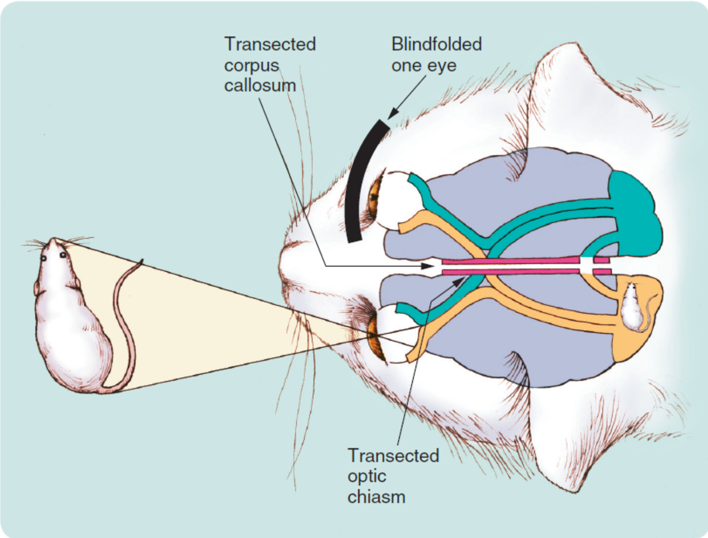
The split brain

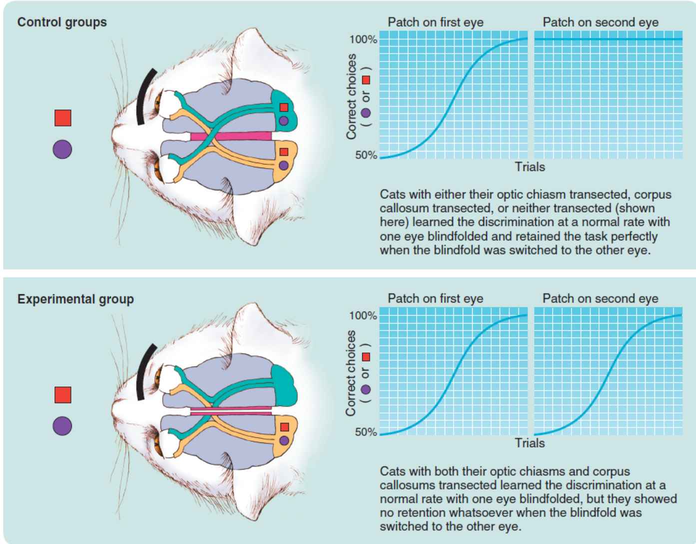
Corpus callosum – largest cerebral commissure.

- One function of the corpus callosum is to transfer learned information form one hemisphere to the other.
- When cut, each hemisphere can function independently; appears to have two brains.

Split-Brain Cats

- *Transected* (cut completely through) the corpus callosum and optic chiasm so that visual information could not cross to the contralateral hemisphere.





Differences between left and right hemispheres

GENERAL FUNCTION	Left-Hemisphere Dominance	Right-Hemisphere Dominance
VISION	Words Letters	Faces Geometric patterns Emotional expression
AUDITION	Language sounds	Nonlanguage sounds Music
TOUCH		Tactile patterns Braille
MOVEMENT	Complex movement Ipsilateral movement	Movement in spatial patterns
MEMORY	Verbal memory Finding meaning in memories	Nonverbal memory Perceptual aspects of memories
LANGUAGE	Speech Reading Writing Arithmetic	Emotional content
SPATIAL ABILITY		Mental rotation of shapes Geometry Direction Distance

Examples of cerebral lateralisation of function

Right Hemisphere	Left Hemisphere
- Spatial ability - Emotion - Musical ability - Memory differences; left verbal, right non-verbal.	- An "interpreter". - Recognizing and interpreting patterns. - Most of the speech processing area.
- Receives sensory information from left side. - Controls left hand fine motor movement. - Understand simple tasks but not speak.	- Receives sensory information from right side. - Controls right hand fine motor movement. - Verbally capable.

Wernicke-Geschwind model

Language localisation – the location within the hemispheres of the circuits that participate in language-related activities.

Historical antecedents of the Wernicke-Geschwind model

Broca's area – speech production.

- Found that damage in particular parts of the brain leads to expressive aphasia.
    - Normal comprehension; speech is meaningful, but production is impaired/difficult.

Wernicke's area – speech comprehension

- Found that damage in particular parts of the brain causes receptive aphasia.
    - Poor comprehension; speech sounds normal, but has no meaning ("word salad").

Broca's aphasia – a hypothesis disorder of speech production with no associated deficits in language comprehension.
Wernicke's aphasia – a hypothetical disorder of language comprehension with no associated deficits in speech production.

The **arcuate fasciculus** (white matter structure) connects Broca's to Wernicke's areas.

- Damage to the arcuate fasciculus causes conduction *aphasia* (inability to repeat words just heard).
- Comprehension and speech production are normal, it's just the connection that's missing.

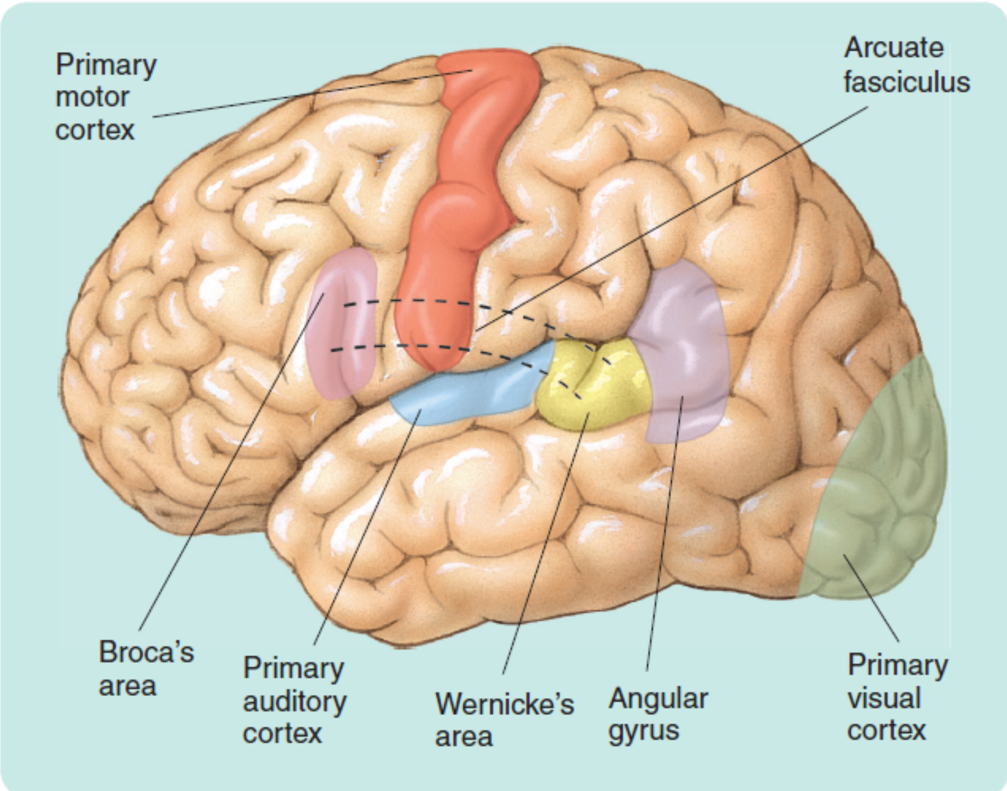
Left **angular gyrus** (important for transporting visual information to the language area): posterior to Wernicke's area.

- Damage causes *alexia* (inability to read) and *agraphia* (inability to write).

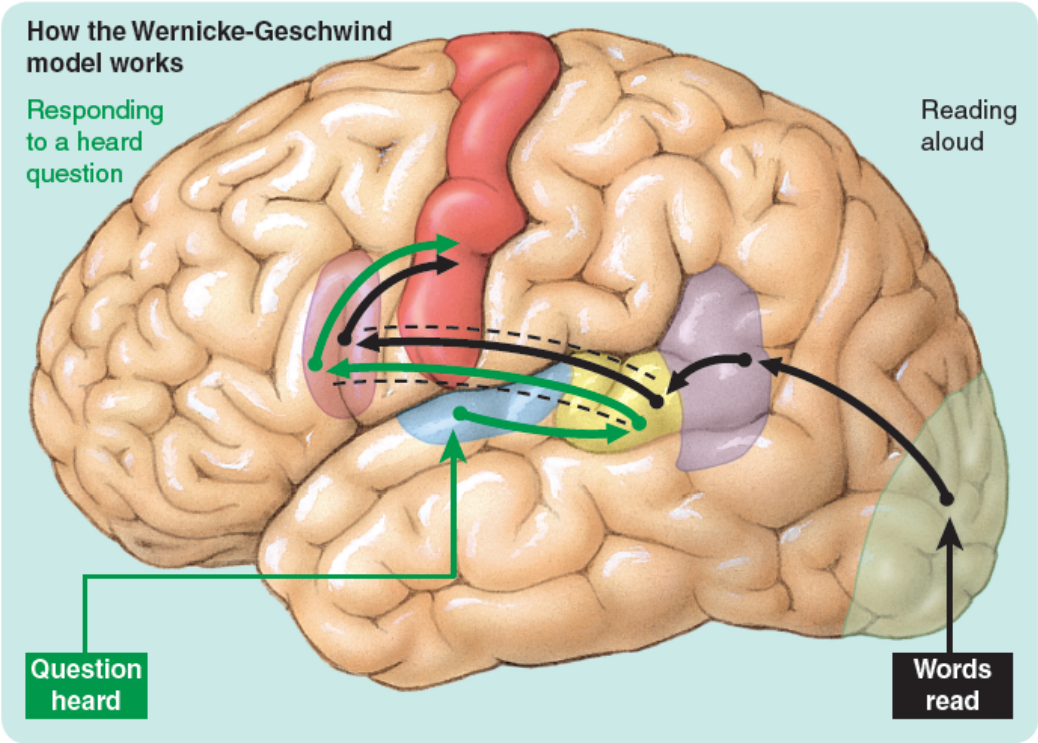
The Wernicke-Geschwind model

Wernicke-Geschwind model – an influential model of cortical language localisation in the left hemisphere.

- The predominant theory of language localisation.
- Primary visual cortex, angular gyrus, primary auditory cortex, Wernicke's area, arcuate fasciculus, Broca's area, and the primary motor cortex – all of which are in the left hemisphere.



How the Wernicke-Geschwind model works in a person who is responding to a heard question and reading aloud. The hypothetical circuit that allows the person to respond to heard questions is in green; the hypothetical circuit that allows the person to read aloud is in black.



Wernicke-Geschwind model: The evidence

- There is a lack of evidence that damage to various parts of the cortex has the expected effects.
- Surgery that destroys only Broca's area has no lasting effects on speech.
- Removal of much of Wernicke's area has no lasting effects on speech.

Effects of cortical damage on language abilities

- No aphasic patients have damage that is just restricted to Broca's or Wernicke's areas.
- Aphasics almost always have damage to subcortical white matter.
- Large anterior lesions are most likely to produce expressive symptoms.
- Large posterior lesions are most likely to produce receptive symptoms.
- Global aphasia is usually related to massive lesions of several regions.
- Aphasics sometimes have damage that does not encroach on Wernicke-Geschwind areas.

Current Status of the Wernicke-Geschwind Model

- Empirical evidence supports two elements:
  1. Important roles are played by Broca's and Wernicke's—many aphasics have damage in these areas.
  2. Anterior damage associated is with expressive deficits and posterior damage is associated with receptive deficits.
- There is no support for more specific predictions.
  - Damage limited to identified areas has little lasting effect on language.
  - Brain damage in other areas can produce aphasia.
  - Pure aphasias (expressive OR receptive) are rare.

Human Language

- Communication is observed throughout the animal kingdom.
- Animals have ways of communicating with their own species
  - Bees – dance for other bees to tell them where the food source is.
  - Vervet Monkeys – have different calls for different prey.
    - Snake – find him and chase him away.
    - Bird of prey – jump out of the tree and hide in the bushes.

        - Leopard – climb in tree.
- Animals can interpret a wide range of sounds from their environment.
    - However, expression is very limited compared to humans.
- Language is believed to be a human exclusive. We make an infinite amount of new sentences which can be directly understood.
- Interestingly when learning new and artificial grammars, humans and monkeys engage the same brain area: Broca's area.
- **Artificial grammar**: Sequences with simple transitional probabilities.

Functional brain imaging and the localisation of language

Bavelier's fMRI study of reading

- Used fMRI to measure brain activity of healthy volunteers while they read silently.
- The differences in cortical activity during the reading and control periods served as the basis for determining those areas of cortical activity associated with reading.
- Findings:
    - The areas of activity were patchy; that is, they were tiny areas of activity separated by areas of inactivity.
    - The patches of activity were variable; that is, the areas of activity differed from persons to person and even from trial to trial in the same person.
    - Although activity was often observed in parts of the classic Wernicke-Geschwind areas, it was widespread over the lateral surfaces of the brain.

Damasio's PET study of naming

- Objective was to selectively look at the temporal-lobe acidity involved in naming objects within particular categories.
    - Naming objects activated areas of the left temporal lobe outside the classic Wernicke-Geschwind area.

Cognitive neuroscience of dyslexia

Dyslexia – a pathological difficulty in reading, one that does not result from general visual, motor, or intellectual deficits.

- 3-7% of population is diagnosed with dyslexia, 20% has some degree of symptoms.
- There are two fundamentally different types of dyslexia:

1. **Developmental** – becomes apparent when a child tried to read but has little success.
    - Heritability estimate = 50 percent.
    - More common in boys than in girls.
2. **Acquired** – caused by brain damage in people already capable of reading.
    - Relatively rare.

Developmental dyslexia: Causes and neural mechanisms

- Brain differences have been identified, but none seem to play a role in the disorder.
- Not one common brain pathology.
- Cause/ result?
    - 12-15% of people with dyslexia have ADHA. Up to 30% of people with ADHD have dyslexia.
    - There are multiple types of developmental dyslexia – perhaps there are multiple causes.
    - Perhaps dyslexia is a deficit of phonological processing rather than of sensorimotor processing.

Developmental Dyslexia

- Various subtle visual, auditory, and motor deficits are commonly seen.
- There is a genetic component—yet the disorder is also influenced by culture.
    - More English speakers have reading deficits than do Italian speakers, perhaps because sound-symbol correspondence in English is more complex than it is in Italian.

Cognitive Neuroscience of Deep and Surface Dyslexia

Two Procedures for Reading Aloud

1. **Lexical**: using stored information about words.
2. **Phonetic**: the mapping of the word form to the sounding out.

Surface dyslexia	Deep dyslexia
- Regular pronunciation (*mint*) read more accurately than irregular pronunciation (*colonel).* - Difficulty distinguishing homophones *(sound the same: ate-eight).* - Word recognition issues (lexical procedure). - Loss of visual recognition of words (Can't "look and say").	- Can't sound out unfamiliar words, and relies on meaning (says 'chicken' for 'hen' or 'wise' for 'wisdom'). - Sound recognition issues (phonetic procedure). - Loss of ability to "sound out" unfamiliar words or nonwords.