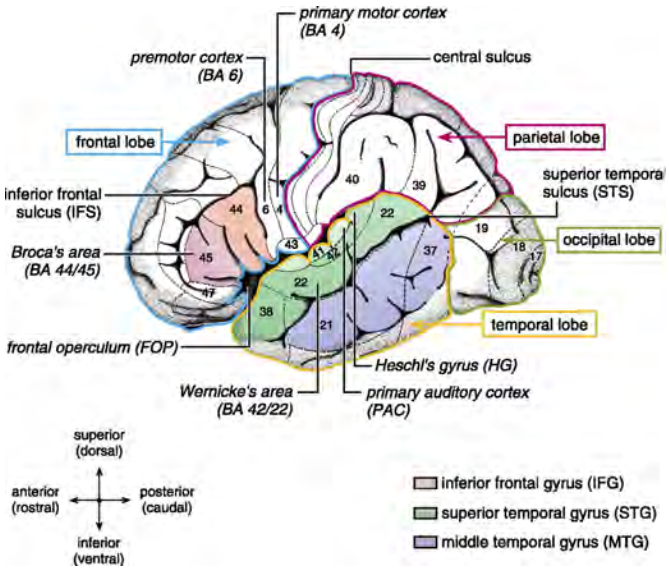
Language impairments: the aphasias

AIMS

- Provide a brief description of the neurological structures supporting language and auditory processing;
- Describe what is aphasia;
- Recap and extend information on theories of aphasia
- Outline deficits of semantic and lexical processing in light of a processing model of language

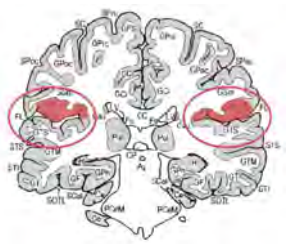
Brain localization of language

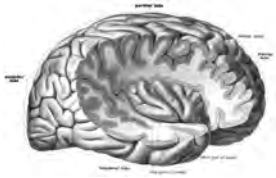
- **The temporal lobe**
  - Anterior part: semantic processing
  - Posterior part: phonological processing
  - Insula: articulation
- **The frontal lobe**:
  - Inferior semantic processing
  - Precentral/supplemental motor cortex articulation



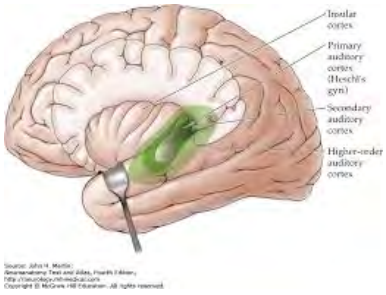
From: Friederici, 2011.The brain basis of language processing: from structure to function. Physiological Reviews, 91, 1357-1392

Insula





Hesch's girus
part of primary auditory cortex



Functions of the temporal lobe

The functions of the temporal lobe are very diverse. It is involved in:

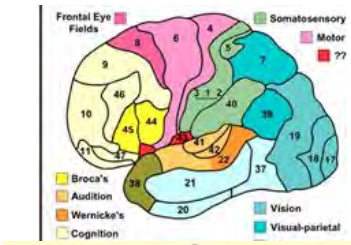
- Object recognition
- **Auditory perception**
- **Language processing**

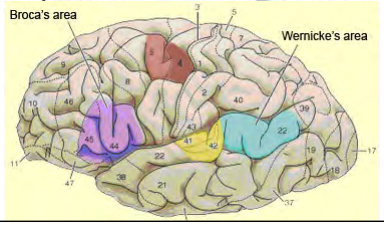
} this lecture

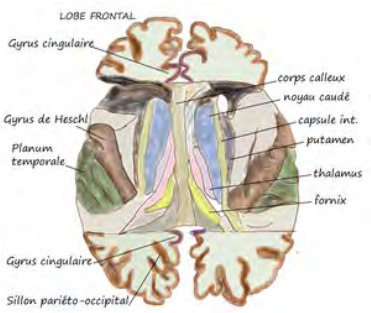
- Memory
- Adding affective tone to sensory input and memory

Disorders of auditory perception

The primary auditory cortex comprises the upper bank of the superior temporal lobe on what is known as the Heschl's gyrus. It is mostly hidden within the lateral fissure (roughly Brodmann areas 41, 42). Area 22 on the lateral surface of the temporal lobe is also partially involved (Wernicke's area). The planum temporale is the the heart of Wernicke's area.







Damage to the primary visual and somatosensory cortex produces a loss of conscious perception. However, even bilateral lesions to the auditory cortex do not result in deafness.

Instead, damage to the auditory areas produces deficits in recognizing sounds.

Damage to the left produces more severe impairments recognizing speech sounds. Damage to the right, more severe impairment in recognizing music.

Aphasia: A language disorder

Acquired disorders of language are called **aphasia** from the Greek 'a' (withouth) + 'phemio' (to speak).

- Aphasia refers to *acquired* language disorders resulting from insult to the central nervous system.

- Language deficits stem mainly from lesions to the **temporal and frontal lobes**, but the other lobes can also be involved.

- Aphasia is a *cognitive* disorder.
  - is not a peripheral impairment
  - is not psychiatric impairment
  - is not a disturbance of thought

Acquired disorders of speech can take a great variety of forms

They may impair, in different combinations:

- speech comprehension,
- speech production,
- reading and writing

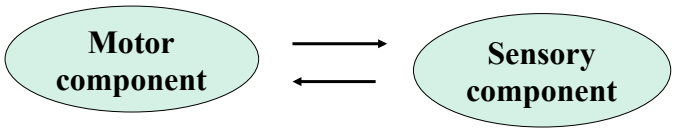
Within each of these modalities deficits can be very different depending on which linguistic representations and processes are spared and impaired. Impairments may affect:

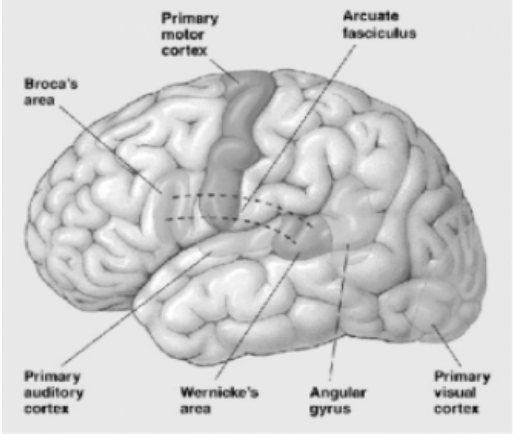
- Different part of speech (e.g., content vs. function words)
- Different semantic categories
- In reading, regular vs. Irregular words

Aphasia history recap: from the classic view to modern neuropsychology

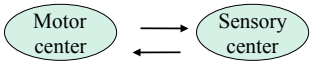
Wernicke's Model

Language can be analysed into two main components: a motor component responsible for language expression and a sensory component responsible for language understanding.





Wernicke's model



Motor (Broca's) aphasia : damage to a cortical center where the motor images of words are stored.

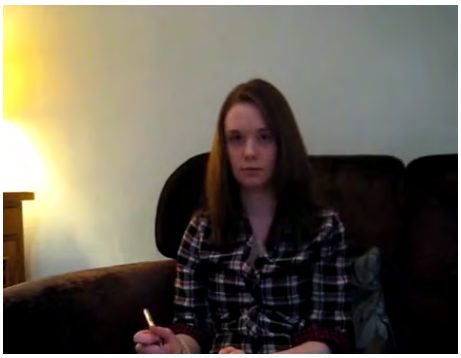
- Mainly a deficit of language production.
- Slow, effortful speech, manly limited to content words – telegraphic quality.

Sensory (Wernicke's) aphasia: Damage to the cortical center were the auditory images of words are stored.

- Poor comprehension.
- Fluent speech, but with phonological and verbal paraphasias.

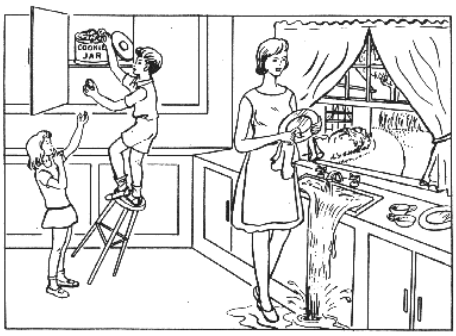
Conduction aphasia: Damage to the bundle of fibres that connects the sensory and the motor centers (arcuate fasciculus).

- Spared comprehension.
- Speech similar to Wernicke aphasia.
- Very impaired repetition.



More examples to do in your own time

Try to guess which patient is which (patients are describing the 'Cookie Theft picture)



From the Boston Diagnostic Aphasia Examination by Goodglass and Kaplan

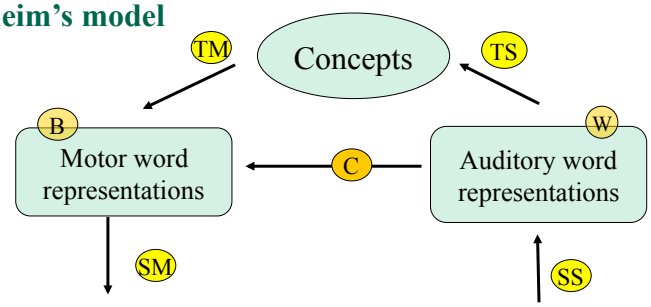
Patient 1: This is a boy and that's a boy an' that's a thing ! An this is going off pretty soon. This is a .... a place that is mostly in .....[examiner suggests bathroom] No .... kitchen. An' this is a girl ...an' that something that they're running an' they've got the water going down here.

Patient 2: 'Well this is .... mother is always here working her work out o' here to get her better, but when she is looking , the two boys looking the other part. One their small ***tile*** into her time here. She is working another time because she's getting to. So two boys work together and one is sneaking' around here, making his work an' his further **funnas** his time he had.

Patient 3: Cookie jar .... fall over ...chair.... water.....empty

From Goodglass and Kaplan (1983)

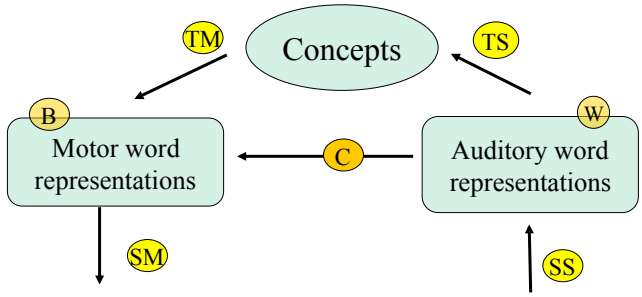
Lichtheim's model



B = Broca's aphasia; W = Wernicke's aphasia; C = Conduction aphasia

TS = Transcortical sensory aphasia
TM = Transcortical motor aphasia
SM = Subcortical motor aphasia
SS = Subcortical sensory aphasia

Lichtheim's model (1895)



B = Broca's aphasia; W = Wernicke's aphasia; C = Conduction aphasia

TS = Transcortical sensory aphasia
relatively good production; poor comprehension; good repetition

TM = Transcortical motor aphasia
poor/confused production; good comprehension; good repetition

SM = Subcortical motor aphasia; impaired oral but not written production
SS = Subcortical sensory aphasia; poor spoken but not written comprehension

Reasons for demise of Lichtheim's model

Problems with the anathomical aspects of the model

•**Lack of correspondence between even pure syndromes and hypothesized locus of lesion**,

but means of investigation were limited at the time + some individual differences in location should be recognized.

•**The center of concepts –**No patients fitting damage to this centre were described at the time,

but they were described later

Problems with the cognitive aspect of the model

•**Poor motivation for clusters of symptoms**

E.g., poor production and reading impairments in Wernicke's aphasia

•**The variety of patients was not captured by few discrete syndromes**

E.g, Anomia (see Pitres, 1898), Jargonaphasia, apraxia of speech

The Globalist Approach in Aphasia

Leading figures: the French Neurologist Pierre Marie and the English Neurologist Henry Head. Beliefs:

-There is only one form of aphasia (Wernicke's aphasia).

- Aphasic deficits always involve an impairment of thinking and a general lowering of intelligence.

-Inclusion of non-verbal tasks (e.g., drawing pictures, imitating gestures of the examiner, etc.).

- Using a group study methodology and putting stress on quantitative reliable results (in contrast with the anecdodical reports of the diagram makers).

Demise of the Globalist approach

- Very low correlation between severity of aphasia and Performance IQ. Some patients with severe aphasia have normal or superior IQ.

- Difficulty of using a group study methodology given the idiosyncraticies shown by each patient.

Series of case studies are a good compromise

Positive contributions

- Importance of distinguishing extra-linguistic deficits superimposed to linguistic deficits.

Importance of distinguishing different components in a task.

- Emphasis on a more precise, quantitative approach.

The Cognitive Neuropsychology approach

Putting cognitive models first !

- It is a model of normal language processing which provides the framework to interpret different impairments seen in the patients.
- No two patients may be alike because different parts of the model can be impaired.
- What is important is that all symptoms shown by a patient can be interpretable (if not the model needs revising).

Cognitive models are more articulated

- This reflects new knowledge of language processing and allows us to describe a variety of different impairments.

The original syndromes are fractioned in a number of distinct impairments which can characterize patients in different combinations

Broca's aphasia fractionates into:

Word production impairments

- Deficits accessing the lexicon (anomia)
- Articulatory planning deficits (apraxia of speech)
- Articulatory deficits (anarthria)

Sentence production impairments

- Syntactic deficits
- Morphological deficits
- Deficits in processing function words

} agrammatism

Spelling impairments

Wernicke's aphasia fractionates into:

Word comprehension impairments

- Word deafness
- Semantic/lexical word deafness
- Semantic impairments

For word production impairments

- Semantic jargon
- Phonological-lexical impairments

Sentence processing impairments

- Syntactic comprehension deficit

Reading impairments

But the labels Broca's Wernicke's and conduction aphasia,fluent/non-fluent are still use as short-hands description.

Conduction's aphasia fractionates into:

- Phonological encoding impairments
- Phonological STM impairments

Characteristics of Neuropsychology and current aphasiology

1. To use information processing models of normal cognitive functions as a framework for understanding the patterns of cognitive deficits that arise after brain damage or because of learning difficulties.

2. To use patterns of selective deficits to guide further developments of information processing models of normal cognitive functions. To specify:
    1) the sequence of cognitive components that carry out a given function.
    2) The inner working of these components.

Other disciplines share with CN the aim of understanding cognition.

- Experimental Psychology
- Developmental Psychology
- Artificial Intelligence (computer simulations of behaviour)
- Linguistics
- Neurosciences

The relation with the neurosciences is particularly close.

- CN has an independent focus. The level of analysis is functional and, thus, distinct from an anatomical/physiological focus.
- Still, neuro-anatomical findings can put constraints on the possible types of cognitive architectures.

What is special of CN and aphasiology: Cognitive functions are very complex. By looking at the performance of brain-damage patients, we can observe the workings of some cognitive components in isolation or in semi-isolation since other components with which they normally interact are damaged.

Main Assumptions

Modularity: The cognitive system is made of separate components or modules.

- Each module is characterized by the specific computations it performs (it takes only a certain input and transforms it into a certain output).
- Modules are functionally separate, that is, they can be disrupted and leave other modules intact.

Processing is **mandatory**. It operates in a all-or-none fashion. Once activated a module will carry out the entire processing operation for which it is responsible.

More controversial – from Fodor's Modularity of the Mind (1983)
- **Modules are innate** and they cannot be acquired developmentally
- Information **encampsulation**. Modules carry out their operations in isolation from what is going on elsewhere.

Assumptions

Subtractivity (or Transparency): Brain-damaged patients operate with a reduced, but otherwise 'normal' set of modules.

Universality: The cognitive modules underlying performance are not particular to the individual, but they reflect a common cognitive architecture.

Method

- Consider the types of deficits which can arise from brain-damage
- Use theoretical considerations and double dissociations to assume cognitive modules: If patient 1 can have damaged function A but spared functions B and the opposite is true for patient 2, A and B are separate functions with an independent representation in the brain (more in the method lecture)

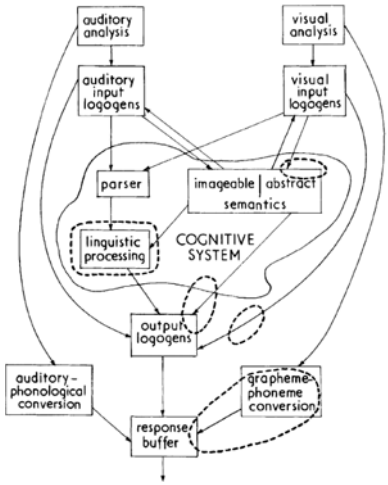
Discuss in groups of three:

- **What is special about the method of CN?**
- **What do you think of the main assumptions of CN?**
- **Can you cite three of them? Do you think they are testable?**

CN and the architecture of the mind

- Modern neuropsychological and aphasiology research assume that brain damage can produce selective effects
  - Damage can affect some capacities without affecting others
- This means neuropsychological patients can help define an "architecture of the mind
  - Catalogue of all the capacities that can be damaged independently; Result: a list of the faculties of the mind
  - This could be represented by a box and arrow diagram
  - Selective effects mean that modules/functions can be damaged independently and to the logic of double dissociations

Example "box and arrow" model



- Model is for repetition and reading
- Morton & Patterson, 1980
- In a complete system, components and connections predict all of the types of aphasic patient that should be possible
- And all of these should be observed

Traditional Neuropsychology	Cognitive Neuropsychology
Medical Framework Localize groups of symptoms (syndromes) into brain areas	**Computational Framework** Specify models of normal cognitive functions
Group studies Correlational studies Association of syndromes with sites of lesions	**Single case studies/ case series** The goal is not or not only correlational It is to find out what is wrong in a particular patient and why Task analysis - to find out why a patient fails in a task you need first to know what the components of the task are
Behaviorism Syndromes are defined in terms of gross behaviour The focus is on the anatomical deficit	**Cognitivism** Which inner processes and representations realize a behaviour The focus is on the functional deficit

Test your acquired knowledge!!

1. **Aphasic patients often experience:**
   a) a change in handedness
   b) disturbances of thought
   c) problems with self esteem
   d) all of the above

2. **Where is conduction aphasia traditionally localized?**
   a) Posterior temporal lobe
   b) Temporal gyrus
   c) Anterior temporal lobe
   d) Arcuate fasciculus

3. **In contrast with the diagram-makers (e.g., Lichtheim, Wernicke etc.), the globalist school argued that:**
   a) there is only one form of aphasia
   b) there are more forms of aphasia than any model could account for
   c) there is no relation between aphasia and intelligence
   d) It is important to use a single case methodology

4. Cognitive neuropsychology is based on the principles that:

a) Brain damage does not produce a complete reorganization of the language system;
b) Some principles of language are the same across languages;
c) Individuals speaking the same language share the same cognitive architecture;
d) All of the above

5**. According to CN aphasic deficits are best interpreted:**

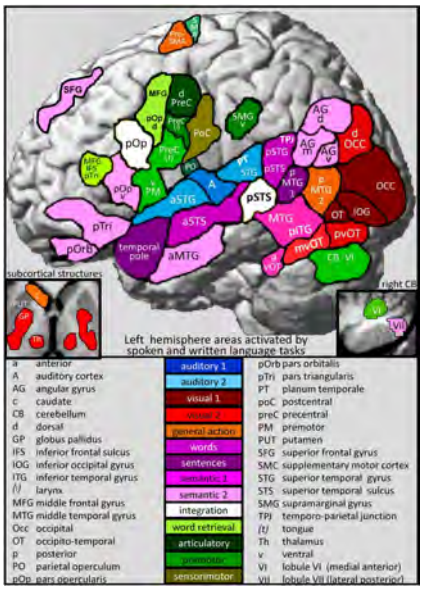
a) By establishing a discrete number of aphasic syndromes;
b) By considering that there is only one true form of aphasia;
c) By finding deficits in a model of normal language processing

Modern studies have improved:

- our knowledge of language localization and
- our knowledge regarding the existence of a central semantic system and relationships with other language components

PART 2: MODERN APHASIA STUDIES

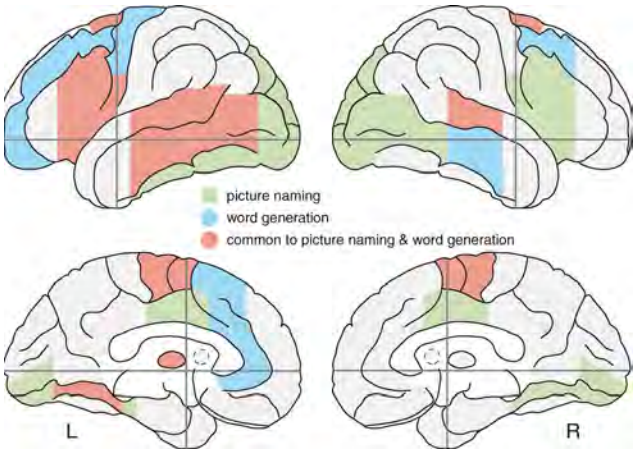
Language localization: Modern studies



Using a combination of techniques: PET, fMRI, lesion studies, we know now that **networks** of brain areas are involved in language processing.

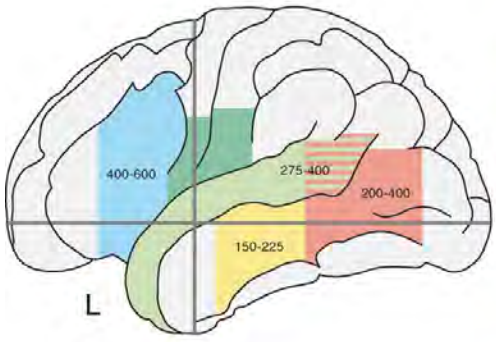
From Price, C. (2012).. *Neuroimage*, *62*, 816-847.

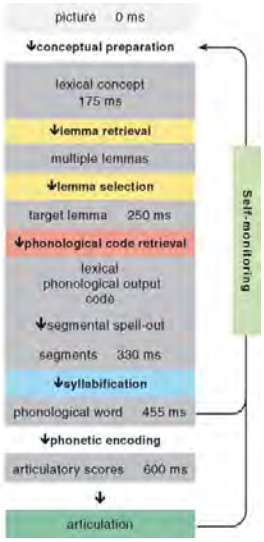
Studies using picture naming and word generation tasks show that most of the cortical areas of the brain (especially on the left) are activated when performing these tasks.



From Indefrey & Levelt (2004). *Cognition*, *92*, 101-144

They also show, however, that different areas are associated with different processing components which are activated at different times during task performance.

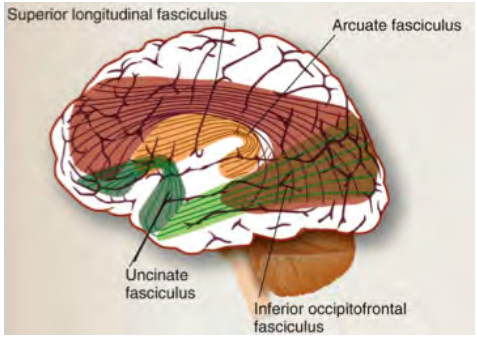


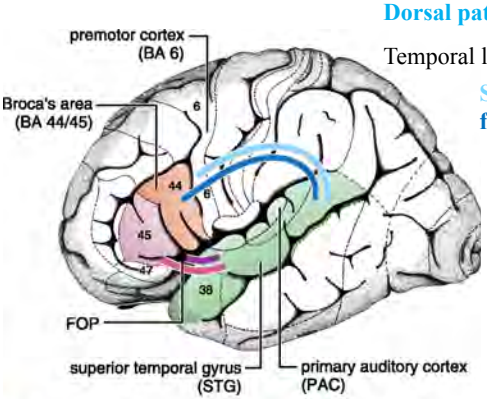


From Indefrey & Levelt (2004). *Cognition*, 92, 101-144

Dual Pathways in language processing: Lichteims revised

- Finally, modern studies have allowed us to built a more accurate picture of the anatomical and functional **relationships** between different brain areas.
- DTI – Diffusion tensor imaging studies have been in particularly instrumental
- These studies have allowed us to identify **two pathways** involved in language processing.





Dorsal pathway: phonology ⇄ articulation

Temporal lobe to pre-motor cortex and Broca's area

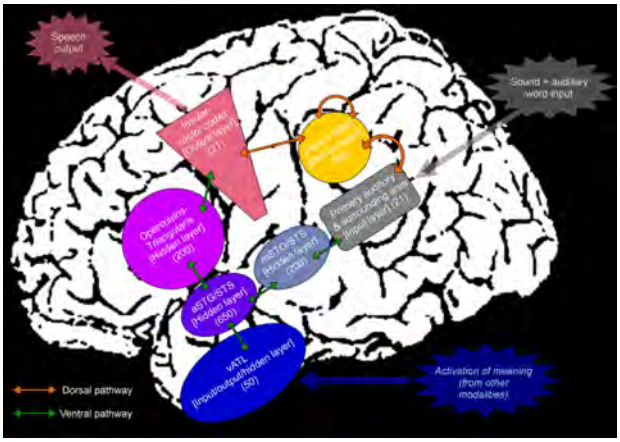
Superior longitudinal fasciculus/Arcuate fasciculus

Ventral pathway: phonology ⇄ semantics

Temporal lobe to inferior frontal lobe

Uncinate fasciculus
Extreme fiber capsule system

From: Friederici, A.D.(2011)
Physiological Review, *91*, 1357-1392



From: Ueno, Saito et al., 2011. *Neuron*, *72*, 385-396

Dorsal pathway - phonology to articulation - underpinned by the arcuate fasciculus and superior longitudinal fasciculus

primary auditory → inferior supramarginal gyrus → insular-motor cortex

Ventral pathway - phonology to semantics –

underpinned by middle superior fasciculus and extreme capsule

primary auditory → mid-superior Temporal Gyrus → anterior- superior Temporal Gyrus → Broca's areas/opercularis-triangularis → insular-motor cortex

The functions of the two pathways have been confirmed by studies using a technique known as voxel-based symptom-lesion mapping.

These studies have shown:

Phonological errors occur mainly following lesions of the dorsal pathways – phonology to articulation(Schwartz et al., 2012)

Semantic errors occur mainly following lesions of the ventral pathways—phonology to semantics (Schwartz et al., 2009)

Language impairments
in light of
normal language processing models

Lecical-Semantic processing and its impairments:

The meaning and sounds of words: storing and retrieval

Plato compared memory to an aviary

Some of his ideas are still with us today.

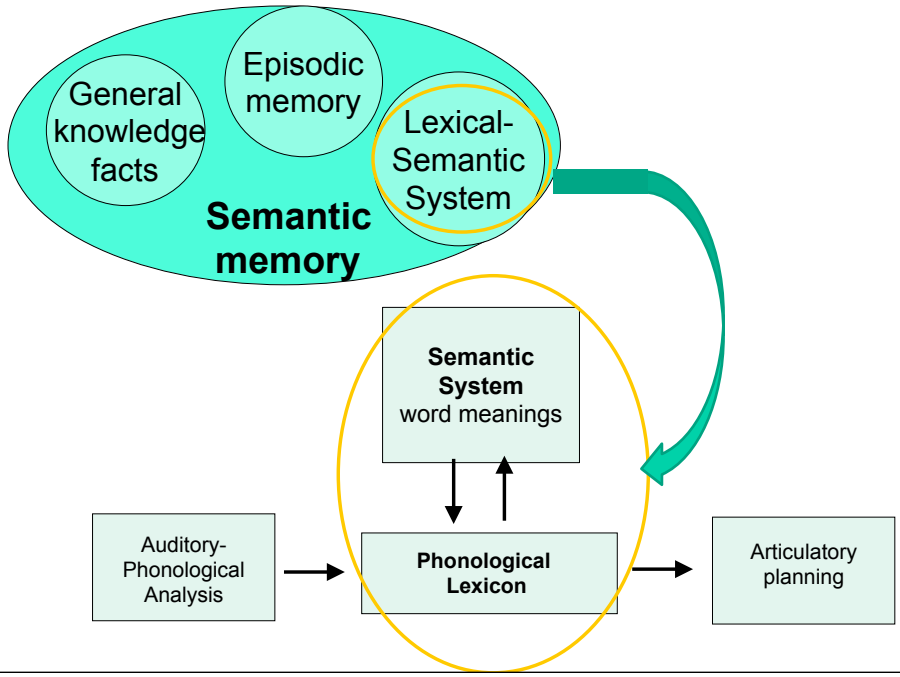
Adding a new bird to the aviary is like placing a new memory into storage

Recapturing the bird at a later date, is like retrieving a memory

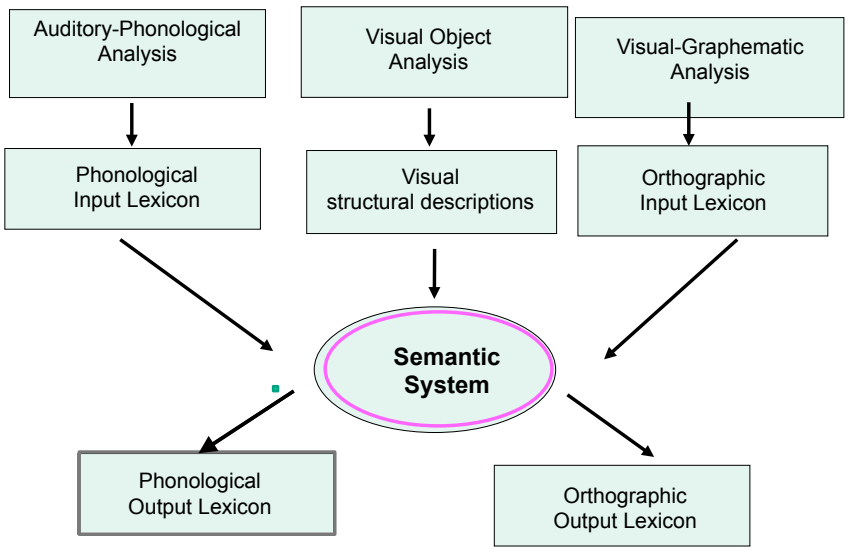
Inability to capture a bird or its escape from the cage is like inability to store a memory or forgetting a memory.

The meaning and sound of words are the memories that we use in language comprehension and production.

Today we still talk of storing, retrieving and forgetting words in terms of their sounds and meaning.



The semantic system at the center of the language architecture



The (lexical) semantic system

Is the component which represents the meanings of words.

According to some models, a single meaning corresponds to each word (e.g., Levelt, 1992).

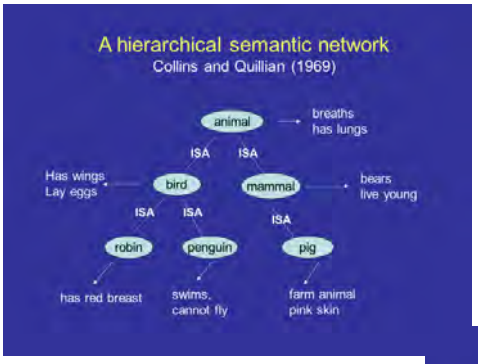
More commonly, however, meanings are represented decomposed in a number of semantic features which are shared across words (e.g., Dell, 1988).

This second characteristic will explains semantic priming and the occurrence of semantic errors in aphasia.

Classical approaches to semantics

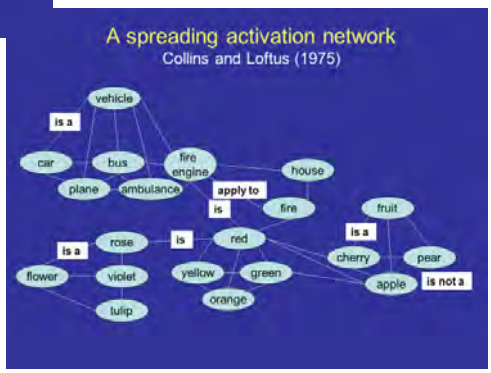
According to the referential theory of meaning, the meaning of a word is the entity it refers to. However,

- Abstract words or function words do not have precise referents.
- Several words may refer to the same entity, depending on which aspect is on focus.
- Words often take their meaning by their relation with other words.



Meanings represented as networks

1. Meanings and features organized into networks
2. Meanings: made of features



Meanings as combinations of semantic features

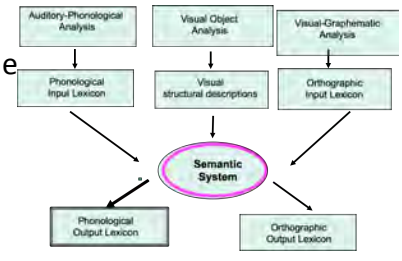
Current theories stress both

- **An organization of meanings into *hierarchical* networks**
- **Semantic decomposition**
  - A word meaning can be derived from a set of smaller units (semantic features or semantic primitives).
  - Semantic features can contribute to the meaning of different words whose meanings then overlap.
  - This provides an economical system of representing meanings.

Semantic impairments

General characteristic:

Given the centrality of the semantic system in the architecture of language, an impairment to this system should affect **both comprehension and production** tasks and **both** tasks in the **spoken and written modality**.



Assessment:

How would you assess an impairment in <u>comprehension?</u>

Picture-word matching tasks - words with similar meanings are confused.

Categorization - problems in categorizing pictures or words in semantic categories if these are close enough (e.g., vegetables vs. fruits).

Identification of features - which are the right attributes corresponding to a word or a depicted item. E.g., Is a cat tame? Does it like bread?

Etc…

Assessment:

How would you assess an impairment in <u>production</u>?

Picture naming (spoken and written)

Naming to definition – What is that animals which has two humps and lives in the desert?

Spontaneous speech

(e.g., Hillis, Rapp, Romani & Caramazza, 1990)

Types of errors

- Errors should should be semantic in nature;
  -- **super-ordinate errors** where a super-ordinate category is produced instead of a more specific item (e.g., camel>animal)
  -- **coordinate errors** where a different item at the same level is produced instead of the target
  -- **associate errors** where a related item is produced instead of the target camel>desert

- Decomposition theories well explain semantic errors; If representations share features (and there is noise in the system) one can pick a representation which is co-activated through shared features;

- If some representations are degraded, representation at a higher hierarchical level may be more robust and more easily spared by brain-damage.

Category-specific semantic impairments

Sometimes brain-damage selectively disrupts knowledge about particular semantic categories (e.g., Warrington & Shallice, 1984);

Most commonly knowledge of animate objects is impaired in the face of preserved knowledge of inanimate objects (living nonliving dissociation). E.g.,

Impaired	Spared
Animals	Furniture
Plants	Clothing
Flowers	Kitchen utensils
	Buildings
But not	But not
Precious stones	body partS
foods	

In some patients selective impairments are present even after confounding variables such as familiarity and visual complexity are taken into account.

Double dissociations with patients showing spared and impaired performance in opposite sets of categories also rule out effects of confounding variables.

Possible explanations

The sensory-functional theory >> categories differ for type of attributes: perceptual attributes vs functional attributes.

However, categories do not always cluster together consistent with this interpretation and double dissociations are reported (e.g., some patients have problem with animate categories, but no categories which are defined by visual attributes such as precious stones)

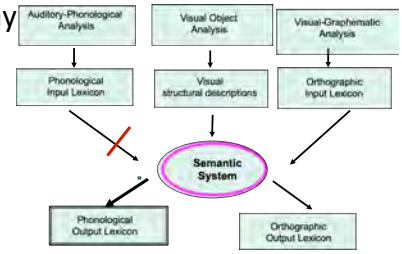
The domain specific knowledge hypothesis >> different neural mechanisms to encode different types of categories – distinction between living and non-living of evolutionary importance.

Semantic access impairments

If one assumes that brain-damage may affect not only components but also connections between components, one can also predict impairments where the semantic system is intact, but access to it is impaired.

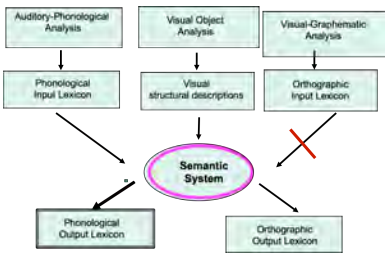
An impairment **accessing** the semantic system, may affect a single modality, because it is only the connection from a specific input which is impaired.

A connection impairment



only errors in spoken comprehension

A connection impairment



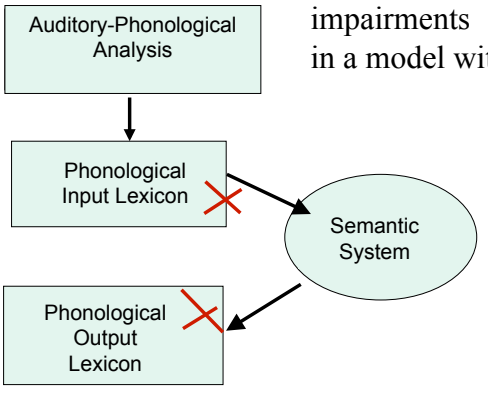
only errors in ??

The Phonological Lexicon

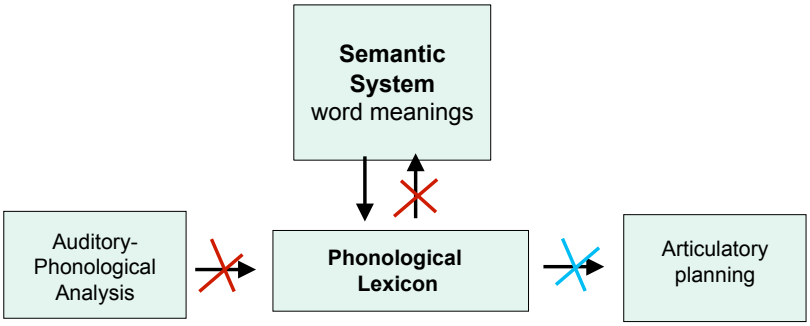
- Is the component which represents words in terms of sequences of phonemes (the sounds of one's language).
- Phonemes are abstract, symbolic units
- Phonological representations should be distinguished from phonetic representation which specify articulatory targets (which movement you have to make to realize the phonemes in speech);

Phonological impairment could be in comprehension and in production

Selected comprehension and production impairments
in a model with two phonological lexicons



Selected comprehension and production impairments
in a model with a single phonological lexicon



Discuss in groups of three:

How would you assess phonological impairment in comprehension and production?

Comprehension

- Word-picture matching
- Same-different with syllable, words and nonwords
- Lexical decision
- Auditory tests?

Production

- Picture naming
- Spontaneous speech
- Naming to definition
- Reading

Phonological Impairments in Comprehension

- Errors picking phonological distractors in
  - Word (spoken) -picture matching tasks - confusion with phonological distractors (e.g., luggage/cabbage; door/floor)
  - Same-different syllable or word tasks – low % correct
  - Lexical decision – low % correct
- No difficulties with audiometric tests

See **word deafness** in the next lecture

Phonological Impairments in Production

In spoken tasks

Lexical phonological errors (phonological paraphasias):

Sound errors which do result in an existing word of the language; e.g., table> cable

Non lexical phonological errors:

Sound errors s which do NOT result in a another word of the language. E.g.,

- Substitutions e.g., trombone >drombone
- Deletions e.g., trombone >tombone
- Insertions e.g., trombone> trombrone
- Transpositions e.g., trombone> dromtone

See **conduction aphasia, Wernicke's aphasia and jargonaphasia** in next lecture

Locus of Phonological Errors

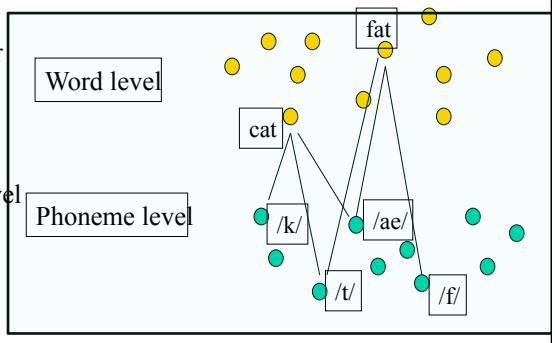
Lexical phonological errors

Confusion in picking the right entry in the lexicon; why?

The lexicon includes two levels

- Word nodes
- Phoneme nodes
- Interacting with one another

When two words share phonemes They activate each other and sometime one reaches a higher 'level of activation' and it is produced instead of the target.



Evidence for interaction between word and phoneme units comes from:

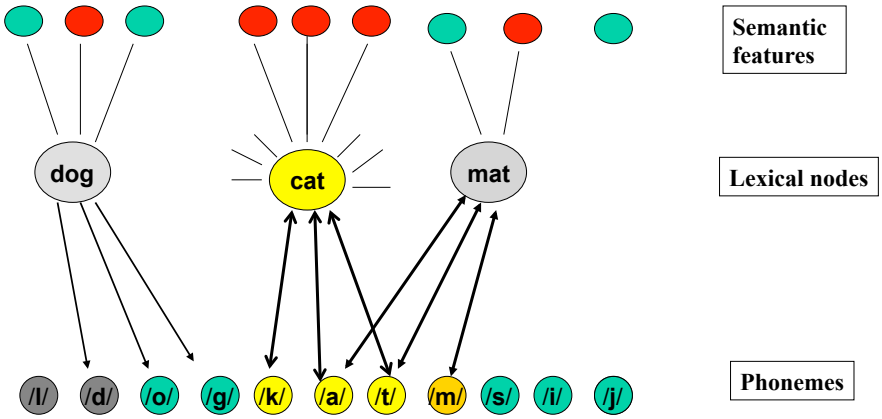
Lexical bias:

- Normal speakers make more lexical phonological errors than would be expected on the basis of the non-lexical errors (e.g., Dell & Reich, 1981).

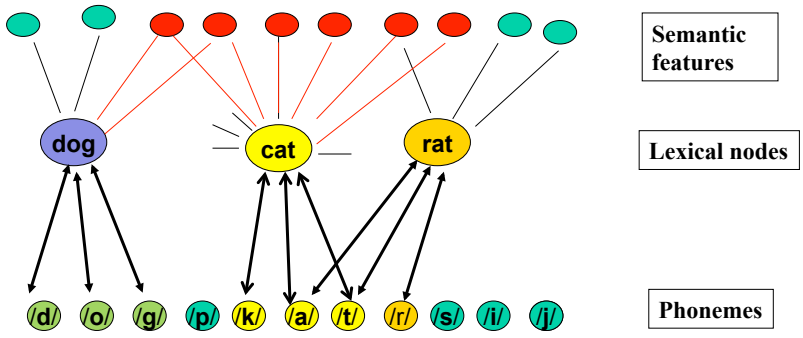
- Some aphasic patients make a great number of phonological lexical errors in the face of many fewer non-lexical errors.

Mixed phonological/semantic errors (e.g., cat> rat): They occur more often than what is expected on the basis of the conjoint, but independent occurrence, of semantic and phonological errors.

Explanations in terms of an interactive model
(e.g., (Dell, 1986; Dell et al., 1997)



cat>mat more than cat>dat; **lexical errors** are more frequent than non-lexical errors because they receive activation from both the phoneme and word level. They are a consequence of the positive feedback from the phoneme level to the lexical/word level.



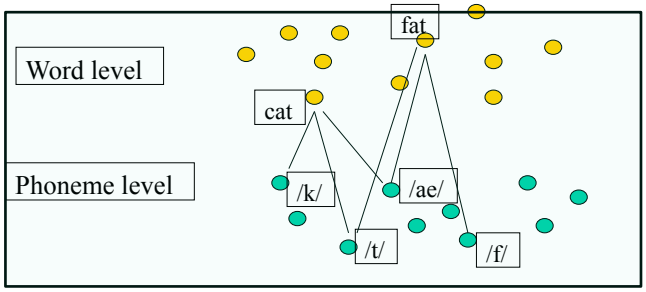
Mixed errors are more likely to be selected in error (cat>rat more frequent than cat>dog), because both phonemes and meanings influence phoneme selection.

Locus of Phonological Errors

Non-lexical phonological errors

Confusion in picking the right phonemes; why?

These errors would arise in picking phonemes (this is level is called phonological encoding or phoneme selection) rather than in selecting word nodes

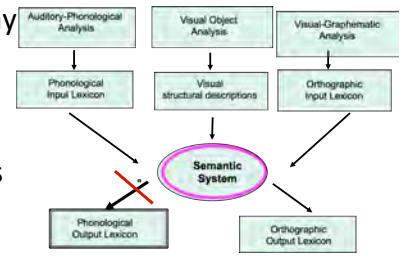


Lexical access impairments

If one assumes that brain-damage may affect not only components but also connections between components, one can also predict impairments where the lexicon is intact, but access to it is impaired.

See **anomia** in next lecture.

A connection impairment



Errors in spoken production

At the end of this lectures and after the related readings you should be able to:

1. Have general knowledge on the localization of language;
2. Describe the general characteristics of aphasic patients;
3. Describe early approaches to aphasia and the transition to modern approaches;
4. Describe and discuss the modern approach to aphasia in comparison to previous approaches.

Test your acquired knowledge!!

1**. Semantic impairments:**
a) Involve comprehension and production;
b) Can produce phonological errors;
c) Can involve impairments to specific semantic categories;
d) a) and c)

2. **Aphasic impairments can involve:**
a) Degradation in language components
b) Difficulties accessing semantic components
c) The creation of new language components
d) a) and b)

3. Phonological production impairments:
a) Always also affect comprehension;
b) Can be assessed through lexical decision and same-different tasks;
c) Can be assessed through repetition and picture naming tasks;
d) All of the above

4. Which is <u>not</u> true of phonological (production) errors

a) They can be lexical and non-lexical;
b) They can involve substitutions, deletions, insertions and transpositions of phonemes;
c) Can be produced by degradation in the semantic system
d) All of the above

Readings for this and following lecture:

T. Harley, (2013). The Psychology of Language. Chapter 11 Word meaning. Chapter 12 Word production

Also for following lecture:
Banich, M., & Compton (2011). Chapter 9 – Language.
Kolb, B., & Whishaw, Q. (2008). Chapter 15.3, 19 - Language.
Ellis, A.W., & Young, A.W. (1989). Chapters 1, 5, and 6.
Parkin, A.J. (1999). Chapter 7; Spoken Language impairments.

Further readings:
Rapp, B. (2001). *The handbook of cognitive neuropsychology: What deficits reveal about the human mind*. Philadelphia, Pa.; Hove: Psychology Press. Chapter 12, Spoken word production.