Introduction to Cognition – Language 2

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Learning Objectives

By the end of this lecture you should:

- Explain to your peers how we produce and understand speech.
- Describe to your peers the key components and stages of speech production and perception.
- Describe and critically appraise theories and empirical evidence for speech production and perception.

This session

This session is made up of a number of videos, with narrative I've written, and links to some resources that I hope you'll find interesting.

Chapters 9 and 11 in Eysenck and Keane supports this session.

Reading and speech perception

CHAPTER 9

Language production

CHAPTER 11

Components of language & definitions

Phonemes: elementary (smallest) units of sound. For example, 'rice' and 'lice' differ from each other by just one phoneme

Morphemes: elementary (smallest) units of meaning in language. For example, dog-s

Phonology: rules governing the sound of words and parts of words.

Syntax: rules governing word order and meaning resulting in sentences. For example, 'pass the salt', not 'the pass salt'

Semantics: the meanings of words and sentences. For example, 'bank', 'oink'

Pragmatics: the use of language as a function of content & social rules. For example, 'hello', 'hi' or 'hey'

What is Language?

Language is a system of *symbols* and *rules* that enable us to communicate.

- Symbols: written and spoken words, signs.
- Rules: specify how sentences are formed.

The paradox of language: it is rapidly produced and understood, yet complex.

How straightforward is speech production?

Average speech rate ≈ 150 words per minute

Speech Errors:
- *You have hissed all of my mystery lectures.*
- *Where is my tennis bat?* instead of *Where is my tennis racquet?*
- *He has already trunked two packs.*
- *The key to the cabinets were well hidden.*

# How straightforward is speech perception?

Imagine hearing the speech fragment "The child ate the..." while looking at a visual scene containing these objects:

There's good evidence that you'll look at the picture of the apple in anticipation of what is likely to come next in the sentence (Altmann & Kamide, 1999).

How straightforward is speech perception?

When you listen to speech, you'll hear a continuous pattern of speech sounds. You need to segment these sounds - which isn't always easy, especially where there is variability in the speech signal.
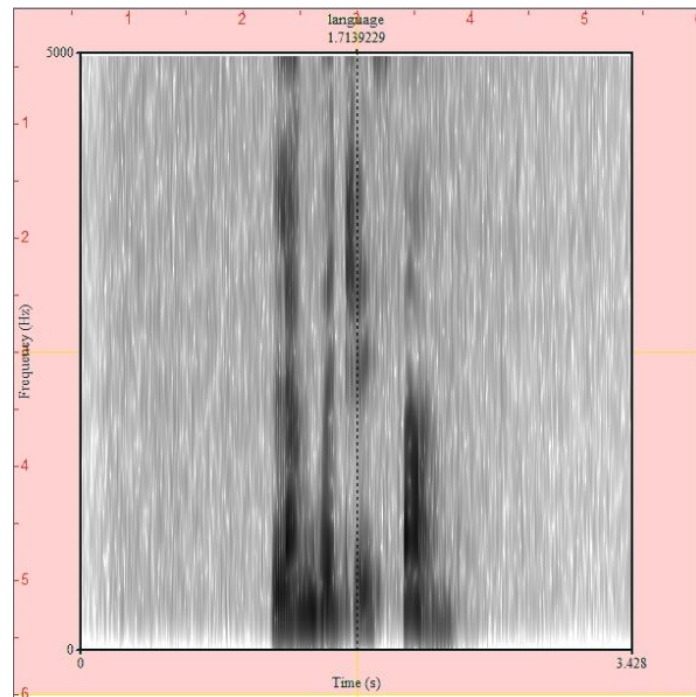
Speech Production

- Conceptualization
  - Think of something to say
- Formulation
  - Find a way to express your idea given the specific language tools
- Articulation
  - Physical action of moving your muscles to produce speech
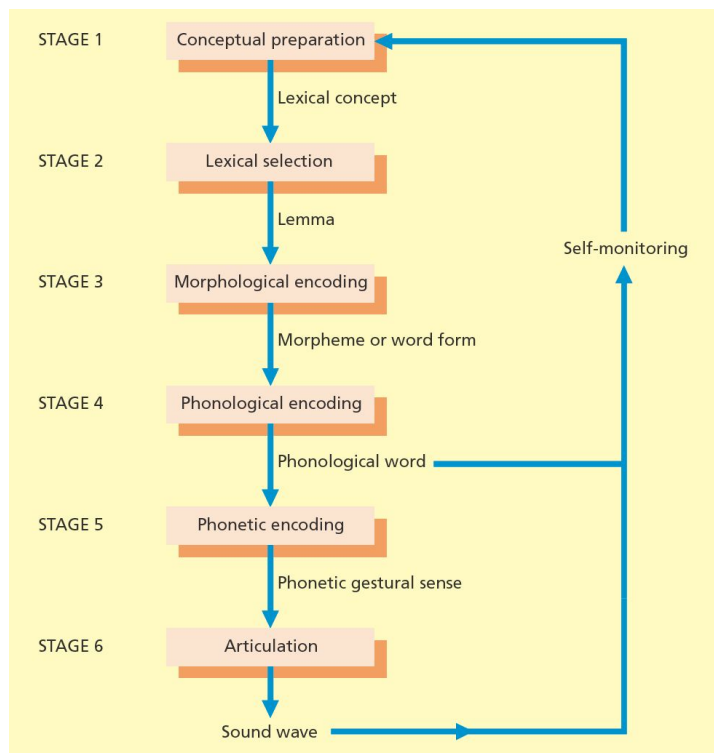
Theories of Speech Production

WEAVER ++ (Levelt et al., 1999)
- Feed-forward processing
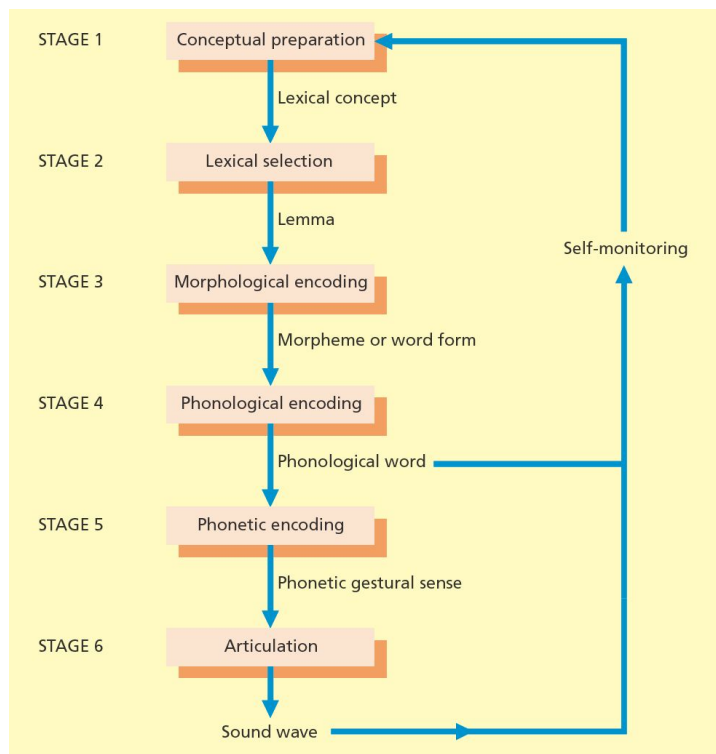
Spreading activation (Dell,1986)
- Interactive processing

WEAVER ++ (Levelt et al., 1999)

1. Idea
2. Zoom in on the appropriate lexical item in the mental lexicon (→ lemma level)
3. Retrieve a word's morphemic code
4. Retrieve a word's phonological code
5. Syllabify the word & access the corresponding articulatory gesture
6. Move the muscles and produce speech waves

WEAVER ++ (Levelt et al., 1999)

☞ Feed-forward information flow

☞ Lemma is an intermediate stage between activating an idea and the speech sound
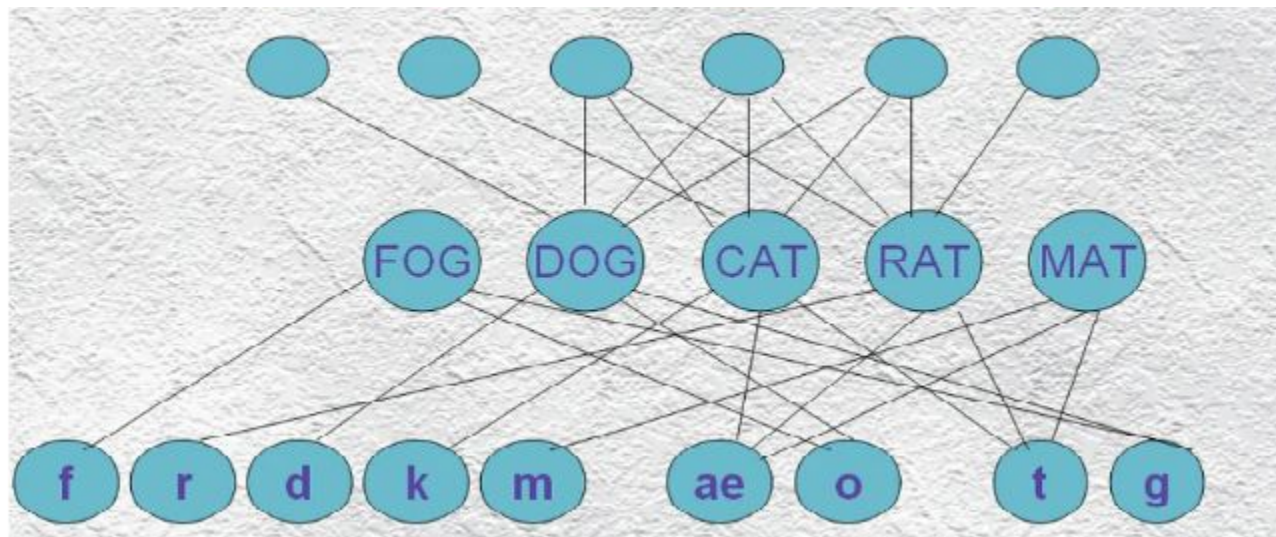
☞ The link from meaning to sound (i.e., lexicalisation) is **not** a one stage process

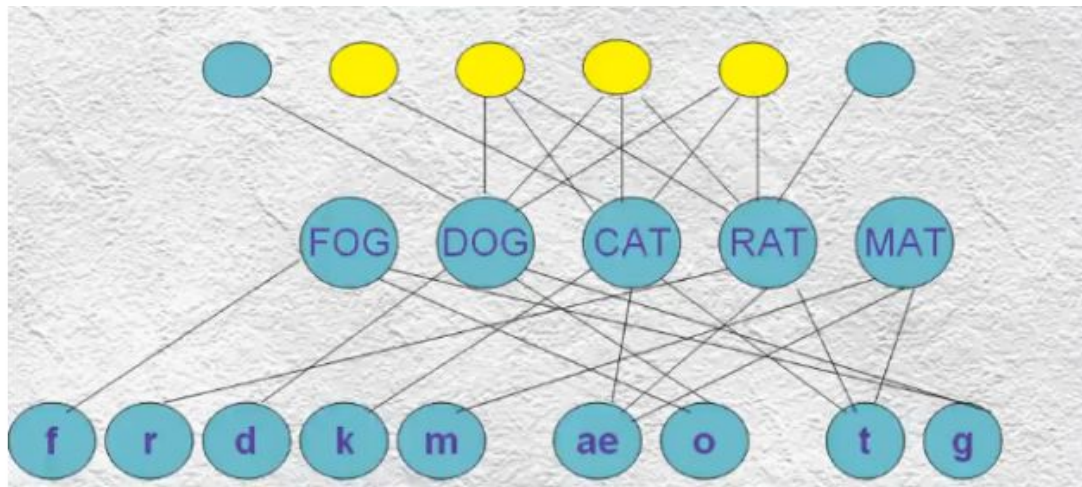# Spreading Activation (Dell, 1986)

Semantics

Words

Phonemes

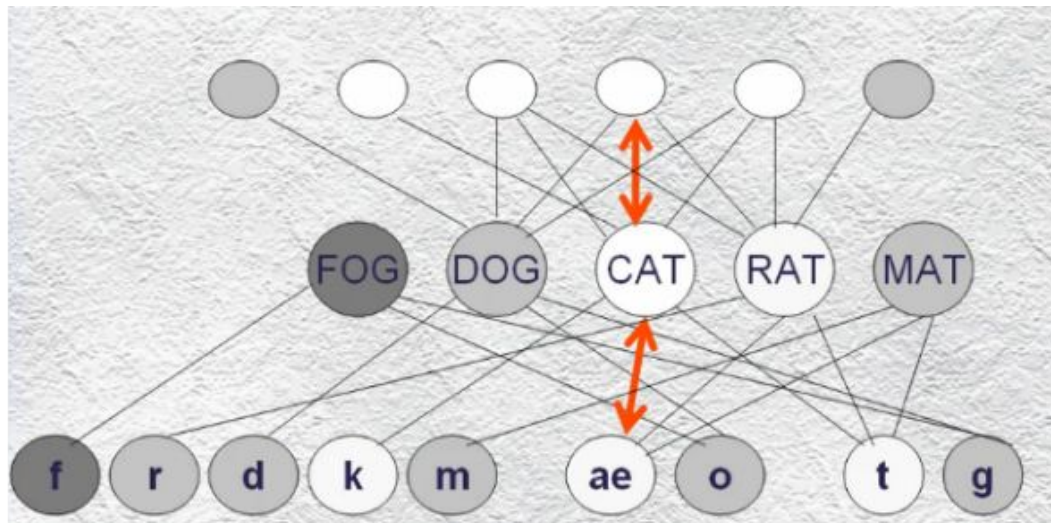# Spreading Activation (Dell, 1986)

Semantics

Words

Phonemes
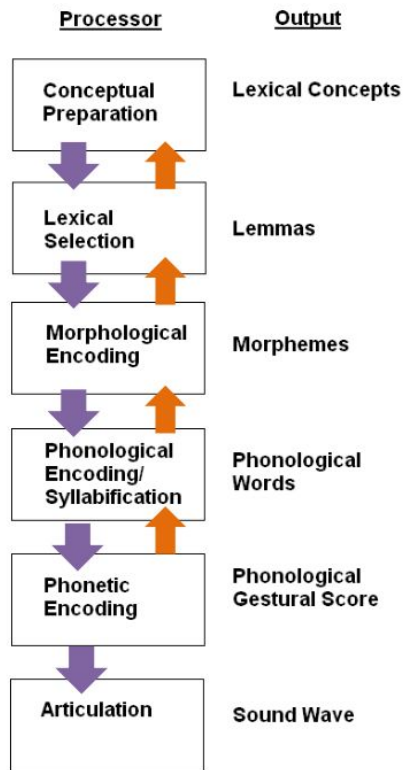
Spreading Activation (Dell, 1986)

Semantics

Words

Phonemes

Spreading Activation (Dell, 1986)

Processor	Output
Conceptual Preparation	Lexical Concepts
Lexical Selection	Lemmas
Morphological Encoding	Morphemes
Phonological Encoding/ Syllabification	Phonological Words
Phonetic Encoding	Phonological Gestural Score
Articulation	Sound Wave

☞ Interactive information flow (from meaning to sound & sound to meaning)

☞ Lemma is an intermediate stage between activating an idea and the speech sound

☞ Lexicalisation is **not** a one stage process

End of video 3

Ask students to watch this video before moving on: Nice video about TOTs:
- https://www.youtube.com/watch?v=sFeibGnZ6tc

Supporting evidence for the models of speech production

Tip-of-the-tongue state (TOTs)

Picture-word interference

Speech errors

Tip of the Tongue States (TOTs)

- What word means to formally renounce the throne?
- Do you feel you know the word? How many syllables it has? What does it sound like?

Tip of the Tongue States (TOTs)

- TOTs occur when we have an idea or concept in mind but cannot find the appropriate word.
  ☞ Lexicalisation is not a one stage process
- Some TOTs features:
- While in TOTs, people can retrieve the first phoneme of the target word, the number of syllables of the target word, and the gender of the target word.
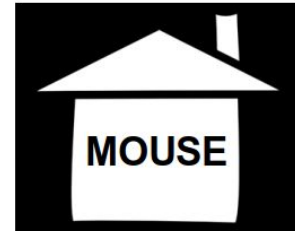- Most of the TOTs occur with low-frequency words (Harley & Bown, 1998).

Picture–word interference

Semantic relatedness slows down picture naming.
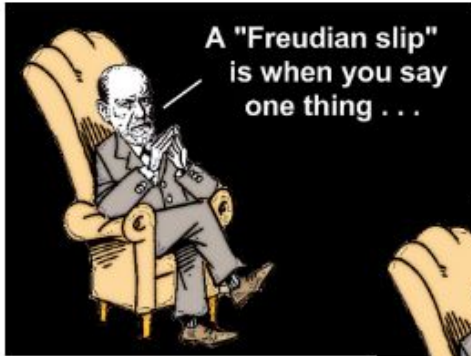
☞ Lexicalisation is not a one stage process.

Phonological relatedness speeds up picture naming.

Arieh & Algom (2002)

Speech Errors

https://goo.gl/images/mabh4e

Why study errors?
1. We gain insights into how the complex cognitive system involved in speech production works when it actually breaks!
2. We understand how information flows between different mental processes during speech production
3. We understand how much planning speakers do when they speak

Types of Speech Errors

	Utterance	Target
Semantic substitution	Where is my tennis bat	Where is my tennis racquet
Word-exchange	My chair looks empty without my room	My room looks empty without my chair
Sound-exchange (*spoonerisms*)	Go and shake a tower	Go and take a shower

Activity

Type of error	Utterance	Target
	The knife light is great	
	Guess whose mind came to name?	
	Get me a whiskey to eat	

Activity

Type of error	Utterance	Target
Sound-exchange (*spoonerisms*)	The knife light is great	The night life is great
Word-exchange	Guess whose mind came to name?	Guess whose name came to mind?
Semantic substitution	Get me a whiskey to eat	Get me a whiskey to drink

Q: Can you think of any constraints? Do you think you would ever say *the night grife is leat*?

Errors are Not Random

Lexical bias effect
- ○ 'Fig beet' instead of 'big feet' more often than 'hig borse' instead of 'big horse' (Baars, Motley, & MacKay, 1975)

Mixed-error effect
- ○ 'Let's start' but not 'Let's begin' instead of 'Let's stop' (Dell, 1986)
- ○ 'I thought that there would still be some cookies left, but there were…' If image of is shown. 'none' instead of 'not' (Ferreira & Griffin, 2003)

Support

Tip-of-the-tongue state (TOTs)

Picture-word interference

Speech errors

☞ Lexicalisation is not a one stage process

But what about information flow in the models of speech production?

Evaluation

	WEAVER++	Spreading Activation Model
TOTs	✓ (?) ○	✓
Picture-word interference	✓ ○	✓
Speech errors	✓ (?)	✓

BUT
Lexical bias effect
Mixed-errors

BUT
Prospecting

Summary So Far

- Speaking is a complex multi-stage process
  - From having an idea you want to talk about to move your articulators and produce the sound waves

- Several theoretical models have tried to describe the process
  - WEAVER++ (feed-forward)
  - Spreading activation (interactive)

- Several empirical evidence support different components of the models
  - TOTs, picture-word interference, speech errors

Speech Perception

Co-articulation

The pronunciation of a phoneme by a speaker depends on the preceding and following phonemes.
- The /b/ phonemes in 'bill', 'ball', 'able', 'rub' are acoustically different.
- The word 'job' is likely to be misperceived if the 'jo' part was recorded from the word 'jog'.

Bad news
No one-to-one relationship between acoustic signal and phonemes.

Good news
Allows for prediction and makes perception faster.

Theories of Speech Perception

Motor theory (Liberman et al., 1967)

TRACE (McClelland & Elman, 1986)

Motor Theory (Liberman et al., 1967)

- 'Listeners perceive spoken words by reproducing the movements of the speaker's vocal tract rather than by identifying the sound patterns that speech generates'

- The motor system is involved in both speech production and perception
  - There is a 'bridge' between production and perception

Motor Theory and Mirror Neurons
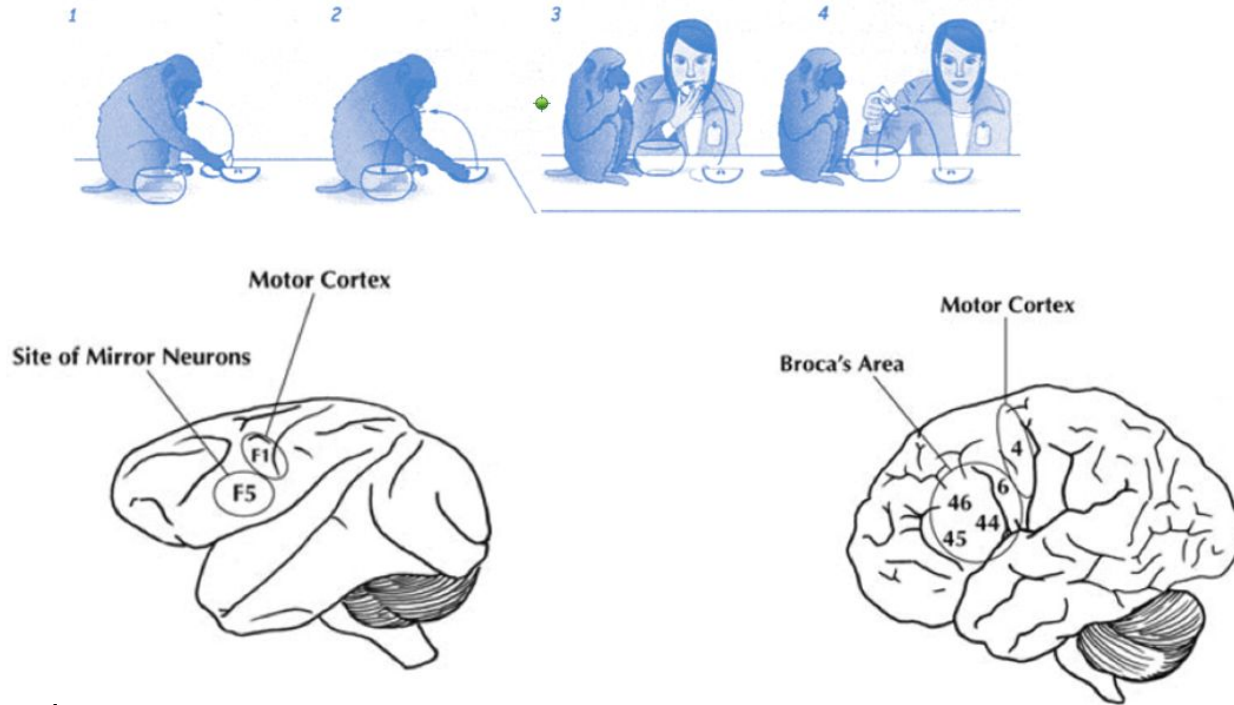
Rizollatti's work, early 1990s

Support

McGurk effect

Categorical perception

Motor cortex is functionally involved in speech perception

McGurk Effect

- An illusion occurs when the auditory component of one sound is paired with the visual component of another sound, leading to the perception of a **third** sound.
- We integrate non-acoustic information into what we hear.
- Our auditory and visual information processing is merged.

Categorical Speech Perception

🦻 Artificial 1 to 10 sound continuum where 1 sounded as /b/ and 10 as /d/
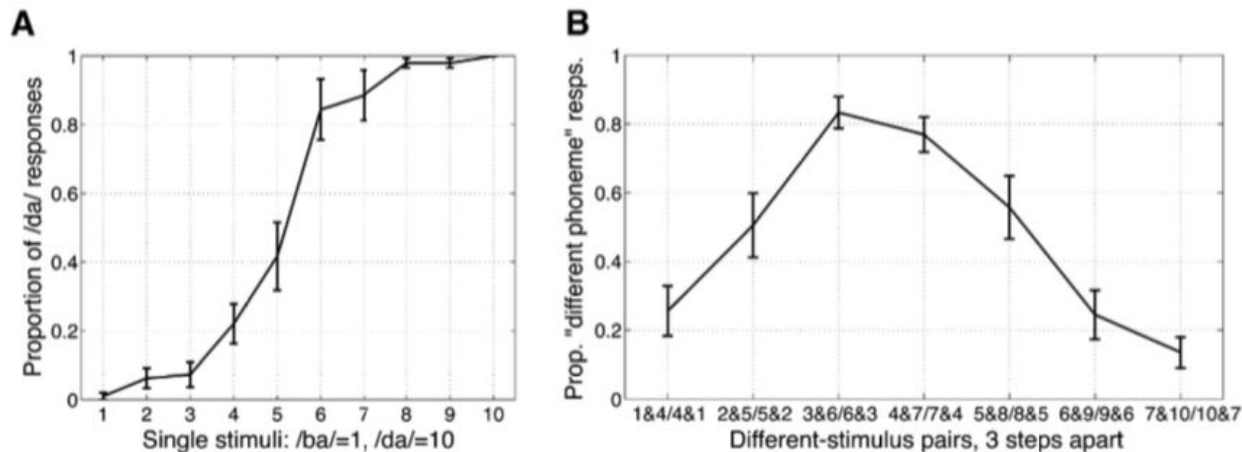
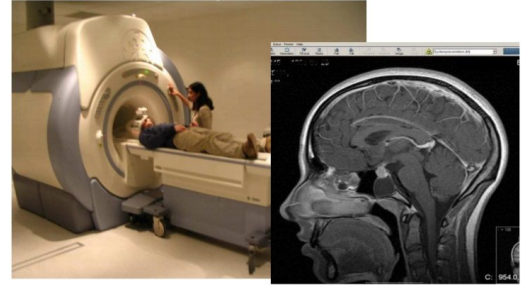Speakers did not perceive gradual change.
They suddenly switched from perceiving one sound to perceiving the other.
Better discrimination of pairs of sounds when sounds were across the crucial point.

Raizada & Poldrack (2007)

Motor Cortex and Speech Perception

fMRI
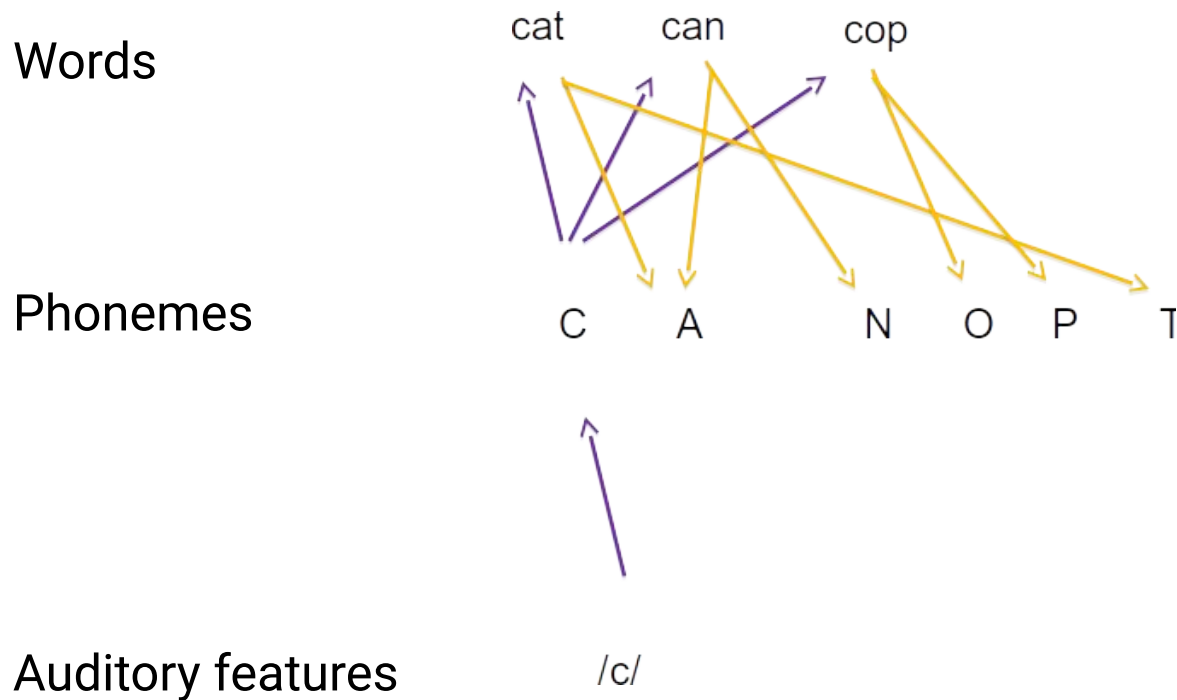- ○ Listening to speech and imagining you are speaking activates speech motor cortex.

TMS
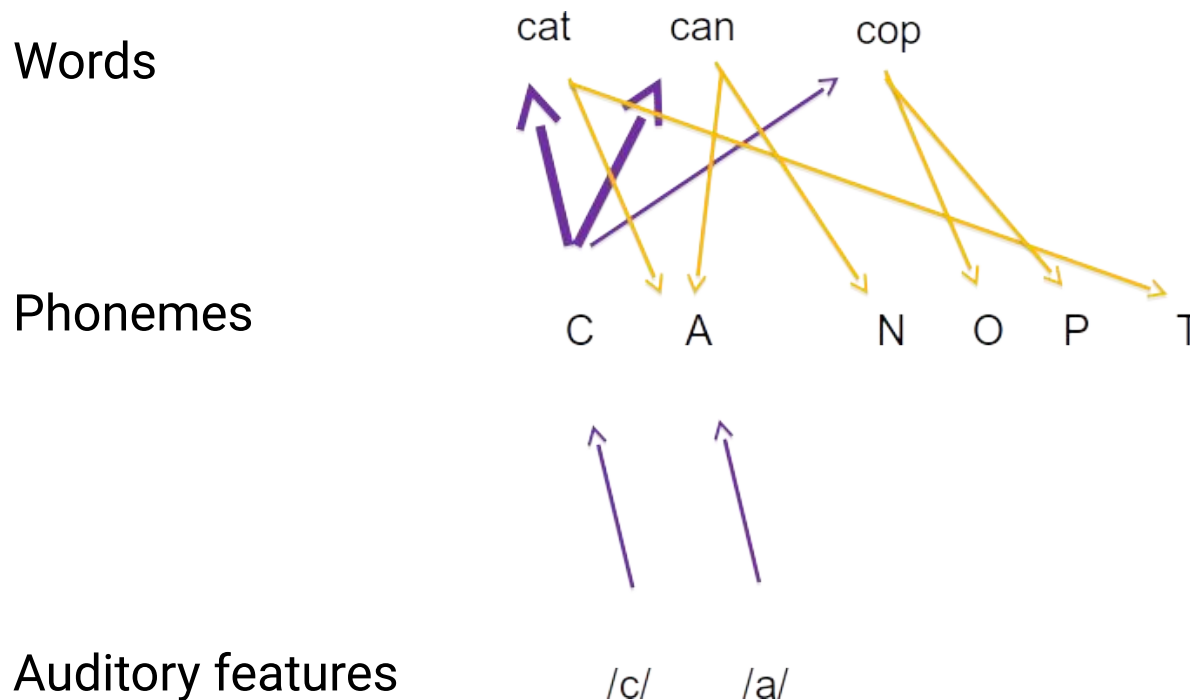- ○ Motor TMS decreases phoneme discrimination.

Iacobini (2008)

TRACE (McClelland & Elman, 1986)

Words

cat   can   cop

Phonemes

C   A   N   O   P   T

Auditory features   /c/

TRACE (McClelland & Elman, 1986)

Words

cat   can   cop

Phonemes

C   A   N   O   P   T

Auditory features

/c/   /a/

TRACE (McClelland & Elman, 1986)

Words

cat   can

Phonemes

C   A   N   T

Auditory features

/c/   /a/   /t/

TRACE (McClelland & Elman, 1986)

Basic TRACE model

Bottom-up processing

Word units

Phoneme units

Feature units
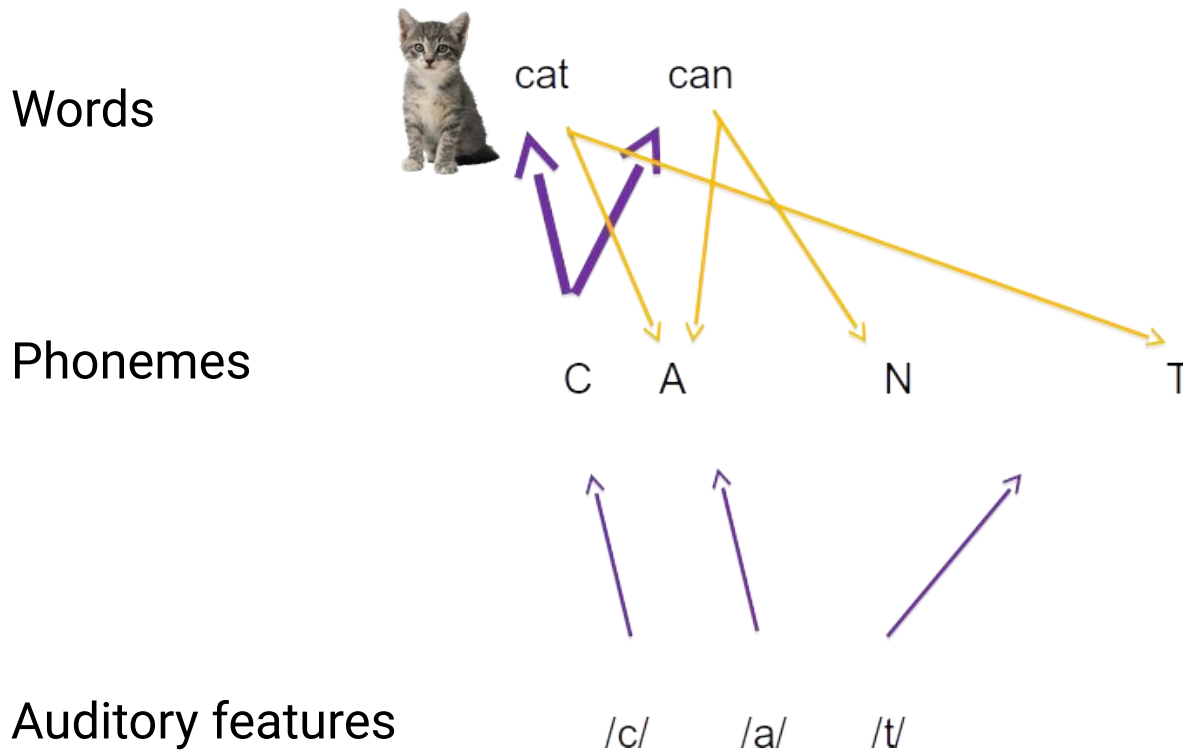
Top-down processing
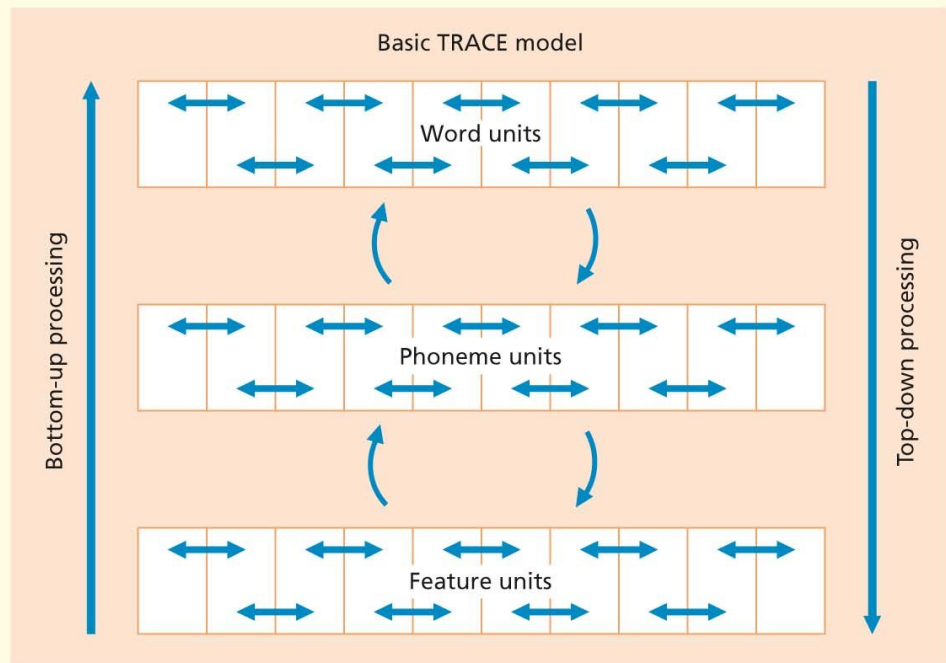
1. Nodes influence each other creating patterns of activation

2. Interaction of bottom-up and top-down processes

Support

Lexical identification shift aka Ganong effect
- When listening to sounds ranging from /dash/ to /tash/, phonemes were assigned to words rather than non-words (Ganong, 1980)

Phonemic restoration effect
- http://www4.uwm.edu/APL/demonstrations.html
- When listening to 'It was found that the *eel was on the shoe', participants heard 'heel'.
- When listening to 'It was found that the *eel was on the orange', participants heard 'peel' (Warren & Warren, 1970)

☞ Interactive processing

Summary Part Two

Understanding speech is a complex multi-stage process
- From registering the presence of a speech stimulus to figuring out what it means

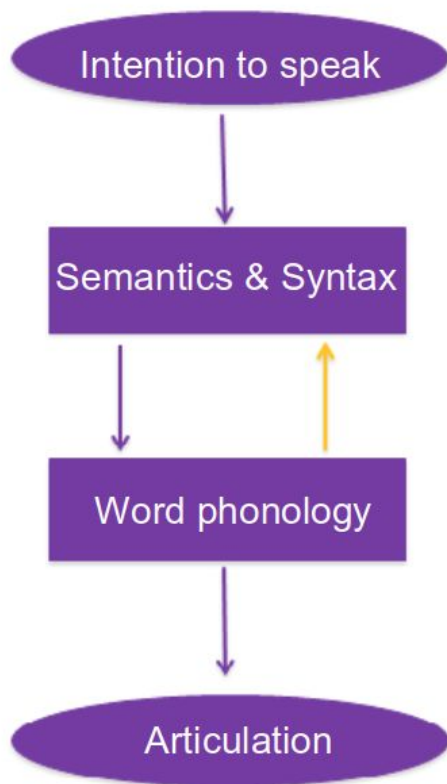Several theoretical accounts have tried to describe the process
- Motor theory (feed-forward)
- TRACE (interactive)

Several empirical evidence support different components of the theories
- McGurk effect, categorical perception, motor cortex involvement, phonemic restoration, Ganong effect

Speech Production

Is not just motor execution

Intention to speak

↓

Semantics & Syntax

↓ ↑

Word phonology

↓

Articulation

Speech Perception

Is not just sensory interpretation

Comprehended meaning

↑

Semantics & Syntax

↓ ↑

Word phonology

↑

Auditory input