Introduction to Formal Linguistics

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September 3, 2015

Based on slides by Robin Cooper

Outline

Practicalities

The course website

LT2112 H15 Introduction to formal linguistics on https://gul.gu.se

https://gul.gu.se/courseId/65958/content.do?id=26978419

http://gul.gu.se/public/courseId/70822/lang-en/publicPage.do

Course lecturers

- Ellen Breitholtz
  (morphology)
- Simon Dobnik
  (syntax and semantics with pragmatics, course organiser)
- Johan Gross
  (phonetics and phonology)

Overview of linguistics

Linguistics – a scientific view of language

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- pre-Chomskyan 20th century – synchronic (Saussure), structuralists (Leonard Bloomfield, Charles Hockett, Zellig Harris)

Linguistic methods

- corpus linguistics
- formal analysis
- experimental methods

Computational linguistics

. . . the scientific study of human language – specifically of the system of rules and the ways in which they are used in communication – using mathematical models and formal procedures that can be realised and validated using computers; a cross-over of many disciplines. (Stanford Linguistics Professor, 1980s)

Borrowed from Stephan Oepen's slide

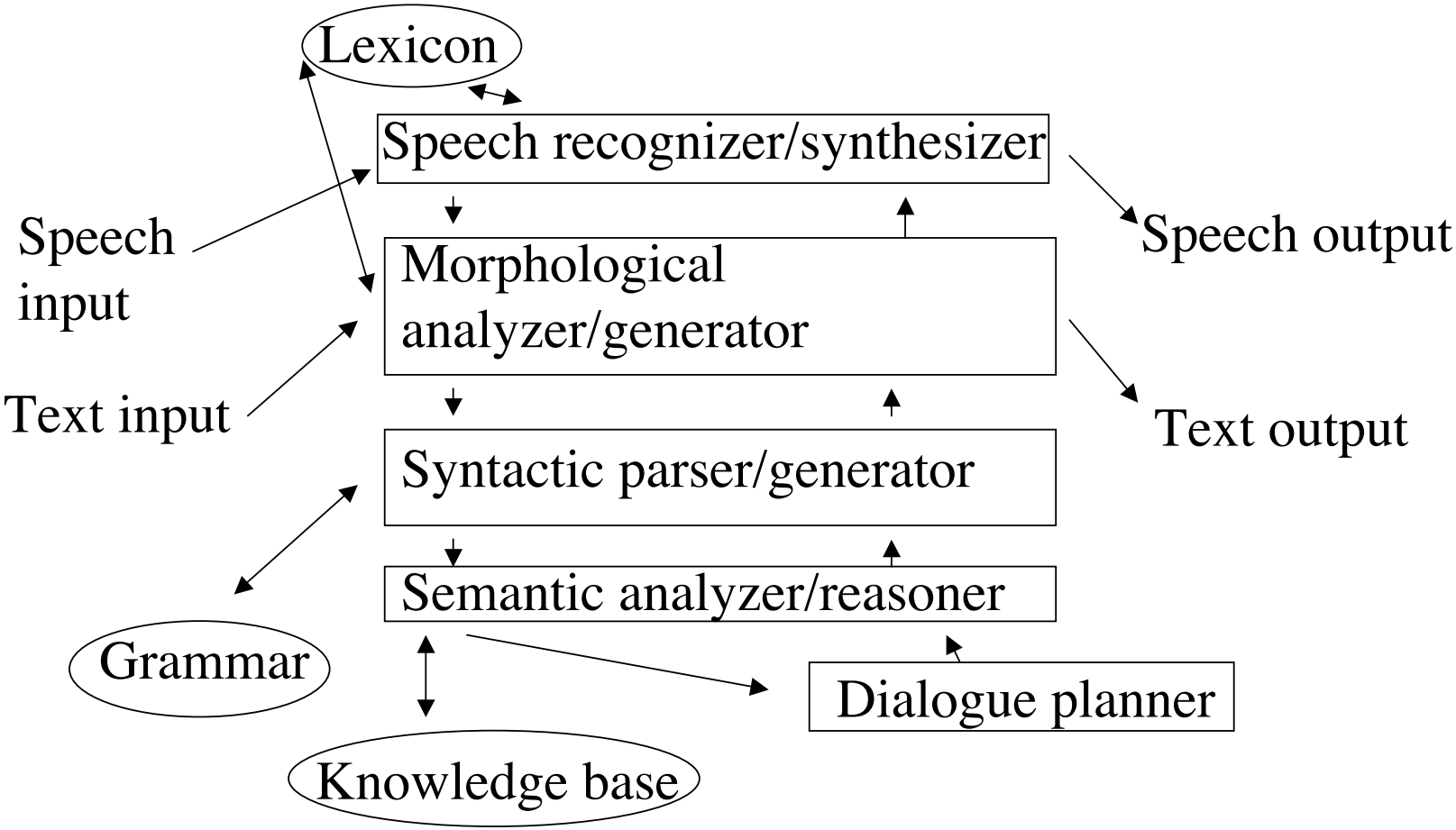
Computational Linguistics

Wikipedia

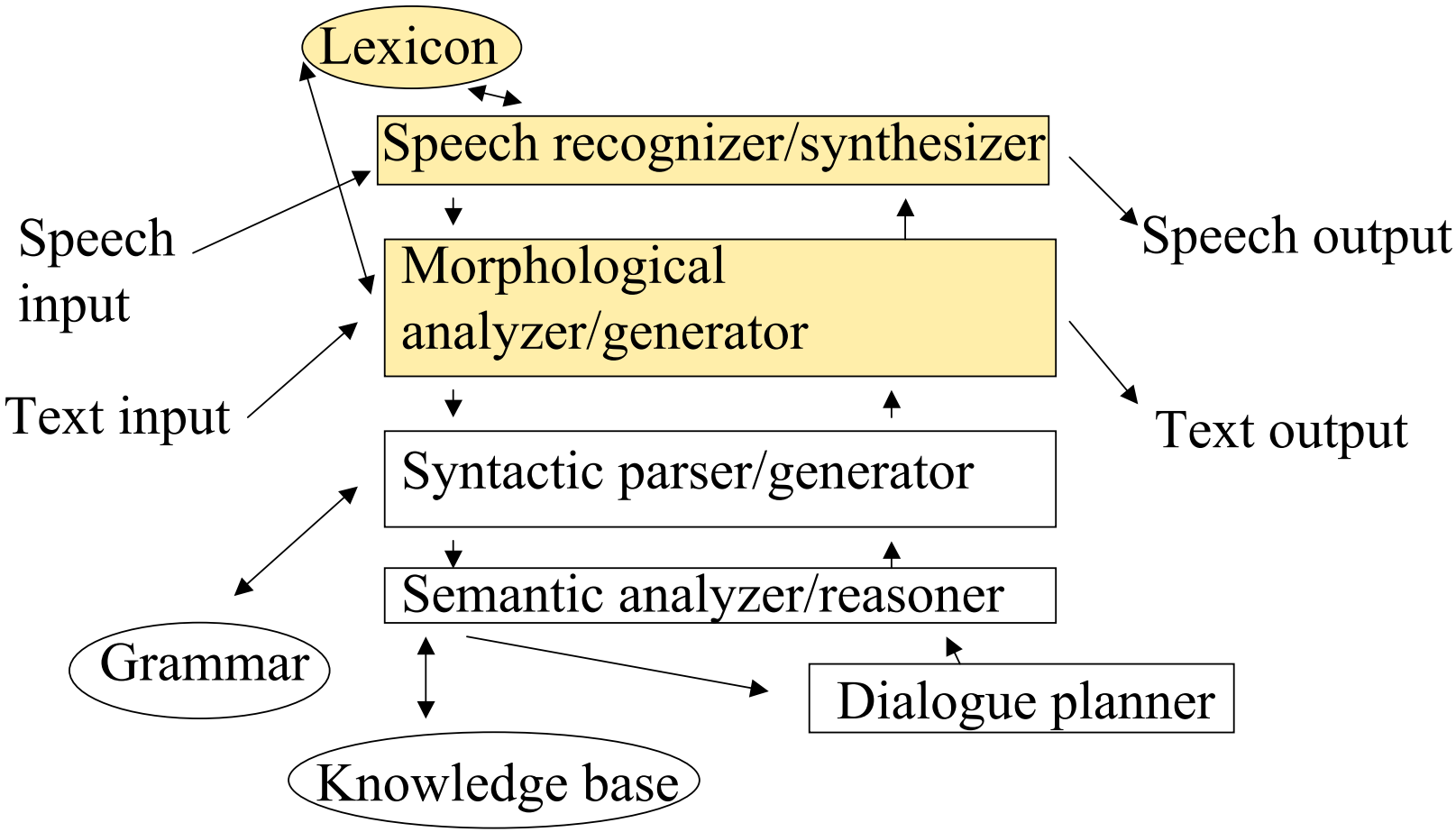
University of Saarland

GÖTEBORGS UNIVERSITET

A language module



Phonetics and Phonology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Knowledge base

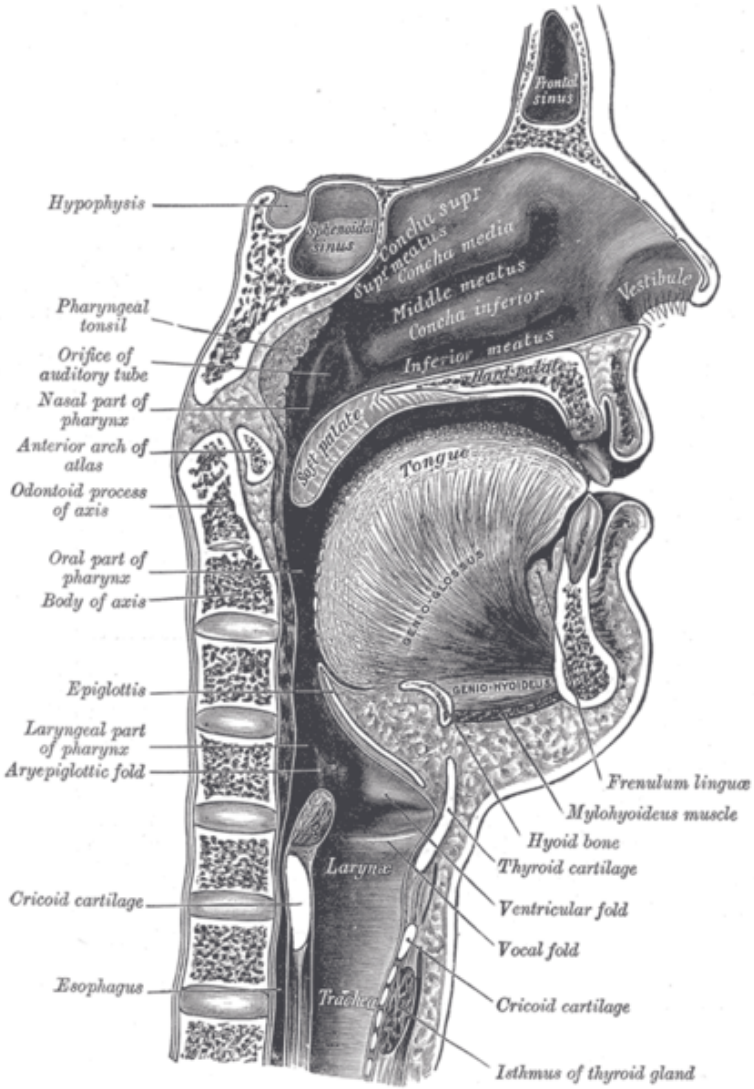
Articulatory phonetics

- how we use our mouth, vocal tract to produce speech sounds

Articulatory phonetics

- how we use our mouth, vocal tract to produce speech sounds
- classification of speech sounds according to articulation

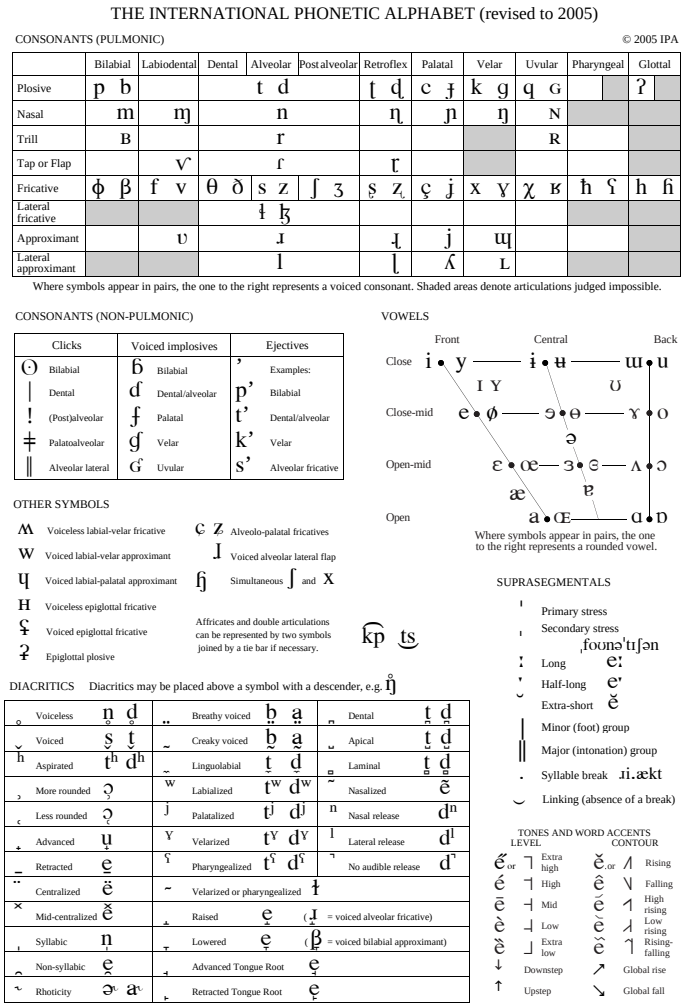
The vocal tract



From Wikipedia.

The IPA chart

http://www.internationalphoneticalphabet.org/ipa/



THE INTERNATIONAL PHONETIC ALPHABET (revised to 2005)

CONSONANTS (PULMONIC) © 2005 IPA

	Bilabial	Labiodental	Dental	Alveolar	Postalveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Glottal
Plosive	p b			t d		ʈ ɖ	c ɟ	k g	q ɢ		ʔ
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	ɴ		
Trill	ʙ			r					ʀ		
Tap or Flap		ⱱ		ɾ		ɽ					
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	h ɦ
Lateral fricative				ɬ ɮ							
Approximant		ʋ		ɹ		ɻ	j	ɰ			
Lateral approximant				l		ɭ	ʎ	ʟ			

Where symbols appear in pairs, the one to the right represents a voiced consonant. Shaded areas denote articulations judged impossible.

CONSONANTS (NON-PULMONIC)

Clicks		Voiced implosives		Ejectives	
ʘ	Bilabial	ɓ	Bilabial	’	Examples:
ǀ	Dental	ɗ	Dental/alveolar	pʼ	Bilabial
ǃ	(Post)alveolar	ʄ	Palatal	tʼ	Dental/alveolar
ǂ	Palatoalveolar	ɠ	Velar	kʼ	Velar
ǁ	Alveolar lateral	ʛ	Uvular	sʼ	Alveolar fricative

OTHER SYMBOLS

ʍ	Voiceless labial-velar fricative	ɕ ʑ	Alveolo-palatal fricatives
w	Voiced labial-velar approximant	ɺ	Voiced alveolar lateral flap
ɥ	Voiced labial-palatal approximant	ʄ	Simultaneous ʃ and x
ʜ	Voiceless epiglottal fricative		
ʢ	Voiced epiglottal fricative		
ʡ	Epiglottal plosive		

Affricates and double articulations can be represented by two symbols joined by a tie bar if necessary. k͡p t͡s

VOWELS

Where symbols appear in pairs, the one to the right represents a rounded vowel.

DIACRITICS Diacritics may be placed above a symbol with a descender, e.g. ŋ̊

◌̥	Voiceless	n̥ d̥	◌̤	Breathy voiced	b̤ a̤	◌̪	Dental	t̪ d̪
◌̬	Voiced	s̬ t̬	◌̰	Creaky voiced	b̰ a̰	◌̺	Apical	t̺ d̺
◌ʰ	Aspirated	tʰ dʰ	◌̼	Linguolabial	t̼ d̼	◌̻	Laminal	t̻ d̻
◌̹	More rounded	ɔ̹	◌ʷ	Labialized	tʷ dʷ	◌̃	Nasalized	ẽ
◌̜	Less rounded	ɔ̜	◌ʲ	Palatalized	tʲ dʲ	◌ⁿ	Nasal release	dⁿ
◌̟	Advanced	u̟	◌ˠ	Velarized	tˠ dˠ	◌ˡ	Lateral release	dˡ
◌̠	Retracted	e̠	◌ˤ	Pharyngealized	tˤ dˤ	◌̚	No audible release	d̚
◌̈	Centralized	ë	◌̴	Velarized or pharyngealized	ɫ			
◌̽	Mid-centralized	e̽	◌̝	Raised	e̝	(ɹ̝ = voiced alveolar fricative)		
◌̩	Syllabic	n̩	◌̞	Lowered	e̞	(β̞ = voiced bilabial approximant)		
◌̯	Non-syllabic	e̯	◌̘	Advanced Tongue Root	e̘			
◌˞	Rhoticity	ə˞ a˞	◌̙	Retracted Tongue Root	e̙			

SUPRASEGMENTALS

ˈ	Primary stress	ˌfoʊnəˈtɪʃən	
ˌ	Secondary stress		
ː	Long	eː	
ˑ	Half-long	eˑ	
˘	Extra-short	ĕ	
|	Minor (foot) group		
‖	Major (intonation) group		
.	Syllable break	ɹi.ækt	
‿	Linking (absence of a break)		

TONES AND WORD ACCENTS

LEVEL			CONTOUR	
e̋ or	˥	Extra high	ě or	˩˥ Rising
é	˦	High	ê	˥˩ Falling
ē	˧	Mid	e᷄	˧˥ High rising
è	˨	Low	e᷅	˩˧ Low rising
ȅ	˩	Extra low	e᷈	˥˩˥ Rising-falling
↓		Downstep	↗	Global rise
↑		Upstep	↘	Global fall

The IPA chart for pulmonic consonants

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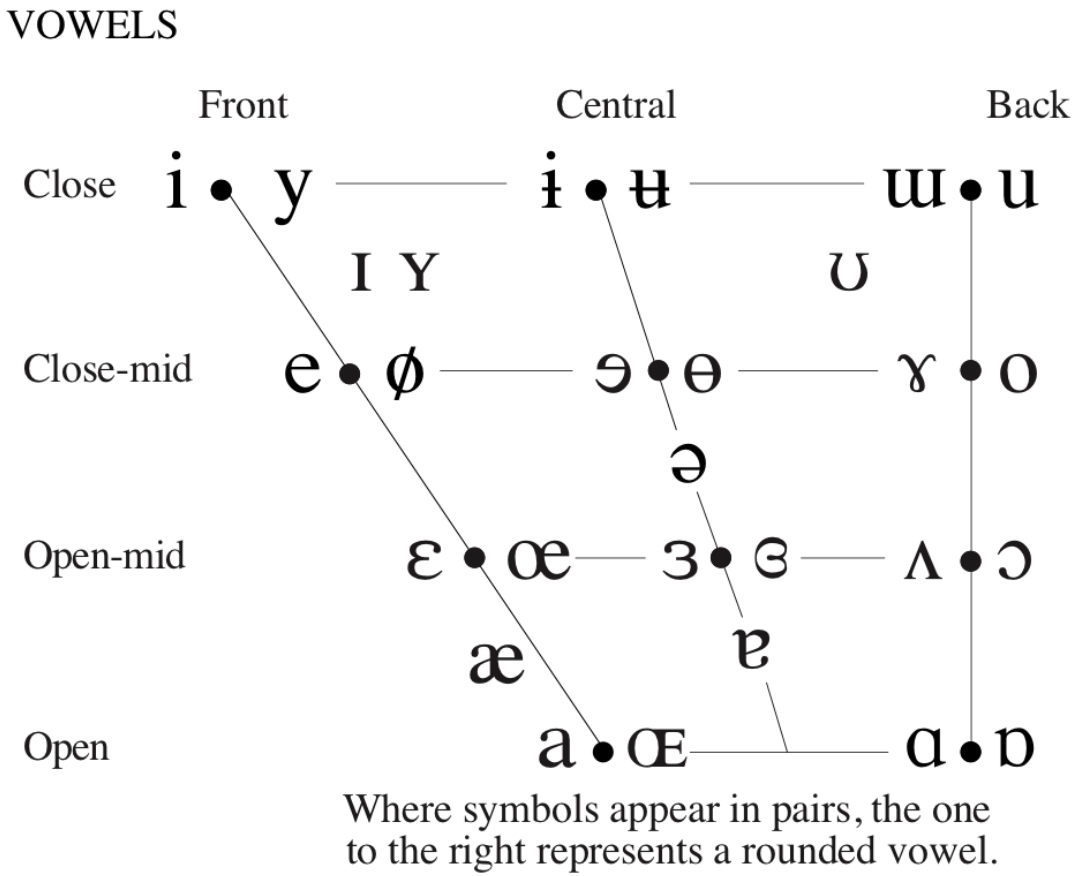
The IPA chart for vowels



Acoustic phonetics

- the data from sound waves

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- can we recognise speech sounds from the acoustic data?

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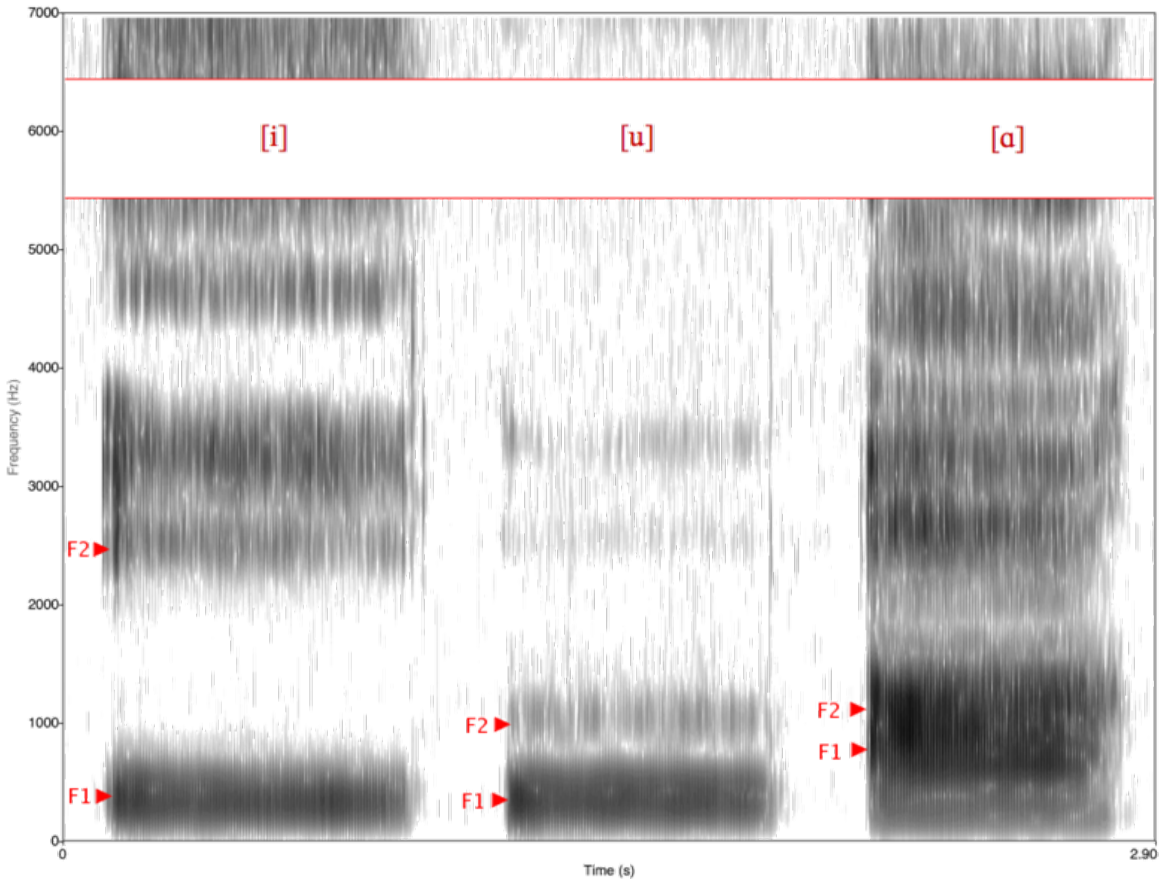
- not just acoustic data: McGurk effect, video
- continuous speech to discrete speech sounds, co-articulation

Spectrogram



From Wikipedia.

Phonology

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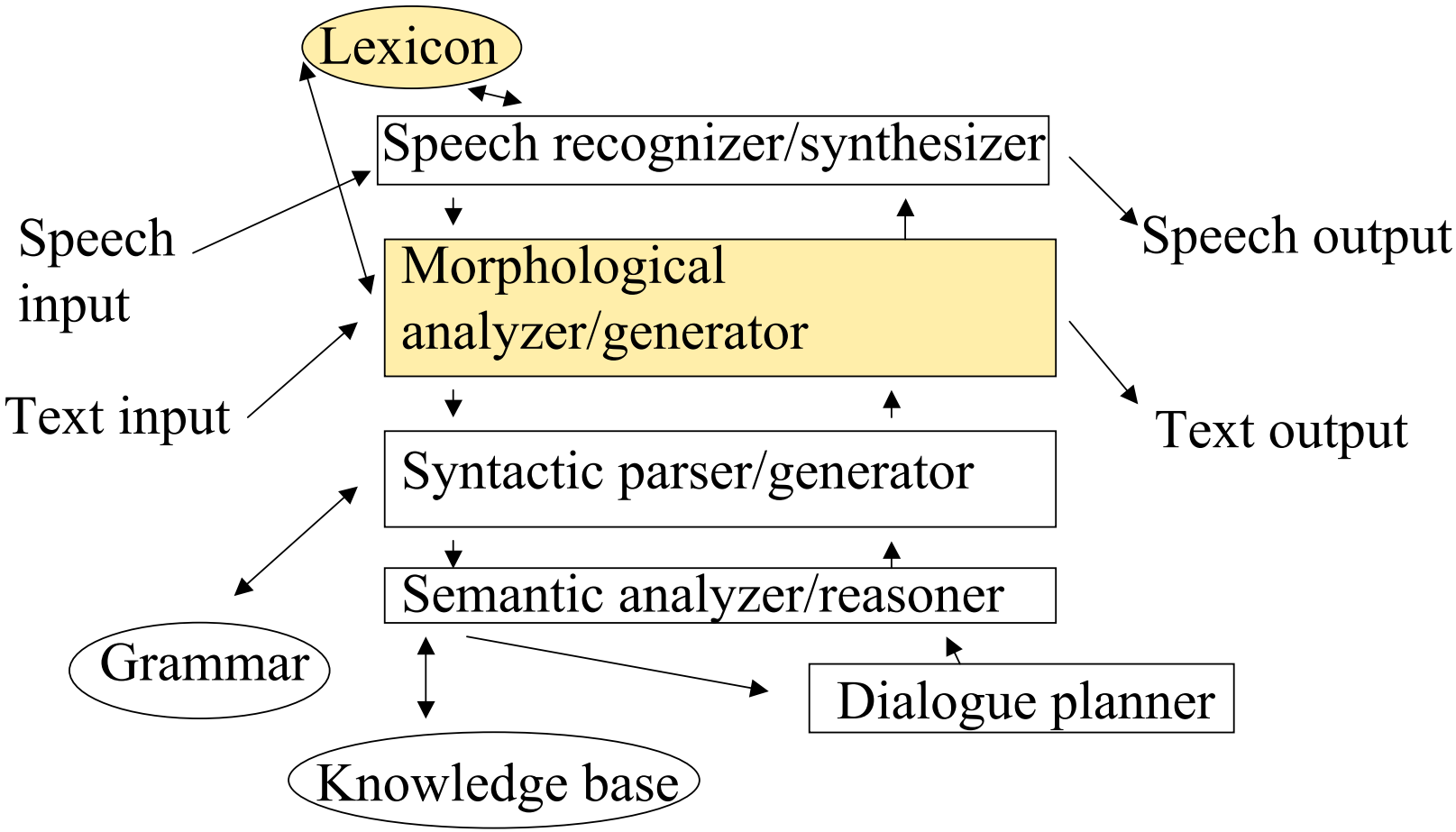
Morphology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Inflectional morphology

- different forms in a paradigm
- singular vs plural (*cat* vs *cats*, *run*, *runs*, *ran*)

Derivational morphology

- creating new words, perhaps of a different category, perhaps with a different meaning
- *clever* $\approx$ *cleverness*, *able* $\approx$ *ability*

Other morphological processes

- not clear if there is a clear boundary between morphology and syntax
  - cliticization – *John's coming*, *je l'ai vu*
  - compounding – language technology

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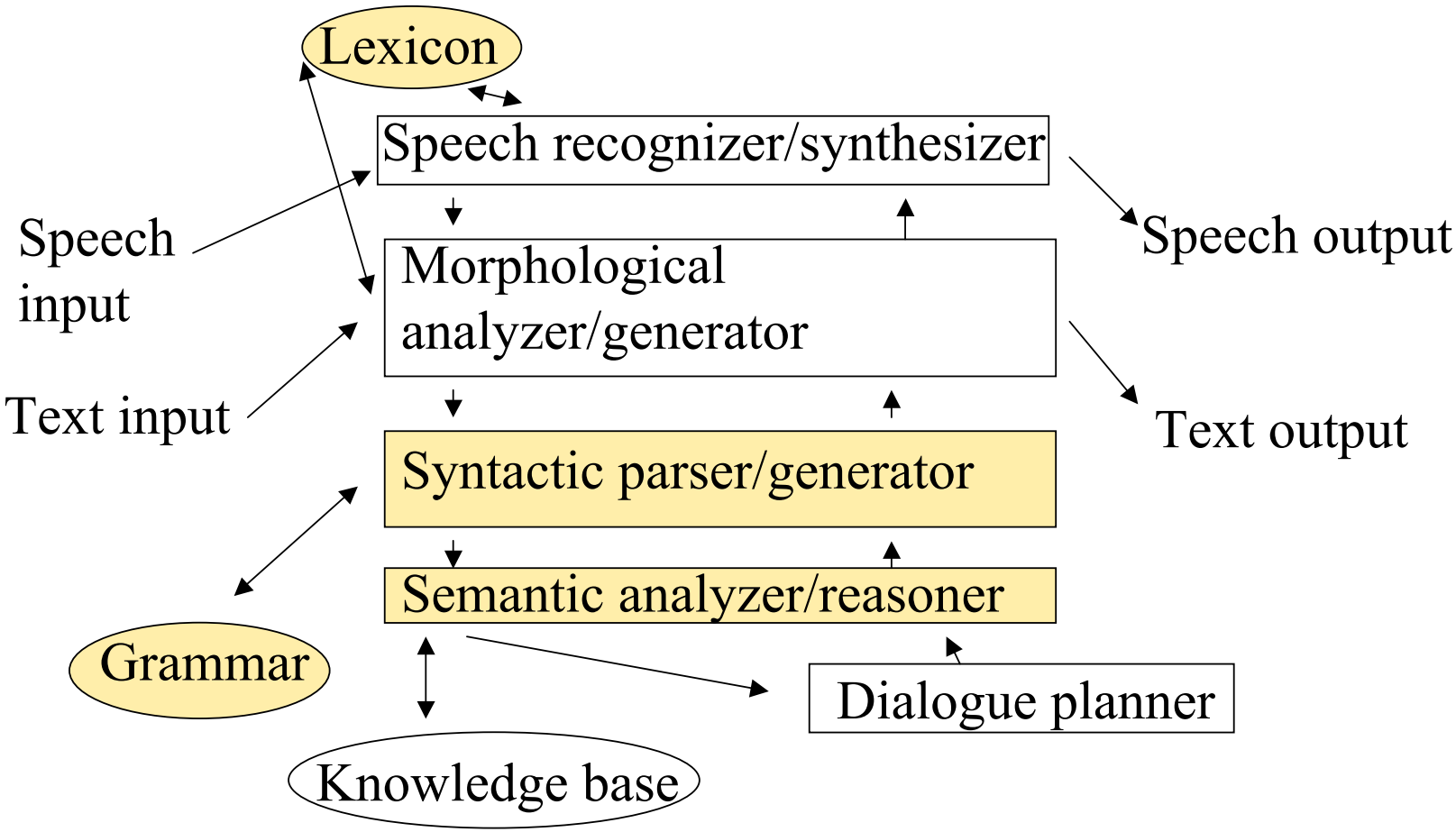
- sometimes not just a sum of meanings of sub-parts:
  white house, White House

Syntax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Parts of speech

- *dog* – noun
- *run* – verb
- *the* – determiner, definite article

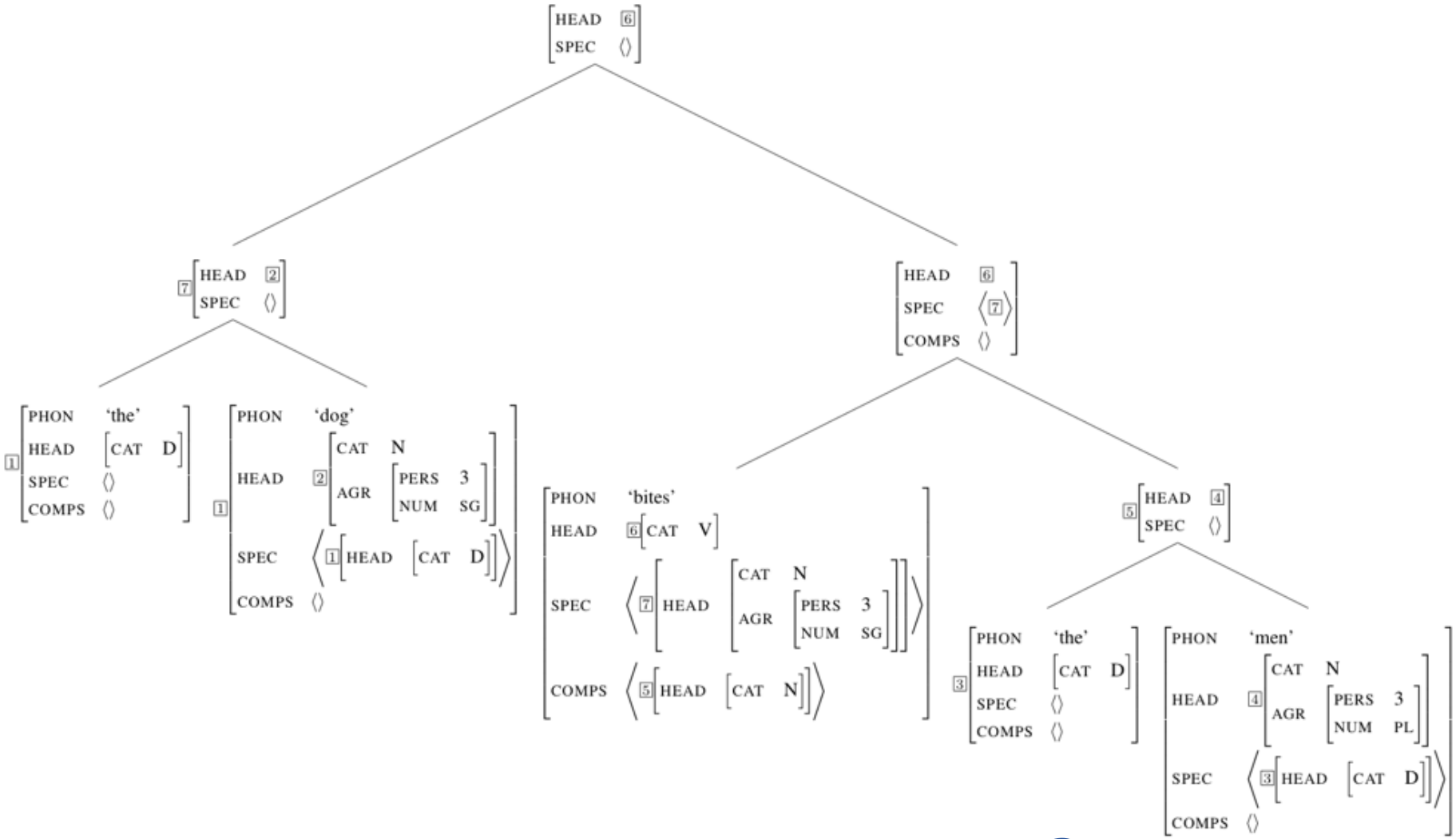
Construction types

- *the dog* – noun phrase
- *the dog ran* – sentence
- *the thief [who saw the policeman] ran into the shop* – relative clause
- *I wonder [who saw the policeman]* – embedded question

Grammars and grammar rules

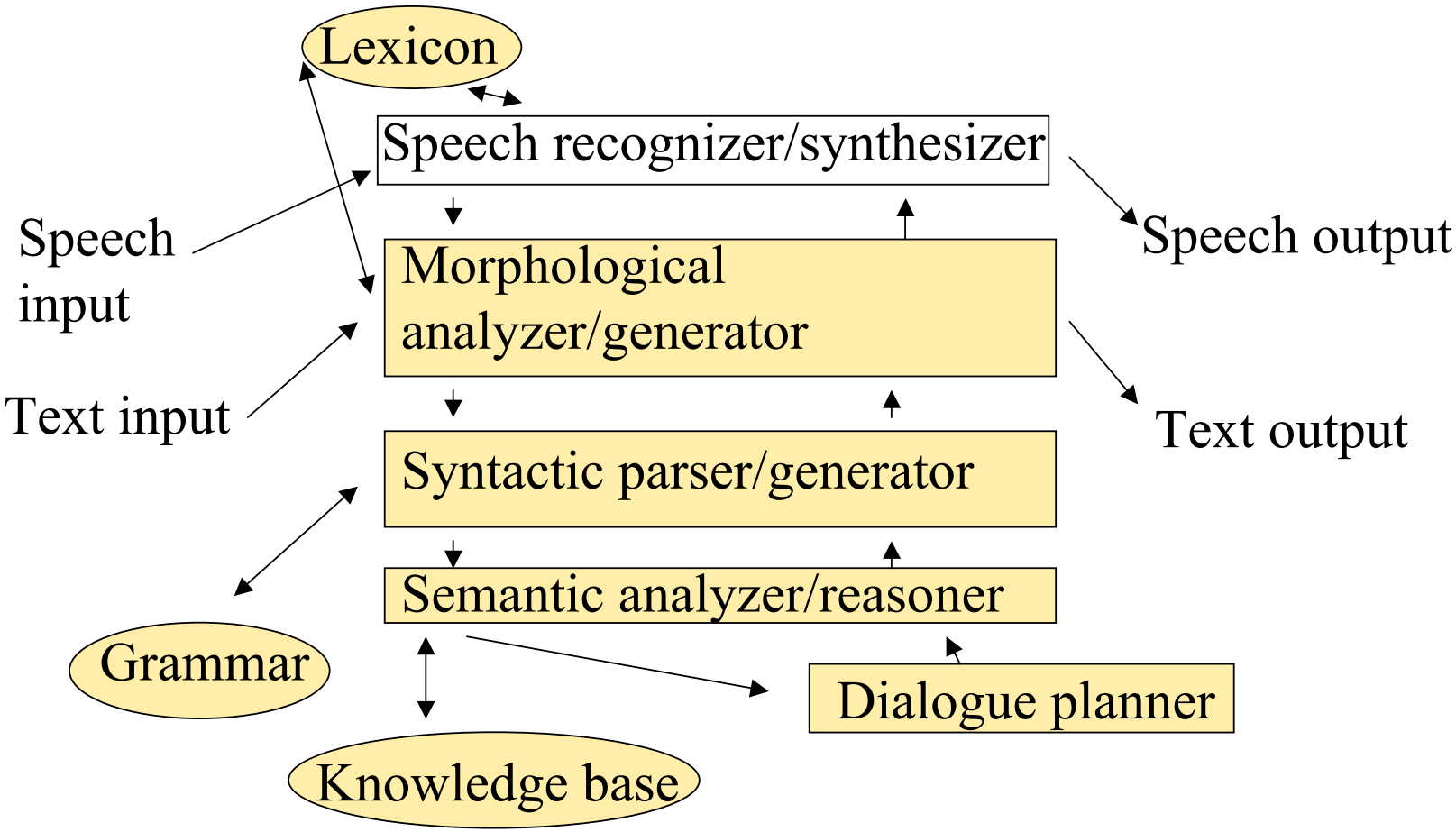
- sentences may consist of a noun phrase followed by a verb phrase – $S \rightarrow NP\ VP$
- phrase structure grammars, context free grammars (Chomsky hierarchy)
- are natural languages context free?
- features **the dog run*, **the dogs runs*

Syntactic structures



From here.

Semantics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Semantic properties and model theory

- "to know the meaning of a (declarative) sentence is to know the conditions under which it would be true"
- truth in a model

Logic

- propositional logic
- first order logic
- predicates, constants, variables, quantifiers
  - Every television presenter has a secret.
    $\forall x.(\text{television\_presenter}(x) \Rightarrow \exists y.(\text{secret}(y) \wedge \text{have}(x, y)))$
    $\exists y.(\text{secret}(y) \wedge \forall x.(\text{television\_presenter}(x) \Rightarrow \text{have}(x, y)))$
- model theory for logic
- inference

Pragmatics

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Pragmatics

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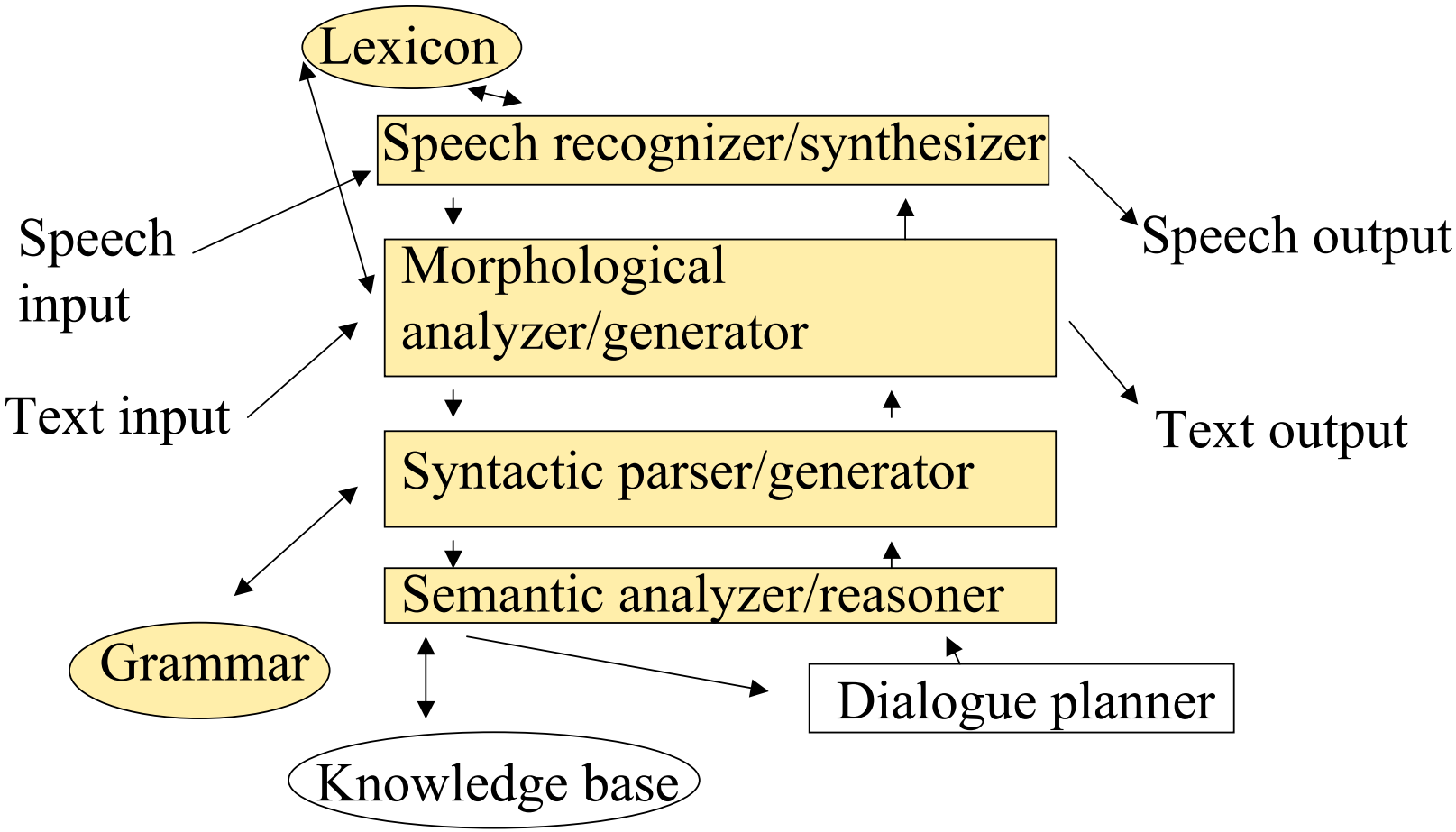
- speech acts (assert, query, . . .)
- language in context (deictic pronouns *I*, *you*, but also demonstratives (*this*, *that*) and tense)
- presuppositions (*my wife is coming* $\rightarrow$ *I have a wife*, *my wife isn't coming* $\rightarrow$ *I have a wife*)

Dynamic meaning

From here.

Lexicon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Words and phrases

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- seems also to include phrases – *look up (the number)*, *keep track of (the score)*, *kick the bucket*
- more information than just the words: phonology, morphology, syntax semantics

A broader view

Some other areas of linguistics

. . . which may be relevant to language technology:

- historical linguistics
- comparative linguistics and language typology
- dialect studies
- sociolinguistics
- psycholinguistics (language acquisition, human language processing)

Language variation and universals

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- . . . except perhaps because of sickness, developmental characteristics or unusual social conditions

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- native speakers

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- . . . except perhaps because of sickness, developmental characteristics or unusual social conditions
- native speakers
- linguistic (un)consciousness (lexicon vs grammar rules)

Language acquisition

From here.

Linguistics and psychology

- developmental psychology
- human processing

Linguistics and psychology

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- human processing
- should language technologists be concerned with this?

Linguistics and psychology

- developmental psychology
- human processing
- should language technologists be concerned with this?
- should language technology systems imitate humans?

Why is linguistics (and language technology) difficult?

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- natural languages are complex
- interaction with context
- multimodality, body language
- difficult to give a precise scientific theory of our linguistic behaviour

Human languages and other languages

- animal languages
- artificial languages (logic, programming languages)
- human languages

Some properties of human languages

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- displacement (talking about things not present, time/tense, negation, (im)possibilities)

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- arbitrary (compare different words for common objects in unrelated languages)
- productive (take any sentence, can you create a longer sentence which contains it?)
- discrete (digitisation)