COMP5046: Linguistic Fundamentals

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2018-03-27

Part I

The structure of language

Linguistics: the science of language

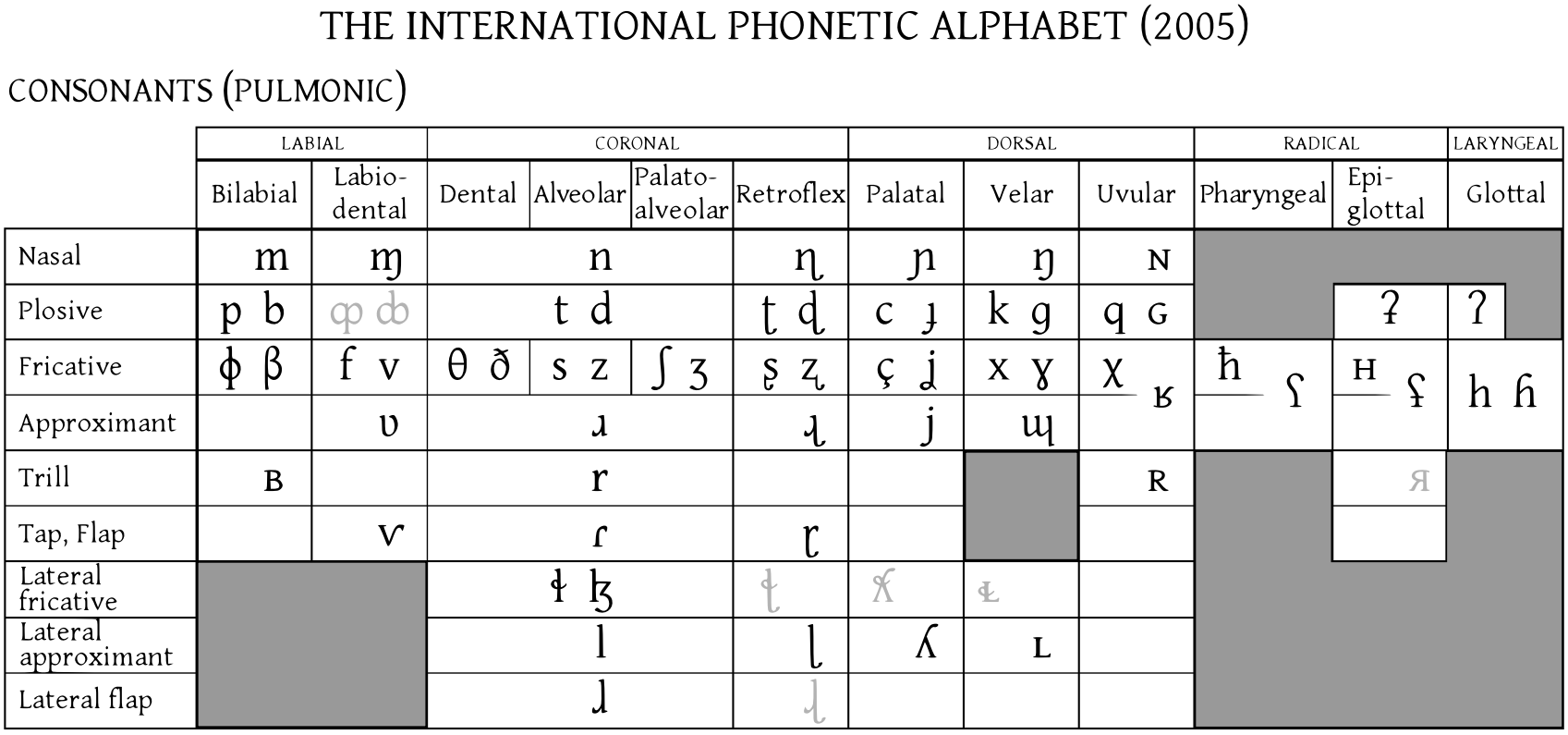
- How does language work?
- How can we analyse language?
- What qualifies as evidence?

- How can linguistics inform NLP?
- How can NLP inform linguistics?
- Why is NLP hard?

Linguistics models various components of language

- Phonetics
- Phonology
- Morphology
- Syntax
- Semantics
- Pragmatics and discourse

Phonetics: the mechanics of language sounds



THE INTERNATIONAL PHONETIC ALPHABET (2005)

CONSONANTS (PULMONIC)

	LABIAL		CORONAL				DORSAL			RADICAL		LARYNGEAL
	Bilabial	Labio-dental	Dental	Alveolar	Palato-alveolar	Retroflex	Palatal	Velar	Uvular	Pharyngeal	Epi-glottal	Glottal
Nasal	m	ɱ		n		ɳ	ɲ	ŋ	N			
Plosive	p b	pˠ bˠ		t d		ʈ ɖ	c ɟ	k g	q ɢ		ʡ	ʔ
Fricative	ɸ β	f v	θ ð	s z	ʃ ʒ	ʂ ʐ	ç ʝ	x ɣ	χ ʁ	ħ ʕ	ʜ ʢ	h ɦ
Approximant		ʋ		ɹ		ɻ	j	ɰ				
Trill	ʙ			r					ʀ		ʀ̠	
Tap, Flap		ⱱ		ɾ		ɽ						
Lateral fricative				ɬ ɮ								
Lateral approximant				l		ɭ	ʎ	ʟ				
Lateral flap				ɺ		ɭ̆						

- articulation
- acoustics
- audition

Phonology: the structure of language sounds

- show that [d] and [t] are distinct in English.

Phonology: the structure of language sounds

- show that [d] and [t] are distinct in English.
- **substitution tests** and the distributional properties of sounds
- in contrast, [t^h], [t], [ɾ], [ʔ] are allophones of /t/ in English.
  butter; stow vs. tow
- valid sequences: stop vs ftop
- syllable structure, stress, intonation, . . .

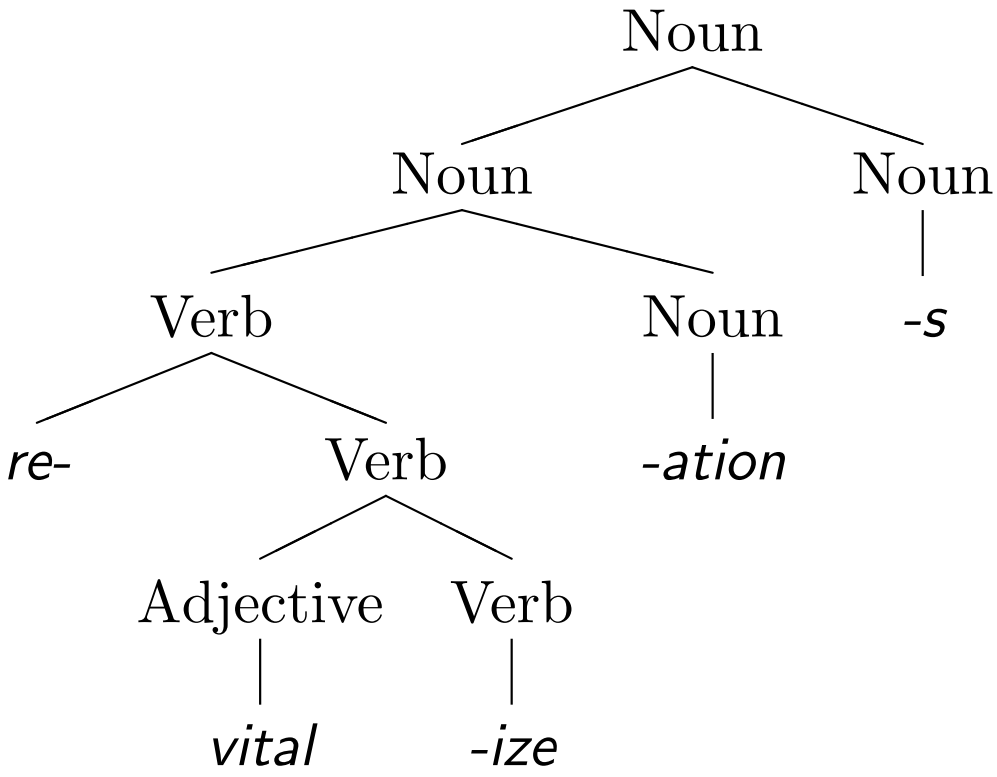
Morphophonology: Word structure can affect sound

- in-
- irrelevant
- improbable
- incapable

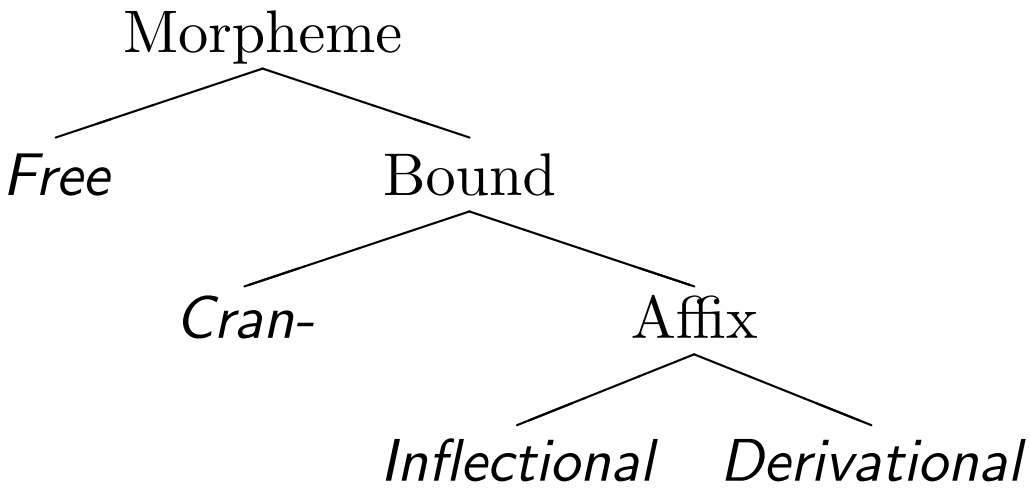
- the layers of linguistic analysis often blur

Morphology: the structure of words

a **morpheme** is the smallest discrete piece of meaning



Morphological typology



Inflection rarely affects meaning or syntactic class

Person/Number	Inflected form	Gloss
1st s.	am**o**	I love
2nd s.	ama**s**	you (sing.) love
3rd s.	amat	he/she/it loves
1st pl.	ama**mus**	we love
2nd pl.	ama**tis**	you (pl.) love
3rd pl.	ama**nt**	they love

Table: Present (tense) indicative (mood) active (voice) of amare, to love.

Full conjugation of amare
Finnish: morphology to the EXTREME!

Take-home messages about inflectional morphology

- English, like Chinese, is a low-inflection outlier
- some inflection is through prefix/suffix/infix
- most inflectional morphology is non-concatenative: the pieces fuse or the stem is altered, e.g. swim/swam
  - makes parsing/generating hard
  - even makes manual classification tricky
- a single affix encodes multiple pieces of information
  - the -o in amo specifies number, tense, mood and voice
- affixes are very frequently overloaded/ambiguous
  - context + statistics needed for morphological analysis

Derivational morphemes can change the part of speech

- noun to adjective: cheek*y*, Italian*ate*, joy*ous*, pigg*ish*
- noun to verb: chlorin*ate*, zero morpheme
- verb to noun: reflect*ion*, imprison*ment*, *'*subject
- verb to adjective: accept*able*, prohibit*ive*

Derivational morphemes might not change part of speech

- *in*sufferable
- *un*wind
- *dis*like
- *a*moral
- *co*-author
- *over*write
- cyclo*phobia*
- fancy *shmancy*

Derivational morphology is semi-productive

- not all combinations are automatically words
  sneaky vs. *discussy; action vs. *waition; agreeable vs. ?sleepable
- not always compositional: react
- some morphemes are no longer very productive: be- of become, between;
  although A sulky adolescent and his be-jeaned girl-friend. (Manchester Guardian, 1958)

Cranpheme (cranberry morpheme) problem

- a **free** morpheme can occur on its own as a word
- cran- morphemes don't have a corresponding independent word but can't be bound freely
- cran- morphemes are often **fossilised** forms
  - cran- in cranberry (from Middle English cran for crane)
  - ten- in tenable (from French tenir for hold/keep)
  - cob- in cobweb (from Middle English coppe for spider)

- berry, able and web here are clearly morphemes
- -nov- in innovate: cran- or free?

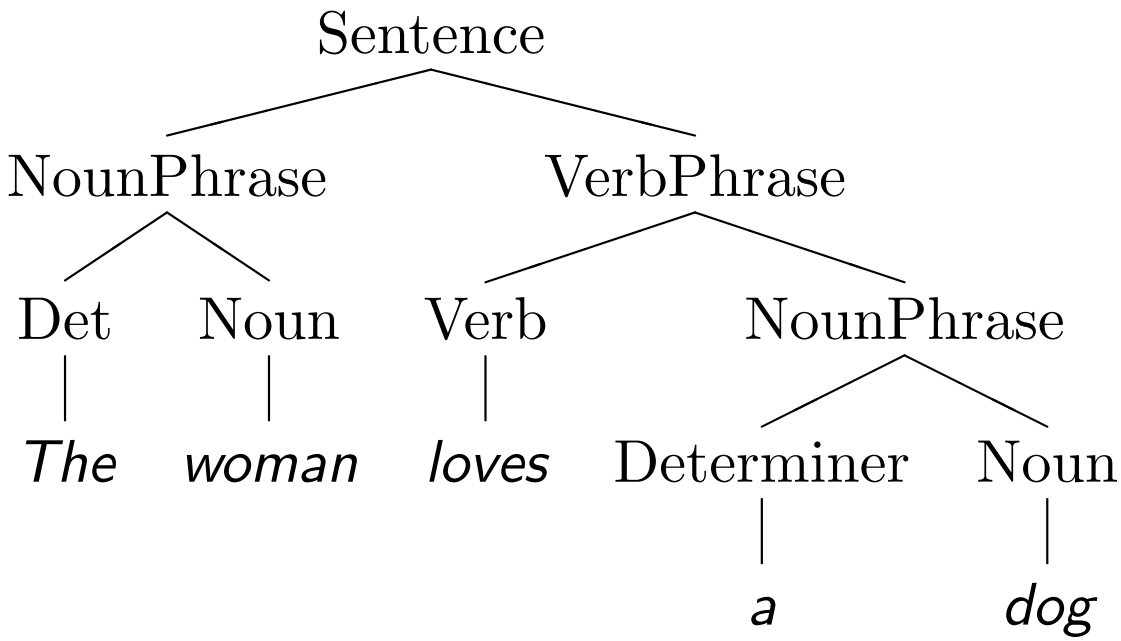
Open vs. closed-class morphemes

Open Class Lexemes

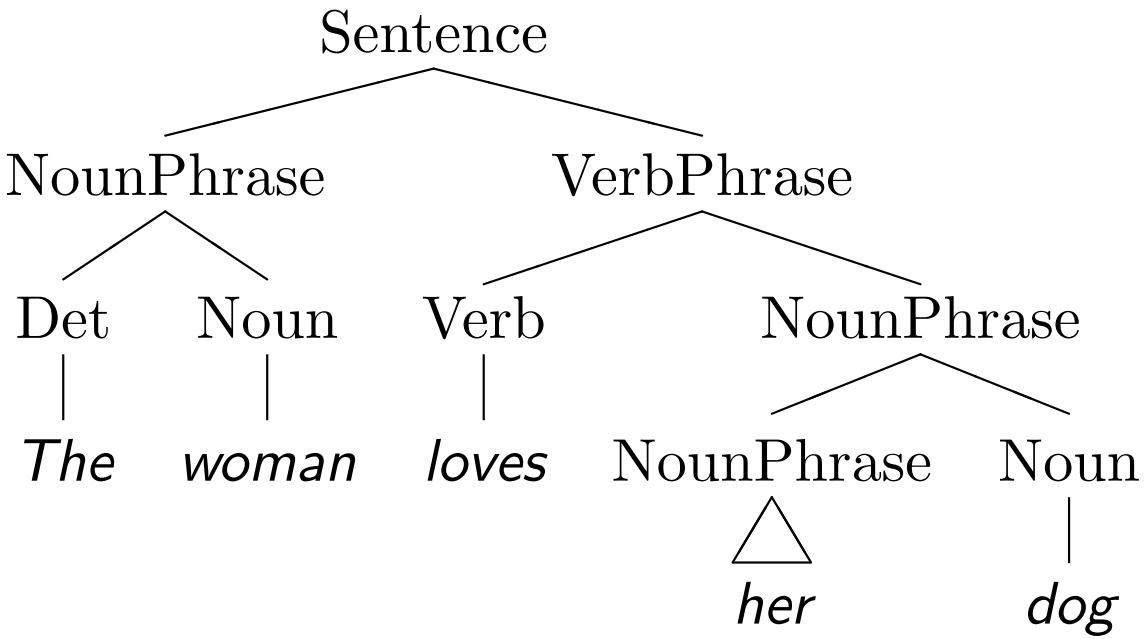
Open-class morphemes determine the content of a sentence, while closed-class morphemes and function words help determine sentence structure. Open-class morphemes are part of the lexicon, while closed-class items are part of the grammar.

- open: open, class, morpheme, determine, content, sentence, closed, class, funct(ion?), word, help, structure, part, lexicon, grammar
- closed: -s, the, of, a, are, while, and

Syntax: how words combine into phrases and sentences



Syntax: how words combine into phrases and sentences



substitutability is key to constituency

also note movement, insertion, . . .

Part of speech / syntactic class / parse nonterminal

- is a verb a *doing word*? be? think? destroy vs. destruction?
- are nouns *things*? intelligence? destruction? correctness?

Part of speech / syntactic class / parse nonterminal

- is a verb a *doing word*? be? think? destroy vs. destruction?
- are nouns *things*? intelligence? destruction? correctness?
- **test** for adjectives: that seems *X*
  - substitute and **judge grammaticality**
  - that seems correct vs. *that seems correctness
  - how about the *X* thing?
- when substitution needs context:
  - Could you set the table?
  - I have the complete set.
- syntactic subtlety means some substitutions won't work
  - cutlery is a noun, but *a cutlery
  - sleep is a verb, but *tigers sleep other tigers

Let's tag some parts-of-speech

(1) *The Pied Currawong is a medium-sized black passerine*
– – – – Adj. Adj. Adj.

bird native to eastern Australia and Lord Howe Island
Noun Adj. – Adj. – – – –

(2) *The male and female are similar in appearance*
– ?? – ?? – ?? – ??

(3) *Known for its melodious calls, the species ' name*
?? – – ?? ?? ?? – ?? –

currawong is of indigenous origin
?? – – ?? ??

Generative grammar

- **generative grammar** proposes to identify a procedure which
  - generates all valid sentences in a language
  - generates only valid sentences in a language

- avoiding both over- and under-generation is tricky. . .
- She loves her dog, She loves herself, *She loves herself's dog
- $\langle NP \longrightarrow DT\ JJ \rangle$ such as The elderly

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- She loves her dog, She loves herself, *She loves herself's dog
- $\langle NP \longrightarrow DT\ JJ \rangle$ such as The elderly
  . . . but not an elderly :(

- in practice, all formal grammars are at least a little leaky
- and NP (noun phrase) remains a useful abstraction

Grammaticality and acceptability

- **autonomy of syntax**: grammatical $\neq$ meaningful
  - grammatical sense: harmless young children sleep peacefully
  - grammatical nonsense: ?colourless green ideas sleep furiously
  - ungrammatical: *peacefully children young sleep harmless

- **acceptability** is gradient. Is grammaticality?
- acceptable but ungrammatical:
  But if this ever changing world **in** which we live **in**
  Makes you give in and cry
  Say live and let die. (Paul McCartney, 1973)
- linguistic **competence** vs **performance**

Ambiguity in grammar

- natural language grammars are massively ambiguous
  - I saw the girl on the hill with the telescope
  - I saw the girl and the boy on the hill with the telescope
- PP-attachment and coordination are the major sources of ambiguity
- ambiguity tends to grow exponentially with sentence length
- not all ambiguities are meaningful
  - I saw the lions at the circus

Syntax and free word order languages

- morphologically rich languages specify much of syntactic structure in inflectional suffixes

(4) *puer* *amat* *puellam*
boy (doer) love (3s) girl (doee)
'The boy loves the girl'

(5) *puellam* *amat* *puer*
girl (doee) love (3s) boy (doer)
'The boy loves the girl' or 'It is the girl that the boy loves'

- popular phrase structure grammars fit the English-centric assumption that word order is key
- some formalisms are better for some languages, perhaps like programming languages

Abstracting semantics from syntax

- Different parses, common proposition:
  - Google bought YouTube.
  - YouTube was bought (by Google).
  - It was YouTube that Google bought.
  - Google's purchase (of YouTube) was ...
  - Did(n't) Google buy YouTube?
- require a single representation: buy(Google, YouTube)
- **semantic roles**: who did what to whom?
- semantic value of a sentence is a proposition which is true or false in some state of the world

Semantics is not just a derivative of syntax

- one of these is syntactically ambiguous
  - Kim fed her dog biscuits
  - Everyone knows one language

- lexical semantics vs compositional semantics
  - Google cancelled the purchase of X
  - Google did not purchase X
- presupposition

Why so many ways to say the same thing?

- listeners don't just need the message, they also need to understand its significance
- we signal how new content relates to the prior discourse
- natural information structure:

(6) When did Mary graduate?
She graduated in 2006.

(7) Did Mary enrol in 2006?
In 2006 she graduated.

- less natural information structure:

(8) When did Mary graduate?
In 2006 she graduated.

(9) Did Mary enrol in 2006?
She graduated in 2006.

Pragmatics: effective communication in context

Q: Do you have the time?

A1: Yes

A2: No, but I have a watch

A3: It's 4pm

A4: It's 4:02 and 53 seconds

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- Grice's **cooperative principle**: make your contribution helpful given the purpose(s) of the conversation
- maxims: quality, quantity, relevance, manner
- **violation is ostensive**
- basis of modelling: humour, irony, metaphor, politeness...

Discourse structure: how sentences/clauses are related

- **Time.** I finished my thought and then went for lunch.
- **Cause.** I was hungry. I decided to get some lunch.
- **Concession.** I wasn't hungry. I only agreed to get some lunch because Robin was famished.
- **Purpose.** I went to the store so that I could get some lunch
- **Elaboration.** I was very hungry. I was simply famished.

et cetera

Reference and ambiguity

- Please shut the door.
  The house was empty. The door was broken.
- Kim thinks that he is clever.

Summary: The structure of language

- languages have rules/preferences defining their phonological, morphological, syntactic and pragmatic structure
- grammar = morphology + syntax
- meaning derives from lexicon, grammar and context
- alternatively: given context, the lexicon and grammar encode meaning as structured messages

- blurring at all boundaries
- ambiguity and change at all layers
- number of possible messages is infinite

Part II

The linguistic discipline and NLP

Evidence in linguistics

- **Acceptability judgements**: Intuitions of a native speaker.
- **Corpus linguistics**: Is the appearance or non-appearance of some phenomenon proof? What about errors and their correction?
- **Comparative linguistics**: Are there universals across languages? What distinguishes human language?
- **Language acquisition**: How do children gain linguistic knowledge? How does this compare to second language learners?
- **Psycholinguistics**: How do our minds process language? E.g. *garden path sentences*: The horse raced past the barn fell. Time flies like an arrow; Fruit flies like a banana. Reaction times.
- **Neurolinguistics**: How does this work physically inside our brains? What happens with brain damage?

Language variation

- Languages are very different from one another. Most have very little record. Field linguistics: documenting a language.
- Historical (or diachronic) linguistics: How do languages change over time? How do languages interact?
  French influence in English: sheep/mutton, cow/beef, calf/veal, swine/pork, deer/venison.
- Sociolinguistics: Variation with social context.
  Dialect: have a shower vs. take a shower; /t/ in butter.
  Labov's *fourth floor* experiment. Code switching.
- Variation across genre

- how do humans deal with variation?
- how does variation affect NLP?

What is a language?

a language is a dialect with an army and a navy.

an ensemble of idiolects ...
rather than an entity per se.

a language as an ideal system
outside the practice of language users.

Linguistic insight in NLP

> Every time I fire a linguist, the performance of the speech recognizer goes up (Fred Jelinek)

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But remains an open question. Relates to questions of innateness.

NLP as evidence for linguistic theories

Can predictive modelling
tell us how language works?

Linguistics: the science of language

- How does language work?
- How can we analyse language?
- What qualifies as evidence?

- How can linguistics inform NLP?
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- Why is NLP hard?