Why NLP is Hard?

1. Ambiguity
2. Scale
3. Sparsity
4. Variation
5. Expressivity
6. Unmodeled Variables
7. Unknown representations

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Ambiguity

- Ambiguity at multiple levels
  - Word senses: **bank** (finance or river ?)
  - Part of speech: **chair** (noun or verb ?)
  - Syntactic structure: **I can see a man with a telescope**
  - Multiple: **I made her duck**

"One morning I shot
an elephant in my pajamas"

I made her duck

[SLP2 ch. 1]

- I cooked waterfowl for her
- I cooked waterfowl belonging to her
- I created the (plaster?) duck she owns
- I caused her to quickly lower her head or body
- …

The Challenges of “Words”

- Segmenting text into words
- Morphological variation
- Words with multiple meanings: bank, mean
- Domain-specific meanings: latex
- Multiword expressions: make a decision, take out, make up

Part of Speech Tagging

ikr smh he asked fir yo last name

so he can add u on fb lolololol

Part of Speech Tagging

I know, right	shake my head			for	your		
ikr	smh	he	asked	fir	yo	last	name

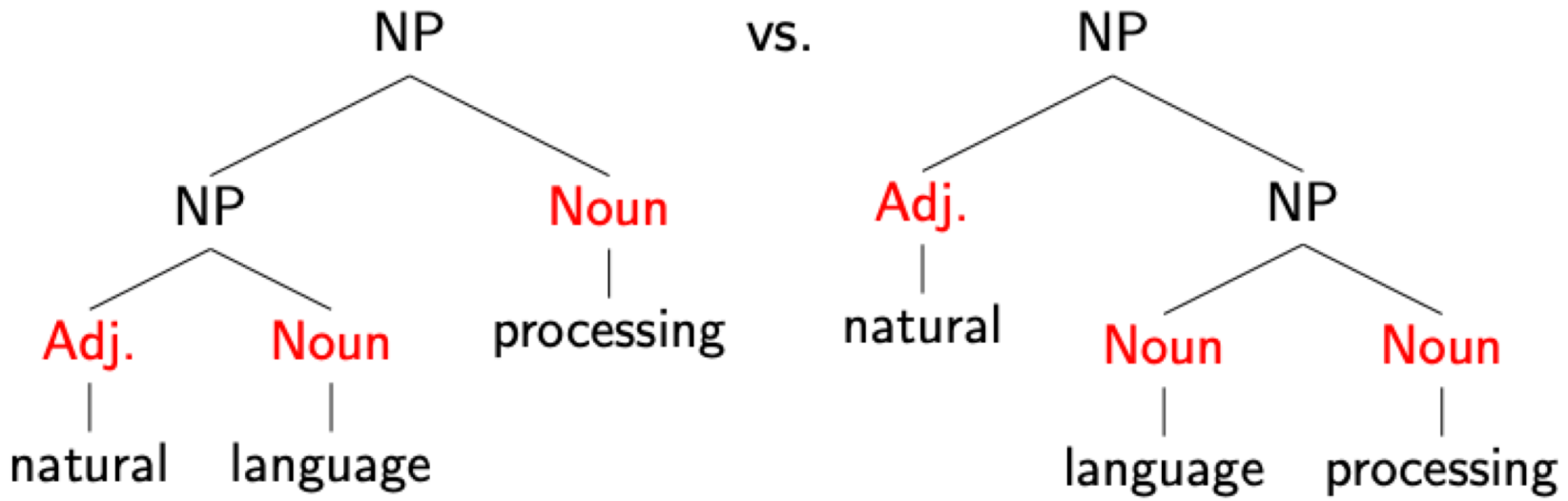
				you		Facebook	laugh out loud
so	he	can	add	u	on	fb	lolololol

Part of Speech Tagging

I know, right	shake my head			for	your		
ikr	smh	he	asked	fir	yo	last	name
!	G	O	V	P	D	A	N
interjection	acronym	pronoun	verb	prep.	det.	adj.	noun

				you		Facebook	laugh out loud
so	he	can	add	u	on	fb	lololol
P	O	V	V	O	P	∧	!
preposition						proper noun	

Syntax


NP
NP
Noun
Adj.
Noun
processing
natural
language
vs.
NP
Adj.
NP
natural
Noun
Noun
language
processing

Morphology + Syntax

A ship-shipping ship, shipping shipping-ships

Semantics

- Every fifteen minutes a woman in this country gives birth. Our job is to find this woman, and stop her!

– Groucho Marx

Syntax + Semantics

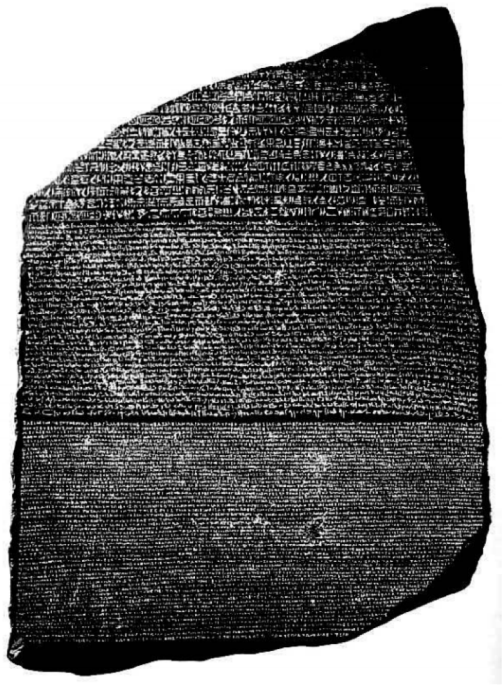
- We saw the woman with the telescope wrapped in paper.
  - Who has the telescope?
  - Who or what is wrapped in paper?
  - An even of perception, or an assault?

Dealing with Ambiguity

- How can we model ambiguity?
  - Non-probabilistic methods (CKY parsers for syntax) return all possible analyses
  - Probabilistic models (HMMs for POS tagging, PCFGs for syntax) and algorithms (Viterbi, probabilistic CKY) return the best possible analyses, i.e., the most probable one
- But the "best" analysis is only good if our probabilities are accurate. Where do they come from?

Corpora

- A corpus is a collection of text
  - Often annotated in some way
  - Sometimes just lots of text
- Examples
  - Penn Treebank: 1M words of parsed WSJ
  - Canadian Hansards: 10M+ words of French/English sentences
  - Yelp reviews
  - The Web!



Rosetta Stone

Statistical NLP

- Like most other parts of AI, NLP is dominated by statistical methods
  - Typically more robust than rule-based methods
  - Relevant statistics/probabilities are learned from data
  - Normally requires lots of data about any particular phenomenon

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Sparsity

- Sparse data due to Zipf's Law
- Example: the frequency of different words in a large text corpus

any word

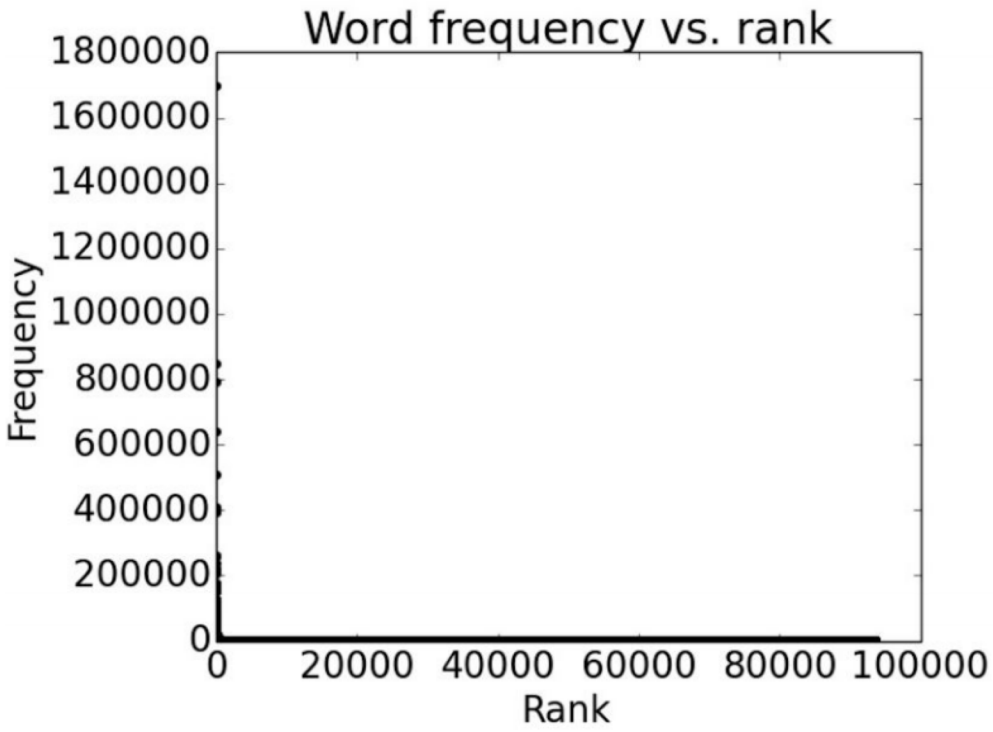
Frequency	Token
1,698,599	the
849,256	of
793,731	to
640,257	and
508,560	in
407,638	that
400,467	is
394,778	a
263,040	I

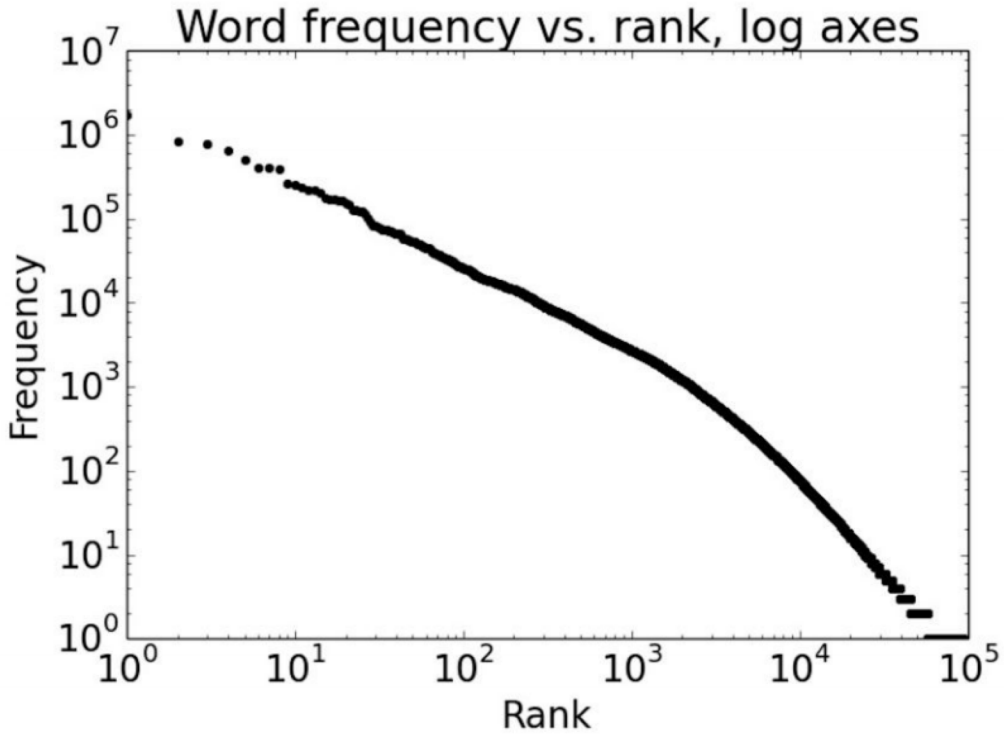
nouns

Frequency	Token
124,598	European
104,325	Mr
92,195	Commission
66,781	President
62,867	Parliament
57,804	Union
53,683	report
53,547	Council
45,842	States

Sparsity

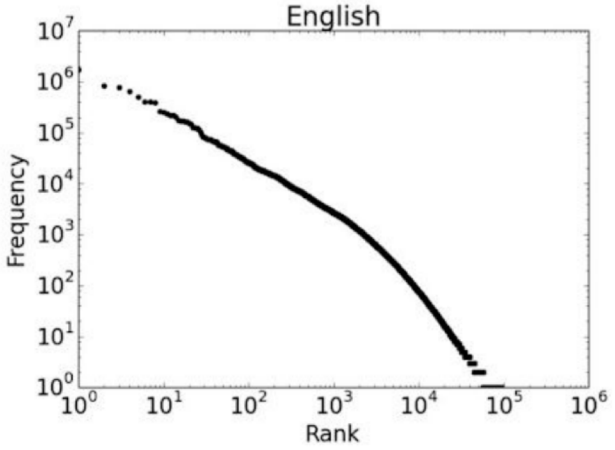
- Order words by frequency. What is the frequency of nth ranked word?

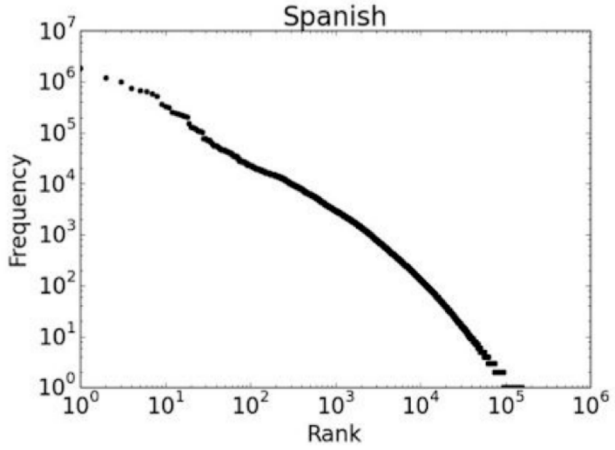


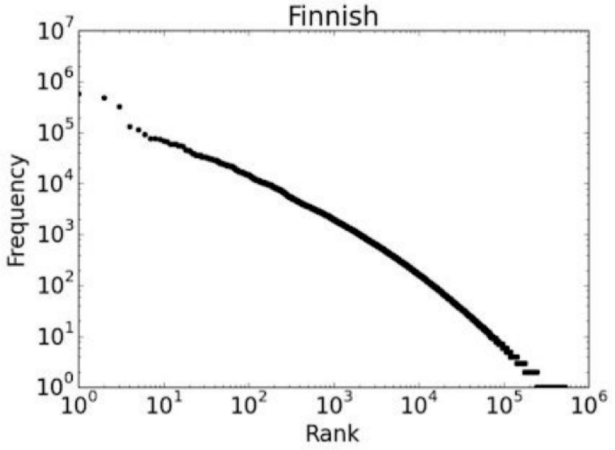


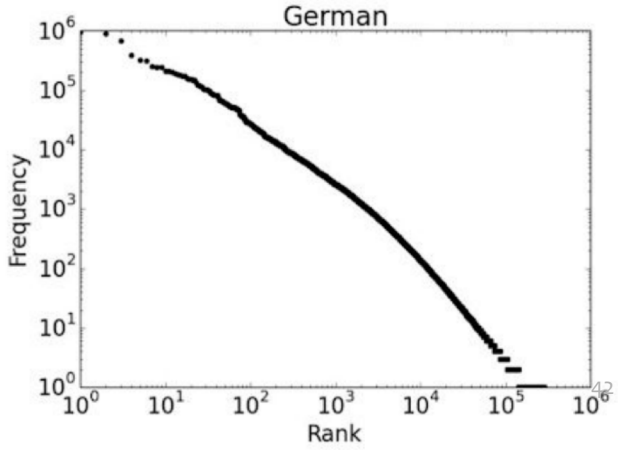
Sparsity

- Regardless of how large our corpus is, there will be a lot of infrequent words
- This means we need to find clever ways to estimate probabilities for things we have rarely or never seen









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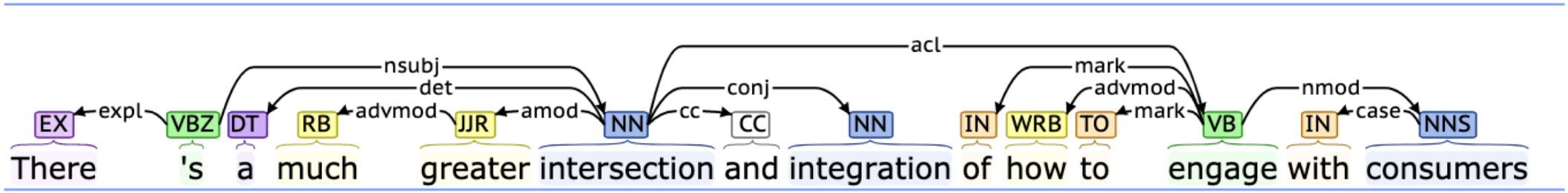
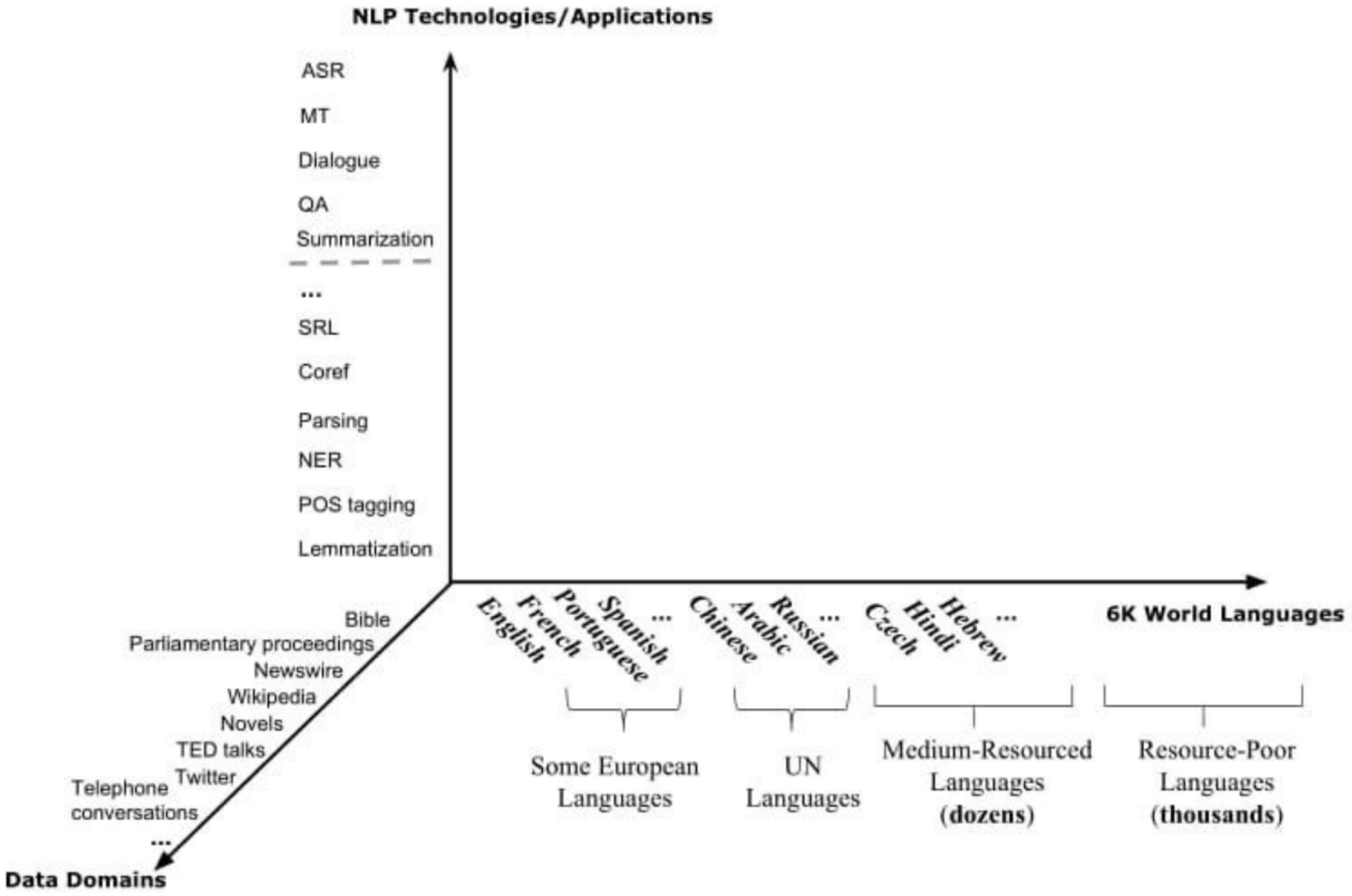
Variation

- Suppose we train a part of speech tagger or a parser on the Wall Street Journal



- What will happen if we try to use this tagger/parser for social media?
  - *"ikr smh he asked fir yo last name so he can add u on fb lolololol"*

Variation


NLP Technologies/Applications
ASR
MT
Dialogue
QA
Summarization
...
SRL
Coref
Parsing
NER
POS tagging
Lemmatization
Bible
Parliamentary proceedings
Newswire
Wikipedia
Novels
TED talks
Twitter
Telephone conversations
...
Data Domains
English
French
Portuguese
Spanish
...
Chinese
Arabic
Russian
...
Czech
Hindi
Hebrew
...
6K World Languages
Some European Languages
UN Languages
Medium-Resourced Languages (dozens)
Resource-Poor Languages (thousands)

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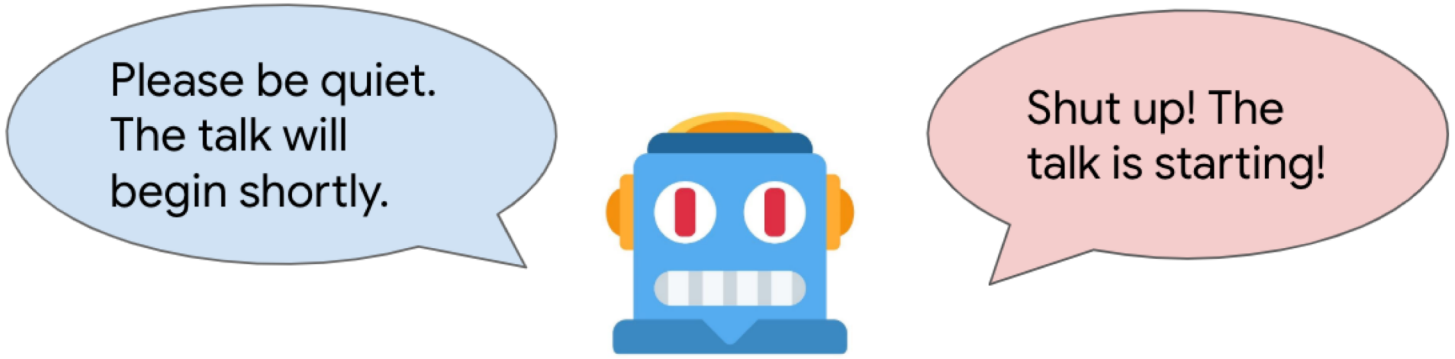
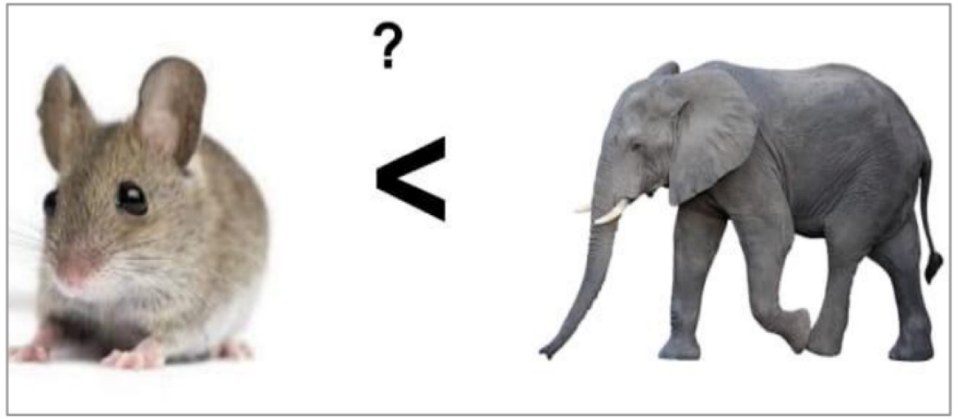
Expressivity

- Not only can one form have different meanings (ambiguity) but the same meaning can be expressed with different forms:
  - *She gave the book to Tom* vs. *She gave Tom the book*
  - *Some kids popped by* vs. *A few children visited*
  - *Is that window still open?* vs. *Please close the window*



Unmodeled Variables

"Drink this milk"



World knowledge

I dropped the glass on the floor and it broke

I dropped the hammer on the glass and it broke