
Introduction to Artificial Intelligence

Language

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Summer Term 2003

Outline

- **Communication**
- **Grammar**
- **Syntactic analysis**
- **Problems**

Communication

“Classical” view (pre-1953)

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Searle (1969) *Speech Acts*

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Why?

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Why?

To change the actions of other agents

Speech Acts



Speech acts achieve the speaker's goals

| | |
|--------------------|---------------------------------|
| <i>Inform</i> | “There’s a pit in front of you” |
| <i>Query</i> | “Can you see the gold” |
| <i>Command</i> | “Pick it up” |
| <i>Promise</i> | “I’ll share the gold with you” |
| <i>Acknowledge</i> | “OK” |

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Speech act planning requires knowledge of

- Situation
- Semantic and syntactic conventions
- Hearer's goals, knowledge base, and rationality

Stages in Communication (Informing)

| | |
|------------------------------|---|
| <i>Intention</i> | S wants to inform H that P |
| <i>Generation</i> | S selects words W to express P |
| <i>Synthesis</i> | S utters words W |
| <i>Perception</i> | H perceives W' |
| <i>Analysis</i> | H infers possible meanings P_1, \dots, P_n |
| <i>Disambiguation</i> | H infers intended meaning P_i |
| <i>Incorporation</i> | H incorporates P_i into KB |

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How could this go wrong?

- **Insincerity (S doesn't believe P)**
- **Speech wreck ignition failure**
- **Ambiguous utterance**
- **Differing understanding of current situation**

Grammar

Purpose

**Grammar specifies the compositional structure of complex messages
e.g., speech (linear), text (linear), music (two-dimensional)**

Formal language

A set of strings of terminal symbols

Each string in the language can be analyzed/generated by the grammar

Grammar

Rewrite rules

The grammar is a set of rewrite rules

Example

$$S \rightarrow NP VP$$

$$Article \rightarrow the \mid a \mid an \mid \dots$$

S: **the sentence symbol**

NP, VP: **nonterminals**

the, a: **terminal symbols**

Wumpus Lexicon

Noun → *stench* | *breeze* | *glitter* | *nothing*
| *wumpus* | *pit* | *pits* | *gold* | *east* | ...

Verb → *is* | *see* | *smell* | *shoot* | *feel* | *stinks*
| *go* | *grab* | *carry* | *kill* | *turn* | ...

bAdjective → *right* | *left* | *east* | *south* | *back* | *smelly* | ...

Adverb → *here* | *there* | *nearby* | *ahead*
| *right* | *left* | *east* | *south* | *back* | ...

Pronoun → *me* | *you* | *I* | *it* | *S/HE* | *Y'ALL...*

Name → *John* | *Mary* | *Boston* | *UCB* | *PAJC* | ...

Article → *the* | *a* | *an* | ...

Preposition → *to* | *in* | *on* | *near* | ...

Conjunction → *and* | *or* | *but* | ...

Digit → 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9

Divided into **closed** and **open** classes

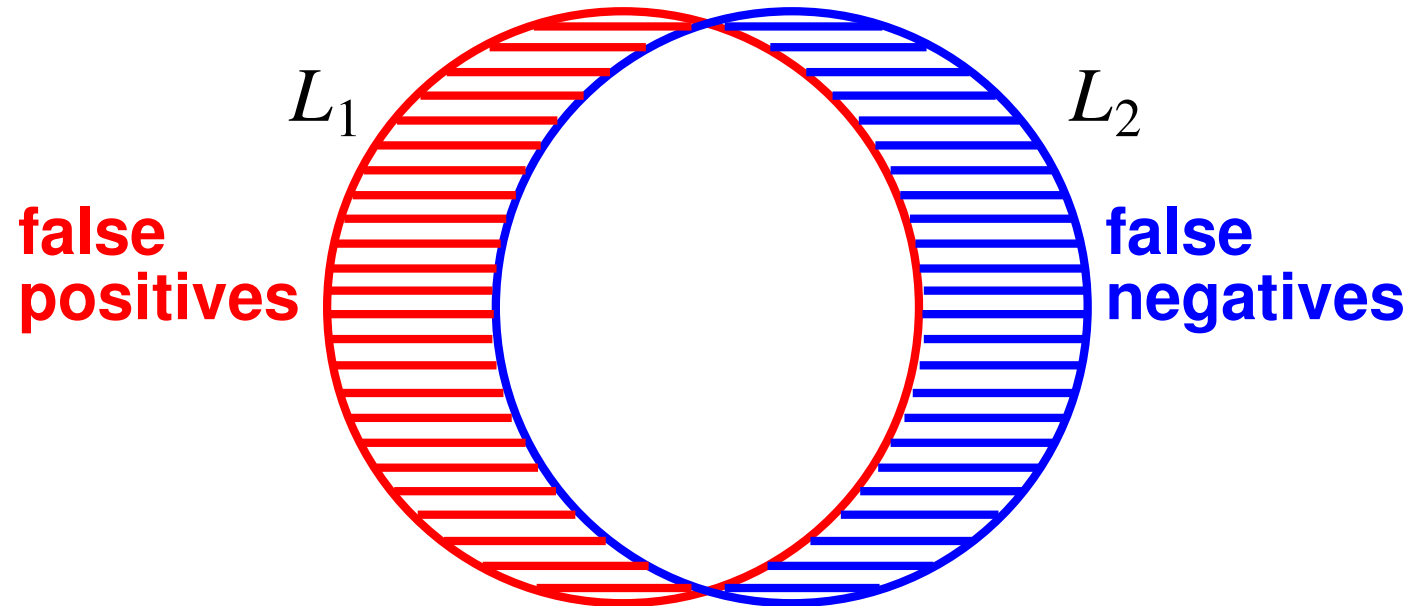
Wumpus Grammar

| | | | |
|------------------|---|------------------------|---|
| <i>S</i> | → | <i>NP VP</i> | I + feel a breeze |
| | | <i>S Conjunction S</i> | I feel a breeze + and + I smell a wumpus |
| <i>NP</i> | → | <i>Pronoun</i> | I |
| | | <i>Noun</i> | pits |
| | | <i>Article Noun</i> | the + wumpus |
| | | <i>Digit Digit</i> | 3 4 |
| | | <i>NP PP</i> | the wumpus + to the east |
| | | <i>NP RelClause</i> | the wumpus + that is smelly |
| <i>VP</i> | → | <i>Verb</i> | stinks |
| | | <i>VP NP</i> | feel + a breeze |
| | | <i>VP Adjective</i> | is + smelly |
| | | <i>VP PP</i> | turn + to the east |
| | | <i>VP Adverb</i> | go + ahead |
| <i>PP</i> | → | <i>Preposition NP</i> | to + the east |
| <i>RelClause</i> | → | <i>that VP</i> | that + is smelly |

Grammaticality judgements

Note

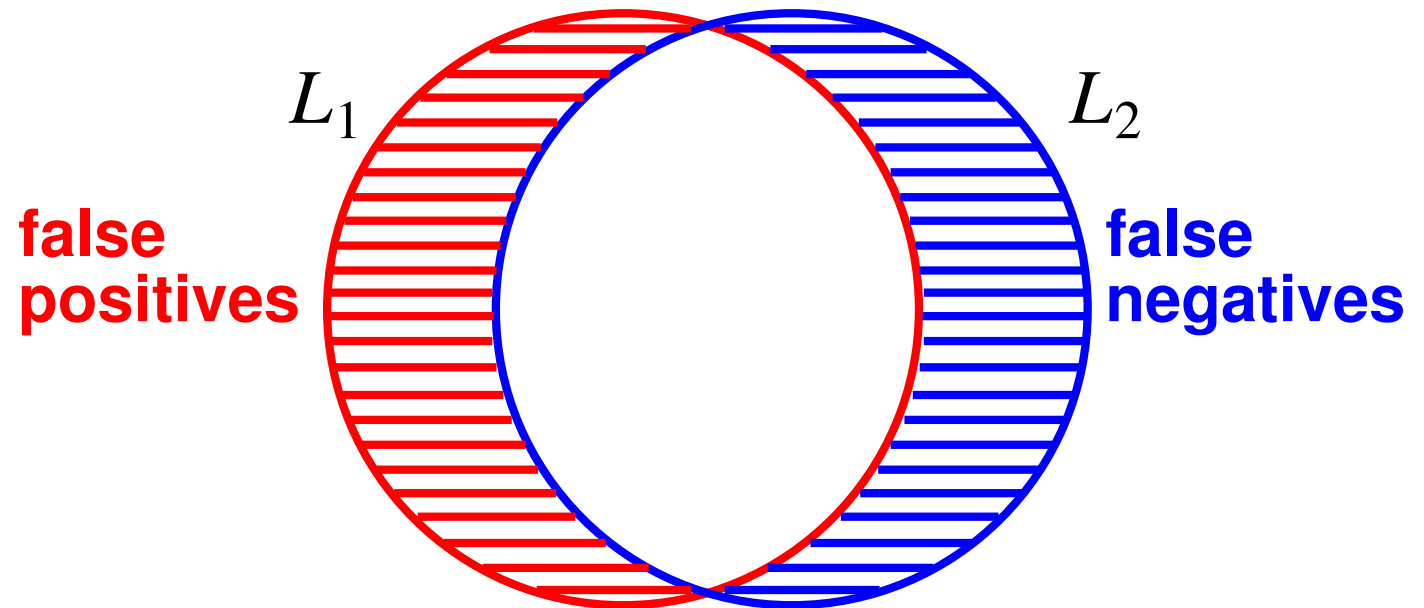
Formal language L_1 may differ from natural language L_2



Grammaticality judgements

Note

Formal language L_1 may differ from natural language L_2



Examples

- + the gold grab the wumpus
- + I smell the wumpus the gold
- I give the wumpus the gold
- + I donate the wumpus the gold

Parse Trees

Exhibit the grammatical structure of a sentence



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Pronoun

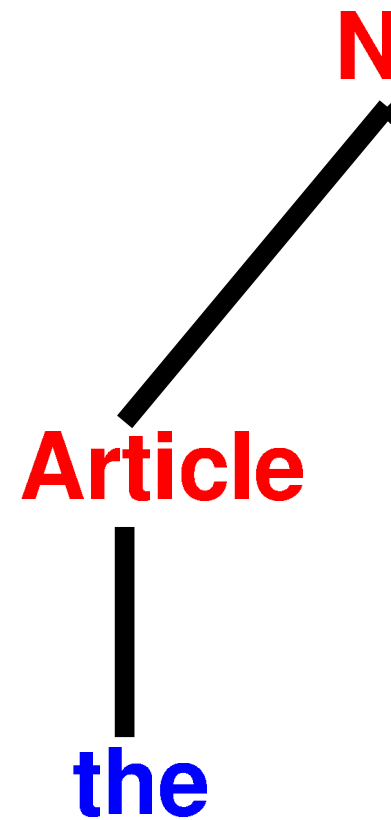
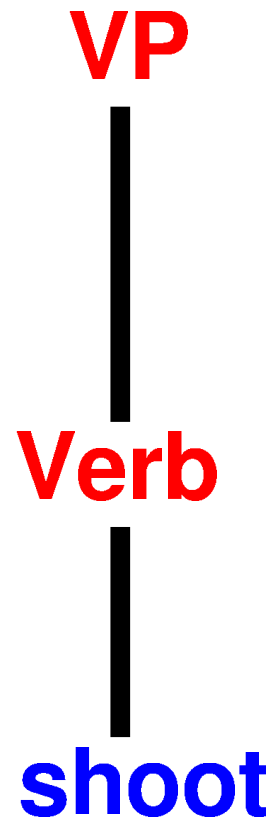
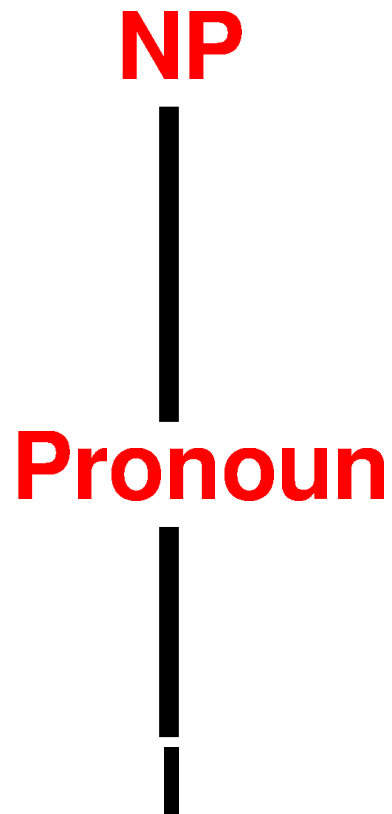


Verb



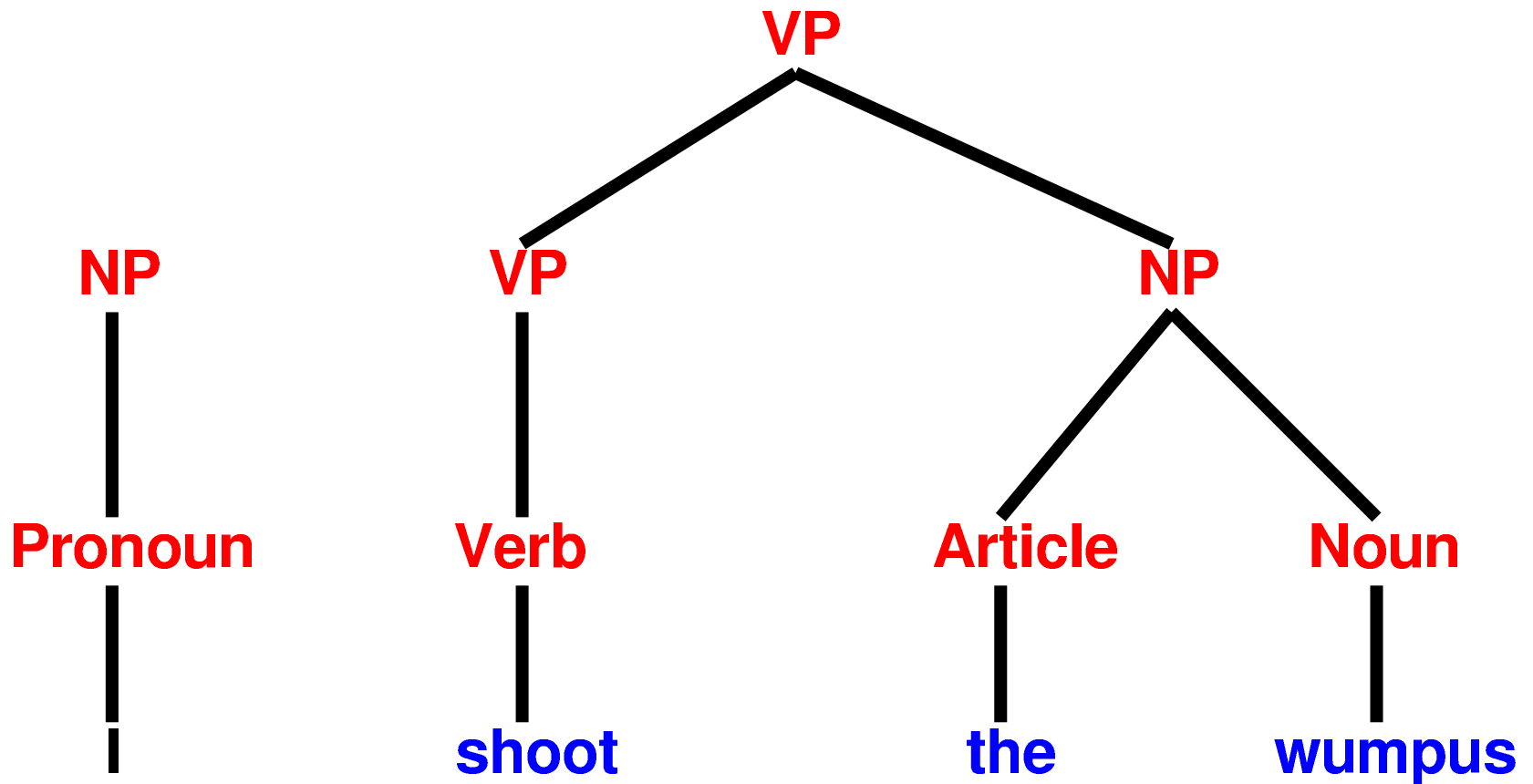
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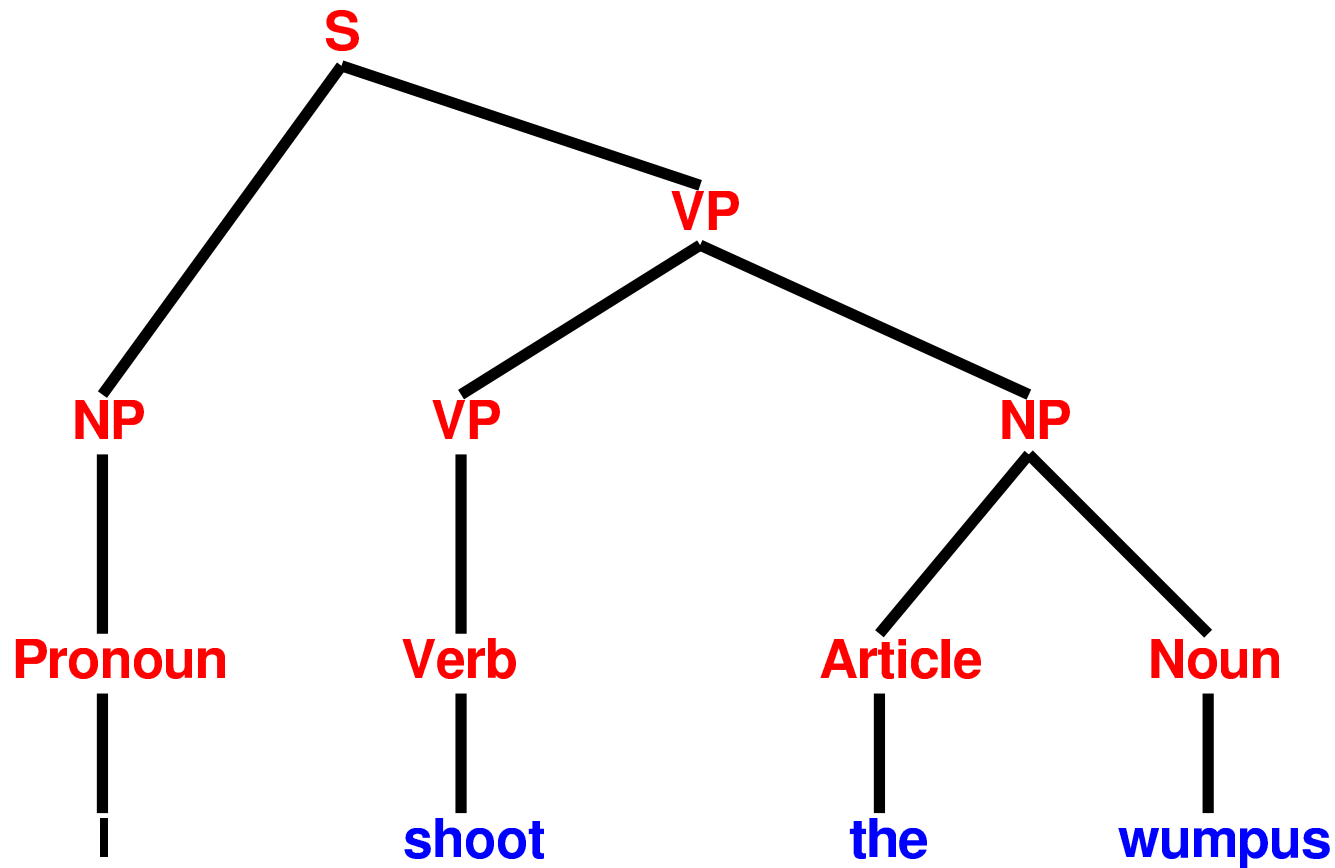
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Syntax in Natural Language Processing

Syntactic structure is an essential step towards meaning

● “Mary hit John” \neq “John hit Mary”

Syntax in Natural Language Processing

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- **“Mary hit John” \neq “John hit Mary”**
- **“And since I was not informed—as a matter of fact, since I did not know that there were excess funds until we, ourselves, in that checkup after the whole thing blew up, and that was, if you’ll remember, that was the incident in which the attorney general came to me and told me that he had seen a memo that indicated that there were no more funds.”**

Syntax in Natural Language Processing

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- **“Mary hit John” \neq “John hit Mary”**
- **“And since I was not informed—as a matter of fact, since I did not know that there were excess funds until we, ourselves, in that checkup after the whole thing blew up, and that was, if you’ll remember, that was the incident in which the attorney general came to me and told me that he had seen a memo that indicated that there were no more funds.”**
- **“Wouldn’t the sentence ‘I want to put a hyphen between the words Fish and And and And and Chips in my Fish-And-Chips sign’ have been clearer if quotation marks had been placed before Fish, and between Fish and and, and and and And, and And and and, and and and And, and And and and, and and and Chips, as well as after Chips?”**

Real Language

Real human languages provide many problems for natural language processing

- **ambiguity**
- **anaphora**
- **indexicality**
- **vagueness**
- **noncompositionality**
- **discourse structure**
- **metonymy**
- **metaphor**

Ambiguity

Examples

- Squad helps dog bite victim

Ambiguity

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Ambiguity

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- Helicopter powered by human flies
- I ate spaghetti with meatballs
 - salad
 - abandon
 - a fork
 - a friend

Note

Ambiguity can be

- lexical
- syntactic
- semantic
- referential

Indexicality

Indexical sentences

Refer to utterance situation (place, time, etc.)

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Examples

- I am over **here**
- Why did **you** do **that**?

Anaphora

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Using pronouns to refer back to entities already introduced in the text

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Using pronouns to refer back to entities already introduced in the text

Examples

- After Mary proposed to John, **they** found a preacher and got married.
- For the honeymoon, **they** went to Hawaii
- Mary saw a ring through the window and asked John for **it**
- Mary threw a rock at the window and broke **it**

Metonymy

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Using one noun phrase to stand for another

Metonymy

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Using one noun phrase to stand for another

Example

- I've read **Shakespeare**
- **Chrysler** announced record profits
- The **ham sandwich** on Table 4 wants another beer

Metaphor

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“Non-literal” usage of words and phrases, often systematic:

Metaphor

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Example

I’ve tried killing the process but it won’t die.

Noncompositionality

Examples

- **basketball shoes**
- **baby shoes**
- **alligator shoes**
- **designer shoes**
- **brake shoes**

Disambiguation

Requires knowledge of different kind

- **World model**
- **Mental model (of the speaker)**
- **Language model**
- **Acoustic model**