Detecting Meaning with Sherlock Holmes*

Sentence meaning and compositionality

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Overview

- Revision
- Compositionality
- Sentence Meaning
  - Semantic Roles and Alternations
  - Tense, Aspect, Modality and Evidentiality
- Close Reading and Word Sense Disambiguation

Revision of Word Meaning

Word meaning

- What is a word? How easy is it to define ‘word’ ?
- Different ways of representing meaning
- Lexical Relations
- Derivational Relations
  - Inchoative, causative, conative, …(**alternations**)
  - Agentive nouns
- Meaning: Relative or universal?

Words

word slippery to define: orthographic, phonological, conceptual definitions mainly overlap

lexeme base (uninflected) form of a word (or multi word expression)

vagueness having an underspecified meaning

ambiguous having more than one possible meaning

Senses and Relations

polysemous having multiple meanings
monosemous having just one meaning
homonyms words unrelated meaning; grammatically equivalent; with identical forms

Lexical Relations

synonymy all meanings identical; in all contexts; descriptive and non-

hyponymy is-a, kind-of: supertype **hypernym**; subtype **hyponym**

meronymy part-whole: part **meronym**; whole **holonym**

antonymy (complementary, gradable, reverse, converse, taxonomic sisters)

member-collection member of a group (*tree-forest*)

portion-mass element of stuff (*grain-rice*)

domain used in a domain (*[software] driver -golf*)

Wordnet

- Defines words as linked semantic nets
- Concepts are represented by synsets (synonym-sets)
- Synsets have both definitions and semantic relations
- We will use Princeton Wordnet of English as our sense-inventory for projects one and two
- Wordnets are available for many languages

Compositionality

Meaning is built up

- **Compositional Semantics**: the meaning of the whole depends (only) on the meanings of the parts and the method of combination.

- The hearer/reader's **interpretation** brings in much more
  - we bring in our existing knowledge
  - we make inferences

- These inferences are based on (or constrained by) the semantics

- two central ideas (formalized by: Katz and Fodor, 1963)
  - Semantic rules must be recursive to deal with infinite meaning
  - Semantic rules interact with syntactic rules to build up meaning

- Two major components:
  - A dictionary pairing lexical items with semantic representations
  - A set of **projection rules** that show how meaning is built up

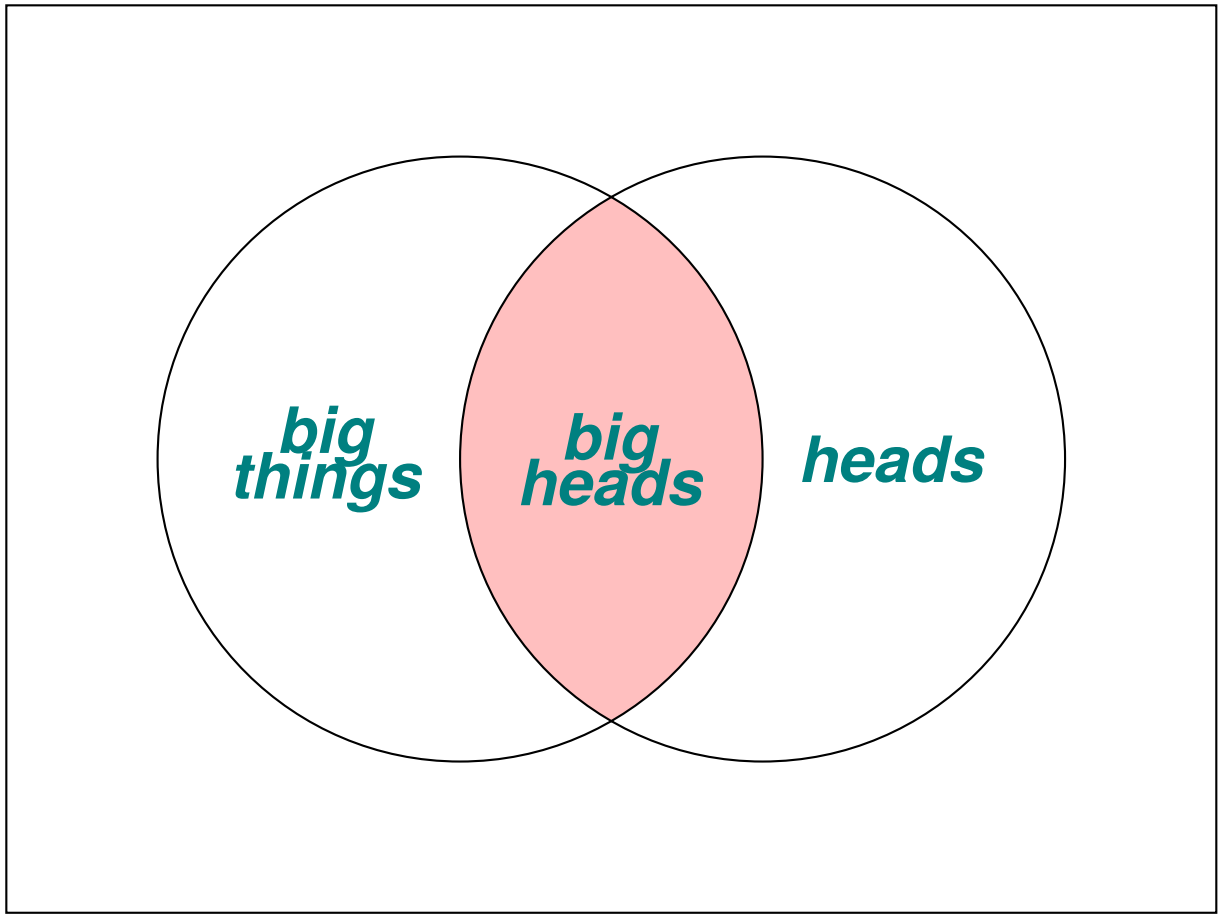
Intersective Modification

- Consider the simplest case of a noun and an adjective
  - ***big*** "above average in size or number or quantity or magnitude or extent"
  - ***head*** "the upper part of the human body or the front part of the body in animals; contains the face and brains"

- Each constrains the world, one picks out things that are "big" and the other things that "are heads".

- Together ***big head*** picks out things that have both properties: they are "big" and they "have heads".

This is like intersection for sets



- This is the simplest form of composition

Other kinds of intersective modification

- **Manner**: *We live very quietly, sir* REDH
- **Restriction**: *That trick of staining the fishes' scales of a delicate pink is quite peculiar to China* REDH
- **Location:** *I would rather have my bracelets on him than on any criminal in London*
- **Time:** *one day in the autumn of last year*
- **State:** *And sit in the dark*

The syntactic dependency (the fact that one word/phrase is associated with another) helps us build the semantic model.

Some exceptions

- Not all modification is intersective
  - *fake gun* is a thing like a gun: not a gun
  - *toy horse* is not a horse
  - ? come up with another example of non-intersective modification

  This requires different projection rules

- Word combinations (**multi-word expressions**) can pick up new meanings
  - *They have a big head* “They are vain”
  - *They are a red head* “They have red hair”

  This requires a richer lexicon

- There are many other ways of composing words (not just modification)
  - Semantic roles: *The dog barked*
  - Intensification: *They have a very big head*
  - Embedding: *I think they have a big head*
  - Quantification: *They have two heads/no head*

Projection Rules

1. Projection rules combine with syntactic rules to produce the meaning of a sentence
   these can be grouped together in **signs** or **constructions**

   - Information is built up as we parse a sentence
     - Information is only added, never deleted
     - It must come from words or rules (or constructions)

2. Different languages show these combinations in different ways

   - English primarily uses word order
   - Japanese uses case-marking

   ...

? Consider *a very stout, florid-faced, elderly gentleman, with fiery red hair*

- How many examples of intersective modification are there here?
- Can you describe the other relations involved?

Completion

- When we listen (or read) we actively anticipate the next word (or words)
- We can guess them fairly well
  - *Recognising, as I do, that you are the second highest expert in Europe-'*
  - *'Indeed, sir! May I inquire who has the honour to be the first?' asked Holmes, with some asperity. …*
  - *But as a practical man of affairs it is acknowledged that you stand alone. I trust, sir, that I have not inadvertently-'* ???
  - *'Just a little,' said Holmes. '*
- What is missing here?

Sentence Meaning

Situations

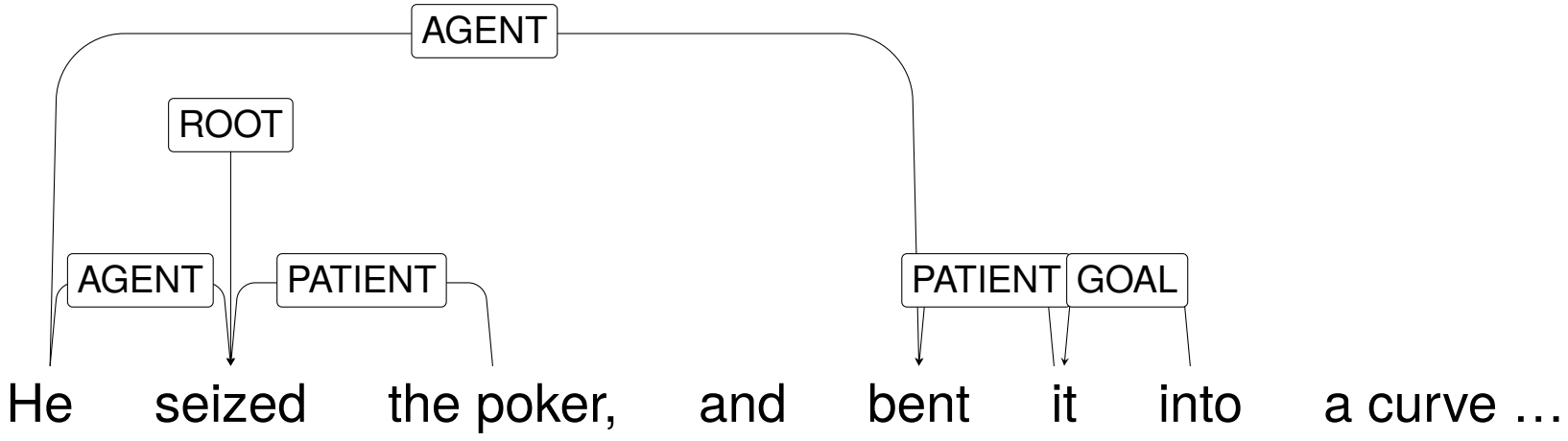
- Noun phrases refer to entities
- Sentences refer to situations
  - Situations can be constrained in various ways
  - What is the event in question?
  - Who participates in it?
  - When did it happen?
  - Is it ongoing or has it finished?
  - Is our knowledge of it certain?
- The core of an event is typically represented by a verb or adjective
  - Verbs typically refer to actions (but can refer to states)
    He stepped swiftly forward … DANC
    I know you, you scoundrel! DANC
  - Adjectives typically refer to states
    Your sister is dead, then? DANC

Semantic Roles

In this section we talk about the relations between the participants in a situation and the situation itself.

- **Semantic roles** are parts of the sentence that correspond to the participants in the situation described

- They classify relations between entities in a situation

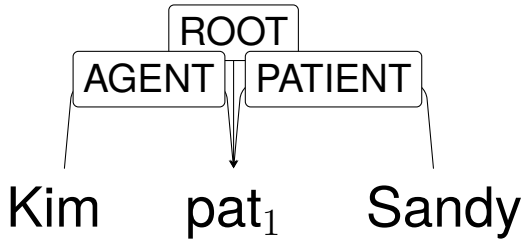


- Also known as
  - Deep case (Fillmore, 1968)
  - Thematic roles; Theta roles; θ-roles
  - Participant Roles

Roles link different alternations

(1) *Kim patted Sandy*
(2) *Sandy was patted by Kim*

- The semantic roles are different from the grammatical relations.
- Which is the **subject** and which the **object** in these sentences?
- What are the semantic roles of Kim and Sandy?
- **semantic dependencies**: An abstract representation of the meaning links word-senses to each other using semantic roles: different sentences may end up the same at this level



Semantic Roles

- **AGENT** (takes *deliberately, on purpose, what did X do?*)

  A participant which the meaning of the verb specifies as doing or causing something, possibly intentionally.

  - The initiator, performer of controller of an action; typically volitional, typically animate
  - Typically SUBJECT

  (3) *Kim kicked Sandy*

  (4) *The ogre leaped into the fray*

  (5) *The student watched the video*

- (**ACTOR**) generalization of **AGENT** that allows non-volitional, non-actor
  if you use this, then **AGENT** is restricted to animate, volitional participants

- Find an example of AGENT in *The Final Problem*

➢ **PATIENT** (*What happened to X?*)

A participant which the verb characterizes as having something happen to it, and as being affected by what happens to it.

- ➢ The undergoer of an action
- ➢ Undergoes change in state usually, both animate and inanimate
- ➢ Typically OBJECT

(6) *Kim kicked Sandy*

(7) *The ogre ate the dog*

(8) #*The student watched the video*

(9) #*I heard a sound*

➢ Find an example of PATIENT in *The Final Problem*

➢ THEME

A participant which is characterized as changing its position or condition, or as being in a state or position.

- ➢ Moved, location or state is described
- ➢ Typically OBJECT

(10) *Hiromi put the book on the shelf*

(11) *Freddy gave you the chocolate*

(12) *The book is on the shelf*

(13) *The protagonist died*

(14) **The dog walked home*

➢ Find an example of THEME in *The Final Problem*

➢ EXPERIENCER

A participant who is characterized as aware of something.

- ➢ Non-volitional, displaying awareness of action, state
- ➢ Typically SUBJECT

(15) *Liling heard thunder*

(16) *Jo felt sick*

(17) *The lecturer annoyed the students*

- ➢ Find an example of EXPERIENCER in *The Final Problem*

➢ BENEFICIARY

- ➢ for whose benefit the action was performed
- ➢ Typically indexed by ”for” PP in English
  or OBJECT in ditransitive verbs

(18) *They made me a present*

(19) *They made a present for me*

➢ LOCATION

- ➢ Place
- ➢ Typically indexed by locative PPs in English

(20) *I am living in Indonesia*

(21) *It is on the table*

➢ Find examples of BENEFICIARY and LOCATION in *The Final Problem*

➢ GOAL

- towards which something moves (lit or metaphor)
- Typically indexed by ”to” PP in English
  or OBJECT in ditransitive

(22) *She handed the form to him*

(23) *She handed him her form*

➢ SOURCE

- from which something moves or originates
- Typically indexed by ”from” PP in English

(24) *We gleaned this from the Internet*

- Find examples of SOURCE and GOAL in *The Final Problem*

➢ STIMULUS

- ➢ Usually used in connection with EXPERIENCER

(25) *The lightning scared them*

(26) *I don't like the lightning*

➢ INSTRUMENT/MANNER

- ➢ Means by which action is performed
- ➢ Can be indexed by "with" PP in English

(27) *I ate breakfast with chopsticks*

- ➢ Find examples of STIMULUS and INSTRUMENT in *The Final Problem*

PropBank Roles

- An influential set of semantic roles comes from PropBank (Palmer et al., 2005)
- They have 6 core roles and 17 modifier roles
- The core roles, meaning is defined per verb sense

Role	Description	Example
ARG0	agent	
ARG1	patient	
ARG2	instrument, benefactive, attribute	
ARG3	starting point, benefactive, attribute	
ARG4	ending point	
ARGA	secondary agent	*Kim*$_A$ *trotted her horse*$_0$

- ***seize.01*** "acquire (forcefully or stealthily)"
  - Arg0-PAG: agent, entity acquiring something
  - Arg1-PPT: thing acquired
  - Arg2-DIR: acquired-from

  Sandy$_0$ *seized the poker*$_1$ *from Kim*$_2$

The Modifier Roles

COM: Comitative
LOC: Locative
DIR: Directional
GOL: Goal
MNR: Manner
TMP: Temporal
EXT: Extent
REC: Reciprocals
PRD: Secondary Predication
PRP: Purpose
CAU: Cause
DIS: Discourse
ADV: Adverbials
ADJ: Adjectival
MOD: Modal
NEG: Negation
DSP: Direct Speech
LVB: Light Verb
CXN: Construction

Some Issues

- Every theory has a different set of roles
- It is hard to generalize: roles can be very word specific
- Roles are very under-specified, these are all PATIENT!

(28) *The genie touched the lamp with their nose.*
(29) *The baby rubbed the lamp with its hands.*
(30) *The baby squeezed the rubber toy with its hands.*
(31) *She cracked the mirror with a stone.*

Linking Grammatical Relations and Semantic Roles

- Semantic roles typically map onto grammatical functions systematically
  - AGENT is usually the subject
  - PATIENT is usually the object

- It is possible to predict how arguments are linked to the verb from their semantic roles, and hence their grammatical functions.

- Many verbs allow **alternation**s "syntactic variants with different roles"

  (32) *Jo broke the ice with a pickaxe* ⟨AGENT, PATIENT, INSTRUMENT⟩
  (33) *The pickaxe broke the ice* ⟨INSTRUMENT, PATIENT⟩
  (34) *The ice broke* ⟨PATIENT⟩

Other Predicates

- Adjectives (normally theme)

  (35) *John is tall* (THEME)

  (36) *John is cold [to touch]* (THEME)

  (37) *John is/feels cold* (EXPERIENCER)
  different adjectives in e.g., Japanese：
  冷たい *tsumetai* “cold (to touch)” vs 寒い *samui* “(feel) cold”

- Predicative Copula (treat second NP as predicate)

  (38) *John is a boy* (THEME)

- Identity Copula (reversible)

  (39) *Kim is my teacher* (THEME, THEME)?

  (40) *My teacher is Kim* (THEME, THEME)?

Alternations

- Many verbs have multiple possible mappings of grammatical function to role

(41) a. *Kim broke the window with the hammer*
b. *The hammer broke the window*
c. *The window broke*

(42) a. *I cut the cake with the knife*
b. *This cake cuts easily*

- The relations between them are called **alternations**

- *English Verb Classes and Alternations* (Levin, 1993)

There are many alternations

- A common way to change the number of arguments is called **voice**: passive, middle

(43) **Transitive Passive**

a. *Kim ate Sandy*

b. *Sandy was eaten (by Kim)*

(44) **Ditransitive Passive**

a. *Abraham gave Brown chocolate*

b. *Abraham gave chocolate to Brown*

c. *Chocoloate was given to Brown (by Abraham)*

d. *Brown was given chocolate (by Abraham)*

(45) **Transitive Middle** (or just causative/inchoative)

a. *They open the gate very quietly*

b. *The gate opens very quietly*

(46) **Intransitive Middle**

a. *The knife cuts the cake well*

b. *The knife cuts well*

➢ But there are many other alternations:

(47) **Conative** alternation:

a. *Kim hit the door* $\leftrightarrow$ *Kim hit at the door*

(48) **Body-part possessor ascension** alternation:

a. *Kim cut Sandy's arm* $\leftrightarrow$ *Kim cut Sandy on the arm*

Why so many possibilities?

- So we can emphasize different participants
- We may not know all the participants
- We may not care about all the participants
- There are also lexical alternations

(49) *Kim killed Sandy* vs *Sandy dies*

(50) c.f. *Kim melted the ice* vs *the ice melted*

(51)

金が	氷を	溶かした	*vs*	氷が	溶けた
Kim-ga	koori-wo	tokashita		koori-ga	toketa
Kim-SBJ	ice-OBJ	*melt:trans*		ice-SBJ	*melt:intrans*

Video

- *I want to cook with you* IT Crowd, Series 2 - Episode 3
  https://www.youtube.com/watch?v=gOE-q20RcDM

```
Moss    Look, I've got your advert here.
        I printed it out.
        I want to cook with you.
Johann  No, my English is not so good
Moss    You want to cook with me, using me, you mean.
Johann  Ah yes! Yes.
        You see.
Moss    I see where the confusion was.
        I thought this was a cookery course.
        But you wanted someone who would agree to let you kill and eat
Johann  Ja! You see?
Moss    That is funny.
Johann  So you're not interested?
Moss    No, thanks, it's not for me.
Johann  How disappointing.
```

Tense, Aspect and Modality (TAM)

TAM

- We need to distinguish grammatical expression from meaning
  - Tense vs Time
  - Grammatical Aspect vs Semantic Aspect
  - Mood vs Modality
  - Surface Case vs Deep Case

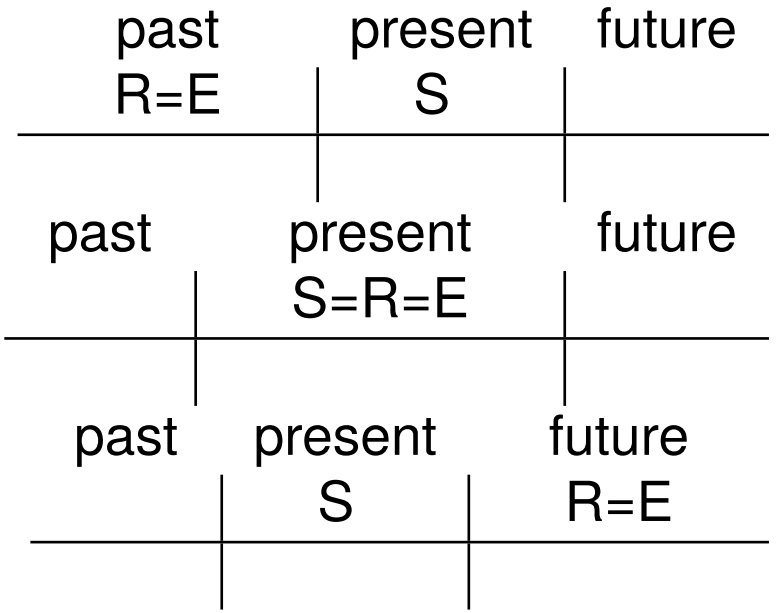
- The relation between them is refered to as
  - linking; syntax-semantics interface; grammar

How Universal is Tense?

- Grammatical tense is different from semantic time
- English has `past/non-past`
- Latin marks `past/present/future`
- Chibemba (Bantu) has **metrical tense**
  - Remote Past ($<$ yesterday)
  - Removed Past (yesterday)
  - Near Past (today)
  - Immediate Past (past few hours)
  - Immediate Future (next few hours)
  - Near Future (today)
  - Removed Future (tomorrow)
  - Remote Future ($>$ tomorrow)

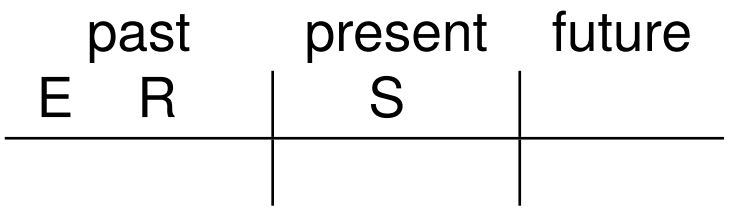
Tense and Time

- Locate a situation to with respect to a point in time
  - S = speech point
  - R = reference time
  - E = event time
- Hans Reichenbach (1947)
- Simple Tense
  - Past ($R = E < S$) *saw*
  - Present ($R = S = E$) *see*
  - Future ($S < R = E$) *will see*



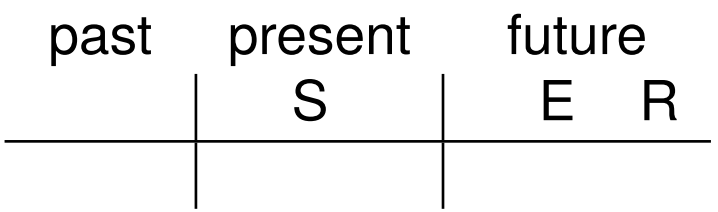
Complex Tense

- Past Perfect ($E < R < S$) *had seen*



By 1939 my Father had seen many arrests

- Future Perfect ($S < E < R$) *will have seen*



By 2039 my son will have seen many things

Aspect in English

- Finer grained talking about time!

- **Progressive** is used for ongoing processes (unfinished)
  - **Past Progressive** *I was building the building*
  - **Present Progressive** *I am building the building*
  - **Future Progressive** *I will be building the building*

- **Perfect** compares the time to the reference point
  - **Past Perfect** *I had built the building* ($E < R < S$)
  - **Present Perfect** *I have built the building* ($E < R = S$)
  - **Future Perfect** *I will have built the building* ($S < E < R$)

Aspect more Generally

- **Perfective** focuses on the end point
  - **Completive** *I built the building*
  - **Experiential** *I have built the building*
- **Imperfective**
  - **Progressive** *I was listening/I am listening*
  - **Habitual** *I listen to the Goon Show*
- Different languages grammaticalize different things

Mood and Modality

- Modality expresses varying degrees of the speaker's commitment and belief

- In English it is typically expressed by an auxiliary verb.

(52) *She has left by now.*
(53) *She must have left by now.*
(54) *She could have left by now.*
(55) *She needn't have left by now.*
(56) *She couldn't have left by now.*
(57) *She has to leave by now.*
(58) *She must leave by now.*
(59) *She can leave now.*

Other means of expression

- Explicit External Verb

  (60) *I know that* S

  (61) *I believe that* S

- Adverb or Adjective

  (62) *It is certain that* S

  (63) *It is likely that* S

  (64) *I will probably* S

  (65) *I will definitely* S

Knowledge vs Obligation

- **Epistemic modality**: Speaker signals degree of knowledge.

  (66) *You can drive this car* (You are able to)

- **Deontic modality**: Speaker signals his/her attitude to social factors of obligation and permission.
  - **Permission**

    (67) *You can drive this car* (You have permission to)

    (68) *You may drive this car*
  - **Obligation**

    (69) *You must drive this car* (You have an obligation to)

    (70) *You ought to drive this car*

? Find examples of each type (auxiliary, verb, adverb/adjective) in *The Final Problem*

? Determine whether they are deontic or epistemic

Possible Worlds

- We can analyze these in terms of **possible worlds**
- We mark how close a hypothetical case is to reality:

  (71) *It must be/might be/is/can't be hot outside*

  And model it as the degree of overlap of the worlds

- Similarly for **conditionals** (condition/consequence)

  (72) *If it is Singapore, it will be hot outside*
  (73) *If it were Singapore, it would be hot outside*
  (74) *If you should go to Singapore, take some cool clothes*

Mood more Generally

- Grammatical Inflection used to mark modality is called **mood**
  - **indicative** expresses factual statements
  - **conditional** expresses events dependent on a condition
  - **imperative** expresses commands
  - **injunctive** expresses pleading, insistence, imploring
  - **optative** expresses hopes, wishes or commands
  - **potential** expresses something likely to happen
  - **subjunctive** expresses hypothetical events; opinions or emotions
  - **interrogative** expresses questions

- In English most things are marked syntactically:

(75)	*I am good*	indicative
(76)	*Am I good?*	interrogative
(77)	*Be good!*	imperative
(78)	*If I were a rich man*	subjunctive

? Find examples of non-indicative sentences in *The Final Problem*

Evidentiality

- Some languages must show you gained the evidence item **nonvisual sensory**: speaker felt the sensation
  - /pʰa • bék^h-ink’ e/ “burned, I felt it”
- **inferential**: speaker saw circumstantial evidence
  - /pʰa • bék-ine/ “must have burned”
- **hearsay (reportative)**: speaker is reporting what was told
  - /pʰa • bék^h- • le/ “burned, they say”
- **direct knowledge**: speaker has direct evidence, probably visual
  - /pʰa • bék-a/ “burned, I saw it”
- Examples from Eastern Pomo (McLendon 2003)

Evidentiality in English

We can, and often do, mark evidentiality in English, although it is not strongly grammaticalized.

(79) *Bob is hungry.*

(80) *Bob looks hungry.*

(81) *Bob seems hungry.*

(82) *Bob is apparently hungry.*

(83) *Bob would be hungry by now.*

(84) *Look at those clouds! It's going to rain!*

(85) *Look at those clouds! # It will rain!.*

Word Sense Disambiguation for Close Reading

Close Reading

- Reading (and often re-reading) a text to uncover multiple aspects of meaning that lead you to understand a text better
- Looking at what the text actually says, as well as the inferences you make from reading it
- After a close reading you should be able to support your conclusions with specific examples from the text
- You can consider many aspects of the text, such as
  - The Title
  - Word Choice
  - The Tone and Style
  - Discerning Patterns
  - Point of View and Characterization
  - Symbolism

The idea comes from the study of poetry and is part of the school of *New Criticism* (e.g., Brooks and Warre, 1938, 1943)

Word Choice and Diction

- What word(s) stand out? Why? (typically vivid words, unusual choices, or a contrast to what a reader expects)
- How do particular words get us to look at characters or events in a particular way? Do they evoke an emotion?
- Did the author use nonstandard English or words in another language? Why? What is the effect?
- Are there any words that could have more than one meaning? Why might the author have played with language in this way?
- Do some words have extra connotations?

Word Sense Disambiguation

- Knowing what individual words mean is the first step towards understanding
- We will try to identify the **sense** of words
  - We use Wordnet (Fellbaum, 1998) as the sense inventory
    because it contains semantic relations as well as definitions
    and it is accessible: there are good interfaces to it
  - For every word we chose the most appropriate sense in wordnet
    or write a comment if we think there isn't one
  - Once we have identified a sense, it is then easy to look at synonyms and other closely related words

➢ *Sherlock Holmes had been leaning back in his chair with his eyes closed and his head sunk in a cushion, but he half opened his lids now and glanced across at his visitor.*

1. ***hat, chapeau, lid*** “headdress that protects the head from bad weather; has shaped crown and usually a brim”
2. ***lid, eyelid, palpebra*** “either of two folds of skin that can be moved to cover or open the eye”
3. ***lid*** “a movable top or cover (hinged or separate) for closing the opening at the top of a box, chest, jar, pan, etc.”

- This is difficult for many reasons
  - Meaning boundaries are not clear: the sense distinctions impose a structure on something that is actually fuzzy
  - Dictionaries are imperfect
    - senses may be missing
    - senses may be too fine-grained
  - Processing a text by computer is difficult
    - The computer may have misinterpreted
      - the part-of-speech
        Does that go “Female deer which go” “Is it the case that is goes?”
        The speckled band “the band that is speckled” “the band that someone speckled”
      - Or the sentence boundaries
      - Or the words boundaries
  - People use language idiosyncratically
    - extending meanings metaphorically
    - sometimes so strangely that we might even say wrongly

- Typically people agree around 72.5% of the time (Snyder and Palmer, 2004).
  - Verbs are hardest (67.8%), then nouns (74.9%) and adjectives (78.5%)
  - Disagreements tend to cluster around a relatively small group of difficult words.
  - For example ***national***
    - In six out of seven instances one annotator chose “limited to or in the interests of a particular nation” and the other annotator chose “concerned with or applicable to or belonging to an entire nation or country”
    - They are hard to distinguish!

Projects 1 and 2

1 Identify and annotate word meaning for your own passage of one of the stories using wordnet as the sense inventory: 3 or 4 people do the same set of sentences.

- For every word that needs to be tagged, either
  - Chose a sense in wordnet
  - Identify it as a named entity
  - Identify a problem in the corpus or wordnet
    and leave a comment saying what the it should be
- Do this on your own — the goal is to think about the words' meanings

2 Compare and contrast your annotations with other annotators; re-annotate based on your discussion and leave comments for at least five words.

- We expect you to disagree 30-40% of the time (more often than experts)
- Sometimes you will have made a careless mistake
- Sometimes you will have interpreted wordnet differently
- Sometimes you will have interpreted the passage differently
- Discussing meaning deepens your understanding of it

Conclusions

- Situations are represented by verbs
- Semantic roles can be used to make the relations between the situation and the participants clearer
- Close reading of a text helps to understand it more fully
- Determining the meanings of words is one part of building up understanding

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References

Emily Bender. 2013. *Linguistic Fundamentals for Natural Language Processing: 100 Essentials from Morphology and Syntax*. Synthesis Lectures on Human Language Technologies. Morgan & Claypool.

Cleanth Brooks and Robert Penn Warre. 1938. *Understanding Poetry*. Appleton-Century-Crofts.

Cleanth Brooks and Robert Penn Warre. 1943. *Understanding Fiction*. Appleton-Century-Crofts.

Christine Fellbaum, editor. 1998. *WordNet: An Electronic Lexical Database*. MIT Press.

Charles J. Fillmore. 1968. The case for case. In Emmon Bach and Robert T. Harms, editors, *Universals in Linguistic Theory*, pages 1–88. Holt, Rinehart and Wilson, Inc, New York.

Jerrold J. Katz and Jerry A. Fodor. 1963. The structure of a semantic theory. *Language*, 39(2):170–210.

Beth Levin. 1993. *English Verb Classes and Alternations*. University of Chicago Press, Chicago, London.

Martha Palmer, Dan Gildea, and Paul Kingsbury. 2005. The proposition bank: An annotated corpus of semantic roles. *Computational Linguistics*, 31(1).

John I. Saeed. 2009. *Semantics*. Wiley-Blackwell, third edition.

Benjamin Snyder and Martha Palmer. 2004. The English all-words task. In *Proceedings of Senseval-3*, pages 41–44. ACL, Barcelona.