

ANLP Lecture 28: Coreference

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- What is co-reference, what makes co-reference resolution hard, and what sources of information are relevant?
 - What is a discourse model and what are discourse entities?
 - What are some different kinds of referring expressions and how do these relate to information status?
 - What is a Winograd schema and what is it supposed to test?

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Recap

In thinking about meaning we have discussed:

- Distributional representations for word meaning.
- Symbolic representations for words and how to combine these to form sentence meanings.
 - Our meaning representation language used **constants** to represent **entities**.
 - Same constant (symbol) always refers to same entity.
 - Does natural language do the same?

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Co-reference exercise

- How many entities are referred to?
- How many **referring expressions (REs)** are there?
- Do all references to a particular entity use the same RE?
- Do all identical REs refer to the same entity?

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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Co-reference exercise

- There are 7 entities and many more REs (aka **mentions**).
- The list of REs that refer to the same entity constitutes a **co-reference chain**. Chains for this example:

- | | |
|---------------------------------|--|
| 1. {Ashwini Noir, She, Ashwini} | 4. {a volunteer, A woman, her, her, She} |
| 2. {the stage} | 5. {her hand} |
| 3. {the audience} | 6. {a card, one, it} |
| | 7. {the deck} |

Note: "The famous magician" is an **appositive phrase** (describing rather than introducing new entity). In some annotation schemes, it's included in the mention: "The famous magician, Ashwini Noir" is a single mention.

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Co-reference exercise

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| 3. {the audience} | 6. {a card, one, it} |
| | 7. {the deck} |
- Unlike constants in MRL, two REs that look the same ("She", "She") may pick out different entities: more ambiguity!
 - Figuring out which REs refer to the same entity (building these chains) is called **co-reference resolution**.

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Discourse entities vs real-world entities

- Last time, we assumed constants denote entities in the world.
- Here, we are one step removed:
 - Assume the listener/system builds a **discourse model** while listening/reading.
 - This model builds up facts about **discourse entities**.
 - We may later need to map those entities to real-world entities (**entity linking**), e.g., to unique IDs of individuals.

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More terminology

- The discourse entity an RE refers to is its **referent**.
 - {The famous magician, Ashwini Noir, She, Ashwini} all have the same referent. That is, they **co-refer**.
 - An **anaphor** is a RE that co-refers with an earlier RE: an **antecedent**. The act of doing so is **anaphora**.

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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More terminology

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Types of REs and information status

- This example included several types of REs:
 - indefinite noun phrases (a volunteer, a woman)
 - definite noun phrases (the stage, the deck)
 - names (Ashwini Noir, Ashwini)
 - pronouns (She, her, one, it)
- Which type is appropriate depends on the **information status** of the RE: where does it fall between
 - **Given**: very salient or predictable
 - **New**: not salient, unpredictable

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Types of REs: indefinite noun phrases

- In English, usually an NP with determiner "a"/"an".
- Normally refers to an entity that is both:
 - **Discourse-new**: not mentioned before, must be added to the discourse model
 - **Hearer-new**: the hearer doesn't know about it already.

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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Types of REs: definite noun phrases

- In English, usually an NP with determiner "the" (but also "his", "her", "this", and others)
- May refer to a **discourse-old** entity. Are these?

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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Types of REs: definite noun phrases

- In English, usually an NP with determiner “the” (but also “his”, “her”, “this”, and others)
- No. Most are discourse-new and hearer-new, but are **inferred** based on world knowledge and the discourse model so far – therefore definite (identifiable).

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

(Can also have something like “the president of the US”: discourse-new but **hearer-old**, because the hearer already knows they exist.)

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Types of REs: names

- May refer to an entity that is either new or old to both discourse and hearer.
 - But given/new still matters: should I use full name (Ashwini Noir), shorter version (Ashwini), or some other type of RE?

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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Types of REs: pronouns

- Normally refer to entities that are **discourse-old** (and therefore also (hearer-old)).
 - More specifically, usually refer to entities that are **highly salient**.

The famous magician, Ashwini Noir, stepped onto the stage. She turned to the audience and asked for a volunteer. A woman raised her hand. Ashwini asked her to step forward and take a card. She pulled one from the deck and gave it to Ashwini.

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Types of REs: pronouns

- Even when unambiguous, it's weird to use a pronoun if the entity isn't salient enough. For example:

The famous magician, Ashwin Noir, stepped onto the stage. He turned to the audience and asked for a volunteer. A woman raised her hand. She was tall and looked a bit nervous, but she stepped forward when chosen. He/Ashwin asked her to take a card. She pulled one from the deck and gave it to him/Ashwin.

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Types of REs: pronouns

- Even when unambiguous, it's weird to use a pronoun if the entity isn't salient enough. For example:

The famous magician, Ashwin Noir, stepped onto the stage. He turned to the audience and asked for a volunteer. A woman raised her hand. She was tall and looked a bit nervous, but she stepped forward when chosen. He/**Ashwin** asked her to take a card. She pulled one from the deck and gave it to **him**/Ashwin.

"Ashwin" is better in the first case. "He" is harder to understand because at this point the woman is more salient than Ashwin.

"him" is better in the second case because Ashwin is salient again (so repeating the name sounds weird).

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Zero anaphora

- In other languages, it's possible to refer to an entity without any surface realization [word] at all.
- E.g., Chinese (ex from JM3):

我 前一会精神上太紧张。 现在比较平静了

I was too nervous a while ago. ... I am now calmer.

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Related tasks

- Mention detection: find NPs and decide which are REs.

She wanted it to rain vs. She wanted it badly
My dog is a black Labrador

- Coreference resolution: which REs co-refer?
- Entity linking: link discourse entities to real-world entities (unique IDs, e.g., entry in ontology or Wikipedia).
- Getting all this right is hard, especially if working with multiple documents!

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What went wrong here?

The screenshot shows a tweet from Iain Murray (@ianmurraymp) dated 7:07 AM - 23 Mar 2016. The tweet text is: "Poor @ianmurraymp gets my picture on Google. @googlere search will be painfully aware that entity resolution is hard!". Below the text is a profile card for Ian Murray, a British politician. The card includes his name, title, a brief bio, and personal details like birth date, spouse, education, and political party. A small photo of Ian Murray is also present. The tweet is marked as 'Follow'.

- Real example of coreference/entity linking failure – even when names are spelled differently!
- (Why? Because names **do** vary in spelling due to errors, use of initials and other real variants)

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Focus here: coreference resolution

- We'll stick to linguistic aspects of this: what features can help? What makes it hard?
- JM3 also discusses the other tasks (mention detection, entity linking) and technical descriptions of some systems. Feel free to read, but non-examinable.

Linguistic agreement

- In English, pronouns agree with their antecedent in:
 - Number (singular/plural):

Take **a card** and look at **it**.
Take **your cards** and look at **them**.

- Gender (neuter/feminine/masculine/unspecified):

Take **a card** and look at **it**.
A **woman** raised **her** hand.
A **man** raised **his** hand.
Someone raised **their** hand.

Linguistic agreement

- In English, pronouns agree with their antecedent in:
 - Person (1st/2nd/3rd):

Kim and I are leaving. **We** need to find **our** car.
Kim and Sandy are leaving. **They** need to find **their** car.

- Agreement varies across languages, e.g.,
 - May have no gender agreement at all, or gender agreement marked on full NPs (not just pronouns).
 - NPs may also have more than 2-3 “genders” (noun classes).

Agreement can help resolve ambiguity

- Which mentions co-refer in each case?

The secretary read the letter to the workers. **It** was angry.
The secretary read the letter to the workers. **They** were angry.
The secretary read the letter to the workers. **He** was angry.

Agreement can help resolve ambiguity

- Which mentions co-refer in each case?

The secretary read the letter to the workers. **It** was angry.

The secretary read the letter to the workers. **They** were angry.

The secretary read the letter to the workers. **He** was angry.

- Using indexing notation:

[The secretary]_i read [the letter]_j to [the workers]_k. [It]_j was angry.

[The secretary]_i read [the letter]_j to [the workers]_k. [They]_k were angry.

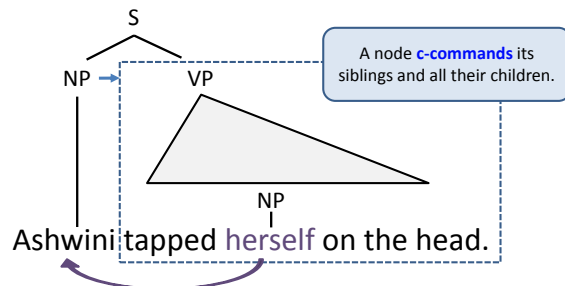
[The secretary]_i read [the letter]_j to [the workers]_k. [He]_i was angry.

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Reflexives

- Use of (non)reflexives is constrained by syntax:



Reflexive NP: antecedent NP **must c-command** the reflexive.

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Reflexives

- Agreement alone can't always force co-reference:

Looking at [the workers]_i, [the woman]_j saw [them]_i critically.

Looking at [the workers]_i, [the woman]_j saw [her]_k critically.

- To co-refer with "woman" requires a reflexive pronoun:

Looking at [the workers]_i, [the woman]_j saw [herself]_j critically.

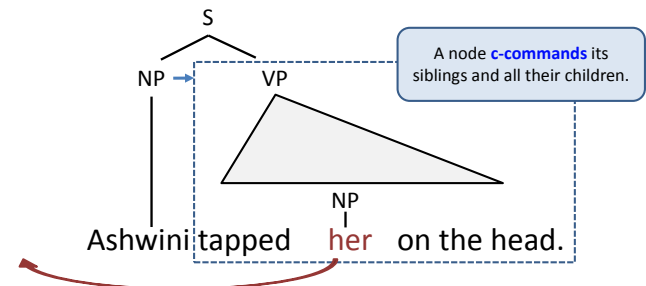
- Use of (non)reflexives is determined by syntactic constraints (ie, relationships in the phrase structure tree).

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Reflexives

- Use of (non)reflexives is constrained by syntax:



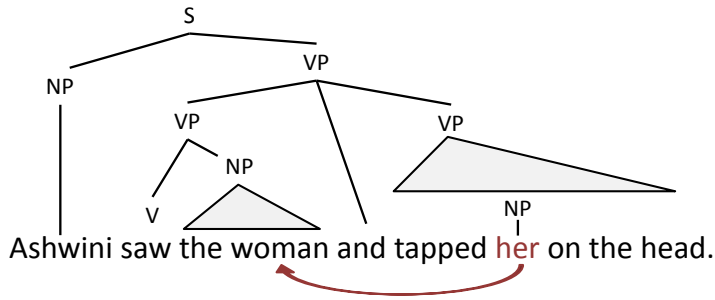
Pronoun NP: antecedent NP **must not c-command** the pronoun.

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Reflexives

- Use of (non)reflexives is constrained by syntax:



(You don't need to memorize the syntactic details here, but you should be able to recognize examples where syntactic constraints might help resolve the coreference.)

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Other features

- Since pronouns usually refer to more salient entities, we can use clues to salience. Salience tendencies:
 - Recency: mentioned more recently > less recently
 - Syntax: subject position > object position > other positions
- Semantics, discourse context and world knowledge...

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Effects of semantics and context

- Sometimes knowing about individual verbs is enough (**selectional restrictions**: what possible types of arguments?)

I took my [homework]_i to the [café]_j and...
...worked on [it]_i all day.
...sat in [it]_j all day.

- But sometimes, things are trickier (Winograd, 1972):

The [city council]_i denied [the demonstrators]_j a permit because...
...[they]_i feared violence.
...[they]_j advocated violence.

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Winograd schemas

- Co-reference challenge data sets, using sentence pairs:
 - Two entities, pronoun can grammatically refer to either.
 - Question asks which entity pronoun refers to.
 - Changing one word changes the human-preferred answer.

The trophy didn't fit into the suitcase because it was too [large/small].
Q: What was too [large/small]? A: the trophy/the suitcase.

Bill passed the gameboy to John because his turn was [over/next].
Q: Whose turn was [over/next]? A: Bill/John

- Seem to require "world knowledge": e.g., about physical world or social conventions.
 - Though sufficiently large language models do surprisingly well.

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What is “world knowledge”?

- Humans observe the physical world and how things behave in it.
- NLP systems observe how humans talk about the world.
 - Our text contains many statistical patterns that reflect our own world knowledge...
 - But also reflects our own biases, and sometimes magnifies them.

Questions for review

- What is co-reference and what can make it hard?
- What sources of information are relevant?
- What is a discourse model and what are discourse entities?
- What are some different kinds of referring expressions and how do these relate to information status?
- What is a Winograd schema and what is it supposed to test?

Example: gender bias

The secretary read the letter to the workers. He was angry.

The secretary read the letter to the workers. She was angry.

- In many cultures today, secretaries tend to be female.
- This bias in the data we observe makes it harder for people from those cultures to process the first (**anti-stereotypical**) example than the second (**pro-stereotypical**) example.
 - Measured, for example, by reading time or eye movements.
- Do NLP systems have similar biases? If so, where do they come from, what are the effects, and can we overcome them?
 - We’ll talk about this next time.

Questions and exercises

Choose a paragraph or two from a news article that includes several people and/or other named entities. Identify all of the referring expressions and cluster them into co-reference chains. Then consider the following questions:

1. Can you identify specific features discussed in the lecture that help disambiguate which REs co-refer?
2. Are there any cases you found difficult to decide about? Are there any cases that you think an NLP system might have trouble with? In each case, what makes them difficult?
3. Pick one or two of the entities that are referred to several times. Do you see the expected pattern between given/new information and the type of referring expression?