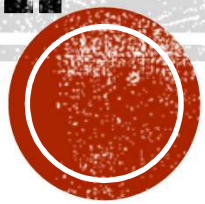
Discourse Linguistics: Coreference Resolution



adopted some materials developed in previous courses by Nancy McCracken, Liz Liddy and others; and some instructor resources for the book "Speech and Language Processing" by Daniel Jurafsky and James H. Martin

Anaphora/Co-Reference Resolution

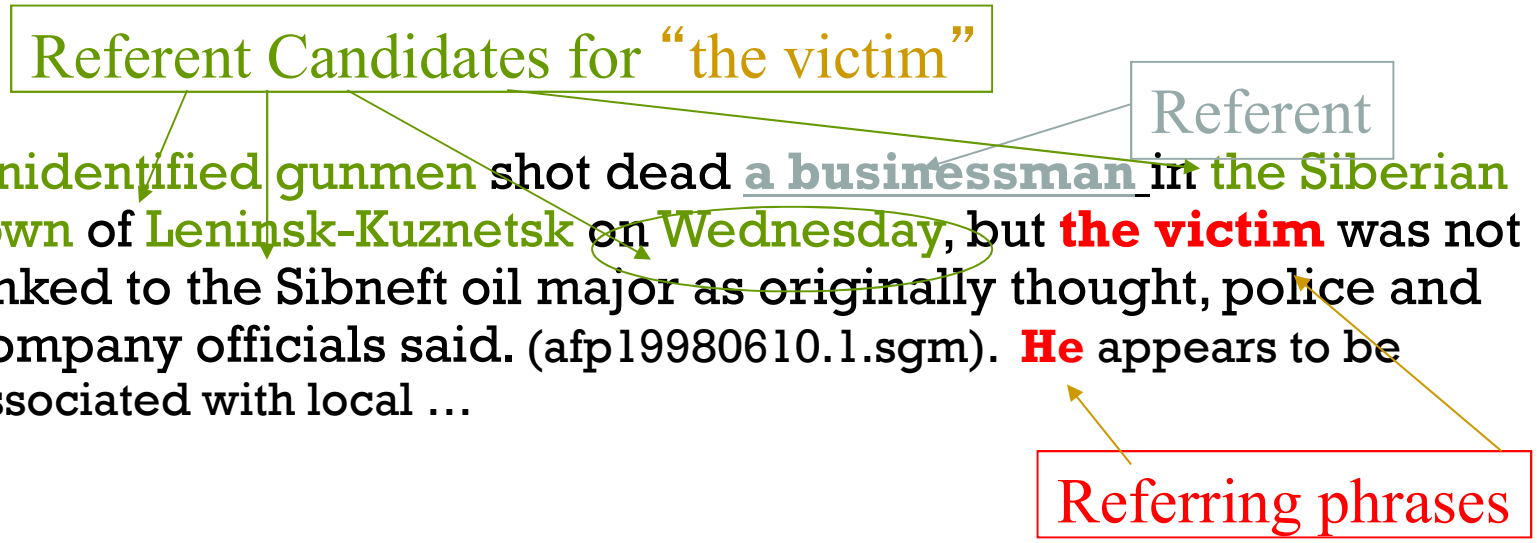
- A linguistic phenomenon of abbreviated subsequent reference
  - A cohesive tie of the grammatical and lexical types
    - Includes reference, substitution and reiteration
  - A technique for referring back to an entity which has been introduced with more fully descriptive phrasing earlier in the text
  - Refers to this same entity but with a lexically and semantically attenuated form

Types Of Entity Resolutions

- **Entity Resolution** is an ability of a system to recognize and unify variant references to a single entity.
  - Coreference algorithms usually performed within larger task of entity resolution
- 2 levels of resolution:
  - within document (includes **co-reference resolution**)
    - e.g. *Bin Ladin = he*
    - *his followers = they*
    - *terrorist attacks = they*
    - *the Federal Bureau of Investigation = FBI = F.B.I*
  - across document (or **named entity resolution**)
    - e.g. *Usama Bin Ladin =Osama Bin Ladin = Bin Ladin*
- **Event resolution** is also possible
  - Bejan, C. A., & Harabagiu, S. (2014). Unsupervised event coreference resolution. *Computational Linguistics*, *40*(2), 311-347.

Terminology Examples

- The referent for a referring phrase is found by the resolution algorithm among the candidates, previous noun phrases.



Reference Types

- An algorithm must first decide which are the referring phrases that must be resolved
  - Pronouns
  - Definite noun phrases (the)
  - Indefinite noun phrases (a, an)
  - Names
  - Others

Pronouns

- **Pronouns** refer to entities that were introduced fairly recently, 1-4-5-10(?) sentences back.
  - ***Nominative*** (he, she, it, they, etc.)
    - e.g. The German authorities said **a Colombian$_1$** who had lived for a long time in the Ukraine flew in from Kiev. **He$_1$** had 300 grams of plutonium 239 in his baggage.
  - ***Oblique*** (him, her, them, etc.)
    - e.g. Undercover investigators negotiated with **three members of a criminal group$_2$** and arrested **them$_2$** after receiving the first shipment.

Pronouns

- **Pronouns** refer to entities that were introduced fairly recently, 1-4-5-10(?) sentences back.
  - ***Possessive*** (his, her, their, etc. + hers, theirs, etc.)
    - e.g. **He$_3$** had 300 grams of plutonium 239 in **his$_3$** baggage. The suspected smuggler$_3$* denied that the materials were **his$_3$**. ***(*chain)***
  - ***Reflexive*** (himself, themselves, etc.)
    - e.g. There appears to be a growing problem of **disaffected loners$_4$** who cut **themselves$_4$** off from all groups .
  - ***Demonstrative pronouns*** (this, that, etc.) can either appear alone or as determiners

    this ingredient, that spice
    - These NP phrases with determiners are ambiguous: they can be indefinite (e.g., I saw this beautiful car today) or definite (e.g., I just bought a copy of Thoreau's Walden. I had bought one five years ago. That one had been very tattered; this one was in much better condition).

Definite Noun Phrases – The X

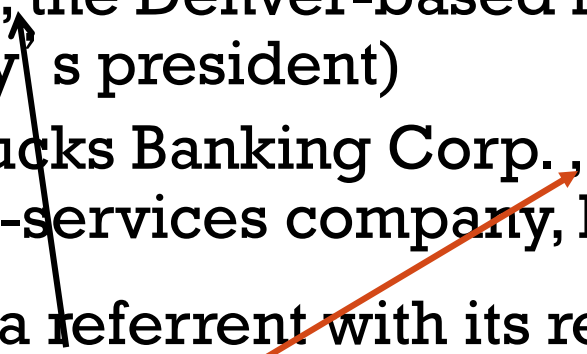
- Definite reference is used to refer to an entity identifiable by the reader because it is either
  - a) already mentioned previously (in discourse), or
  - b) contained in the reader's set of beliefs about the world (pragmatics), or
  - c) the object itself is unique. (Jurafsky & Martin, 2000)
- E.g.
  - Mr. Torres and his companion claimed **a hardshelled black vinyl suitcase$_1$**. The police rushed **the suitcase$_1$** (a) to **the Trans-Uranium Institute$_2$** (c) where experts cut **it$_1$** open because they did not have the combination to the locks.
  - **The German authorities$_3$** (b) said **a Colombian$_4$** who had lived for a long time in **the Ukraine$_5$** (c) flew in from Kiev. He had **300 grams of plutonium 239$_6$** in his baggage. **The suspected smuggler$_4$** (a) denied that **the materials$_6$** (a) were his.

Indefinite Noun Phrases – A X, Or An X

- Typically, an indefinite noun phrase introduces a new entity into the discourse and would not be used as a referring phrase to something else
  - The exception is in the case of cataphora:
    A Soviet pop star was killed at a concert in Moscow last night. Igor Talkov was shot through the heart as he walked on stage.

Names

- Names can occur in many forms, sometimes called name variants.
  Victoria Chen, Chief Financial Officer of Megabucks Banking Corp. since 2004, saw her pay jump 20% as the 37-year-old also became the Denver-based financial-services company's president. Megabucks expanded recently . . . MBC . . .
  - (Victoria Chen, Chief Financial Officer, her, the 37-year-old, the Denver-based financial-services company 's president)
  - (Megabucks Banking Corp. , the Denver-based financial-services company, Megabucks, MBC)
- Groups of a referrent with its referring phrases are called a coreference group.



Unusual Cases

- Compound phrases

  John and Mary got engaged. They make a cute couple.
  John and Mary went home. She was tired.

- Singular nouns with a plural meaning

  The focus group met for several hours. They were very intent.

- Part/whole relationships

  John bought a new car. A door was dented.

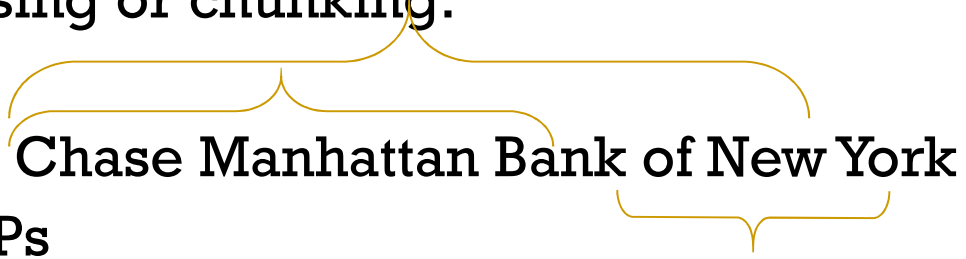
Four of the five surviving workers have asbestos-related diseases, including three with recently diagnosed cancer.

Approach To Coreference Resolution

- Naively identify all referring phrases for resolution:
  - all Pronouns
  - all definite NPs
  - all Proper Nouns
- Filter things that look referential but, in fact, are not
  - e.g. geographic names, *the United States*
  - pleonastic "it", e.g. *it's 3:45 p.m., it was cold*
  - non-referential "it", "they", "there"
    - e.g. *it was essential, important, is understood,*
    - *they say,*
    - *there seems to be a mistake*

Identify Referent Candidates

- All noun phrases (both indef. and def.) are considered potential referent candidates.
- A referring phrase can also be a referent for a subsequent referring phrases,
  - Example: (omitted sentence with name of suspect)
    He had 300 grams of plutonium 239 in his baggage. The suspected smuggler denied that the materials were his. (chain of 4 referring phrases)
- All potential candidates are collected in a table collecting feature info on each candidate.
- Requires either parsing or chunking:
  - chunking
    - e.g. the Chase Manhattan Bank of New York
  - Note nesting of NPs



Some Features

- Define features between a referring phrase and each candidate
  - Number agreement: plural, singular or neutral
    - He, she, it, etc. are singular, while we, us, they, them, etc. are plural and should match with singular or plural nouns, respectively
    - Exceptions: some plural or group nouns can be referred to by either it or they
      IBM announced a new product. They have been working on it …
  - Gender agreement:
    - Generally animate objects are referred to by either male pronouns (he, his) or female pronouns (she, hers)
    - Inanimate objects take neutral (it) gender
  - Person agreement:
    - First and second person pronouns are "I" and "you"
    - Third person pronouns must be used with nouns

Some Features (cont'd)

- Binding constraints
  - Reflexive pronouns (himself, themselves) have constraints on which nouns in the same sentence can be referred to:
    John bought himself a new Ford. (John = himself)
- Recency
  - Entities situated closer to the referring phrase tend to be more salient than those further away
    - And pronouns can't go more than a few sentences away
- Grammatical role, sometimes approximated by Hobbs distance
  - Entities in a subject position are more likely than in the object position

Approaches

- Train a classifier over an annotated corpus to identify which candidates and referring phrases are in the same coreference group
  - Evaluation results (for example, Vincent Ng at ACL 2005) are on the order of F-measure of 0.70, with generally higher precision than recall

- Lassalle, E., & Denis, P. (2015, January). Joint Anaphoricity Detection and Coreference Resolution with Constrained Latent Structures. In *AAAI* (pp. 2274-2280)
  - employ latent trees to represent the full coreference and anaphoricity structure of a document

- Prokofyev, R., Tonon, A., Luggen, M., Vouilloz, L., Difallah, D. E., & Cudré-Mauroux, P. (2015, October). SANAPHOR: ontology-based coreference resolution. In *International Semantic Web Conference* (pp. 458-473). Springer International Publishing
  - Leverages Semantic Web technologies

Summary Of Discourse Level Tasks

- Dialogue structure (discourse segmentations, discourse relations, text coherence)
- Document structure
  - Recognizing known structure, for example, abstracts
  - Separating documents according to known structure
- Named entity resolution across documents

Topic Modelling

- Examination of patterns in the given text(or corpus) at the semantic level by extracting *topics* from *texts*
- What is a topic?
- A list of words that occur in statistically meaningful ways (for the computer)
- What is a text?
- Unstructured text such that no computer-readable annotations available that indicate the semantic meaning of the words in the text
- Is it always useful?
  - Small number of documents (or even a single document) – maybe not
  - Hundreds of documents – may be

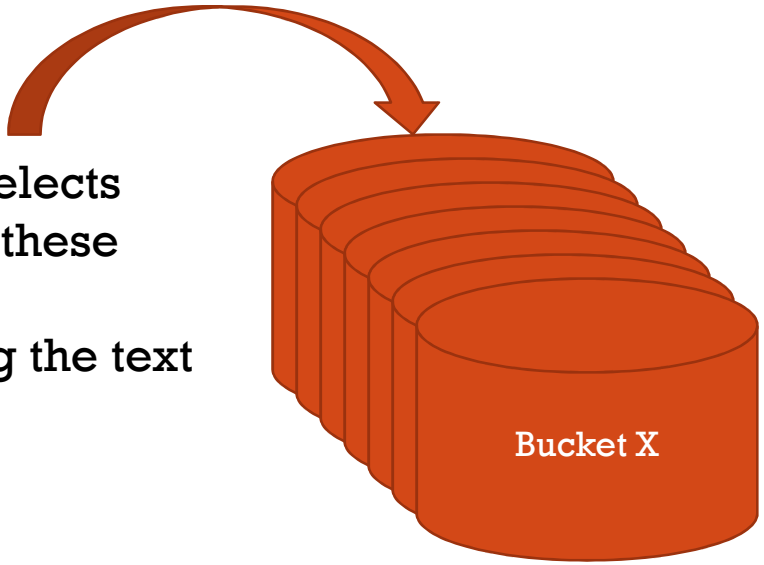
Topic Modelling - LDA

- An unsupervised method that models documents and topics based on Dirichlet distribution
  - each document is considered to be a distribution over various topics and each topic is modeled as a distribution over words.
- To model the distributions, LDA also requires the number of topics (often denoted by *k*) as an input.

  For instance, the following are the topics extracted from a random set of tweets from Canadian users where k = 3:
  - Topic 1: great, day, happy, weekend, tonight, positive experiences
  - Topic 2: food, wine, beer, lunch, delicious, dining
  - Topic 3: home, real estate, house, tips, mortgage, real estate

LDA Topic Modeling: Assumption

An author selects words from these buckets in constructing the text



A bucket contains words that are related to one topic

Topic Modeling - LDA

	W1	W2	W3	…	Wm
D1					
D2					
D3					
…					
Dn					

P1: proportion of words in document d that are currently assigned to topic t

P2: proportion of assignments to topic t over all documents that come from word w

	K1	K2	K3	…	K
D1					
D2					
D3					
…					
Dn					

	W1	W2	W3	…	Wm
K1					
K2					
K3					
…					
K					

Topic Modeling - LDA

- Domain knowledge
  - α:
    - a low α value: more weight on having each document being composed of only a few dominant topics,
    - a high α value: more weight on having each document being composed of a relatively larger set of topics.
  - β:
    - a low β value: more weight on having each topic being composed of only a few dominant words.
    - a high β value: more weight on having each topic being composed of a relatively larger set of topics.
- Number of topics: Kullback Leibler Divergence Score (KL divergence)
  - On Finding the Natural Number of Topics with Latent Dirichlet Allocation: Some Observations

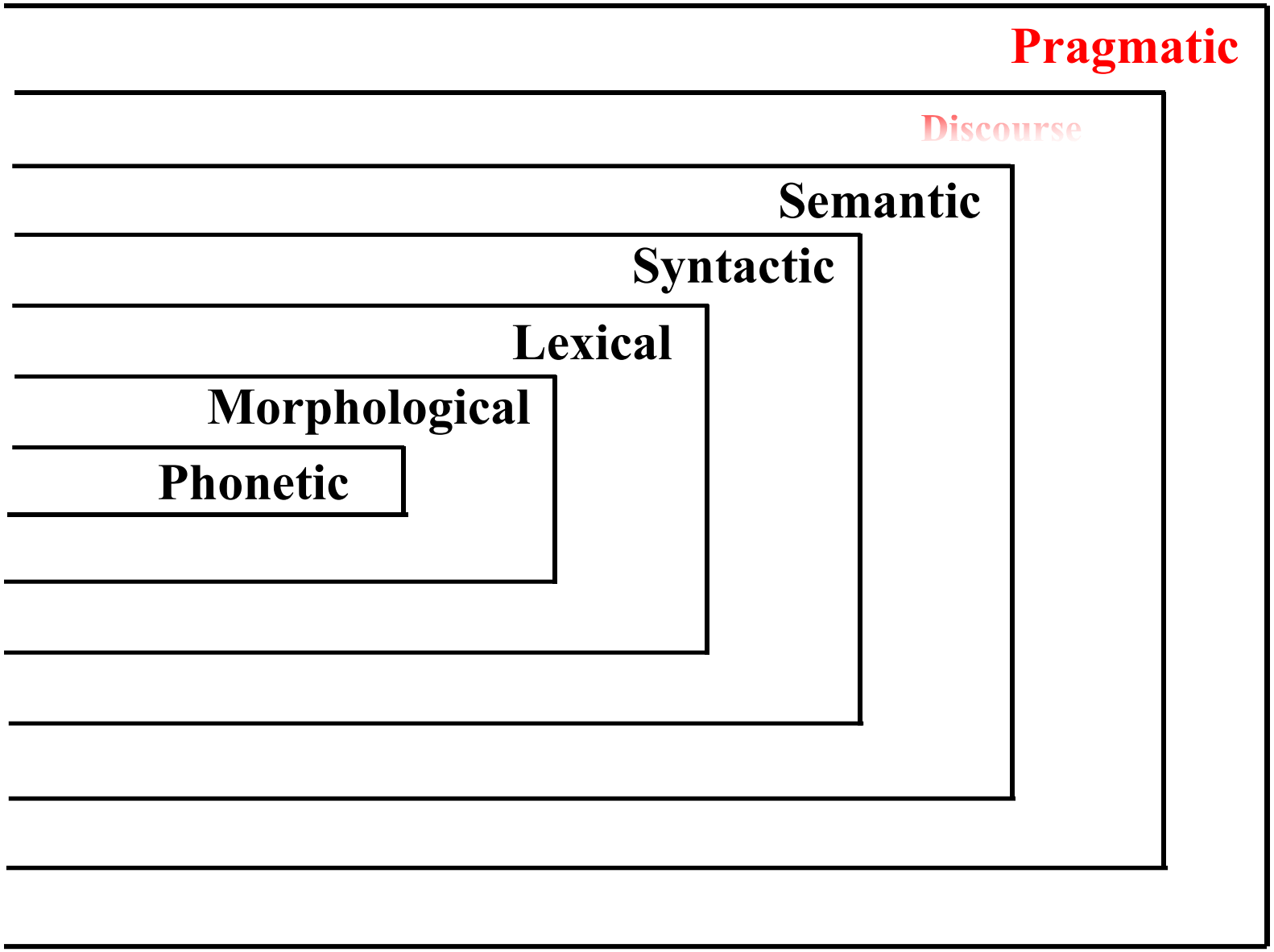
Arun, R., Suresh, V., Madhavan, C. V., & Murthy, M. N. (2010, June). On finding the natural number of topics with latent dirichlet allocation: Some observations. In *Pacific-Asia Conference on Knowledge Discovery and Data Mining* (pp. 391-402). Springer, Berlin, Heidelberg.

Topic Modeling

- Youtube video: https://www.youtube.com/watch?v=yK7nN3FcgUs
- Complete guide to topic modeling
  - https://nlpforhackers.io/topic-modeling/
- LDA (Latent Dirichlet Allocation) paper
  - http://www.jmlr.org/papers/volume3/blei03a/blei03a.pdf
- Topic modeling in Python
  - Non-negative Matrix Factorization (NMF)
    - https://de.dariah.eu/tatom/topic_model_python.html
  - Gensim package

Pragmatics Level: Dialogue Theory

Synchronic Model Of Language



Pragmatics

- Functional perspective - The study of language in use
- Generally, aspects of language which require context to be understood
  - How the situational context is grammaticalized
  - World knowledge (knowledge bases) used for understanding
    - Useful pragmatics for semantic understanding of any text
- **One specific goal is to explain how extra meaning is read into utterance without actually being encoded in them**

Topics

- Theory: Properties of Human Conversations
  - **Speech Act Theory**
  - Gricean Maxims
  - Conversational Structure
  - Dialogue Act Theory

Speech Act Theory

A speech act is a performative utterance in communication

- Communication succeeds only if the intention of the speaker is recognized by the listener
  - Proposed by John Austin in 1962 in *How To Do Things With Words*
  - Systematized by John Searle in 1969 in *Speech Acts: An Essay in the Philosophy of Language*

- Propositional content (the literal meaning of the text) does not always fully communicate the speaker's intent
  - Example: *I'm going to pay you back for that.*

Speech Act Theory

- Three Levels of Speech Acts affecting the social reality of the speaker and listener:
  - Locutionary – proposition of speech act
    - The meaning of the sentence (what we've been working on in NLP)
  - Illocutionary – intention of speech act
    - The act of asking, answering, promising, etc. in uttering a sentence
  - Perlocutionary – consequences of speech act
    - The (often intentional) production of certain effects upon the feelings, thoughts, or actions of the addressee in uttering a sentence

"almost any speech act is really the performance of several acts at once, distinguished by different aspects of the speaker's intention: there is the act of saying something, what one does in saying it, such as requesting or promising, and how one is trying to affect one's audience." *Bach*

Speech Act Theory

- **Examples:**

"I'm telling you not to do that."

→Locutionary analysis: the speaker asks the listener not to do **that**

→Illocutionary analysis: this message is a ***warning***

→Perlocutionary analysis: if the listener does not do it after this message, the message is ***persuasive***

Speech Act Theory

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Taxonomy Of Illocutionary Acts

1. **Assertives** – commit the speaker to something's being the case – *suggest, swear, boast, conclude*

2. **Directives** – attempts by speaker to get listener to do something – *ask, order, request, invite, advise*

3. **Commissives** – obligate oneself to future course of action – *promise, plan, vow, oppose*

4. **Expressives** – share psychological state of speaker about something – *apologize, deplore, thank*

5. **Declarations** – bring about a different state of the world as a result of the utterance – *resign, baptize, marry*

Types Of Directives (Ervin-tripp, 1976)

Type of Directives	Example
Need statements	I need a match.
Imperatives	Give me a match.
Embedded imperatives	Could you give me a match?
Permission directives	May I have a match?
Question directives	Got a match?
Hints	The matches are all gone.

Imperatives

- Imperatives can also be used to express a suggestion, an invitation, a wish, an apology, etc.
  - Let's have dinner together. (suggestion)
  - Come in and have a seat. (invitation)
  - Have a good vacation! (wish)
  - Pardon me (apology)

Speech Act Theory

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