L98: Introduction to Computational Semantics

Lecture 14: Focus and Information Structure

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Lecture 14: Focus and Information Structure

1. Given-New structure and Focus
2. Centering Theory
3. Reference, Co-reference and Bridging
4. Definite Noun resolution

What is Discourse?

- Another subfield in Linguistics
- Concerned with models about how sentences fit together to create a coherent meaning
- Linguistic means of coherence
- Coherence relations (rhetorical relations)
- Reference and co-reference
- Information structure (also called Focus Structure)

NLP tasks concerned with information structure

- NLG
- dialogue systems
- predict topic changes in text
- summarisation
- support pronoun resolution
- bridging
- coherence based correction (beyond grammar correction)
- information packaging and delivery

Focus = New; Topic = Given

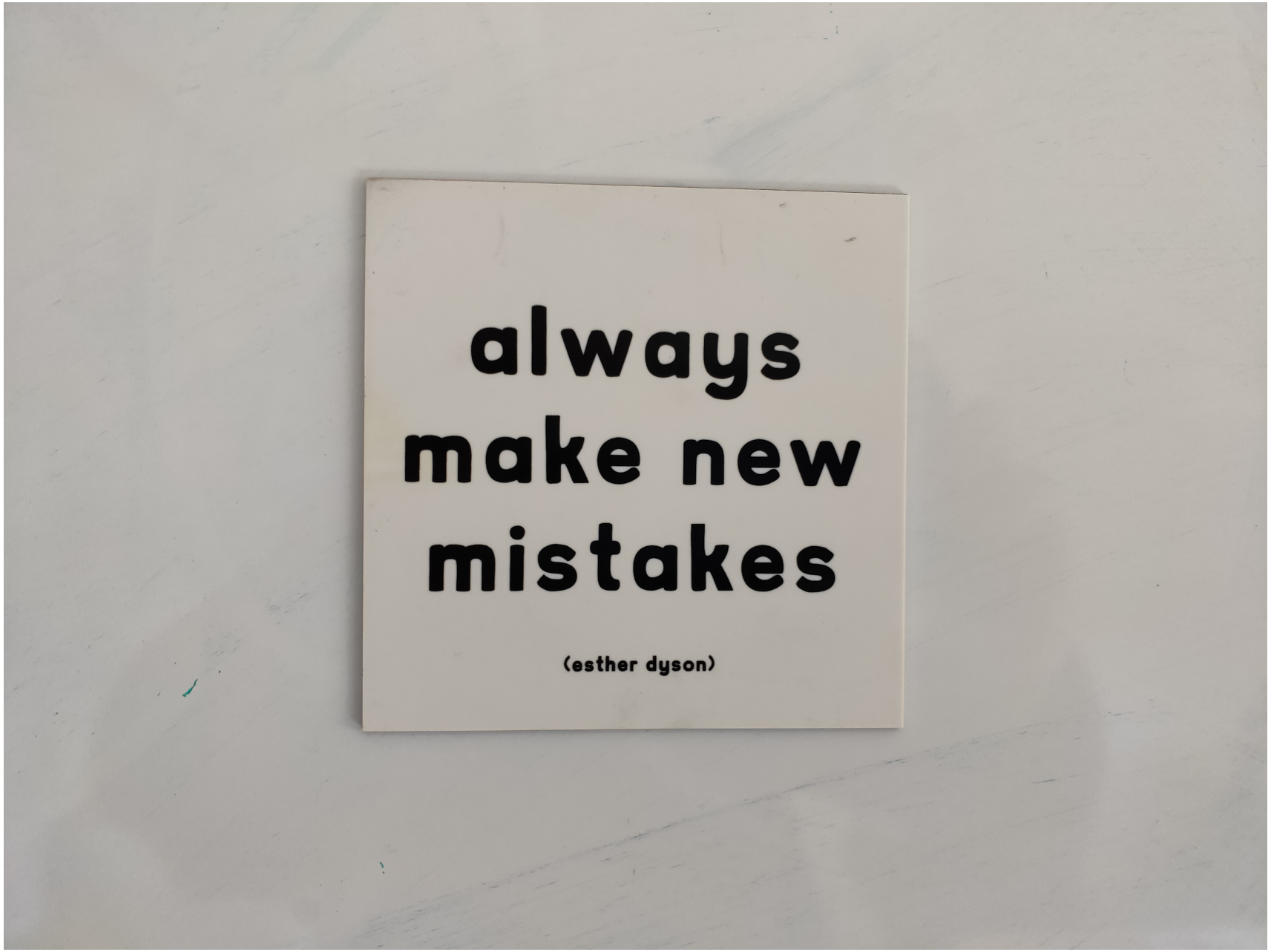
Given–new structure

- Each utterance is a delivery device for the new information we want our listener to understand
- There are specific places for the new information to go in the sentence
- Standard is at end of sentence:

  (1) I have never seen **such a pretty garden**

- Special places at the beginning of sentence also work, for instance in clefts:

  (2) It is **me** who has been waiting for hours


always
make new
mistakes
(esther dyson)

Cognitive Status Constraints

- Form of referring expression that is appropriate in any given context depends on
  - Attentional State of Listener
  - Shared Knowledge between Speaker and Listener

Example from Gundel et al. (1993):

I could not sleep last night.

1. A dog next door kept me awake. (type identifyable)
2. This dog next door kept me awake. (referential)
3. The dog next door kept me awake. (uniquely identifyable)
4. That dog next door kept me awake. (familiar)
5. That kept me awake. (activated)
6. It kept me awake. (in focus)

In Gundel et al's Givenness Hierarchy, a noun phrase is definite if its referent is at least uniquely identifyable.

Cognitive Status

- **type identifiable:** Listener is able to access a representation of the object type (in 1, knowing what a dog is).
- **referential:** Listener can either retrieve from memory the specific dog referred to, or construct a new representation for this specific dog.
- **uniquely identifiable:** Listener can uniquely identify the intended referent on basis of the noun phrase alone.
- **familiar:** Listener already has an accessible representation in memory. (4 can be used if the listener knows there is a dog next door.)
- **activated:** Listener has immediate access to the referent, i.e., it is in short-term memory, either through discourse or real world. (5 is acceptable if the listener can hear the dog barking.)
- **in focus:** The referent is the focus in the discourse, not only in short-term memory (compare to 5).

Givenness Hierarchy

	Focus	Activated	Familiar	Unique	Referential	Type Identifiable
English	it	HE, this, that, this N	that N	the N	indef., this N	a N
Chinese	Ø, ta (he, she, it)	TA, zhe, nei, zhe N (this, that N)		nei N		vi N (a N), Ø N
Japanese	Ø	kare (he), kore (this), sore (that-medial), are (that-distal), kono N (this N), sono N (that-medial N)	ano N (that-distal N)	Ø N		
Russian	Ø, on (he)	ON, eta (this), to (that)	eto N (this N), to N (this N)	Ø N		
Spanish	Ø, el (he)	EL, este (this), ese (that-medial), aquel (that-distal), este N (this N)	ese N (that-medial N), aquel N (that-distal N)	el N (the N)	Ø N, un N (a N)	

Gundel et al's evidence

	In focus	Activated	Familiar	Unique	Referential	Type	Totals
it	214	1					215
HE		1					1
this		15					15
that	1	17					18
this N	1	11					12
that N		10	7				17
the N	30	95	47	108			280
indefinite							
this N					1		1
a N					41	55	96
Totals	246	150	54	108	42	55	655

Table 3. Distribution of English forms according to highest status

	In focus	Activated	Familiar	Unique	Referential	Type	Totals
ø	25	1					26
tā	40						40
zhè		2					2
nèi							
zhè N	12	26	1				39
nèi N	1	7	2				10
yi N					17	2	19
N	12	17	14	49	2	10	104
Totals	90	53	17	49	19	12	240

Table 2. Distribution of Chinese forms according to highest status.

Centering (Grosz et al. 1995)

Centering Theory (Grosz et al. 1995)

A theory of Given-New structure in text. Grosz et al use terminology "attention" instead of topic/focus

Motivation I: Centering provides a model for judging the coherence aspect of text quality.

Less Coherent Text

John went to his favourite music store to buy a piano. It was a store John had frequented for many years. He was excited that he could finally buy a piano. It was closing just as John arrived.

More Coherent Text

John went to his favourite music store to buy a piano. He had frequented the store for many years. He was excited that he could finally buy a piano. He arrived just as the store was closing for the day.

Centering Theory (Grosz et al. 1995)

Motivation II: It can also be used for pronoun resolution, by predicting which references would be hard to process by a human.

A bad example

Tony was furious at being woken up so early. He told Terry$_i$ to get lost and hung up. Of course, he$_i$ hadn't intended to upset Tony.

- We want to predict that the use of *he* is inappropriate for referring to *Terry*.

Centering Theory

- Centering Theory models local aspects of attentional state
  - tracks changes in local focus
  - not concerned with globally relevant entities

Centering

A **center** is an entity that links an utterance to other utterances in the same discourse segment.
Every utterance U in a discourse introduces

- a set of forward-looking centers $C_f(U)$ (contains all the discourse entities evoked by the utterance U)
  - $C_f(U)$ is ordered according to the prominence of its member entities in the utterance U.
  - Ordering principle: grammatical function (subjects>objects > everything else).
- exactly one backward-looking center $C_b(U)$.
  - $C_b(U_n)$ of an utterance U_n is defined as the entity with the highest rank in $C_f(U_{n-1})$ that is evoked in U_n.
  - The backward-looking center $C_b(U_n)$ thus serves as a link with the preceding utterance U_{n-1}.
- Forward-looking centers are potential foci
- Backward-looking centers are potential topics

Centering: A model of discourse

- The forward-looking centers $C_f(U_{n-1})$ are a rough model of the listener's attentional state after hearing U_{n-1}
- They can predict what the backward-looking center of the **next** utterance U_n must be; in particular, $C_b(U_n) = C_{f,top}(U_{n-1})$
- Abrupt changes in the focus of the discourse are reflected in changes in the backward-looking center.
- Discourse is then modelled by the types of transitions in the backward-looking centers from sentence to sentence.
- A discourse that keeps its center (topic) is most coherent, but if changes in topic occur, they should be transitioned smoothly

Four Types of Transitions

Two contributing factors:

- Did C_b change from U_{n-1} to U_n?
  ▷ If so, we have just experienced a topic shift
- Was $C_{f,top}$ correctly predicted by C_b?
  ▷ If not, the speaker might be preparing for a topic shift (or have done something rather rough)

	Same C_b	**Change in C_b**
$C_{f,top}$ **predicted**	CONTINUE	SMOOTH SHIFT
$C_{f,top}$ **not predicted**	RETAIN	ROUGH SHIFT

Continue: $C_b(U_n) = C_b(U_{n-1}) = C_{f,top}(U_n)$

$C_b(U_1)$ = **Undefined***; $C_f(U_1)$ = {**John, store, piano**}

U$_1$: John went to his favourite music store to buy a piano.

*("Undefined-to-any-C_b" counts as "no change")

$C_b(U_2)$ = **John;**

Continue: $C_b(U_n) = C_b(U_{n-1}) = C_{f,top}(U_n)$

$C_b(U_1)$ = **Undefined***; $C_f(U_1)$ = {**John, store, piano**}

U$_1$: John went to his favourite music store to buy a piano.

*("Undefined-to-any-C_b" counts as "no change")

$C_b(U_2)$ = **John**; $C_f(U_2)$ = {**John, store, years**}

U$_2$: He had frequented the store for many years. CONTINUE

$C_b(U_3)$ = **John**;

Continue: $C_b(U_n) = C_b(U_{n-1}) = C_{f,top}(U_n)$

$C_b(U_1)$ = **Undefined***; $C_f(U_1)$ = {**John, store, piano**}

U$_1$: John went to his favourite music store to buy a piano.

*("Undefined-to-any-C_b" counts as "no change")

$C_b(U_2)$ = **John**; $C_f(U_2)$ = {**John, store, years**}

U$_2$: He had frequented the store for many years. CONTINUE

$C_b(U_3)$ = **John**; $C_f(U_3)$ = {**John, piano**}

U$_3$: He was excited that he could finally buy a piano. CONTINUE

▷ In center continuation, the discourse stays focused on the same entity.

Retain: $C_b(U_n) = C_b(U_{n-1})$ but $C_b(U_n) \neq C_{f,top}(U_n)$

$C_b(U_1) =$ **Undefined;** $C_f(U_1) = \{$**John, store, piano**$\}$

U$_1$: John went to his favourite music store to buy a piano.

$C_b(U_2) =$ **John;** $C_f(U_2) = \{$**John, store, years**$\}$

U$_2$: He had frequented the store for many years. CONTINUE

$C_b(U_3) =$ **John;**

Retain: $C_b(U_n) = C_b(U_{n-1})$ but $C_b(U_n) \neq C_{f,top}(U_n)$

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{John, store, piano}\}$$

U$_1$: John went to his favourite music store to buy a piano.

$$C_b(U_2) = \textbf{John; } C_f(U_2) = \{\textbf{John, store, years}\}$$

U$_2$: He had frequented the store for many years. CONTINUE

$$C_b(U_3) = \textbf{John; } C_f(U_3) = \{\textbf{store, John}\}$$

U$_3$: It was closing just as John arrived. RETAIN

▷ In center retaining, we have a possible future topic shift. An utterance U_n evokes the next focus of discourse. C_b is retained from U_{n-1} to U_n, but it is likely to change in U_{n+1}.

Smooth Shift: $C_b(U_n) \neq C_b(U_{n-1})$ but $C_b(U_n) = C_{f,top}(U_n)$

$C_b(U_0)$ = **Undefined**

$C_b(U_1)$ = **Undefined;** $C_f(U_1) = \{$**John, piano**$\}$

$\mathbf{U}_1$: John was excited that he could finally buy a piano.

$C_b(U_2)$ = **John;** $C_f(U_2) = \{$**John, store, piano**$\}$

$\mathbf{U}_2$: He went to his favourite music store to buy it. CONTINUE

$C_b(U_3)$ = **John;** $C_f(U_3) = \{$**store, day**$\}$

$\mathbf{U}_3$: It was about to close for the day. RETAIN

$C_b(U_4)$ = **store;** $C_f(U_4) = \{$**store, John, world**$\}$

$\mathbf{U}_4$: It was his favourite shop in the world.

Smooth Shift: $C_b(U_n) \neq C_b(U_{n-1})$ but $C_b(U_n) = C_{f,top}(U_n)$

$C_b(U_0)$ = **Undefined**
$C_b(U_1)$ = **Undefined;** $C_f(U_1) = \{$**John, piano**$\}$

U$_1$: John was excited that he could finally buy a piano.

$C_b(U_2)$ = **John;** $C_f(U_2) = \{$**John, store, piano**$\}$

U$_2$: He went to his favourite music store to buy it. CONTINUE

$C_b(U_3)$ = **John;** $C_f(U_3) = \{$**store, day**$\}$

U$_3$: It was about to close for the day. RETAIN

$C_b(U_4)$ = **store;** $C_f(U_4) = \{$**store, John, world**$\}$

U$_4$: It was his favourite shop in the world. S-SHIFT

▷ Smooth shifts are predictable changes in focus.

Rough Shift: $C_b(U_n) \neq C_b(U_{n-1}) \neq C_{f,top}(U_n)$

$C_b(U_1)$ = **Undefined;** $C_f(U_1) = \{$**John, store**$\}$

U$_1$: John had always liked going to this store.

$C_b(U_2)$ = **John;** $C_f(U_2) = \{$**store, instruments**$\}$

U$_2$: It had a wide selection of musical instruments. RETAIN

$C_b(U_3)$ = **store;** $C_f(U_3) = \{$**Mary, store, John**$\}$

U$_3$: Mary visited it just as he left. R-SHIFT

$\triangleright$ Rough shifts are unpredictable changes in discourse focus.

Center-Realisation Rules

So far, all pronoun resolution was unambiguous. Now let's move to non-trivial pronoun resolution with this algorithm.
Centering theory postulates two rules that constrain center-realisation:

Rule 1

If any element in $C_f(U_{n-1})$ is realised by a pronoun in U_n, then the center $C_b(U_n)$ must also be realised by a pronoun.

Rule 2

Sequences of center continuation are considered less disruptive than sequences of retaining, which are in turn less disruptive than sequences of shifts (smooth being better than rough).

Centering Algorithm

Goal: Find the referent that causes the smoothest C_b transition according to Rule 2, without violating Rule 1 or any agreement or syntactic constraints.

1. Move through the discourse window from left to right. At each pronoun:
   1. Generate C_f combinations for each possible set of referent assignments; this will create C_bs (top-ranked).
   2. Filter by agreement and syntactic constraints and Rule 1.
   3. Rank remaining referent assignments using Rule 2, i.e., transition orderings

Pronoun Resolution

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{Tony}\}$$

U$_1$: Tony was furious at being woken up so early.

$$C_b(U_2) = \textbf{Tony; } C_f(U_2) = \{\textbf{Tony, Terry}\}$$

U$_2$: He told Terry$_i$ to get lost and hung up. CONTINUE

$$C_b(U_3) = \textbf{Tony; } C_f(U_3) = \{\textbf{Terry, Tony}\}$$

U$_3$: *Of course, he$_i$ hadn't intended to upset Tony. 

- As Terry is a member of $C_f(U_2)$ that is realised as a pronoun in U_3, Rule 1 says that *Tony*, being $C_b(U_3)$, must also be realised as a pronoun in U_3 (but it isn't).
- Rule 1 filters this interpretation out.

Pronoun Resolution

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{Brennan, Alfa}\}$$

$\mathbf{U}_1$: Brennan drives an Alfa Romeo.

$$C_b(U_2) = \textbf{Brennan, } C_f(U_2) = \{\textbf{Friedman, Brennan}\}$$

$\mathbf{U}_2$: Friedman races her on Sundays. RETAIN

$\mathbf{U}_3$: She often beats her.

Pronoun Resolution

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{Brennan, Alfa}\}$$

U$_1$: Brennan drives an Alfa Romeo.

$$C_b(U_2) = \textbf{Brennan, } C_f(U_2) = \{\textbf{Friedman, Brennan}\}$$

U$_2$: Friedman races her on Sundays. RETAIN

U$_3$: She often beats her.

$C_b(U_3) = \textbf{Friedman}$ $C_f(U_3) = \begin{cases} \{\textbf{B, F}\} \triangleright \textbf{R-SHIFT} \\ \{\textbf{F, B}\} \triangleright \textbf{S-SHIFT} \end{cases}$

$\triangleright$ Therefore: She=Friedman and her=Brennan

Looking at the coherence examples again

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{John, store, piano}\}$$

U$_1$: John went to his favourite music store to buy a piano.

RETAIN: $C_b(U_2) = \textbf{John; } C_f(U_2) = \{\textbf{store, John, years}\}$

U$_2$: It was a store John had frequented for many years.

R-SHIFT: $C_b(U_3) = \textbf{store; } C_f(U_3) = \{\textbf{John, piano}\}$

U$_3$: He was excited that he could finally buy a piano.

R-SHIFT: $C_b(U_4) = \textbf{John; } C_f(U_4) = \{\textbf{store, John}\}$

U$_4$: It was closing just as John arrived.

S-SHIFT: $C_b(U_5) = \textbf{store; } C_f(U_5) = \{\textbf{store}\}$

U$_5$: It would open again tomorrow.

Looking at the other coherence example

$$C_b(U_1) = \textbf{Undefined; } C_f(U_1) = \{\textbf{John, store, piano}\}$$

U$_1$: John went to his favourite music store to buy a piano.

CONTINUE: $C_b(U_2) = \textbf{John; } C_f(U_2) = \{\textbf{John, store, years}\}$ **U**$_2$: He had frequented the store for many years.

CONTINUE: $C_b(U_3) = \textbf{John; } C_f(U_3) = \{\textbf{John, piano}\}$

U$_3$: He was excited that he could finally buy a piano.

CONTINUE: $C_b(U_4) = \textbf{John; } C_f(U_4) = \{\textbf{John, store, day}\}$

U$_4$: He arrived just as the store was closing for the day.

RETAIN: $C_b(U_5) = \textbf{John; } C_f(U_5) = \{\textbf{store}\}$

U$_5$: It would open again tomorrow.

Entity-based Coherence: Barzilay and Lapata 2005

Coherence as a model of sequences of entity types in text

Entity Grid:

1. Former Chilean dictator Augusto Pinochet, was arrested in London on 14 October 1998.
2. Pinochet, 82, was recovering from surgery.
3. The arrest was in response to an extradition warrant served by a Spanish judge.
4. Pinochet was charged with murdering thousands, including many Spaniards.
5. He is awaiting a hearing, Pinochet's fate in the balance.
6. American scholars applauded the arrest.

Entity-based Coherence: Barzilay and Lapata 2005

Coherence as a model of sequences of entity types in text

Entity Grid:

1 Former Chilean dictator Augusto Pinochet$_{S}$, was arrested in London$_{X}$ on 14 October$_{X}$ 1998.
2 Pinochet$_{S}$, 82, was recovering from surgery$_{X}$.
3 The arrest$_{S}$ was in response$_{X}$ to an extradition warrant$_{X}$ served by a Spanish judge$_{S}$.
4 Pinochet$_{O}$ was charged with murdering thousands$_{O}$, including many Spaniards$_{O}$.
5 Pinochet$_{S}$ is awaiting a hearing$_{O}$, his fate$_{X}$ in the balance$_{X}$.
6 American scholars$_{S}$ applauded the arrest$_{O}$.

The Entity Grid

1	Pinochet$_{S}$	London$_{X}$	October$_{X}$	
2	Pinochet$_{S}$	surgery$_{X}$		
3	arrest$_{S}$	response $_{X}$	warrant$_{X}$	judge$_{O}$
4	Pinochet$_{O}$	thousands$_{O}$	Spaniards$_{O}$	
5	Pinochet$_{S}$	hearing$_{O}$	Pinochet$_{X}$	fate$_{X}$ balance$_{X}$
6	scholars$_{S}$	arrest$_{O}$		

The Entity Grid

	Pinochet	London	October	Surgery	Arrest	Extradition	Warrant	Judge	Thousands	Spaniards	Hearing	Fate	Balance	Scholars
1	**S**	**X**	**X**	–	–	–	–	–	–	–	–	–	–	–
2	**S**	–	–	**X**	–	–	–	–	–	–	–	–	–	–
3	–	–	–	–	**S**	**X**	**X**	**O**	–	–	–	–	–	–
4	**O**	–	–	–	–	–	–	–	**O**	**O**	–	–	–	–
5	**S**	–	–	–	–	–	–	–	–	–	**O**	**X**	**X**	–
6	–	–	–	–	**O**	–	–	–	–	–	–	–	–	**S**

Columns: entities; lines: sentences

Entity Transitions

Example (transitions of length 2)

	S S	O S	X S	| S	S O	O O	X O	| O	S X	O X	X X	| X	S |	O |	X |	| |
d_1	0	0	0	.03	0	0	0	.02	.07	0	0	.12	.02	.02	.05	.25
d_2	0	0	0	.02	0	.07	0	.02	0	0	.06	.04	0	0	0	.36
d_3	.02	0	0	.03	0	0	0	.06	0	0	0	.05	.03	.07	.07	.29

Learning a Ranking Function

Training Set

Ordered pairs (x_{ij}, x_{ik}), where x_{ij} and x_{ik} represent the same document d_i, and x_{ij} is more coherent than x_{ik} (assume $j > k$).

- Source document and permutations of its sentences.
- Original order **assumed coherent.**
- Given k documents, with n permutations, obtain $k \cdot n$ pairwise rankings for training and testing.
- Two corpora, Earthquakes and Accidents, 100 texts each.
- Use SVMRank for this task

Sentence 1 Sentence 2 Sentence 3 Sentence 4	$>$	Sentence 2 Sentence 3 Sentence 4 Sentence 1	$>$	Sentence 4 Sentence 3 Sentence 2 Sentence 1	$>$	Sentence 2 Sentence 1 Sentence 4 Sentence 3

Results

- Evaluation metric: % correct ranks in test set
- Able to rank scambled texts better than LSA model
- Able to show that coreference, salience of entity (number of occurrences in text) and syntactic information helps
- Unable to apply to new texts to judge their coherence

Reference, Co-reference, Bridging

Repeated from L90: Terminology

- **anaphora:** the phenomenon of referring to an antecedent (metonymically also refers to the referring expression). Subtypes are pronouns and definite NPs.
- **referent:** a real world entity that some piece of text (or speech) refers to.
- **referring expressions:** bits of language used to perform reference by a speaker.
- **coreference:** two references to the same referent
- **antecedent:** the text evoking a referent.
- **cataphora:** the phenomenon where the referring expression precedes the antecedent (metonymically also refers to the referring expression)
  - After **his** class, John will play football.

Anaphora resolution vs. coreference resolution

Anaphora resolution

Task of finding an antecedent for each anaphor (typically, pronoun).

Coreference resolution

Task of partitioning the set of all referring expressions into equivalence classes (chains) that refer to one referent.

Types of referring expressions

- **Indefinite Noun Phrase:** introduce new entities into the discourse; e.g., *a pair of stove-lids*
- **Proper Noun:** evoke uniquely identifyable known entity.
- **Definite and Demonstrative Noun Phrase:** refer to entities that are uniquely identifiable by the listener; e.g., *the room*. (Not all definite NPs are referring, e.g. the fact that the earth is round; the US president)
- **Personal Pronoun:** refers to entities that have high level of activation in the listener's attentional state; e.g., *her, them*.
- **Demonstrative Pronoun:** can refer to entities and to events (e.g., *I had not expected that*).
- **One-Anaphora:** select one from a set of entities. It can introduce a new entity into the discourse, but this is dependent on an existing representation for the larger set; e.g., *I would like one*.

Types of Reference

Coreference

- referring expression refers to an entity that has been explicitly evoked

John owns a car. **It** is a Ford.

Bridging Reference

- refer to entities that are inferable from previously evoked entities

John's car is very old. **The engine** is noisy and **a door** is dented.

- can involve *Synonymy*, *Hyponymy*, *Meronymy*
- or other form of inference, e.g.,

I bought an iPad today. **They** are so cool.

Definite NPs

Definite NPs

Theory says:

- Definite NPs are anaphoric

Corpus studies show:

- At least half of definite descriptions are discourse-new (Prince, 1992)
- Another 15% or so are bridging references
- $\triangleright$ a total of about 66-67% first-mention Definite NPs.

(3) a. Toni Johnson pulls a tape measure across **the front of what was once a stately Victorian home.**

b. The Federal Communications Commission allowed American Telephone & Telegraph Co. to continue offering discount phone services for large-business customers and said it would soon re-examine its regulation of **the long-distance market.**

Vieira and Poesio (2000)

Categories of Discourse-New Definite NPS (DD) licensed to occur as first mention on semantic or pragmatic grounds:

(4) a. the first person to cross the Pacific on a row boat ▷ semantically functional description

b. the belief that the world is flat ▷ semantically functional description

c. the hotel where we stayed last night ▷ restrictive modification

d. Glenn Cox, the president of Phillips Petroleum, left early ▷ predicative descriptions (also in copulas)

e. the Iran-Iraq war ▷ disguised proper nouns

f. the pope ▷ world knowledge establishes uniqueness

Algorithm

1. Try the DN heuristics with the highest accuracy (recognition of some types of semantically functional DDs using special predicates, and of potentially predicative DDs occurring in appositions);

2. Otherwise, attempt to resolve the DD as direct anaphora;

3. Otherwise, attempt the remaining DN heuristics in the order: proper names, descriptions established by relatives and PPs, proper name modification, predicative DDs occurring in copular constructions.

If none of these tests succeeds, the algorithm can either leave the DD unclassified, or classify it as DN.

Results

Version of the System	**P**	**R**	**F**
Baseline	50.8	100	67.4
Discourse-new detection only	69	72	70
Hand-coded DT: partial	62	85	71.7
Hand-coded DT: total	77	77	77
ID3	75	75	75

Table 1: Summary of the results obtained by Vieira and Poesio

Baseline: always classify as Discourse-New

Literature

- Gundel, Hedberg and Zacharski (1993). Cognitive status and the form of referring expressions in discourse. Language, 274-307.
- Grosz, Joshi, and Weinstein (1995). Centering: A framework for modelling the local coherence of discourse. .
- Barzilay and Lapata (2008). Modeling Local Coherence: An Entity-Based Approach. *Computational Linguistics*, 34:1, 1-34.
- Vieira, and Poesio (2000). An empirically-based system for processing definite descriptions. Computational Linguistics, 26(4)