Computational Models of Discourse: Introduction to Discourse: Coherence and Cohesion, Lexical Chains

Caroline Sporleder

Universität des Saarlandes

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29.04.2009

New Schedule

29.04.2009 **Introduction Discourse: Coherence and Cohesion**

06.05.2009 **Cohesion and Local Coherence**

- Lexical Cohesion, Lexical Chains
- Focus, Centering

13.05.2009 **Text Segmentation**

- TextTiling
- Preparatory Meeting "Essay Scoring"

20.05.2009 **Applications (1)**

- Automatic Essay Scoring
- Preparatory Meeting "Information Ordering"

27.05.2009 **Applications (2)**

- Information Ordering for Text Generation
- Preparatory Meeting "Generating Referring Expressions"

03.06.2009 **Generating Referring Expressions**

- rule-based
- machine learning

New Schedule, cont'd

10.06.2009 **Co-reference Resolution**
- rule-based
- supervised machine learning
- unsupervised machine learning

17.06.2009 **Discourse Parsing**
- Discourse Parsing with RST
- Machine Learning

24.06.2009 **Temporal Ordering**

01.07.2009 **Text Summarisation**
- lexical chains
- RST-based
- multi-document
- argumentative zoning

08.07.2009 **Sentiment Analysis**

15.07.2009 **Dialogue Processing**
- classification of dialogue acts
- dialogue planning

22.07.2009 **Speech?, Psycholinguistic Models?, Recap**

Discourse Structure

Background Reading

- Jurafsky & Martin (2000)
  - Ch. 18 (Discourse)
  - Ch. 19 (Dialogue)
  - Ch. 20 (Generation)
- Jurafsky & Martin (2008)
  - Ch. 21 (Discourse)
  - Ch. 23 (Summarisation)
  - Ch. 24 (Dialogue)

What is a Discourse?

- a sequence of utterances
- but: an arbitraty collection of well-formed utterances is not necessarily a "discourse"
- $\Rightarrow$ sequence of utterances has to be coherent
  - topics which are related
  - events which are connected (e.g. cause-result, temporal succession)
  - utterances have to fulfil a purpose in discourse

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At the beginning of June polar bear Knut turned one and started to discover his predatory side.

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$\Rightarrow$ a discourse is coherent if a plausible discourse structure can be found
$\Rightarrow$ interpreting a discourse means finding the connections between individual sentences (discourse relations, co-reference chains, etc.)

Linguistic Models of Discourse Structure

Many different models of discourse. Typically it is assumed that a discourse consists of:

- segments
- relations between segments (discourse/rhetorical relations)

Discourse is structured hierarchically. A minimal/elementary discourse segment is often a clause/sentence:

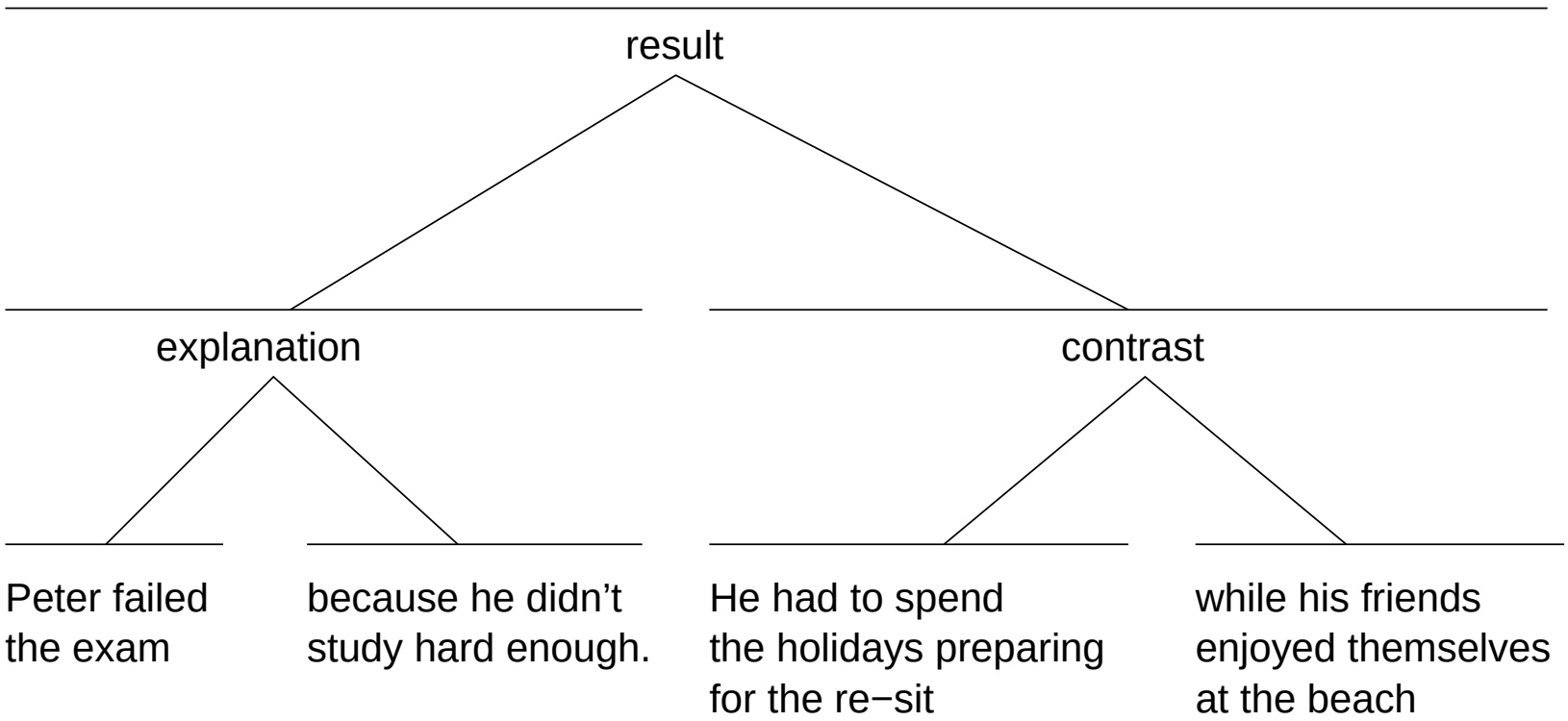
$$\forall w, e \; \mathit{minimal\_segment}(w, e) \Rightarrow \mathit{segment}(w, e)$$

$$\forall w_1, w_2, e_1, e_2, e \; \mathit{segment}(w_1, e_1) \wedge \mathit{segment}(w_2, e_2) \wedge \mathit{DiscourseRel}(e_1, e_2, e) \Rightarrow \mathit{segment}(w_1, w_2, e)$$

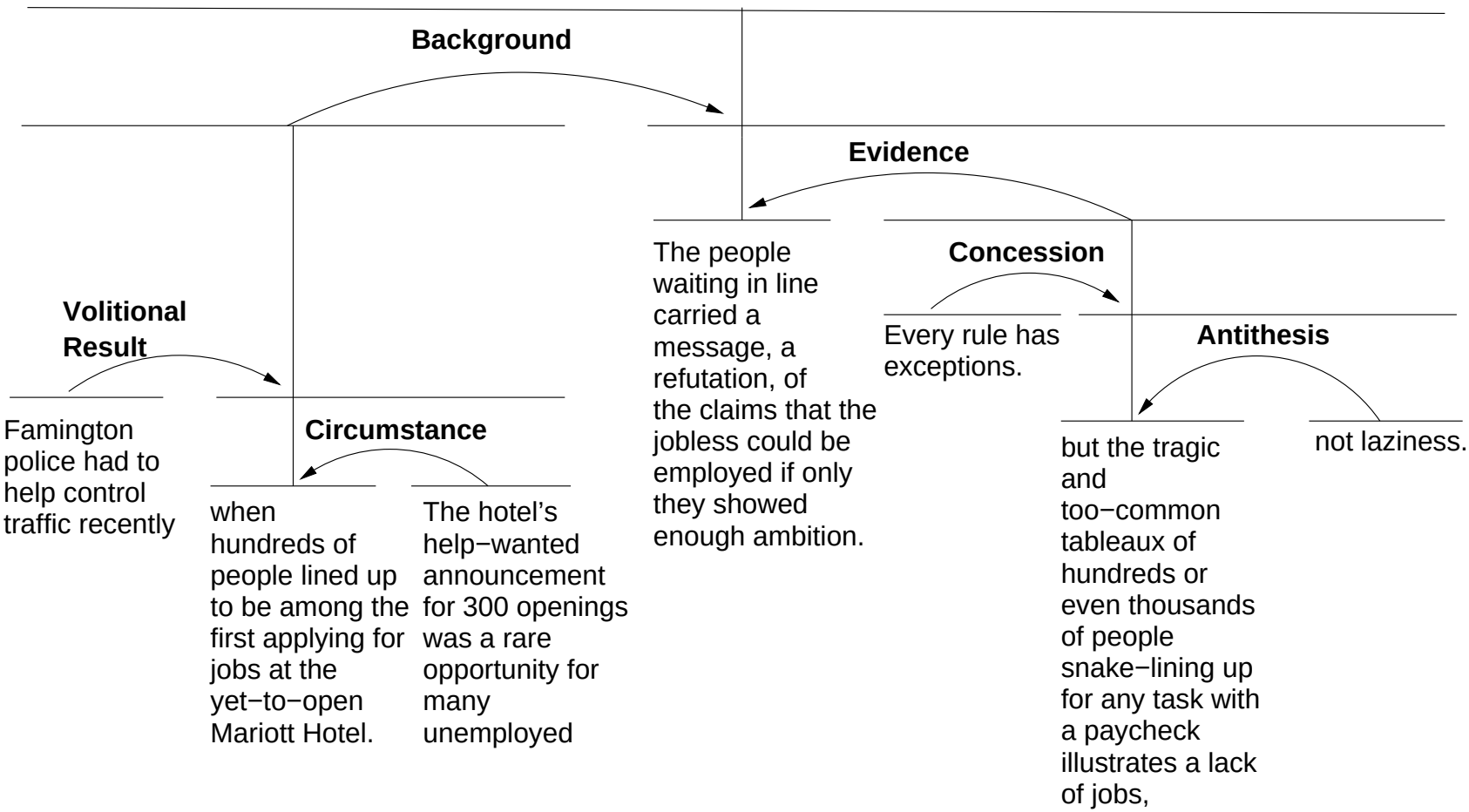
(w is a sequence of words; e is the described event or state)

To interpret a discourse, one has to show that it is a valid segment: $\exists e$ Segment(W,e)

Example: Simplified RST



Example: Real RST



Linguistic Models of Discourse Structure

How do we know that there are segements and relations?

$\Rightarrow$ there are linguistic cues for the existence of both

Linguistic reality of segments

John went to the bank to cash a cheque.
Then he took the bus to his friend Bill who is a car dealer.
He had to buy a car.
The company for which he had just started working could not be reached by public transport.
He also wanted to talk to bill about the upcoming football match.

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Linguistic reality of discourse relations

Discourse relations can be signalled by cue words (discourse markers):

- *John hid Peter's car keys because he was drunk.*
- *Max helped Peter up again after he had fallen.*
- *Tom drinks coffee but Sue prefers tea.*

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Coherence vs. Cohesion (Halliday & Hasan, 1976)

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$\Rightarrow$ Coherence is about underlying structure.

Example: Cohesion

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Example: Coherence with little cohesion

Yesterday Peter passed his driving test.
Afterwards Peter went to see Klaus.
Klaus was happy about the visit
because Klaus hadn't seen Peter for a while.
Later Peter and Klaus went to the pub.

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Yesterday Peter flew to Australia.
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Modelling Discourse Structure

. . . is not just about coherence and cohesion.

Dimensions of Discourse Structure

Four interdependent aspects/dimensions of discourse structure:

- (Para-)Linguistic Structure: linguistic manifestation of discourse structure, e.g., lexical cohesions, cue words, intonation, gesture, referring expressions etc.
- Intentional Structure: each discourse segment fulfils a purpose (why does a speaker/write make a given utterance in a given form?)
- Informational Structure: how do the different segments of a discourse relate to each other (which segments are directly related and which discourse relations hold)?
- Focus/Attentional Structure: which entities are *salient* at a given point in discourse?

Dimensions of Discourse Structure

Linguistic structure is about cohesion.

Intentional, informational, and focus structure are about coherence.

Linguistic Structure

Linguistic form

often an indicator of discourse structure:

- discourse connectives (*but*, *because*):
  $\Rightarrow$ reflect how sentences are related to each other (contrast, explanation etc.)
- referring expressions (*she*, *Mary*, *a girl*, *the girl who likes ice-cream* . . .)
  $\Rightarrow$ reflect the status of an entity in the discourse (salient, not-salient, new, old, inferred etc.)
- semantically related words (*flooding* . . . *torrential rain* . . . *storm*):
  $\Rightarrow$ reflect lexical cohesion

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$\Rightarrow$ The fact that Maggie likes crisps contrasts with Mary's liking of chocolate.

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Another Possible intention: outline to listener what consequences John's drunkenness has (and why something must be done about his binge drinking)

Focus Structure

Susan would like to go on a holiday. But she needs to find somebody to do her work while she's away. She can't think of anybody to do that. She considered Mike but he's a bit unreliable. Yesterday he forgot to turn up for an important meeting with a client. The client was very annoyed and said she would never do business with Susan's company again.

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- informational structure: relatively weak correlation with linguistic form (discourse connectives), difficult to model
- intentional structure: barely visible in linguistic form, extremely difficult to model on analysis side

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$\rightarrow$ focus structure: Centering Theory

$\rightarrow$ linguistic structure, lexical cohesion: Lexical Chains

We'll talk about informational structure (discourse parsing) later

Lexical Chains

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. . . are sequences of semantically related words

From Nineteen Eighty-Four [abridged]:

… the book that he had just taken out of the drawer. It was a peculiarly beautiful book. Its smooth creamy paper was of a kind that had not been manufactured for at least forty years past. He could guess, however, that the book was much older than that. He had seen it lying in the window of a frowsy little junk-shop and had been stricken immediately by an overwhelming desire to possess it. Party members were supposed not to go into ordinary shops. He had slipped inside and bought the book for two dollars fifty. Even with nothing written in it, it was a compromising possession. ¶ The thing that he was about to do was to open a diary. Winston fitted a nib into the penholder and sucked it to get the grease off. The pen was an archaic instrument, seldom used even for signatures, and he had procured one, furtively and with some difficulty, simply because of a feeling that the beautiful creamy paper deserved to be written on with a real nib instead of being scratched with an ink-pencil. Actually he was not used to writing by hand. He dipped the pen into the ink.

(Source: Graeme Hirst & Alexander Budanitsky, Eurolan-2001 presentation)

Computing Lexical Chains

We need:

- a measure of semantic relatedness between words
- a chain building algorithm

Computing Semantic Relatedness

. . . a hot research topic.

Two basic methods:

- concept distance in a hierarchical lexicon (e.g. WordNet)
- distributional similarity computed from a corpus

Structure

- synsets: collections of words with the same sense (e.g., {*bank, depository financial institution, banking concern, banking company*} vs. {*bank, river bank*})
- relations between synsets
  - hyponym (e.g., *Federal Reserve Bank*)
  - hypernym (e.g., *financial organisation*)
  - member holonym (e.g., *banking industry*)
  - antonyms
  - etc.

Relatedness based on WordNet

Simple approach

- count path length between two concepts/synsets
- possibly normalise by overall depth of hierarchy etc.

But:

not all paths are equal, e.g. changes in direction weaken similarity

Relatedness based on WordNet (Hirst & St-Onge, 1998)

Three types of relations:

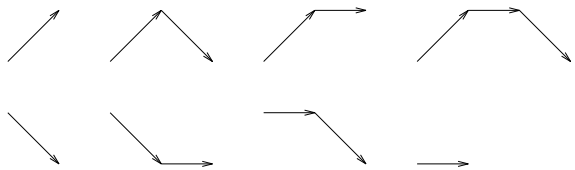
1. **extra-strong:** literal repetition of a word
2. **strong:**
   - concepts are in the same synset (e.g. *human* and *person*), or
   - the concept's synsets are connected by a horizontal link (antonymy or similarity relation, e.g. *precursor* and *successor*), or
   - one of the words is a compound that includes the other (e.g. *school* and *private school*)
3. **medium-strong:** there exists an allowable path between the concept's synsets
   Medium-strong paths are weighted by:
   $C - \textit{path length} - k \times \textit{number of changes of direction}$
   (C and k are empirically set constants)

Relatedness based on WordNet (Hirst & St-Onge, 1998)

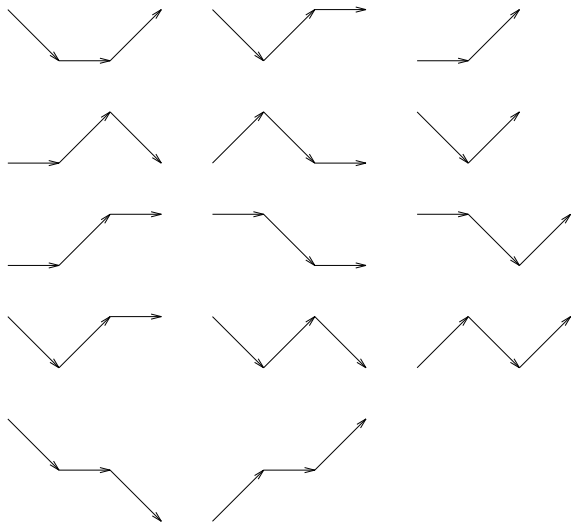
An allowable path:

- contains no more than five links and
- conforms to one of eight patterns, definable by the following rules
  - no other direction may precede an upward link
  - at most one change of direction is allowed
  - it is permitted to use a horizontal link to make a transition from an upward to a downward direction

Relatedness based on WordNet (Hirst & St-Onge, 1998)



(a)



(b)

Figure 2: (a) Patterns of paths allowable in medium-strong relations and (b) patterns of paths not allowable. (Each vector denotes one or more links in the same direction.)

Relatedness based on WordNet (Hirst & St-Onge, 1998)

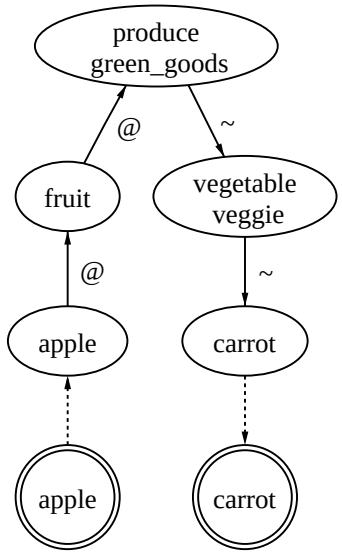


Figure 3: Example of a regular relation between two words. (@ = hypernymy, $\sim$ = hyponymy)

Relatedness based on WordNet

Problems/Disadvantages

Relatedness based on WordNet

Problems/Disadvantages

- availability of hierarchical lexicon
- coverage of lexicon
- sparse and dense areas in hierarchy not comparable (normalisation necessary, not a solved problem)
- only "classical" relations (hypernymy, hyponymy, antonymy etc., can't model fuzzy relations, e.g. *fire* and *coals*)

Relatedness based on distributional similarity

Possible measures:

- Pointwise Mutual Information (PMI):

  $$I(x,y) = log_2 \frac{P(x,y)}{P(x)P(y)}$$

- PMI over-inflates low-frequency events, better:

  $$I_{corrected}(x,y) = log_2 \frac{P(x,y)}{P(x)P(y)} \times \frac{min(freq(x),freq(y))}{min(freq(x),freq(y))+1}$$

- cosine of the angle between the co-occurrence vectors of two words

Relatedness based on distributional similarity

Problems/Disadvantages

Relatedness based on distributional similarity

Problems/Disadvantages

- conflation of word senses
- sometimes unpredictable results (corpus size, domain, similarity measure etc. play a role)

Chain-Building Algorithms

Basic Idea:

place two words in the same chain if their relatedness is above threshold t

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Design decisions

- can a word be placed in several chains?
- does a word have to be related to all other words in the chain or just to one other word? If it has to be related to all words does the avg. similarity have to be above the threshold or the minimum/maximum?
- greedy vs. non-greedy chain building (and its interaction with word-sense disambiguation)

Chain-Building Algorithms (Hirst & St-Onge 1998)

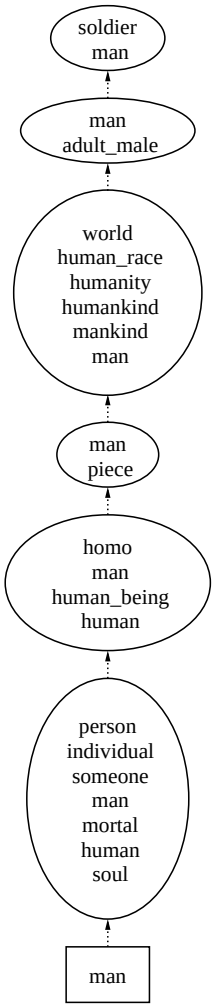

Figure 5: A word starting a new chain. (The word *man* has six synsets.)

Chain-Building Algorithms (Hirst & St-Onge 1998)

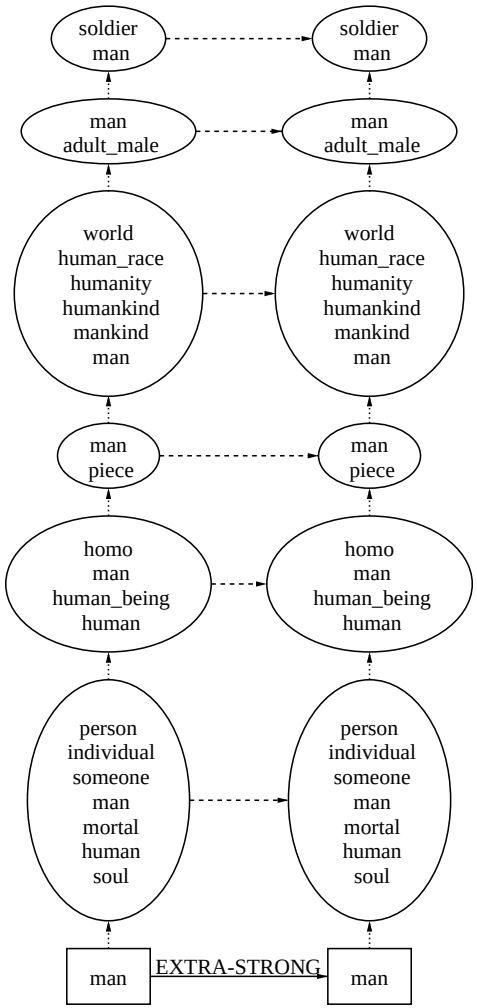

Figure 6: Push the same word

Chain-Building Algorithms (Hirst & St-Onge 1998)

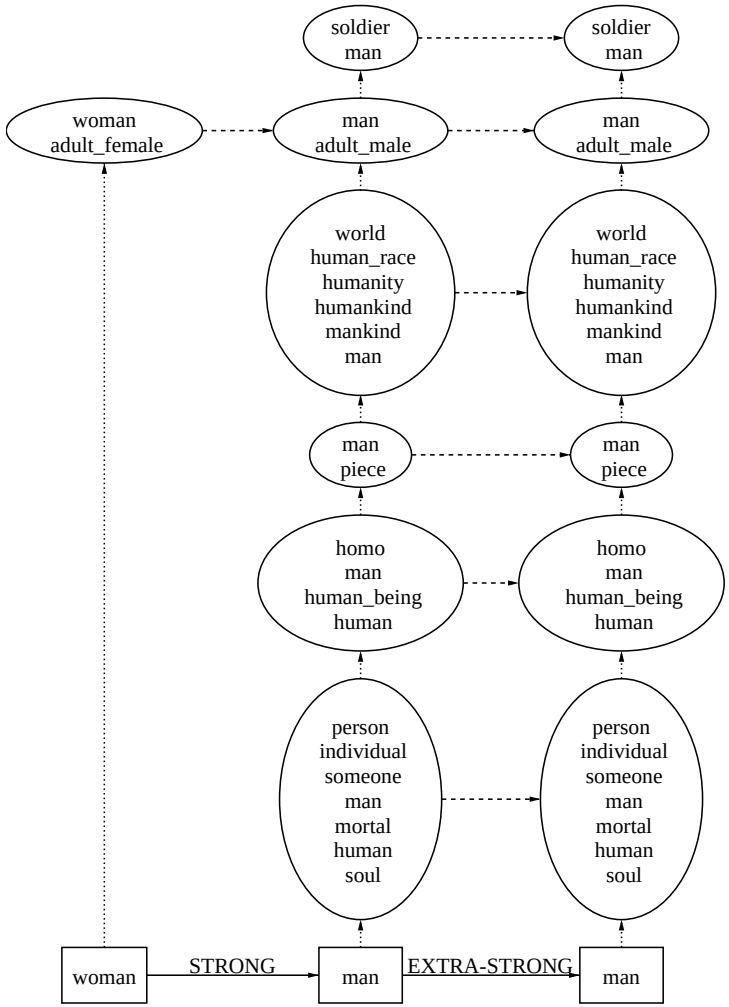

Figure 7: Push an antonym

Chain-Building Algorithms (Hirst & St-Onge 1998)

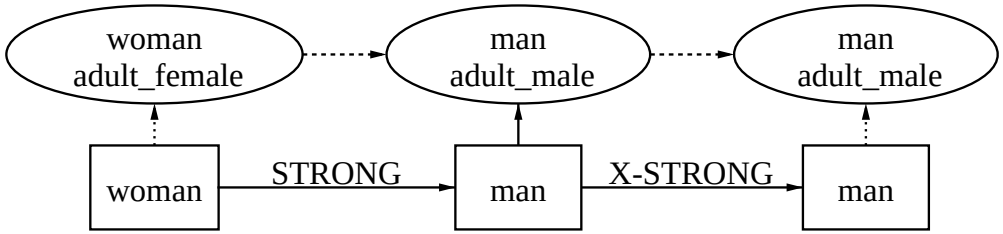

Figure 8: Updated chain after insertion

Lexical Chains. So what are they good for?