# Sources of Lexical Inferences

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# Overview

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- Motivation
- Textual Inference

Natural Logic
- Factives
- Simple Implicatives
- Phrasal Implicatives

Demo of PARC's Bridge system

A Case Study
- not wait to X

Open Problems
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# Motivation

- A measure of understanding a text is the ability to make inferences based on the information conveyed by it. We can test understanding by asking questions about the text.

- A long-standing goal of computational linguistics is to build a system for answering natural language questions.

- This is not a purely academic pursuit anymore. It would improve the quality of Internet search engines such as Google, Yahoo!, Bing, Powerset, Ask and Wolfram Alpha. Question answering is on everyone's agenda.

# Limitations of Search Engines

- Google

  Limited to finding passages that contain keywords and phrases.

- Powerset

  Syntactic parsing and indexing but no reasoning.

These systems cannot answer any questions. At best they can bring up relevant snippets and links to pages where they appear.

- Wolfram Alpha

  Has vast amounts of data. Can tell you how many people live in Edinburgh (446110) but cannot tell whether that number is larger than the population of London.

Alpha can lookup data in tables but it only answers questions that map exactly into a database query or a mathematical formula:

"Is the population of Edinburgh, UK greater than the population of London, UK?"

Alpha: FALSE.

# Need for Textual Inferences

- A successful question answering (QA) system has to recognize semantic relations between sentences.

  Did Roderigo kill Cassio?

- Google, Yahoo! and Bing all bring up links to articles containing snippets such as

  Iago pledges to kill Cassio.

  Iago convinces Roderigo to assassinate Cassio.

  Roderigo fails to kill Cassio.

- None of these systems can give a simple NO as the answer.

# A quote of mine from 1971

"It is evident that logical relations between main sentences and their complements are of great significance in any system of automatic data processing that depends on natural language. For this reason a systematic study of such relations, of which this paper is an example, will certainly have a great **practical value**, in addition to what it may contribute to the theory of the semantics of natural languages." (*The Logic of English Predicate Complement Constructions*)

John forgot that it was raining. => It was raining.

John forgot to bring an umbrella. => John did not bring an umbrella.

Roderigo failed to kill Cassio. => Roderigo did not kill Cassio.

# Current Work on Question Answering

Annual competition on “Recognizing Textual Entailment”

- Started in 2004 by Ido Dagan and others under the European PASCAL project.
  - Text: Muslims believe there is only one God.
  - Hypothesis: Muslims are monotheistic.
  - True ✓
  - False
- Currently run by NIST, now past RTE-5, with a more nuanced task.
  - Text: Yahoo announced Monday it is buying Overture Services.
  - Hypothesis: Overture was acquired.
  - T entails H ✓
  - T contradicts H
  - T neither contradicts nor entails H

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# A Better Term: Textual Inference

- Imagine a “common man” who has no opinion about X. If the person, upon reading or hearing Y, comes to accept X as true or likely, then X is a “textual inference” from Y.

- Textual inference includes but goes beyond logical entailment and presupposition. It allows for background world knowledge (facts of geography, history, mathematics, physics), default reasoning (birds fly), conversational principles, statistical likelihood of situations and consequences of actions…

- To work on textual inference, you cannot rely on your intuitions as a semanticist. You need to collect "real world" data and have a system to test your predictions.

# A Way of Polling the Common Man

Google research

Case study: What does X meant to Y mean?

Majority usage:

X meant to Y => X did not Y

X did not mean to Y => X did Y

Mom says she didn't mean to throw the baby at the boyfriend.

I meant to write something about this, but SmartCity beat me to it.

# More mean to examples in the wild

Michelle Bachman says she meant to call Obama a terrorist not anti-American.

=> M.B. says she did not call Obama a terrorist.

I only meant to commit suicide, says the beauty salon killer.

=> I did not commit suicide.

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I didn't mean to say what I said when I said I didn't mean it.

=> I said what I said.

Oops! I didn't mean to buy insurance.

=> I bought insurance.

# The Good News (for Linguists)

The term NLP (Natural Language Processing) historically refers to linguistically rather uninteresting activities such as building "language models" (bigram statistics), taggers, named entity recognizers, statistical parsers (built from tree banks).

QA and Textual Inference require additional processing based on the syntactic structure and the semantics of particular words and constructions such as mean to X. Finally, semantics matters.

Natural Logic (term invented by Lakoff in the 1970s, recently rebranded by van Benthem, MacCartney, et al) exploits lexical semantics, simple inference patterns and monotonicity relations. It is a good start for QA and Textual Inference.

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# Factives

| | Class | Inference Pattern |
|---|---|---|
| Positive | ++/-+ forget that<br>is odd that | forget that X ⇝ X, not forget that X ⇝ X<br>is odd that X ⇝ X, is not odd that X ⇝ X |
| Negative | +-/-- pretend that<br>pretend to | pretend that X ⇝ not X, not pretend that X ⇝ not X<br>~~pretend to X ⇝ not X, not pretend to X ⇝ not X~~ |

| | | | |
|---|---|---|---|
| *forget that* | host polarity | + + | complement polarity |
| *forget that* | host polarity | - + | complement polarity |
| *pretend that* | host polarity | + - | complement polarity |
| *pretend that* | host polarity | - - | complement polarity |

Abraham pretended that Sarah was his sister. ⇝ Sarah was not his sister

Howard did not pretend that it did not happen. ⇝ It happened.

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# Implicatives

| | Class | Inference Pattern |
|---|---|---|
| Two-way implicatives | ++/-- *manage to*<br>+-/-+ *fail to* | manage to X ⇝ X, not manage to X ⇝ not X<br>fail to X ⇝ not X, not fail to X ⇝ X |
| One-way implicatives | ++ *force to* | force X to Y ⇝ Y |
| | +- *refuse to* | refuse to X ⇝ not X |
| | -- *be able to* | not be able to X ⇝ not X |
| | -+ *hesitate to* | not hesitate to X ⇝ X |

# (not) hesitate to X

Standard dictionaries tell you nothing about the meaning of “not hesitate to X”. The common definition for *hesitate* is ‘to be reluctant to do something’.

Lincoln did not hesitate to overrule his advisers, both military and civilian. => Lincoln overruled his advisers.

Lincoln hesitated to show his wealth of goodness, even to the best he knew. => ??

Negation need not be explicit:

He almost hesitated to tell her. => He told her.

She nearly hesitated to answer. => She answered.

Closest relatives to hesitate, balk at and shrink from, are +-/-+.

# Phrasal Implicatives

| | | | | |
|---|---|---|---|---|
| Have | + | Ability Noun | *(ability/means)* | = --Implicative |
| | | Chance Noun | *(chance/opportunity)* | = --Implicative |
| | | Bravery Noun | *(courage/nerve)* | = ++/--Implicative |
| Take | + | Chance Noun | *(chance/opportunity)* | = ++/--Implicative |
| | | Asset Noun | *(money)* | = ++/--Implicative |
| | | Effort Noun | *(trouble/initiative)* | = ++/--Implicative |
| Use | + | Chance Noun | *(chance/opportunity)* | = ++/--Implicative |
| | | Asset Noun | *(money)* | = ++/--Implicative |
| Seize | + | Chance Noun | *(chance/opportunity)* | = ++/--Implicative |
| Miss | + | Chance Noun | *(chance/opportunity)* | = +-/-+Implicative |
| Waste | + | Chance Noun | *(chance/opportunity)* | = +-/-+Implicative |
| | | Asset Noun | *(money)* | = ++/--Implicative |

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# wasting time vs. wasting a chance

**++/--**

I regret having wasted the time to read it and even more, wasted the money to buy it.

==> I read it. I bought it.

I would not waste the money to buy Vista for a computer that has XP on it.

==> I would not buy Vista…

**+-/-+**

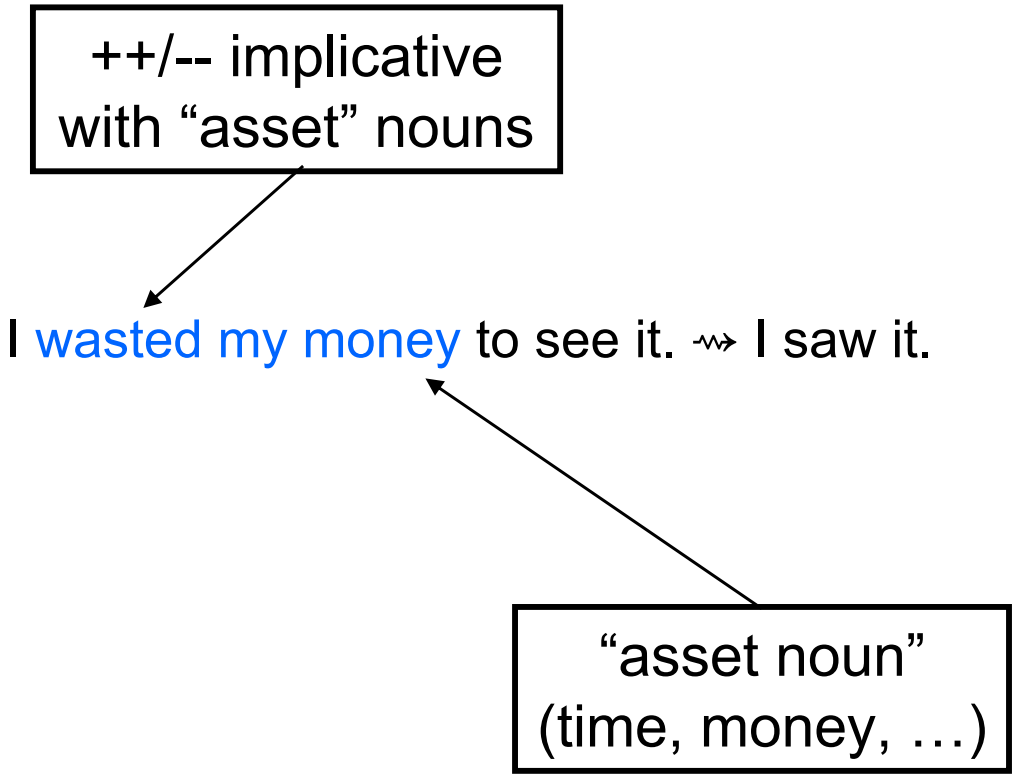
Mr. Spitzer wasted the opportunity to drive a harder bargain.

==> Mr. Spitzer did not drive a harder bargain.

Galileo did not waste the chance to aim a funny mock-syllogism at Grassi's flying eggs.

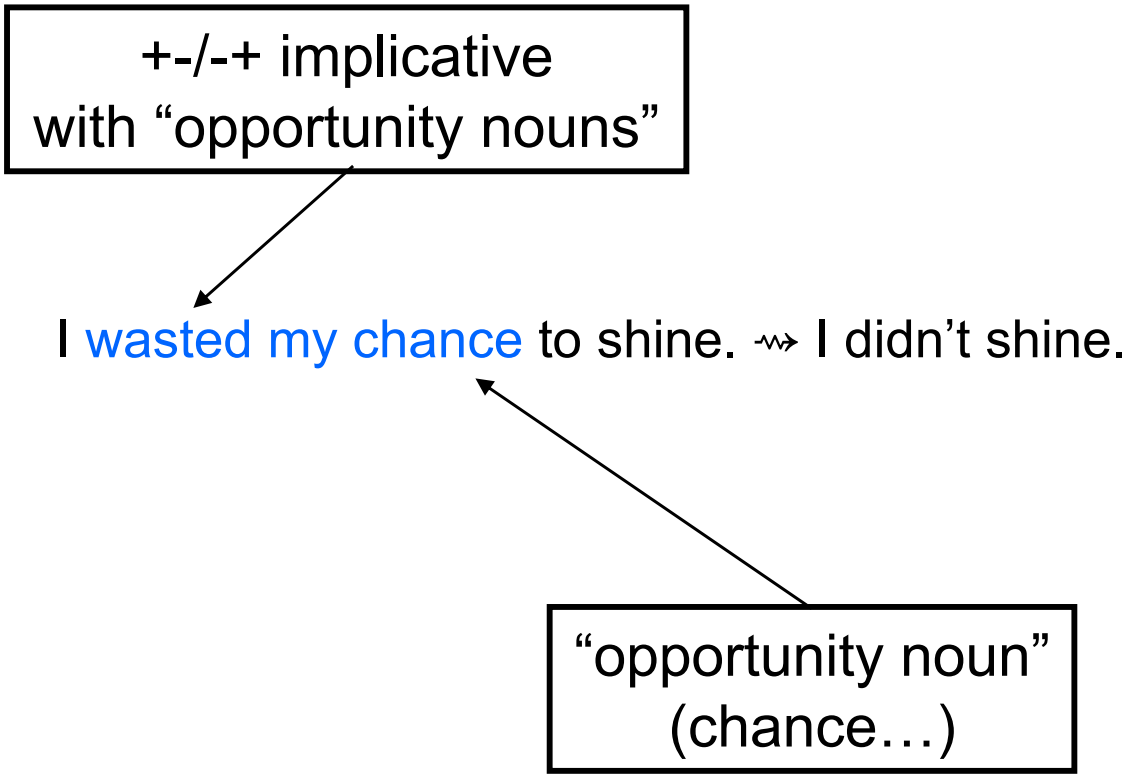
==> Galileo aimed a funny mock-syllogism...

# Lexical Properties of waste X to Y




lex_class(waste, conditional(++/--, ob, asset_noun))

# Lexical Properties of waste X to Y




lex_class(waste, conditional(+-/-+, ob, opportunity_noun))

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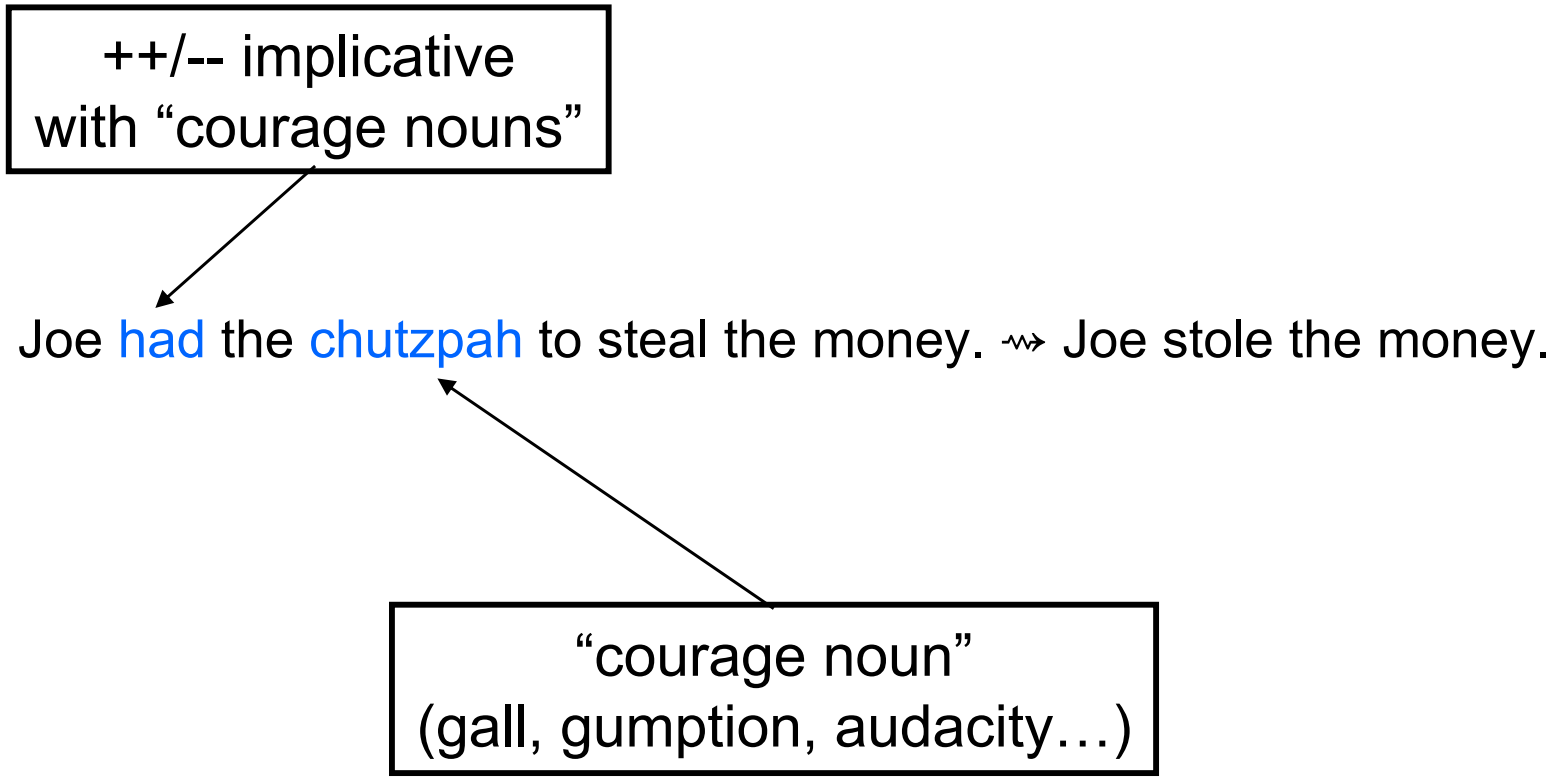
# Lexical Properties of have the X to Y




lex_class(have, conditional(++/--, ob, courage_noun))

# Stacking implicatives

Leona Helmsley managed to have the gumption to leave most of her estate to her,.. wait for it, ... dog!

=> Leona Helmsley left most of her estate to her dog.

The patent attorney did not bother to take the time to understand the slightly angled feature.

=> The patent attorney did not understand the slightly angled feature.

The Arab leaders didn't have the courage to take the decisive step to bring about peace.

=> The Arab leaders did not bring about peace.

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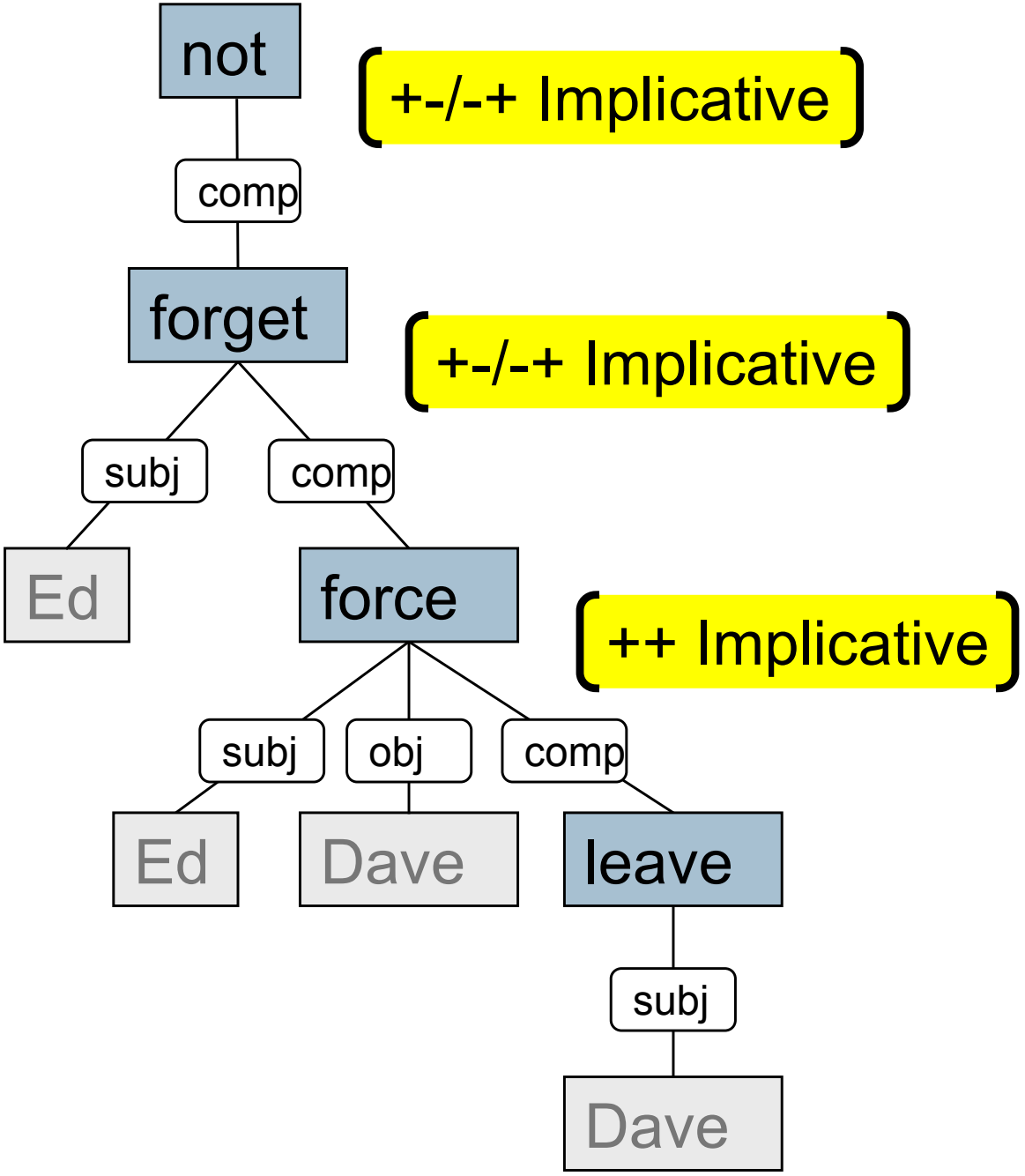
# How does it work?

Example: Polarity Propagation

Ed did **not forget to force** Dave to leave.

==> Dave left.

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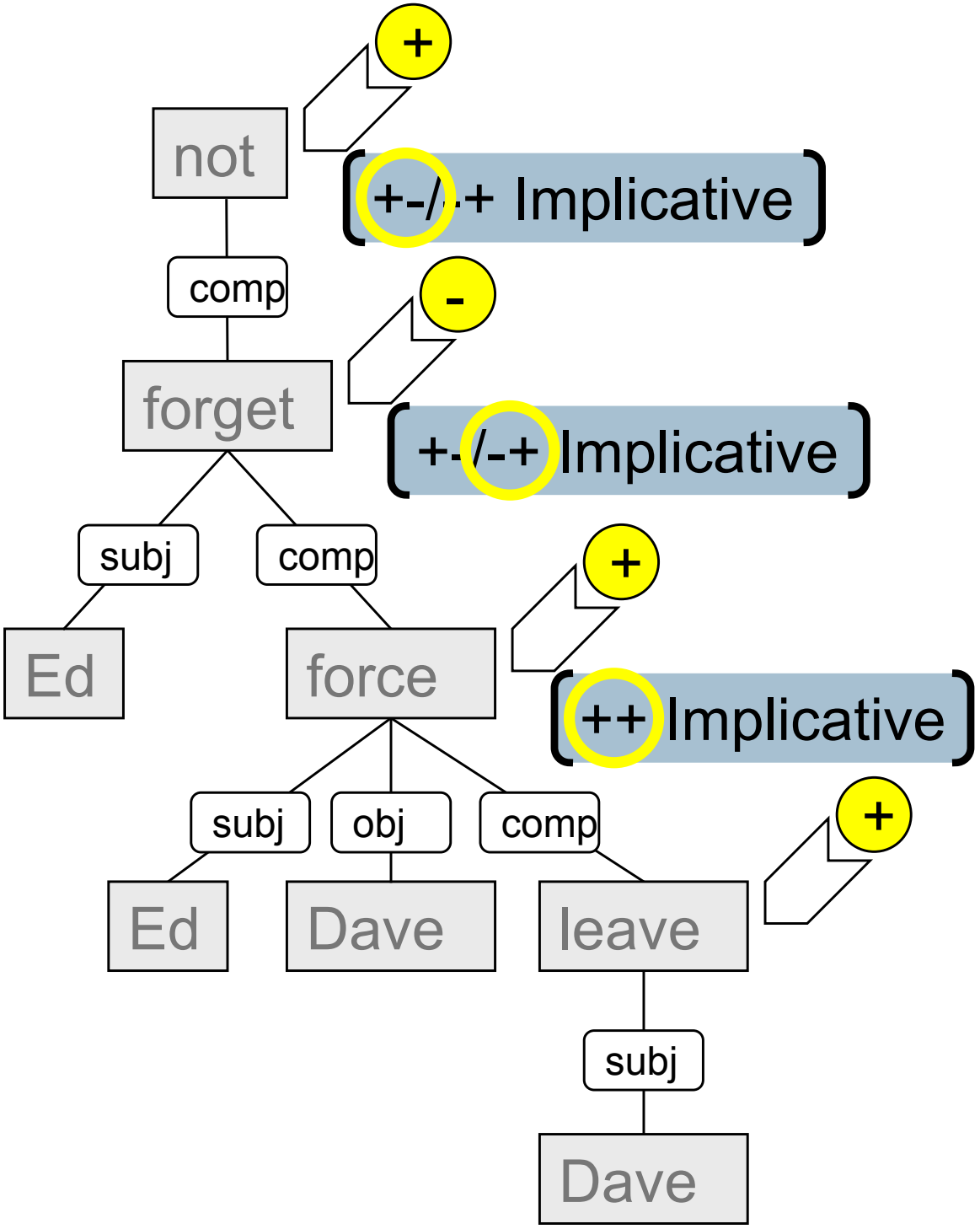


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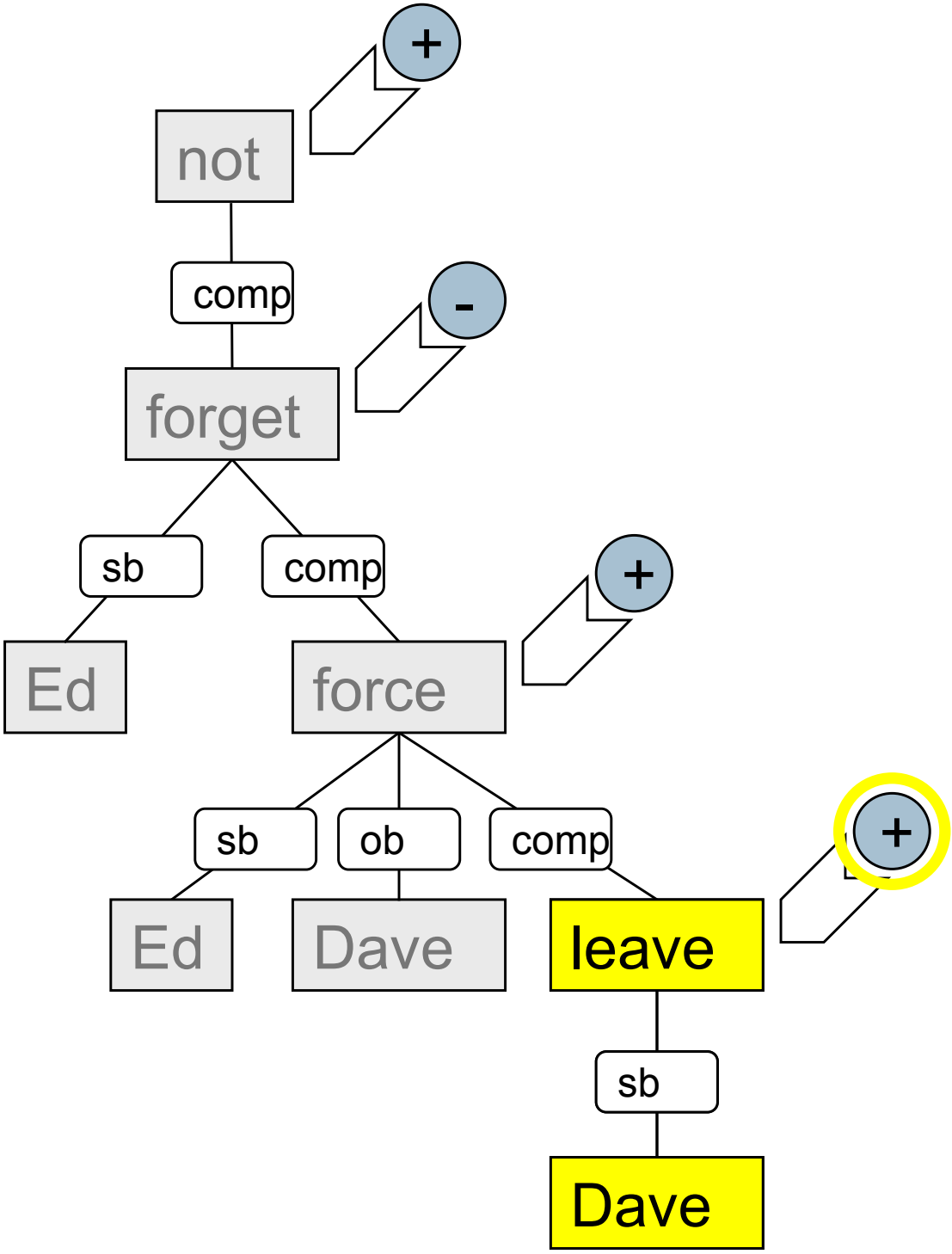


t

veridical

ctx(leave:7)

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# Ignore the **can't wait** idiom

'be eager to', 'look forward to …ing'

> Oh, I **can't wait to suffer** at the hands of my robot master. Will you be really cruel and wicked, please.
>
> I **cannot wait to dance** on the man's political grave.
>
> I **cannot wait to hear** what he'll say next!

The scope of the negation is outside the modal:

> not [ can [ …] ]

# The ambiguity of not wait to X

Ed did not wait to call for help.

… Instead he left the scene in a hurry.

==> Ed did not call for help.

… But it was too late.

==> Ed called for help right away.

# NOT WAIT TO X ==> NOT X

A subcontracted technician came to my house & replaced hard drive on Oct 13, but **didn't wait to see** if new one worked.

Deena **did not wait to talk to anyone**. Instead, she ran home.

He **did not wait to hear Ms. Coulter's response**, but immediately walked up the balcony stairs and left.

He **didn't wait to be served** - he served. He **didn't wait to be waited on** - he labored.

They **didn't wait to open** the Biosphere doors, they simply plowed through them forcefully.

At the top of the stairs Jill **didn't wait to make sure** John had kept up, but immediately kicked the door open and burst inside.

He was so excited to get his Thomas set that he **didn't wait to take off** his coat.

# NOT WAIT TO X ==> X right away

Michael Schiavo's attorney said **his client didn't wait to call** for help. If Michael Schiavo had not called 911 immediately Terri Schiavo would have died that day.

It hurt like hell, but I'm glad she **didn't wait to tell** me.

"We **didn't wait to do** water conservation. We've been doing it," Klein said.

Kalamazoo **didn't wait to strike** back. The K-Wings scored two goals in less than 90 seconds

The young Amazon unfolded her arms and opened them in offer. The bard **didn't wait to fall** into her friend's arms and become surrounded by her warmth.

I **didn't wait to open** the gift. Heck, I **didn't even wait to wear** them. They're the softest most comfy overalls I've ever owned.

# …didn’t wait to…

This is Neil on his third birthday - he was so excited to get his Thomas set that he didn't wait to take off his coat.

Happy Almost My Birthday

My bestest friend Andrea gave me these for my birthday. I'm a weenie and didn't wait to open the gift. Heck, I didn't even wait to wear them. They're the softest most comfy overalls I've ever owned.

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# What *A didn't wait to Z* means

Expectation: First X, then Y

X = Preliminary

Take off the coat

Hold until birthday

Y = Main act

Play with the train

Open the gift

What A didn't wait to Z implies is that A skipped the preliminary and proceeded directly to the main act.

But it does not tell us whether Z is X (take off the coat) or whether Z is Y (open the gift).

# NOT WAIT TO X TO Y ==> NOT X, Y RIGHT AWAY

My biggest regret is that **I didn't wait [to get married] [to have kids]**," says Gerald, a father of three. "If I had it to do over again, I'd wait until I was married to become a father."

==> I didn't get married.

==> I had kids right away.

Also, people with high risk for HIV **should not wait [to get symptoms] [to take the HIV-antibody test]**.

==> People with high risk for HIV should not get symptoms.

==> People with high risk for HIV should take the HIV-antibody right away.

# More “not wait [to X] [to Y]” examples

As I remarked above, they **didn't wait [to see the civilian reaction in America] [to start another offensive]**, so your version might be wrong.

I raised my hand above my head, as if I were in school or something, but **didn't wait [for anyone to give me the "okay”] [to start talking]**.

When Marshall was charged he **didn't wait [to get in front of a judge] [to start trying to destroy you]**, Jess.

Chances are, you probably **didn't wait [to get permission from the scientific establishment] [to start believing in the creative power of thought and the underlying spirituality of the universe]**.

# Unambiguous cases

If the content of either one of the two infinitival complements is expressed in some other way, the remaining one is unambiguous.

The OTP **did not wait [for the demand from Belgrade] [to start this investigation]**.

==> The demand from Belgrade did not come right away.

==> The OTP started this investigation right away.

Researchers **did not wait [to publish journal articles about the SARS outbreak] [before notifying the media about many of their findings]**.

==> Researchers did not publish journal articles right away.

==> Researchers notified the media about many of their findings.

**Don't wait [for a local building inspector] [before calling FEMA]**.

Wearing a Rockies T-shirt, Lecocq said he **did not wait [a day] [to change to American attire]** when he arrived in The US this time around.

# WAIT TO X ==> X IS COMING

When the subject is thematically a patient, we seem to get an implicature from ‘wait to’ that something is going to happen to him.

Watching this torture, Ball decided **not to [wait to suffer a similar fate]**. One night shortly thereafter, he ran away, hoping to go south and join the Seminoles in Florida.

==> Ball decided not to suffer a similar fate.

International lawyers generally agree that a state **need not [wait to suffer the actual blow]** before defending itself, so long as it is certain the blow is coming.

It is beneficial **not to [wait to suffer from lung disease]**, emphysema, chronic bronchitis or severe allergy.

**Do not [wait to suffer from illness]**, discomfort or exhaustion **before looking into** whether a solution of a mineral supplement can take care of a calcium and insomnia issue.

# Summary

- wait can take two optional infinitival complements:

  wait [to X] [to Y]

- *wait* is in the – implicative class, together with have the time/money, etc. and *can*, with respect to the [to X] complement

- *wait* is in the -+ class, together with *hesitate*, with respect to the [to Y] complement

- Both complements are optional. If only one is present, we don't know which one it is.

- If the subject of *wait* is thematically a patient in the [to X] complement, we seem to get a conversational (?) implicature that X will happen to her unless some action is taken to avoid it.

# The untranslatability of not wait to X

Why is it that we cannot translate

I did not wait to get help.

into French/Dutch/German/Finnish/… in a way that preserves the ambiguity?

The ambiguity comes from the two optional [to X] [to Y] complements that do not translate homomorphically to other languages. You can translate either one of the two meanings of not wait [to Z] but the ambiguity is lost. Similarly,

Time flies like an arrow.

I saw her duck.

have no ambiguity-preserving translations to other languages because the lexical and syntactic ambiguity is unique to English.

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# not hesitate/mean to X => X

Churchill's decision was made more difficult ... because he felt that communism was every bit as dangerous to civilized life as Nazism. Yet, ..., he did not hesitate to make the right moral and ethical decision.

=> Churchill made the right moral and ethical decision.

I didn't mean to hurt you. I am sorry I made you cry.

=> I hurt you.

These cases look similar but in fact the two inferences come about in different ways. One is lexical entailment, the other a pragmatic inference. We can test this using the entailment

almost X => not X

# almost hesitate to X => X

I almost hesitated to buy this software because of these shoddy reviews so I felt the need to clear things up after trying the demo and buying Powerrip 7.4.1 for my Epson R1800. It is great software ...

After reading a few negative reviews I almost hesitated to eat at The Shed. I'm so glad I tried it for myself!

He almost hesitated to speak to the boss when he was in this kind of mood, but he had something to tell Steve that couldn't wait.

I almost hesitated to review this. It is already way too popular, but the food is sooo good!

# almost mean to X ?

It was almost meant to be a trilogy. It's 1400 pages. The second book is bigger than this one and the third is big as well.

(It is a trilogy.)

She seems to have a lot of secrets and it's like she almost meant to turn up at that exact house to meet those people.

(She turned up at that house.)

==========

I almost meant to pick it up again and do something about it.

(I did not pick it up again.)

The sealing off of West Berlin was almost meant to starve the West Berliners into wanting to join the communists with East Berlin.

(It did not starve West Berliners into communism.)

# more mean to X in the wild

That Gay Mobster Totally Did Not Mean to Come Out.

(He did come out)

Everybody's having fun with Robert Mormando, the gay mafia hitman the world learned about today. It's like The Sopranos! Except he only meant to come out in front of the judge, not a bunch of newspaper reporters.

(He did not come out in front the judge.)

Hawkins sniper suspect testifies he did not mean to kill when he fired rifle

Brewer testified Wednesday he intended to shoot ... to injure or scare the man with whom he'd been in an ongoing dispute. ... A bullet fired by Brewer from ... missed its intended target and killed 18-year-old Jackson Blue Sellers, an innocent bystander.

(Brewer did kill a man.)

Jennifer Lopez insists she meant to fall on her famous derriere during her performance at the 2009 American Music Awards.

(She did fall.)

# A Pragmatic Interpretation

In the case of mean to X and not mean to X examples, it is already known in the context that X happened or that X did not happen. The inference

She didn't mean to hurt him. => She hurt him.

is not entailment or conventional implicature as it is in the case of the hesitate examples. It comes from understanding what is the most likely situation where the example would occur. It is not a lexical inference but a statistical one.

What remains to be explained is why the pattern

mean to X => not X

not mean to X => X

is the default interpretation in the absence of knowledge of what actually happened but defeasible if we know the facts. That's because we don't generally comment on situations that match our intentions. Typically it is the situations that don't correspond to someone's intention that are worth commenting about.

# Reflections

Textual inference is a good test bed for computational semantics.

- It is task-oriented. It abstracts away from particular meaning representations and inference procedures.
- It allows for systems that make purely linguistic inferences, others may bring in world knowledge and statistical reasoning.

This is a good time to be doing computational semantics.

- Purely statistical approaches have plateaued.
- The number of semantic submissions to the ACL is sharply up.
- There is computing power for parsing and semantic processing.
- Success might even pay off in real money.

# A Quote

[There is a] common misconception that language use has primarily to do with words and what they mean. It doesn't. It has primarily to with people and what *they* mean.

Herbert H. Clark and Michael F. Schober

"Asking Questions and Influencing Answers"

In *Questions about Questions*, Judith M Tanur, ed.,

Russel Sage Foundation, New York, p. 15.

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