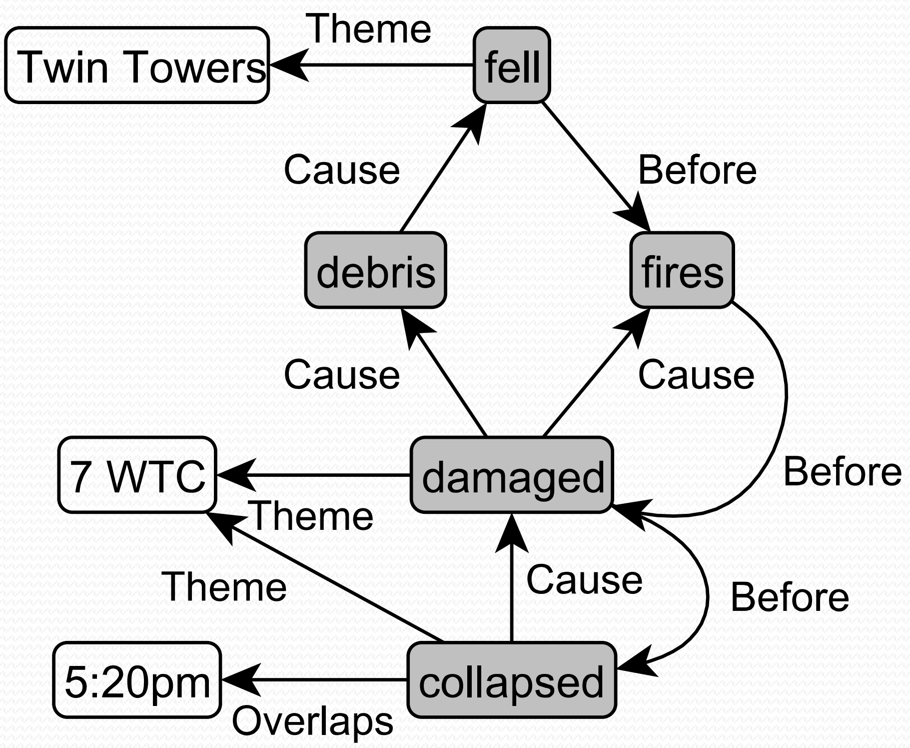
Building a Corpus of Temporal-Causal Structure

**Steven Bethard, William Corvey,
Sara Klingenstein, James H. Martin**

University of Colorado

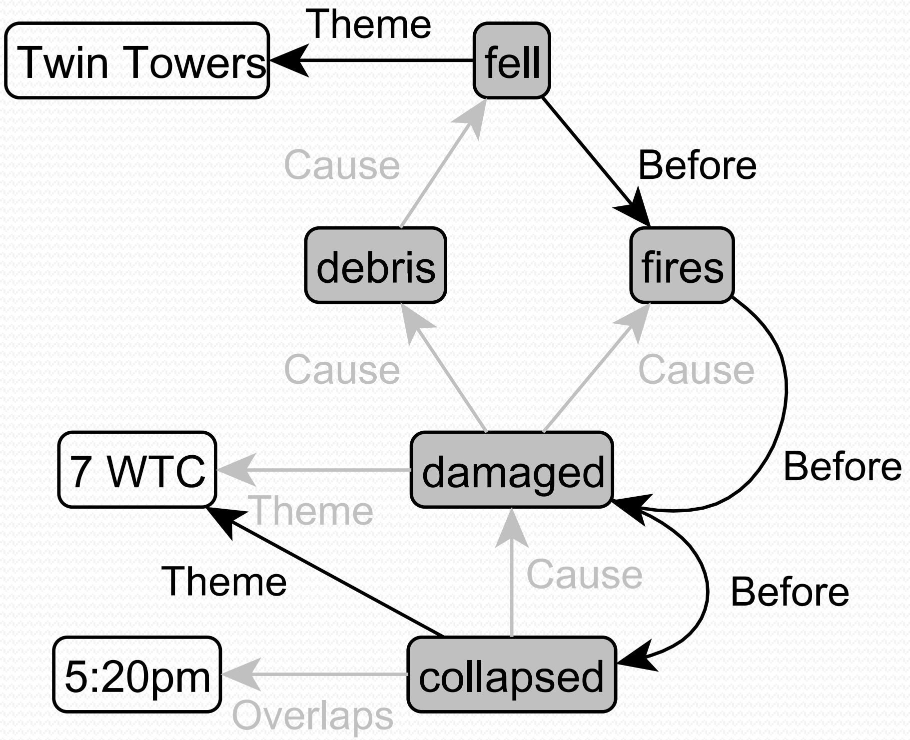
Semantic structures in text

- 7 WTC collapsed at 5:20p.m., after being heavily damaged by debris from the Twin Towers when they fell and from subsequent fires.



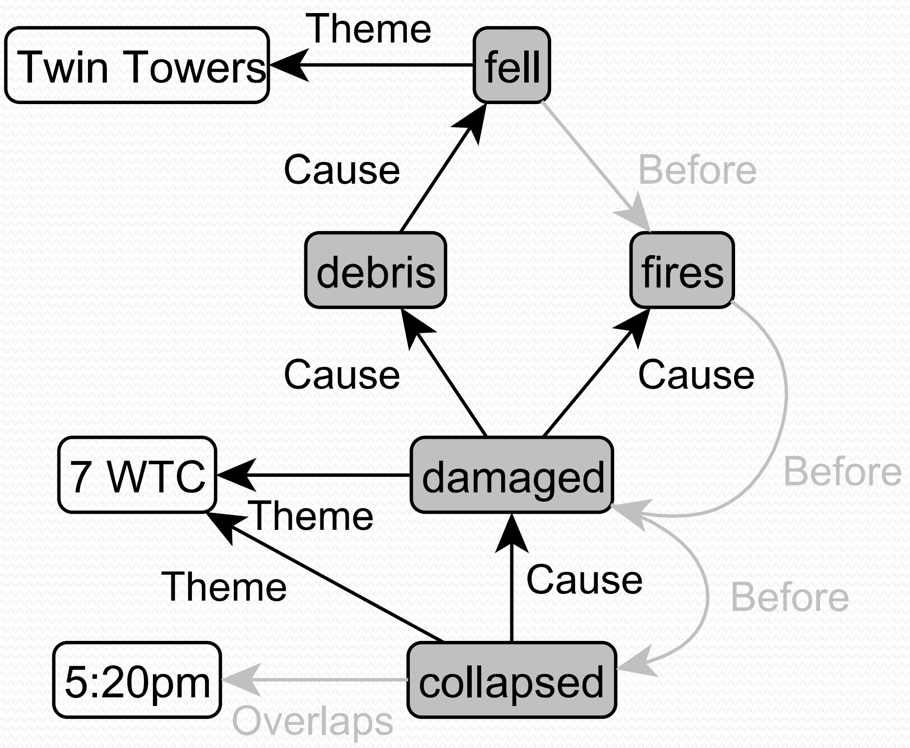
Answering temporal questions

- Which collapsed first, the Twin Towers or 7 WTC?



Answering causal questions

- What caused the 7 WTC collapse?



Temporal-causal structure

- Motivation
- Annotation
  - Temporal guidelines
  - Causal guidelines
- Corpus analysis
- Machine learning
  - Training models
  - Error analysis
- Conclusions

Annotation: corpus

- Conjoined verbal events
  - E.g. *Fuel tanks had* ***leaked*** *and* ***contaminated*** *the soil.*
- Why conjoined events?
  - Frequently expresses both temporal and causal
  - 10% of all adjacent verbal events in the TimeBank
- Corpus
  - WSJ Treebank (0416 – 0971)
  - Events identified automatically

Annotation: temporal scheme

- Labels: BEFORE/AFTER/NO-REL

- Guidelines
  - Separate events from tense and aspect, e.g.
    - *The funding mechanism, which has **received** congressional approval and is **expected** to be signed by President Bush…*
  - Possible worlds analysis, e.g.
    - *Persons who examine the materials may **make** notes and no one will **check** to determine what notes a person has taken.*
  - (See paper for full list)

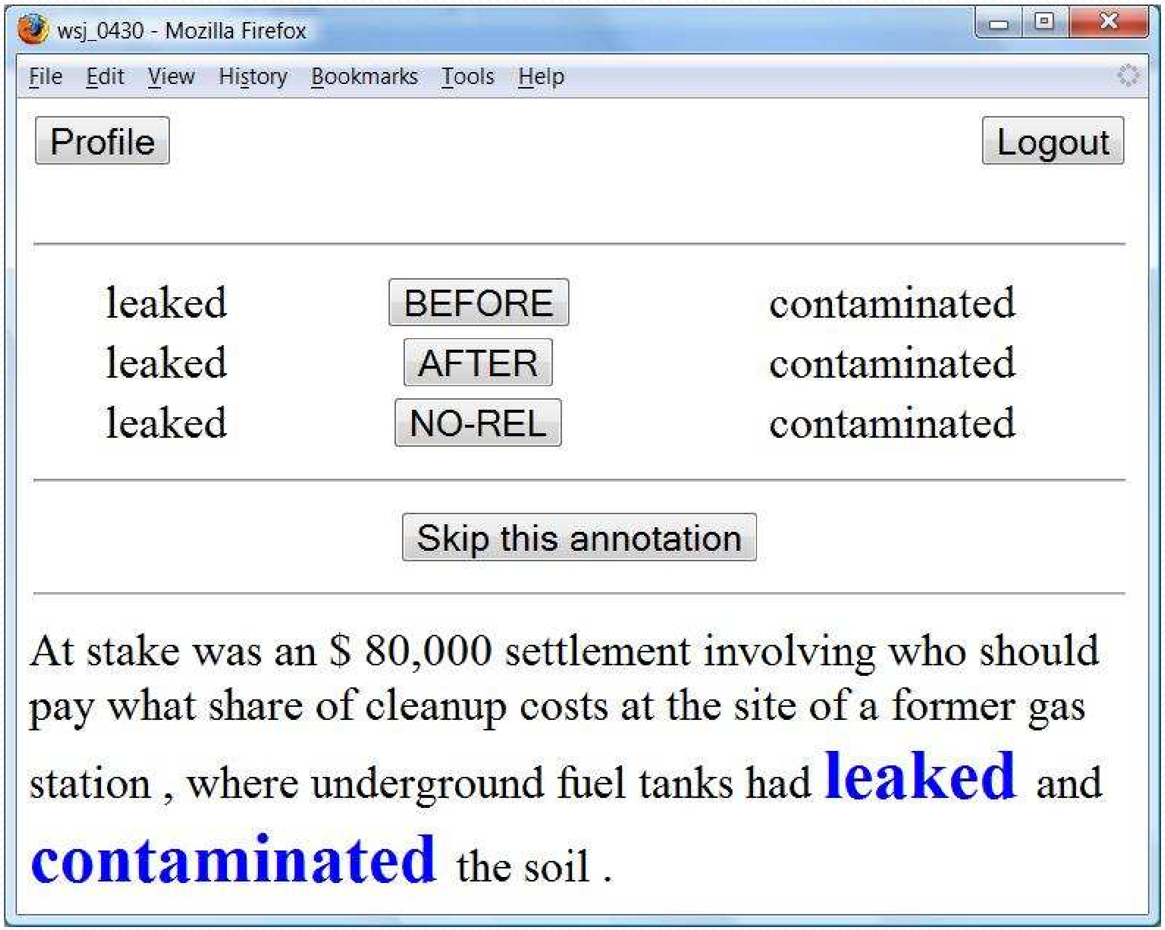
Annotation: causal scheme

- Labels: CAUSAL/NO-REL

- Guidelines: paraphrase that best maintains meaning
  - CAUSAL:
    - *and as a result, and as a consequence, and enabled by that*
  - NO-REL:
    - *and independently, and for similar reasons*

  - E.g. *Fuel tanks had* ***leaked*** *and* ***contaminated*** *the soil.*

Annotation: interface



Corpus: overview

Event pairs	1000
Documents	556
BEFORE	313
AFTER	16
NO-REL (temporal)	671
CAUSAL	271
NO-REL (causal)	729

Task	Agree	Kappa	F
Temporal	81.2	0.715	71.9
Causal	77.8	0.556	66.5

- BEFORE/CAUSAL:
  "We **recognized** the problem and **took** care of it."
- AFTER:
  The Colombian minister was said to have referred to a letter that he **said** President Bush sent to Colombian President Virgilio Barco , and in which President Bush **said** it was possible to overcome obstacles to a new agreement.

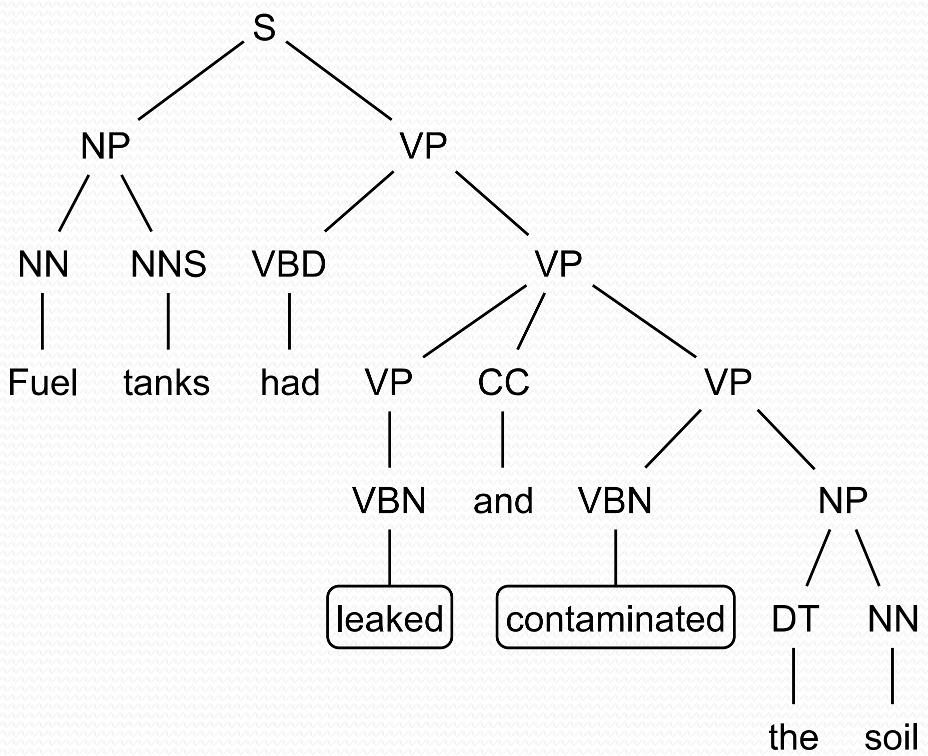
Corpus: analysis

- 975 of 1000 event pairs were unique
- 75% of conjoined events had the same pos (tense)

- 32% of CAUSAL relations had no underlying BEFORE
  - Two views of the same event
    - *Abbie* ***lies*** *back and* ***leaves*** *the frame empty.*
  - Two states, but one starts earlier
    - *Japanese local governments are* ***expected*** *to invest heavily in computer systems over the next few years, and many companies* ***expect*** *that field to provide substantial revenue.*

Machine learning

- Pair-wise classifications
  - BEFORE/AFTER/NO-REL
  - CAUSAL/NO-REL
- Features
  - Words: *leaked contaminated*
  - Lemmas: *leak contaminate*
  - Pos tags: *VBN VBN*
  - Least common ancestor: *VP*
  - Path: *VBN>VP>VP<VP<VBN*
  - Preceding, intervening and following words



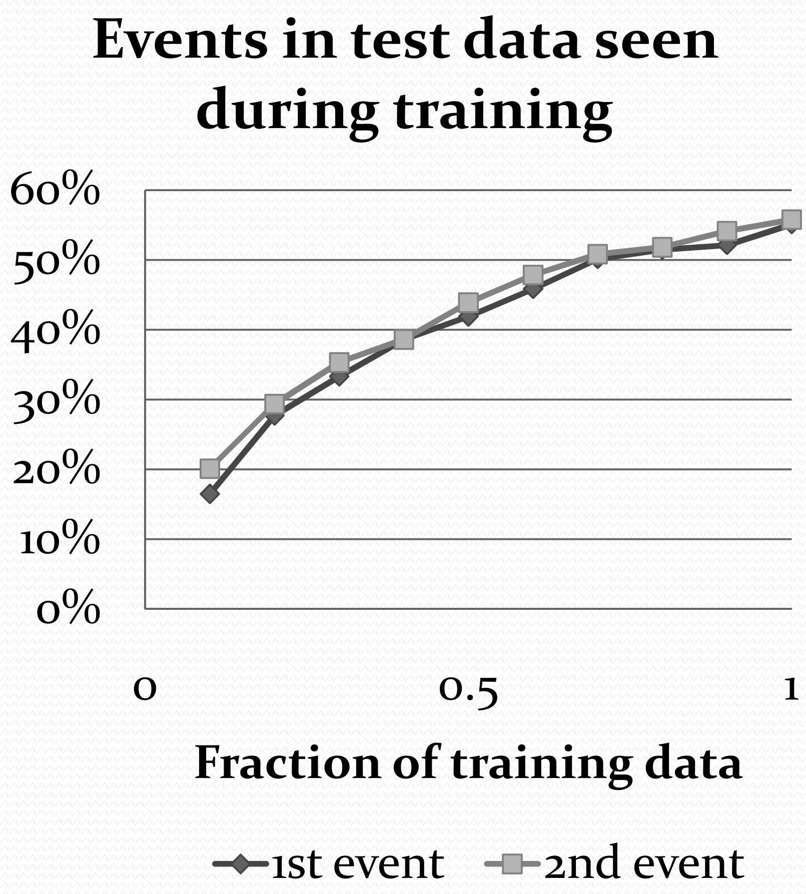
Machine learning: results

Temporal relations	
Model	**F**
All NO-REL	0.0
All BEFORE	41.6
Memorize pair	0.0
Memorize 1st	28.8
Memorize 2nd	32.9
Memorize pos pair	13.9
SVM	**43.4**

Causal relations	
Model	**F**
All NO-REL	0.0
All CAUSAL	34.8
Memorize pair	0.0
Memorize 1st	24.5
Memorize 2nd	19.5
Memorize pos pair	8.1
SVM	**37.4**

Machine learning: analysis

- SVM outperforms all baselines
  - But surface and syntactic features are not enough
- 50% of errors require world knowledge, e.g.
  - *Some of the funds will be used to* ***demolish*** *unstable buildings and* ***clear*** *sites for future construction.*
- More data will help →



Summary

- Annotation
  - 1000 conjoined verbal event pairs
  - Parallel temporal and causal relations
- Corpus
  - 97.5% unique event pairs
  - 32% of CAUSAL relations w/o BEFORE
- Machine learning
  - SVM – 43.4F on temporals, 37.4 F on causals
  - Lexical and syntactic features are not enough
  - Exposure to more words will help

Questions?