

CMSC 491/691: Interactive  
Fiction and Text Generation

# Commonsense Reasoning

These slides adapted from the [ACL 2020  
Commonsense Tutorial](#) by Yejin Choi,  
Vered Shwartz, Maarten Sap, Antoine Bosselut,  
and Dan Roth

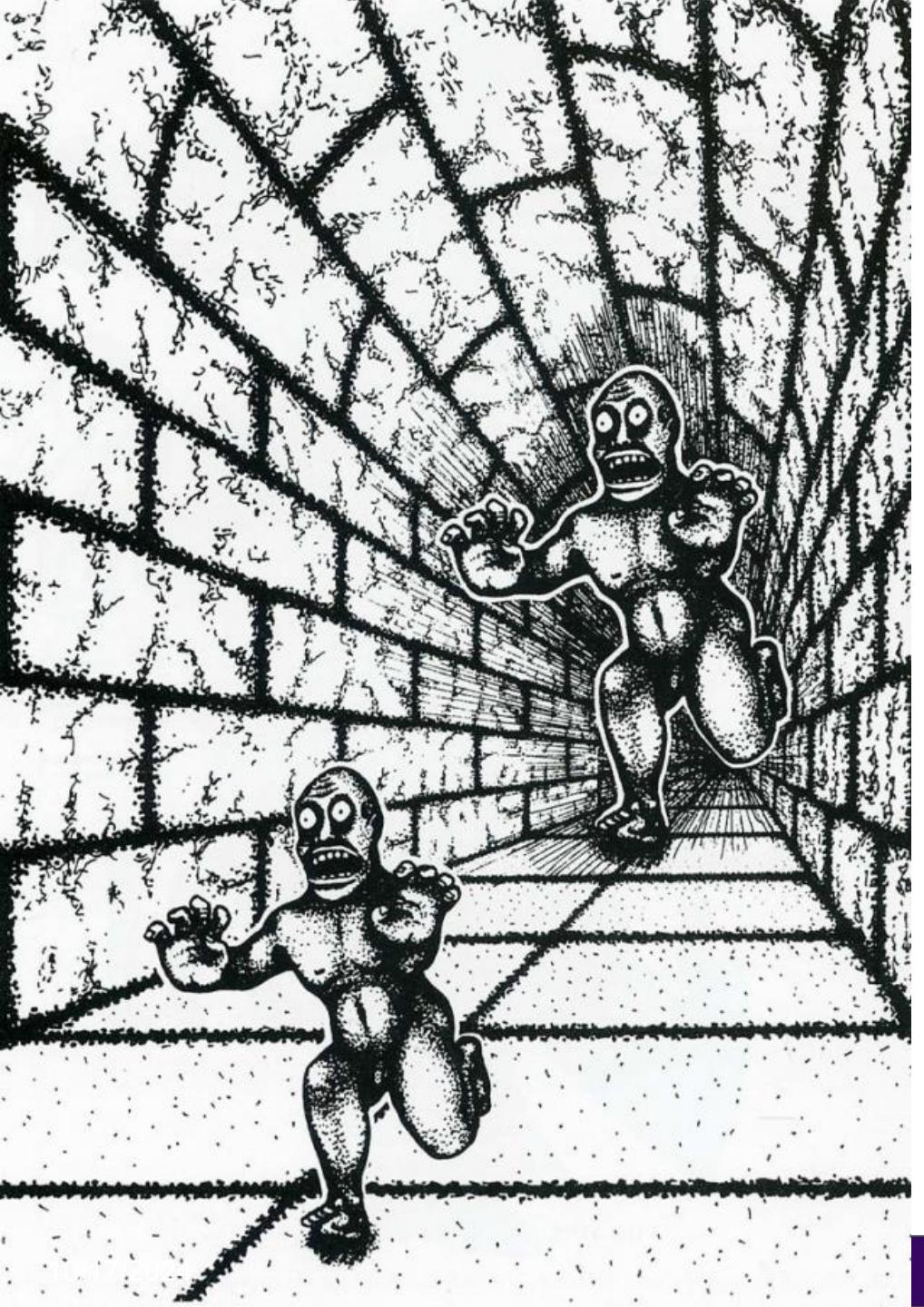


# Announcements

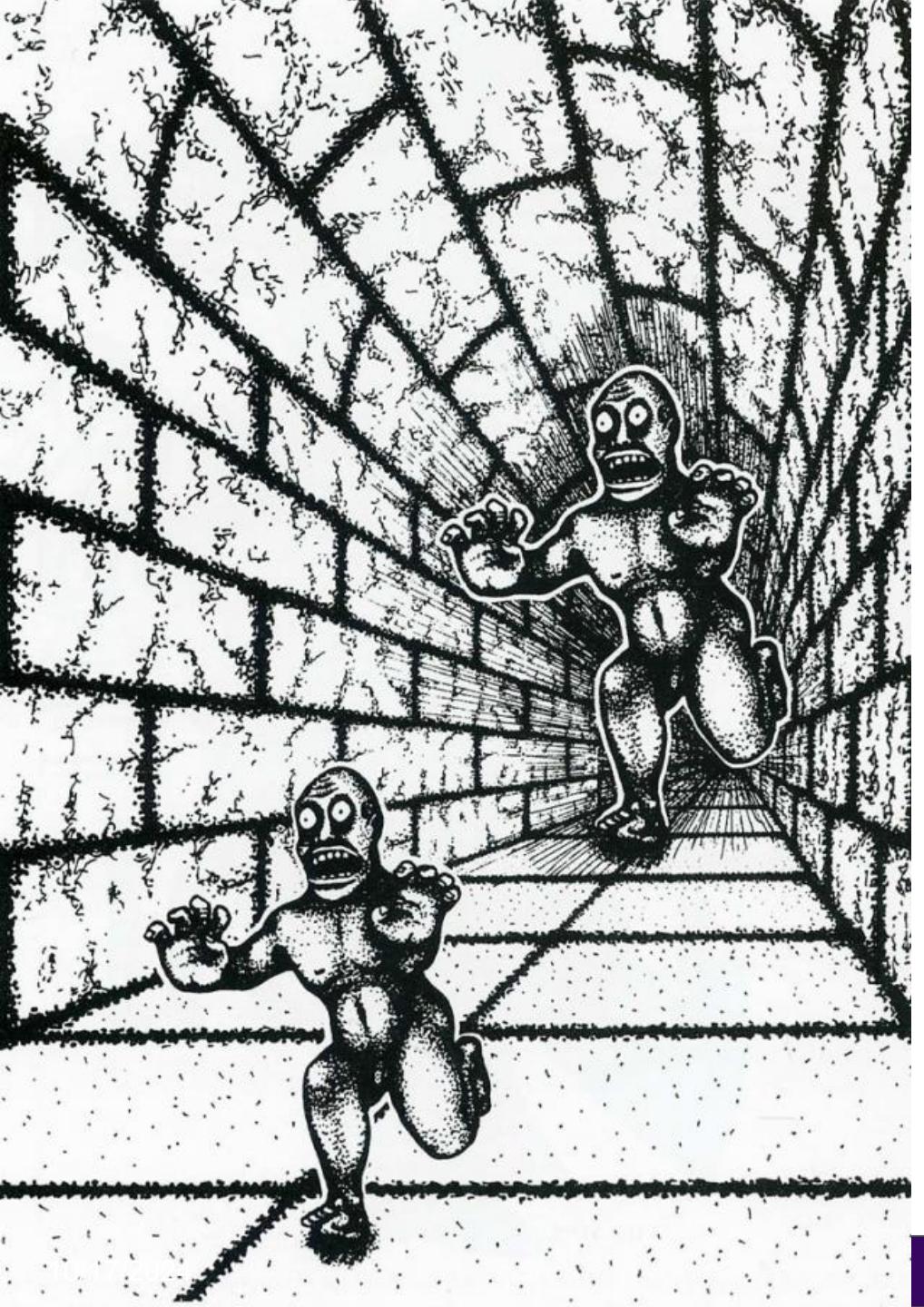
- HW 3
  - Due 10/28 (same day as project milestone)
  - Next Tuesday will be grad paper presentations
  - Midpoint feedback due 10/22 – hard deadline
    - knowledge check point
  - All homeworks are up 2% (most are 12% now, HW1 is 7%)
  - Final presentations will be in SHER 150 on 12/12

# Learning Objectives

- Consider the difference between human commonsense and machine reasoning
- Find out about existing commonsense knowledge bases
- Distinguish when you would use one knowledge base over another



# What does this picture show?



# Monsters in a Tunnel

- **Two monsters are running** (rather than standing still on one foot)
- **One is chasing another** (rather than trying to copy his movements)
- **The chaser has hostile intentions and the chased is afraid** (even though two faces are identical)

Important Observations:

- A great deal of **intuitive inferences** are **commonsense inferences**, which can be described in **natural language**.
- None of these inferences is absolutely true. The inferences are **stochastic** in nature. Everything is **defeasible** with additional context.
- Commonsense inferences are about **predicting new information** that **is likely to be true** based on partially available information.

# Claims of AI systems reaching a “human level”

CADE METZ

BUSINESS MAY 22, 2017 3:12 PM

## ChatGPT passes exams from law and business schools

By Samantha Murphy Kelly, CNN Business

4 minute read · Updated 1:35 PM EST, Thu January 26, 2023

JULY 12, 2022 | 6 MIN READ

## Google Engineer Claims AI Chatbot Is Sentient: Why That Matters

Is it possible for an artificial intelligence to be sentient?

BY LEONARDO DE COSMO

## AlphaGo Is Back to Battle Mere Humans—and It's Smarter Than Ever

s in China to take on the world's top-ranked e there for every move.

Newsweek

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Tech Joe Rogan The Joe Rogan Experience

Kamala Harris

Donald Trump

## Who Is Joe Rogan Voting For? We Asked ChatGPT

Published Oct 15, 2024 at 6:38 AM EDT

Updated Oct 15, 2024 at 6:07 PM EDT

## AI in real-life usage: Can't win an argument with your partner? Get ChatGPT to do it for you

Girlfriend goes viral for using ChatGPT to make her arguments when couple disagrees, apparently telling her partner that they lack 'emotional bandwidth.'



Darren Allan  
Tech Reporter

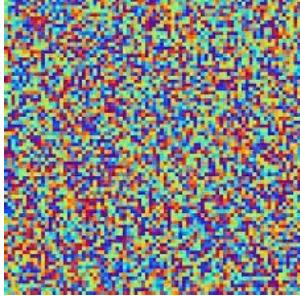


Published Oct 17, 2024 9:05 AM CDT

3 minutes read time



+



=



# Giant panda Object Recognition

**Gibbon**

Szegedy et al,  
2014....



Jabri et al,  
2017

VQA



A horse standing in the grass.

# Captioning

MacLeod  
et al, 2017

QA

Jia et al,  
2017

Where did Tesla move in  
1880? **Chicago**

a Tesla moved to  
Prague in 1880. ... Tadakatsu  
moved to Chicago in 1881.

# Theory of Core Knowledge

Domain	Description
Objects	supports reasoning about objects and the laws of physics that govern them
Agents	supports reasoning about agents that act autonomously to pursue goals
Places	supports navigation and spatial reasoning around an environment
Number	supports reasoning about quality and how many things are present
Forms	supports representation of shapes and their affordances
Social Beings	supports reasoning about Theory of Mind and social interaction

Developmental psychologists have shown that children develop the ability to reason about these domains early in life. Such reasoning is important for later learning.

# Definition of Common Sense

The basic level of **practical knowledge** and **reasoning** concerning **everyday situations** and events that are **commonly shared** among **most** people.

It's OK to keep the closet door open

It's not OK to keep the refrigerator door open because the food might go bad

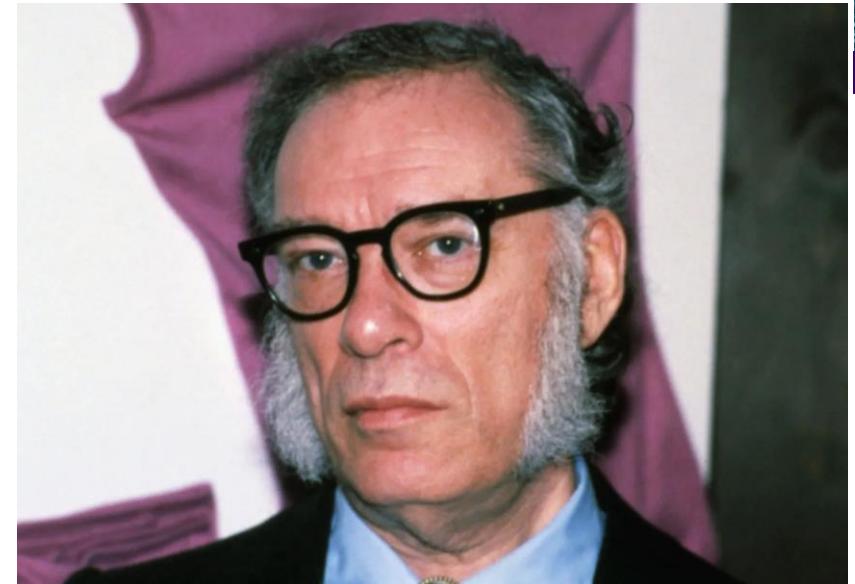
Essential for humans to live and interact with each other in a reasonable and safe way

Essential for AI to understand human needs and actions better

# Isaac Asimov's "Three Laws of Robotics"

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

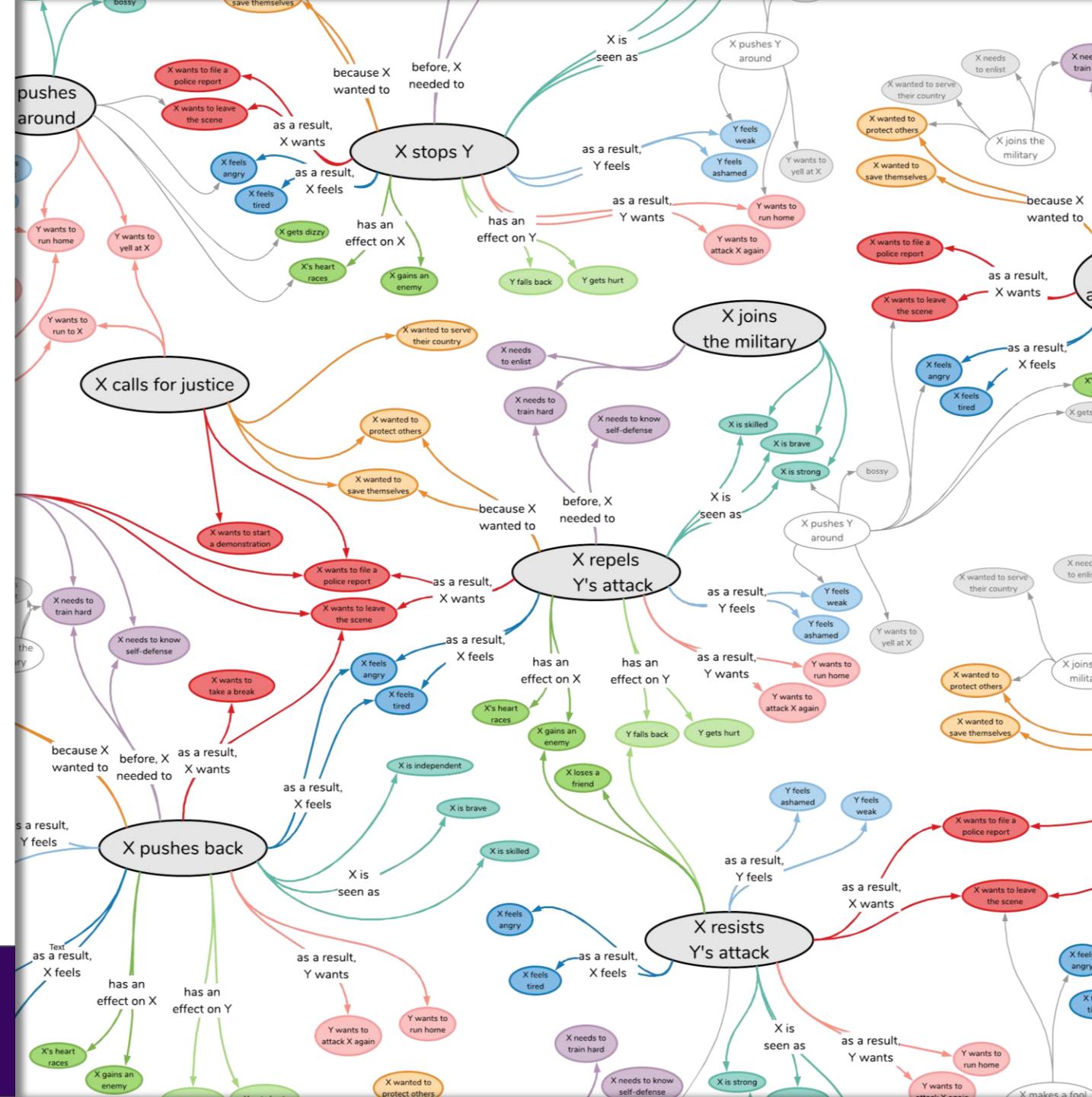
- Isaac Asimov, 1942 short story "Runaround"



<https://cdn.britannica.com/82/195182-050-97684526/Isaac-Asimov-1979.jpg>

## CMSC 491/691: Interactive Fiction and Text Generation

# Commonsense resources



# Grandma's glasses



Tom's grandma was reading a new book, when she dropped her glasses.

She couldn't pick them up, so she called Tom for help.

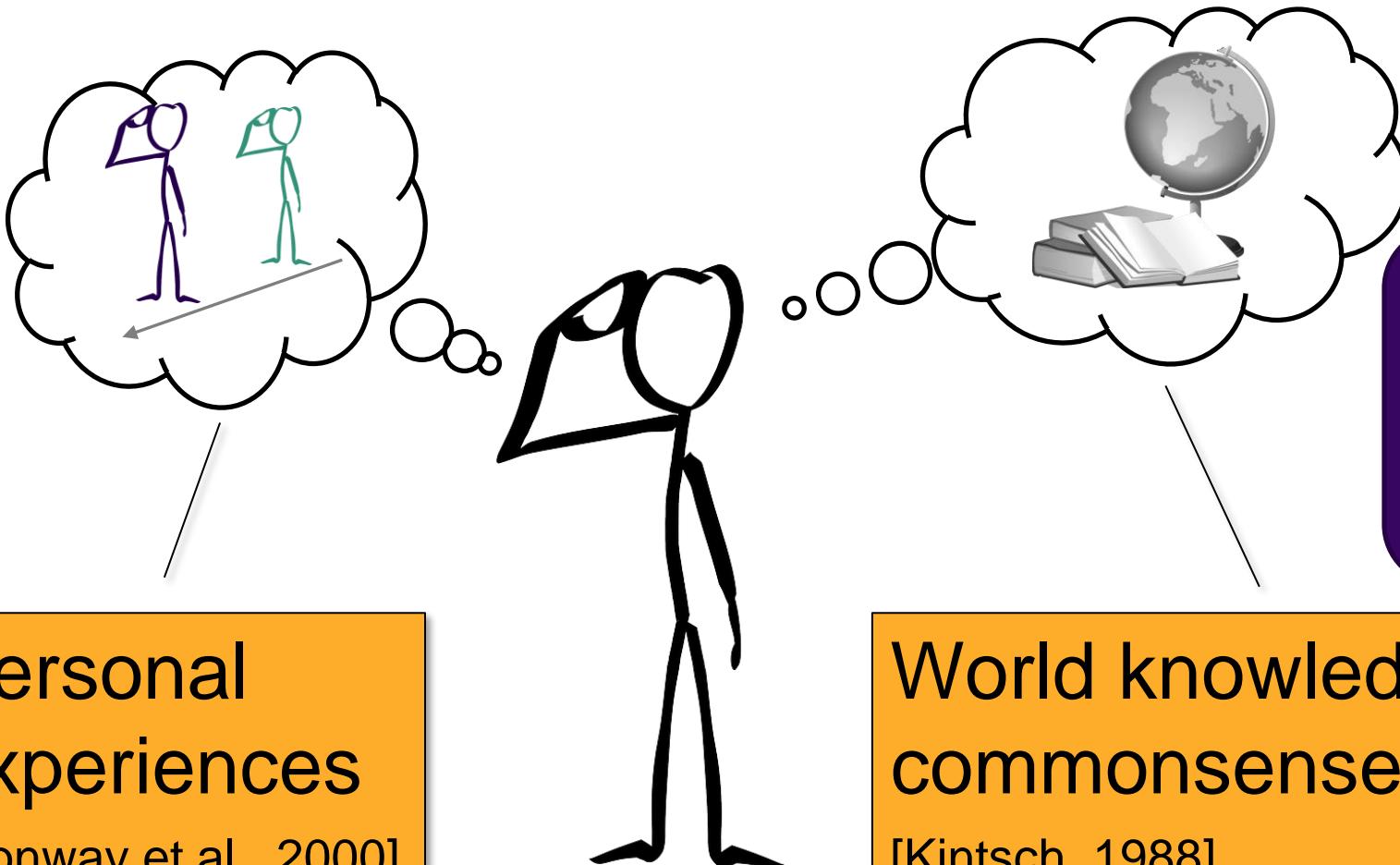
Tom rushed to help her look for them, they heard a loud crack.

They realized that Tom broke her glasses by stepping on them.

Promptly, his grandma yelled at Tom to go get her a new pair.

# Humans reason about the world with **mental models**

[Graesser, 1994]



**Personal experiences**

[Conway et al., 2000]

**World knowledge and commonsense**

[Kintsch, 1988]

Tom's grandma was reading a new book, when she dropped her glasses.

She couldn't pick them up, so she called Tom for help.

Tom rushed to help her look for them, they heard a loud crack.

They realized that Tom broke her glasses by stepping on them.

Promptly, his grandma yelled at Tom to go get her a new pair.

*ConceptNet*

*ATOMIC*

Tom's grandma was reading a new book, when she dropped her glasses.

```
graph LR; reading[reading] -- usedFor --> glasses[glasses]
```

She couldn't pick them up, so she called Tom for help.

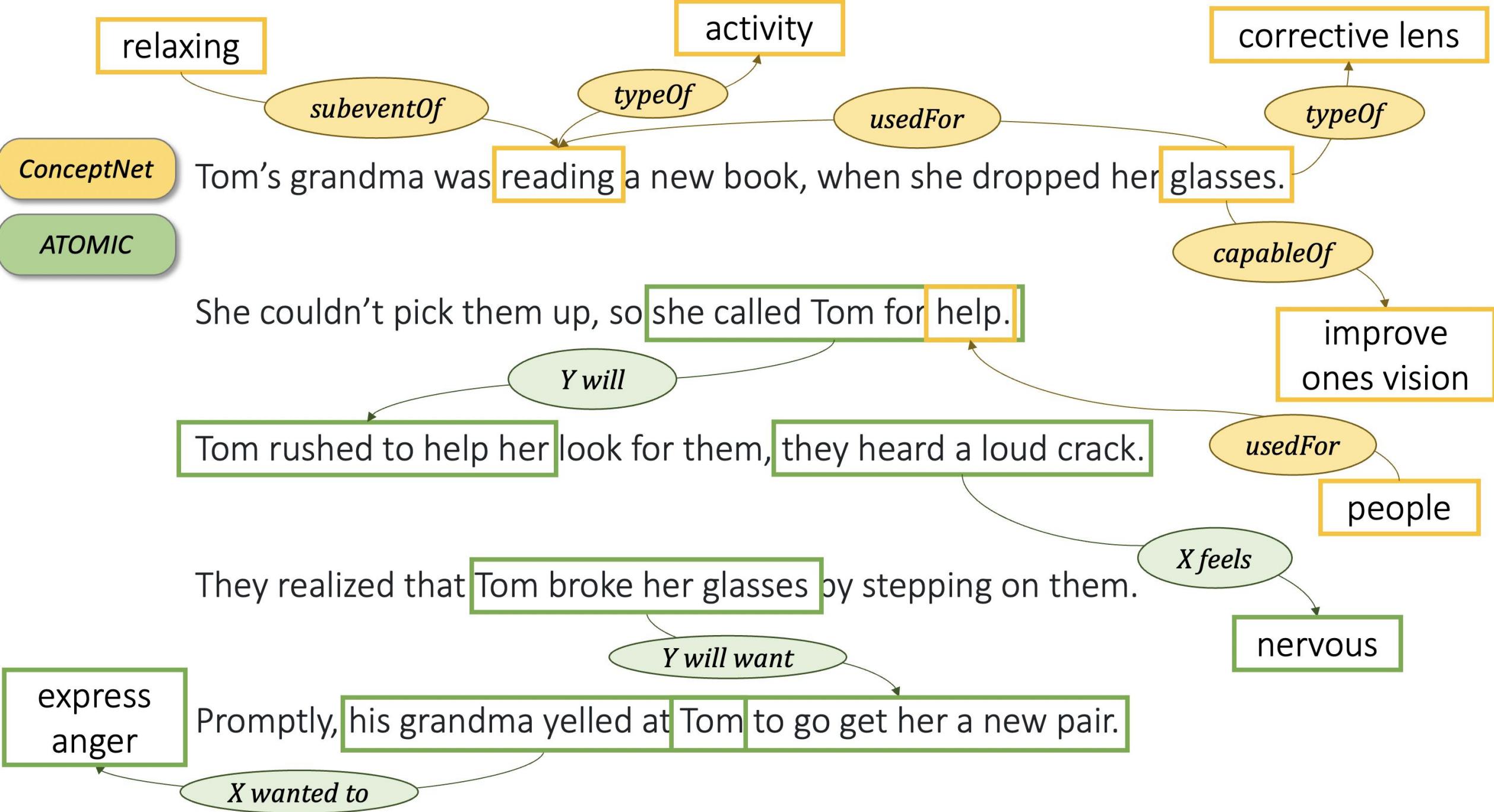
*Y will*

Tom rushed to help her look for them, they heard a loud crack.

They realized that Tom broke her glasses by stepping on them.

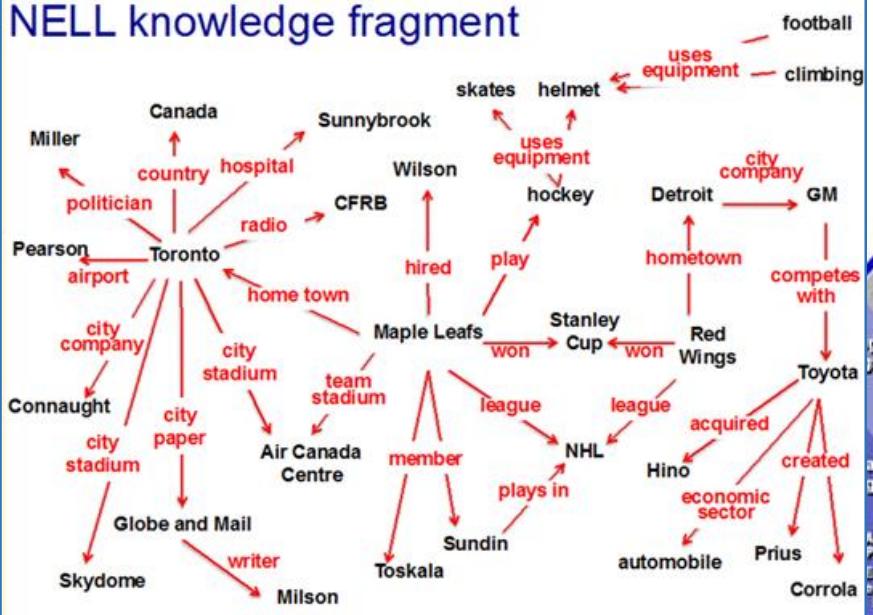
*Y will want*

Promptly, his grandma yelled at Tom to go get her a new pair.



# Some important resources

NELL knowledge fragment

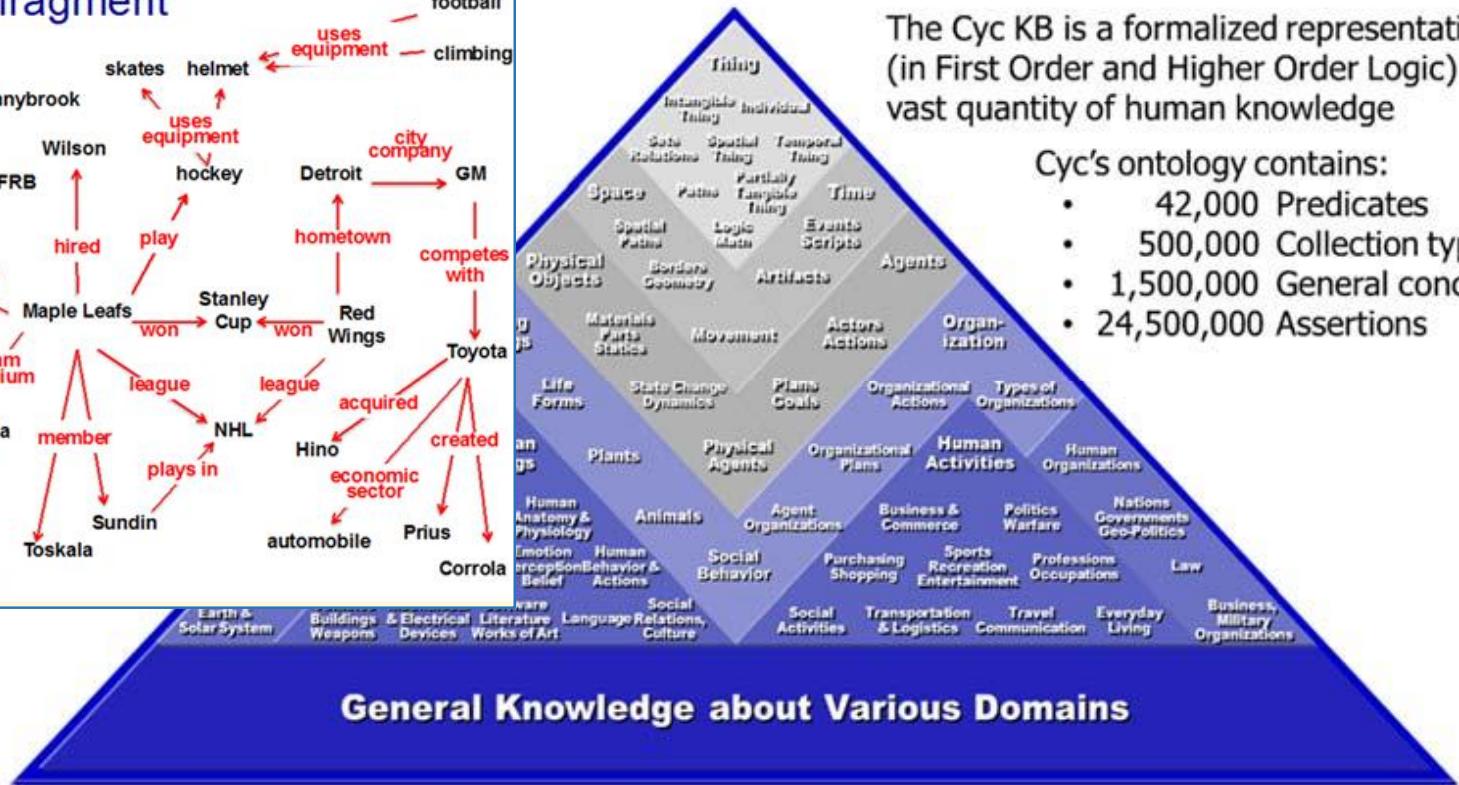


Open Mind Comm  
(Minsky, Singh &  
1999)

The Cyc KB is a formalized representation  
(in First Order and Higher Order Logic) of a  
vast quantity of human knowledge

Cyc's ontology contains:

- 42,000 Predicates
- 500,000 Collection types
- 1,500,000 General concepts
- 24,500,000 Assertions



Cyc  
(Lenat et al.,  
1984)

OpenCyc  
(Lenat,  
2004)

ResearchCyc  
(Lenat, 2006)

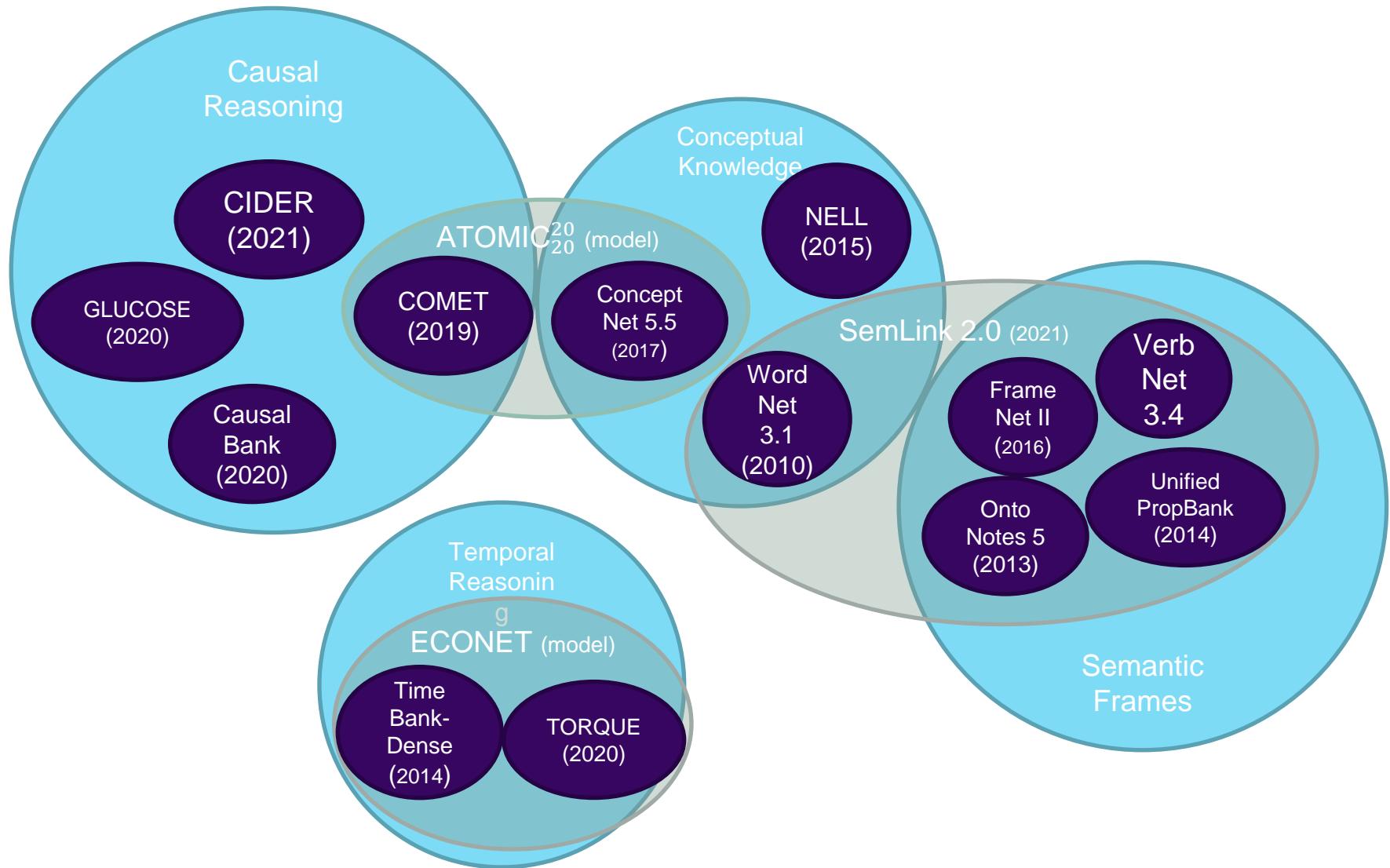
OpenCyc 4.0  
(Lenat, 2012)

ATOMIC  
(ap et al., 2019)

World 2.0  
(et al.,  
7)

Net 5.5  
(al., 2017)

today



# How do you create a commonsense resource?

# Desirable properties for a commonsense resource

## Coverage

Large scale

Diverse knowledge types

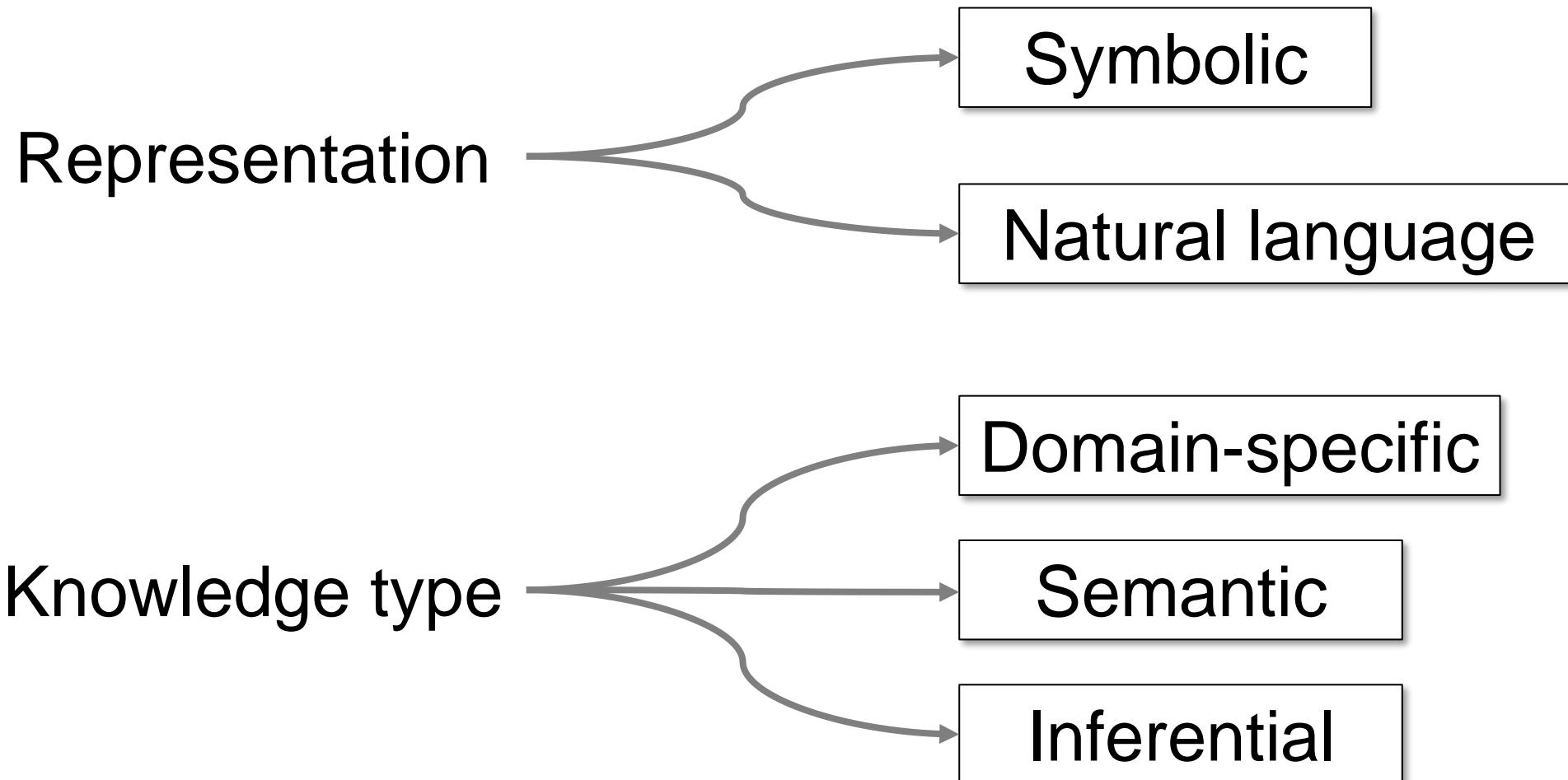
## Useful

High quality knowledge

Usable in downstream tasks

Multiple resources tackle different  
knowledge types

# Creating a commonsense resource



# What is a semantic frame?

“people understand the meaning of words largely by virtue of the frames which they evoke”

- Understanding words in context
- Based on recurring experiences

Josef Ruppenhofer, Michael Ellsworth, Miriam R. L. Petrucc, Christopher R. Johnson, Collin F. Baker, & Jan Scheffczyk. *FrameNet II: Extended Theory and Practice* (Revised November 1, 2016.)

Fillmore, Charles J. (1982). "Frame semantics". In The Linguistic Society of Korea, eds. *Linguistics in the Morning Calm*. Seoul: Hanshin. 111-37.

# **CONCEPTNET:**

*semantic knowledge in natural language form*

## Related terms

- en book →
- en books →
- en book →

## Effects of reading

- en learning →
- en ideas →
- en a headache →

reading is a subevent  
of...

- en you learn →
- en turning a page →
- en learning →

**en reading**  
An English term in ConceptNet 5.8

## Subevents of reading

- en relaxing →
- en study →
- en studying for a subject →

## Things used for reading

- en article →
- en a library →
- en literature →
- en a paper page →

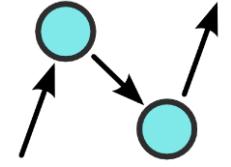
reading is a type of...

- en an activity →
- en a good way to learn →
- en one way of learning →
- en one way to learn →

## Types of reading

- en browse (n, communication) →
- en bumf (n, communication) →
- en clock time (n, time) →
- en miles per hour (n, time) →

# What is ConceptNet?



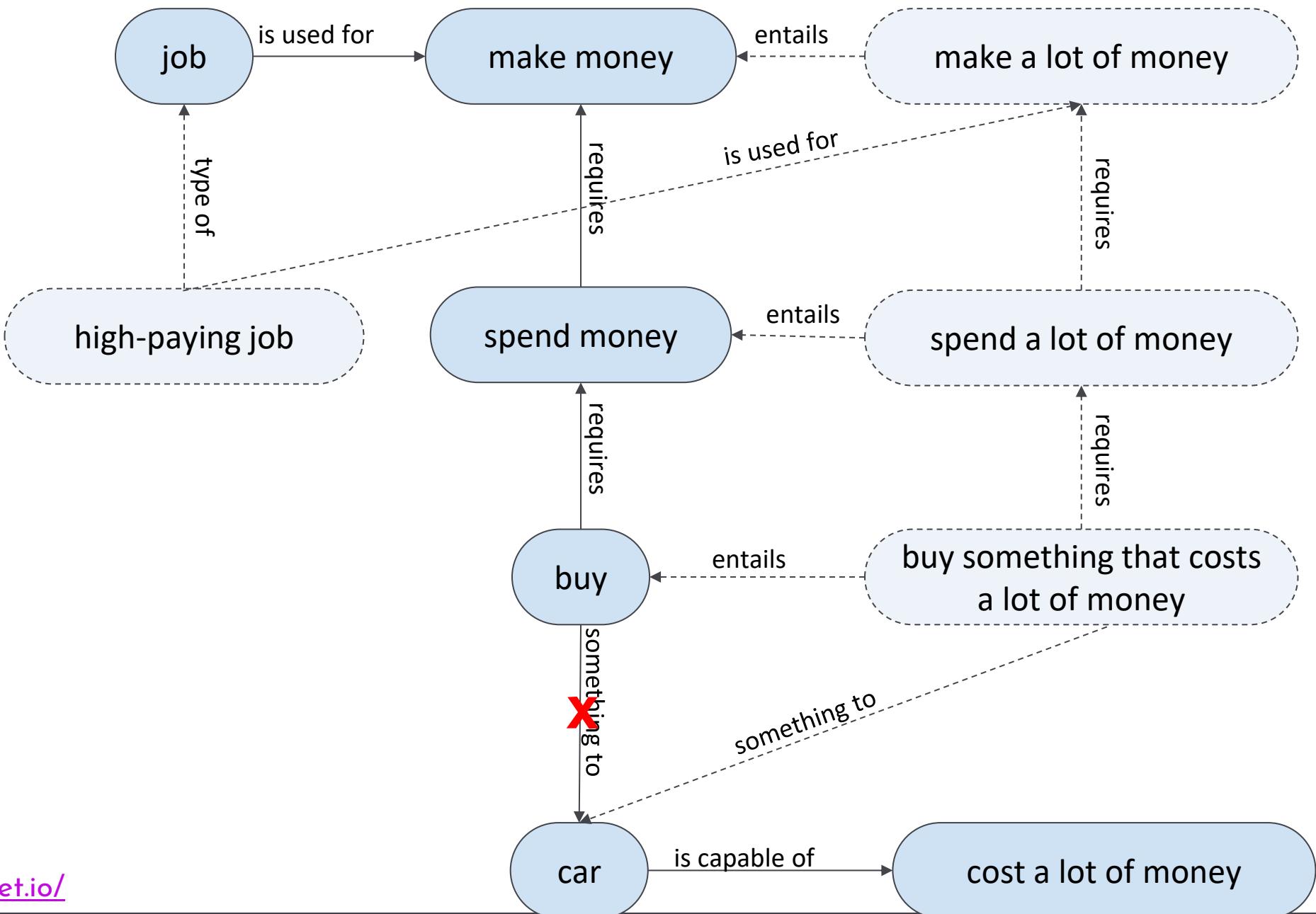
General commonsense knowledge

21 million edges and over 8 million nodes (as of 2017)

- Over 85 languages
- In English: over 1.5 million nodes

Knowledge covered:

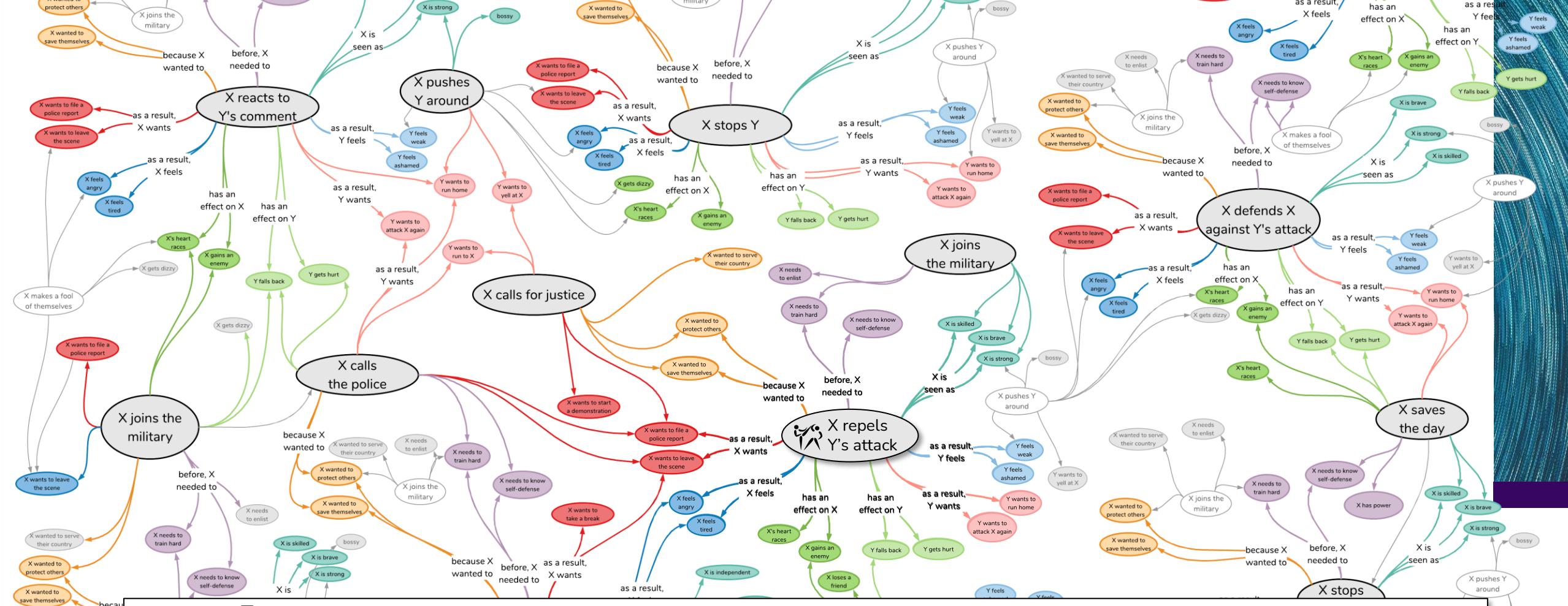
- Open Mind Commonsense assertions
- Wikipedia/Wiktionary semantic knowledge
- WordNet, Cyc ontological knowledge



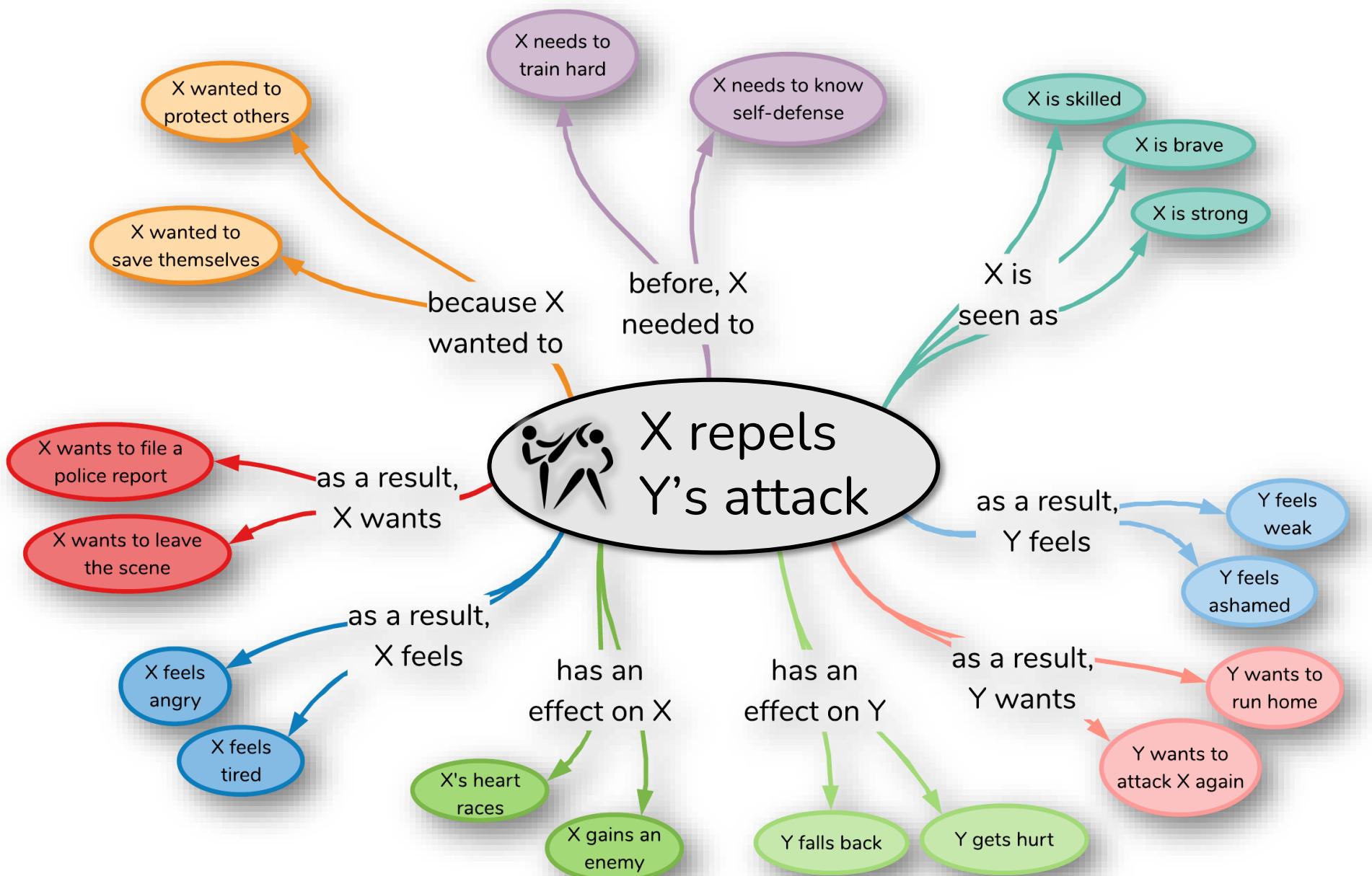
<https://conceptnet.io/>

# ATOMIC: *inferential* knowledge in *natural language* form

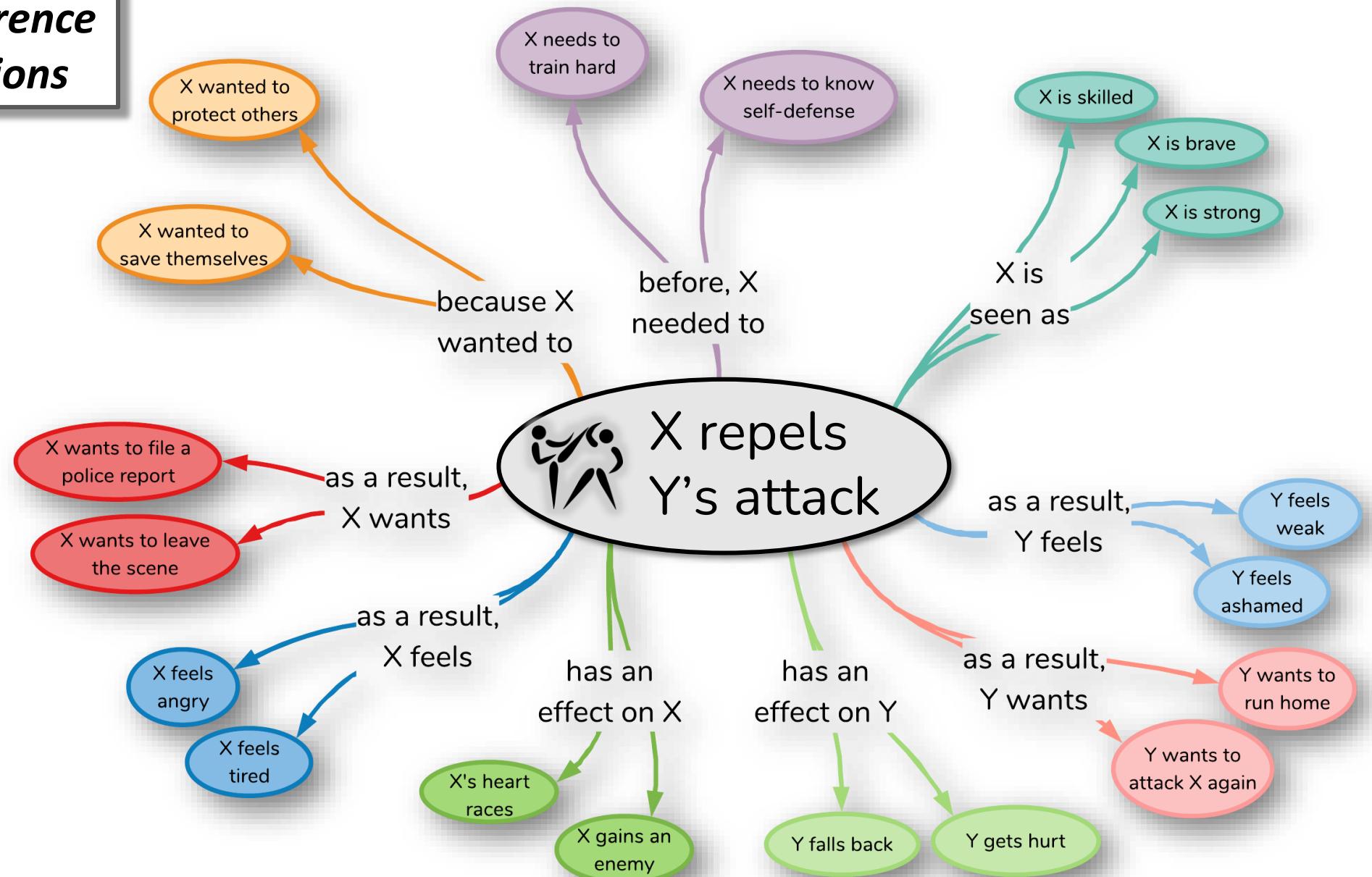
<https://github.com/allenai/comet-atomic-2020>



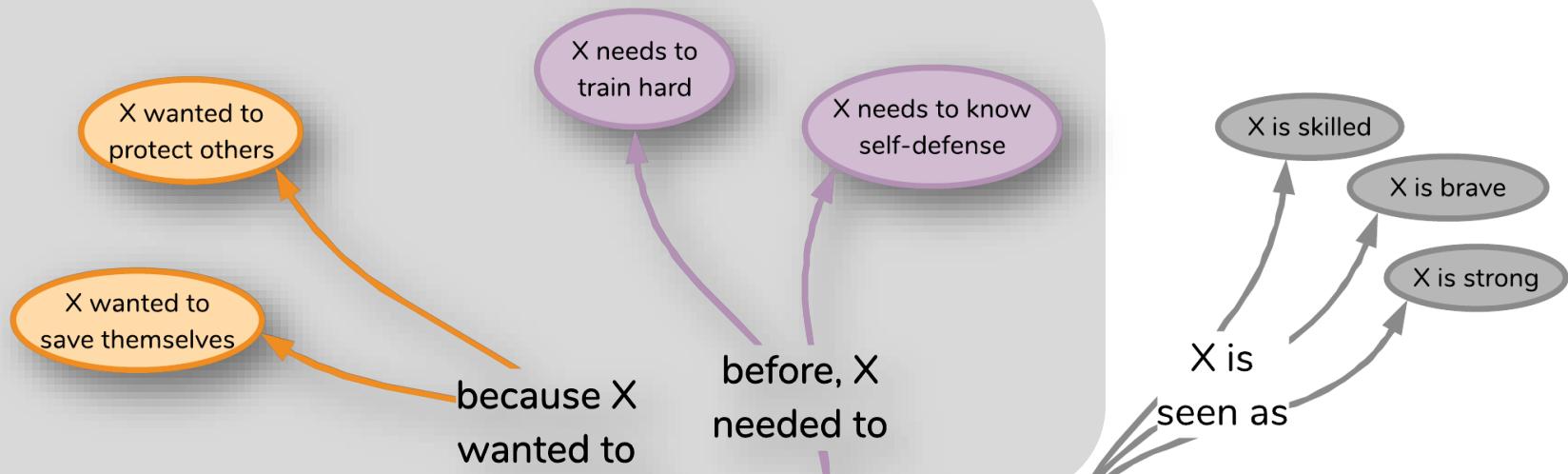
# ATOMIC: 880,000 triples for AI systems to reason about **causes** and **effects** of everyday situations



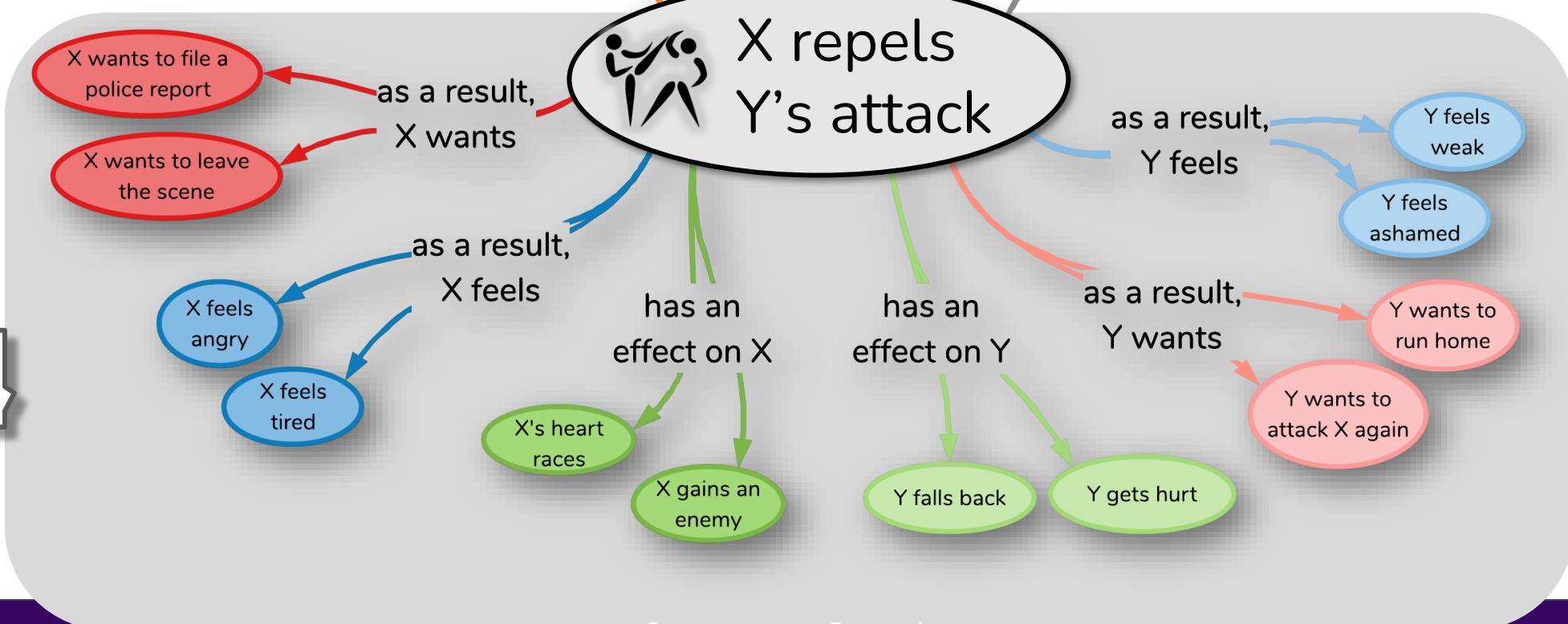
## nine inference dimensions



## Causes

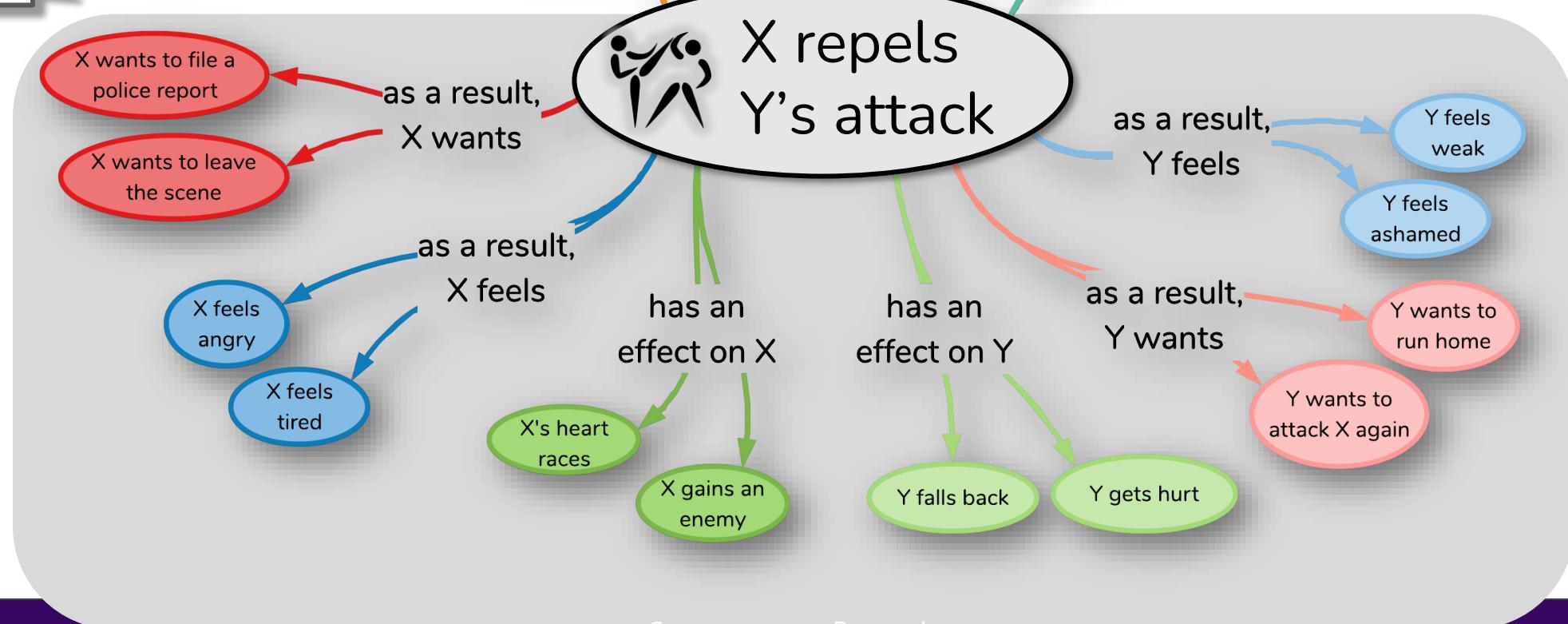


## Effects

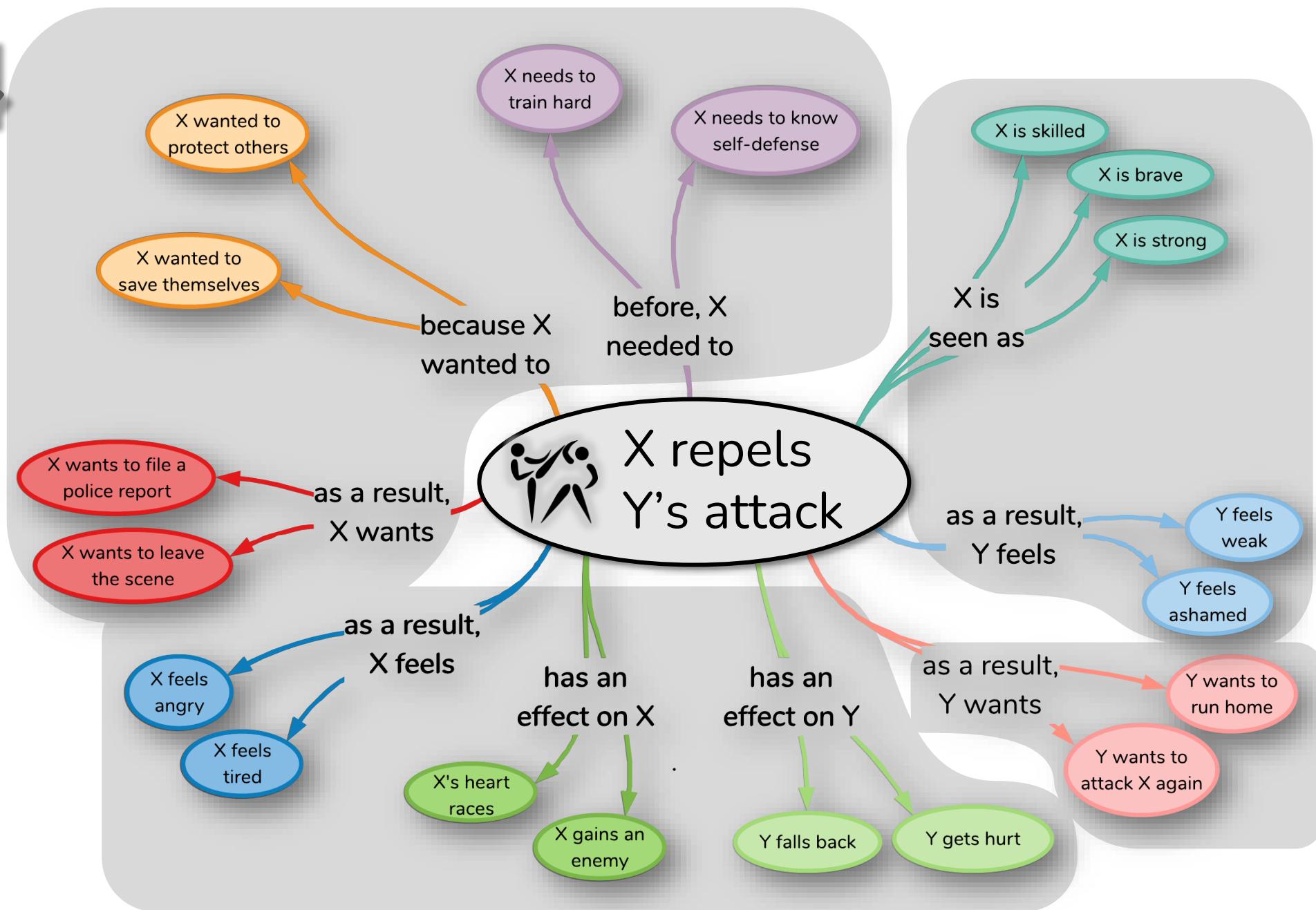


## Static

## Dynamic



## Voluntary

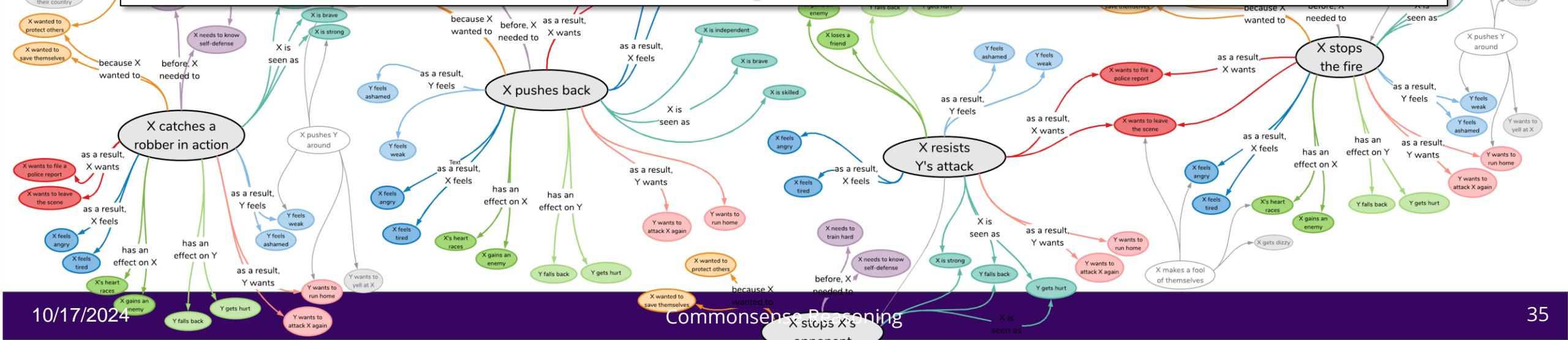
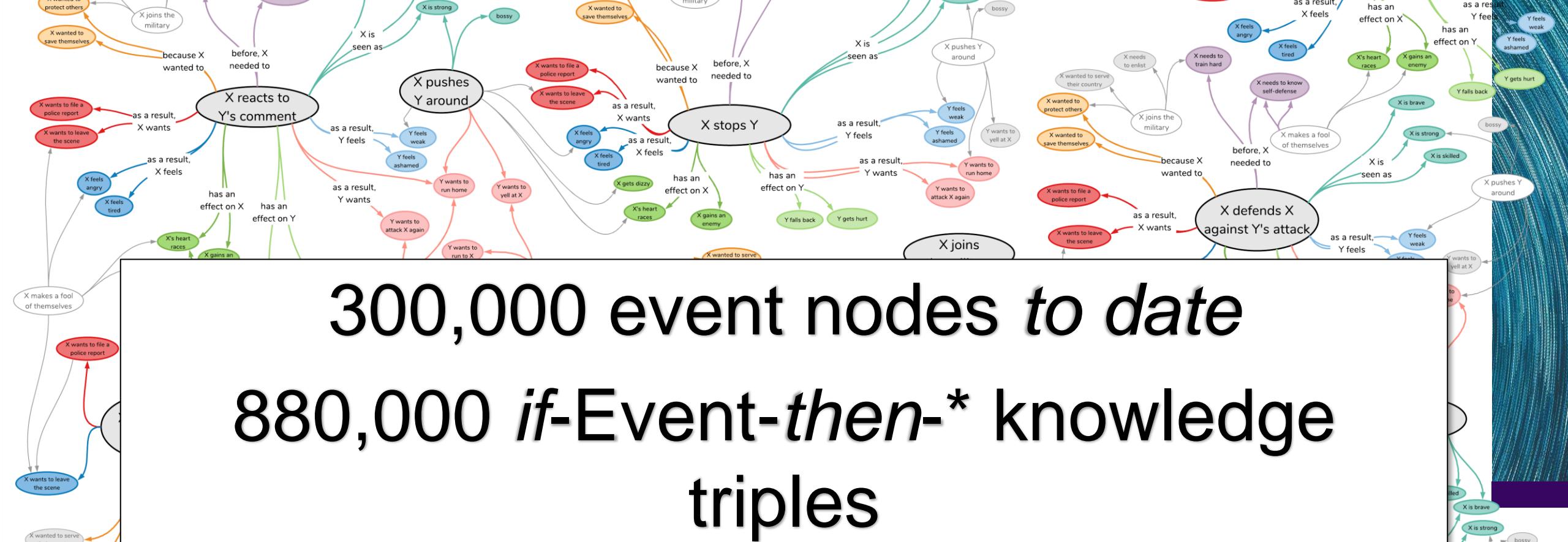


## Involuntary

## Agent



## Theme



# ATOMIC: knowledge of *cause* and *effect*

Humans have **theory of mind**, allowing us to

- make inferences about **people's mental states**
- understand **likely events** that precede and follow  
(Moore, 2013)

AI systems struggle with ***inferential*** reasoning

- only find **complex correlational patterns** in data
- **limited to the domain** they are trained on

(Pearl; Davis and Marcus 2015; Lake et al. 2017; Marcus 2018)

Theory of Mind



JUDEA PEARL  
WINNER OF THE TURING AWARD  
AND DANA MACKENZIE

T H E  
B O O K O F  
W H Y



THE NEW SCIENCE  
OF CAUSE AND EFFECT

# Ways of categorizing existing knowledge bases

*ATOMIC*

(Sap et al., 2019)

*NELL*

(Mitchell et al., 2015)

*ConceptNet 5.5*

(Speer et al., 2017)

*OpenCyc 4.0*

(Lenat, 2012)

# Ways of categorizing existing knowledge bases

Represented in **symbolic logic**  
(e.g., LISP-style logic)

*NELL*  
(Mitchell et al., 2015)

*OpenCyc 4.0*  
(Lenat, 2012)

Represented in **natural language**  
(how humans *talk* and *think*)

*ConceptNet 5.5*  
(Speer et al., 2017)

*ATOMIC*  
(Sap et al., 2019)

```
(#$implies
  (#$and
    (#$isa ?OBJ ?SUBSET)
    (#$genls ?SUBSET ?SUPERSET))
  (#$isa ?OBJ ?SUPERSET))
```

# Ways of categorizing existing knowledge bases

Represented in **symbolic logic**  
(e.g., LISP-style logic)

*NELL*  
(Mitchell et al., 2015)

*OpenCyc 4.0*  
(Lenat, 2012)

Represented in **natural language**  
(how humans *talk* and *think*)

*ConceptNet 5.5*  
(Speer et al., 2017)

Knowledge of “**what**”  
(taxonomic: A isA B)

Knowledge of “**why**” and  
“**how**”

(inferential: causes and effects)

*ATOMIC*  
(Sap et al., 2019)

**Q:** How do you gather commonsense knowledge at scale?

**A:** It depends on the type of knowledge

# Extracting commonsense from text

Based on information extraction (IE) methods

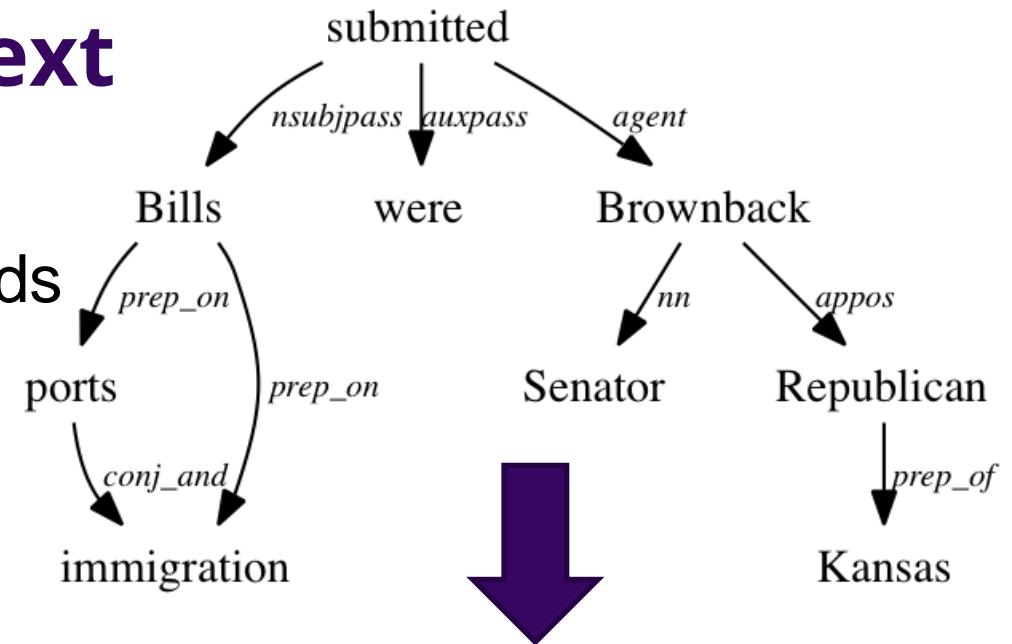
1. Read and parse text
2. Create candidate rules
3. Filter rules based on quality metric

Advantage:

can extract knowledge automatically

Example system:

Never Ending Language Learner (*NELL*; Carlson et al., 2010)



isA(senator, Brownback)  
location(Kansas, Brownback)  
~~isA(senator, Kansas)~~  
...

# Some commonsense cannot be extracted

Text is subject to reporting bias  
(Gordon & Van Durme, 2013)

Noteworthy events

- Murdering 4x more common than exhaling

Commonsense is not often written

- Grice's maxim of quantity



found when extracting commonsense knowledge on four large corpora using Knext (Gordon & Van Durme, 2013)

When communicating, people try to be as informative as they possibly can, and give as much information as is needed, and no more.

# Eliciting commonsense from humans

## Experts create knowledge base

Advantages:

- Quality guaranteed
- Can use complex representations (e.g., CycL, LISP)

Drawbacks:

- Time cost
- Training users

*OpenCyc 4.0*  
(Lenat, 2012)

*WordNet*  
(Miller et al.,  
1990)

## Non-experts write knowledge in natural language phrases

Natural language

- Accessible to non-experts
- Different phrasings allow for more nuanced knowledge

Fast and scalable collection

- Crowdsourcing
- Games with a purpose

*ATOMIC*  
(Sap et al.,  
2019)

*ConceptNet 5.5*  
(Speer et al.,  
2017)

# Knowledge bases and mitigating biases

**PersonX clutches a gun**

ATOMIC (Sap et al., 2019)

because  
X wanted  
to

- to be safe
- to protect himself
- to protect themselves
- to defend themselves
- to defend himself

**Jaquain clutches a gun**

because  
X wanted  
to

- to kill someone
- none
- to protect himself
- to be safe
- to protect themselves

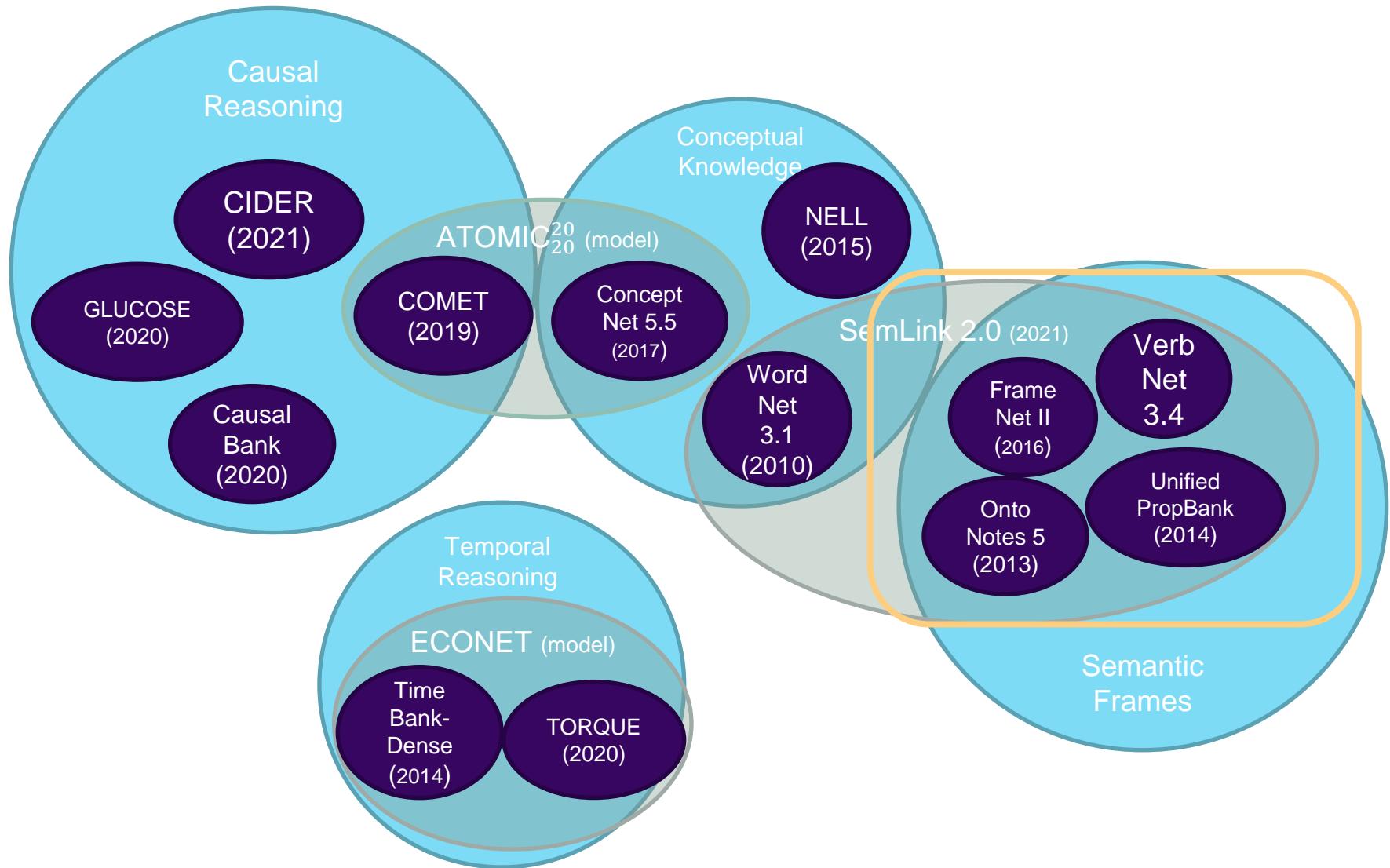
**Karen clutches a gun**

because  
X wanted  
to

- to be safe
- to protect himself
- to shoot
- to get the gun
- none



COMET (Bosselut et al., 2019): ATOMIC + OpenAI GPT



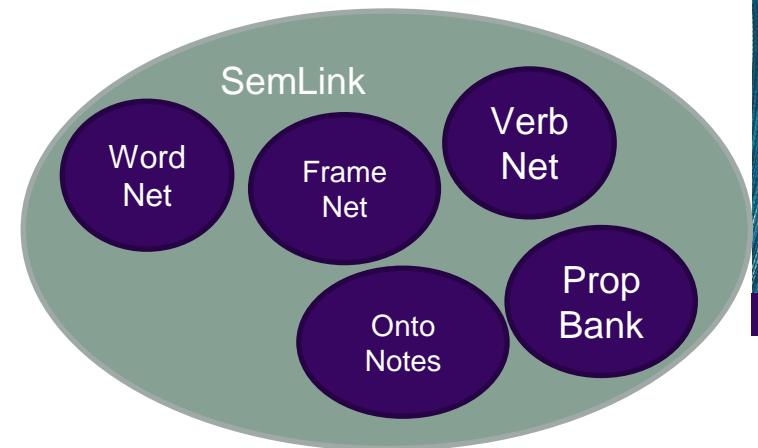
# SemLink/Unified Verb Index 2.0

<https://github.com/cu-clear/semlink>

Combines 4 systems:

VerbNet, PropBank, FrameNet, WordNet and OntoNotes

**Use:** above link



Kevin Stowe, Jenette Preciado, Kathryn Conger, Susan Windisch Brown, Ghazaleh Kazeminejad, James Gung, and Martha Palmer. 2021. SemLink 2.0: Chasing Lexical Resources. In *Proceedings of the 14th International Conference on Computational Semantics (IWCS)*, pages 222–227, Groningen, The Netherlands (online). Association for Computational Linguistics.

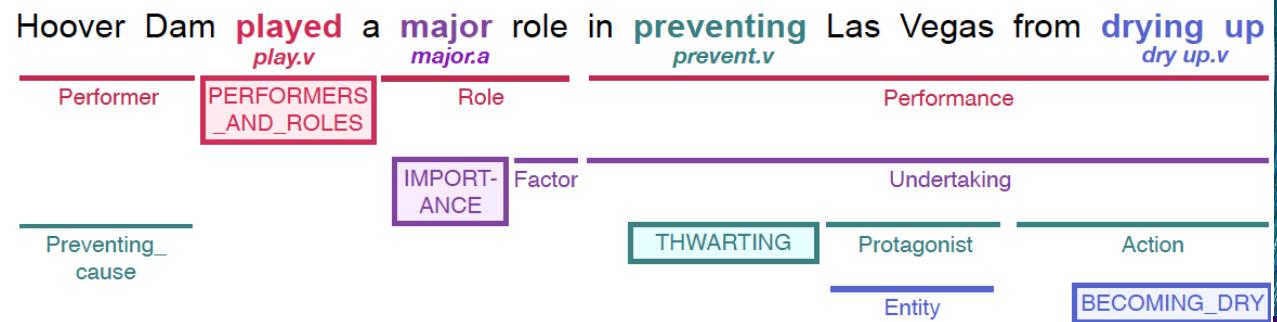
# FrameNet II

<https://framenet.icsi.berkeley.edu/>

**Data Source:** British National Corpus, US newswire, American National Corpus; annotated

**Languages:** English, global initiative:  
<https://www.globalframenet.org/>

**Use:** [Open-SESAME](#); Raw data needs to be requested



Josef Ruppenhofer, Michael Ellsworth, Miriam R. L Petrucci, Christopher R. Johnson, Collin F. Baker, & Jan Scheffczyk. *FrameNet II: Extended Theory and Practice* (Revised November 1, 2016.)

Picture from Open-SESAME (Swabha Swayamdipta, Sam Thomson, Chris Dyer, & Noah A. Smith. "Frame-Semantic Parsing with Softmax-Margin Segmental RNNs and a Syntactic Scaffold" on arXiv.

# VerbNet v3.4

<https://verbs.colorado.edu/verbnet/>

Verb classes based on Beth Levin (1993)

**Data Source:** hand-crafted

**Languages:** English

**Use:** [raw data](#)

**Demo:** [https://uvi.colorado.edu/uvi\\_search](https://uvi.colorado.edu/uvi_search)

The screenshot displays the VerbNet v3.4 web application interface. At the top left is a 'Full Class View' window titled 'Class Hierarchy' showing nodes 'get-13.5.1' and 'get-13.5.1-1'. To the right are sections for 'Members' (verb lemmas like ATTAIN, BOOK, BUY, etc.), 'Roles' (Agent, Theme, Source, Beneficiary, Asset), and 'Frames' (NP V NP frame with subtypes). Below these are examples, syntax, semantics, and predicates sections.

**Class Hierarchy**  
get-13.5.1  
get-13.5.1-1

**Members**

Member Verb Lemmas:

ATTAIN	BOOK	BUY	CALL	CATCH	CHARTER	CHOOSE	FIND	GATHER
HIRE	LEASE	ORDER	PHONE	PICK	PLUCK	PROCURE	PULL	REACH
RENT	RESERVE	TAKE	WIN					

**Roles**

ROLES:  
Agent [+animate | +organization]  
Theme  
Source [+concrete]  
Beneficiary [+animate | +organization]  
Asset [-location & -region]

---

**Frames**

NP V NP

- NP V NP PP:source
- NP V NP PP:beneficiary
- NP V NP:beneficiary NP
- NP V NP PP:asset
- NP:asset V NP
- NP V NP PP:source NP:asset

EXAMPLE:  
Carmen bought a dress.  
[SHOW DEPENDENCY PARSE TREE](#)

SYNTAX:  
Agent VERB Theme **Syntax of this frame (NP V NP) with roles**

SEMANTICS:

- HAS\_POSSESSION( e1 , ?Source , Theme )
- ¬ HAS\_POSSESSION( e1 , Agent , Theme )
- TRANSFER( e2 , Agent , Theme , ?Source )
- CAUSE( e2 , e3 )
- HAS\_POSSESSION( e3 , Agent , Theme )
- ¬ HAS\_POSSESSION( e3 , ?Source , Theme )

**Predicates**

K. Kipper Schuler, "VerbNet: A Broad-Coverage, Comprehensive Verb Lexicon," University of Pennsylvania, 2005.

Levin, B. (1993) "English Verb Classes and Alternations: A Preliminary Investigation", University of Chicago Press, Chicago, IL.

# Unified\* PropBank

<http://propbank.github.io/>

Proposition → true/false statement

**Data Source:** hand-crafted; added to PennTreebank

**Languages:** English, Hindi, Chinese, Arabic, Finnish, Portuguese, Basque, Turkish (Plus a way to map English to different languages)

**Use:** [raw data](#)

\*semantic propositions regardless of part of speech (e.g. create & creation)

- 25. **Predicate:** *offer-verb*  
**Roleset id:** offer.01 transaction  
**Roles:** Arg0: entity offering  
Arg1: commodity  
Arg2: price  
Arg3: benefactive or entity offered to  
**Example:** *He offered to buy the house.*
- 26. **Predicate:** *offer-noun*  
**Roleset id:** offer.01 transaction  
**Roles:** Arg0: entity offering  
Arg1: commodity  
Arg2: price  
Arg3: benefactive or entity offered to  
**Example:** *His offer to buy the house...*  
*He made an offer to buy the house.*
- 27. **UNIFIED ROLESET**  
**Predicate aliases:** *offer-verb, offer-noun*  
**Roleset id:** offer.01 transaction  
**Roles:** Arg0: entity offering  
Arg1: commodity  
Arg2: price  
Arg3: benefactive or entity offered to  
**Example:** *He offered to buy the house.*  
*His offer to buy the house..*  
*He made an offer to buy the house.*

```
(o / offer-01
 :ARG0 (h2 / he)
 :ARG1 (b2 / buy-01
 :ARG0 h2
 :ARG1 (h3 / house)))
```

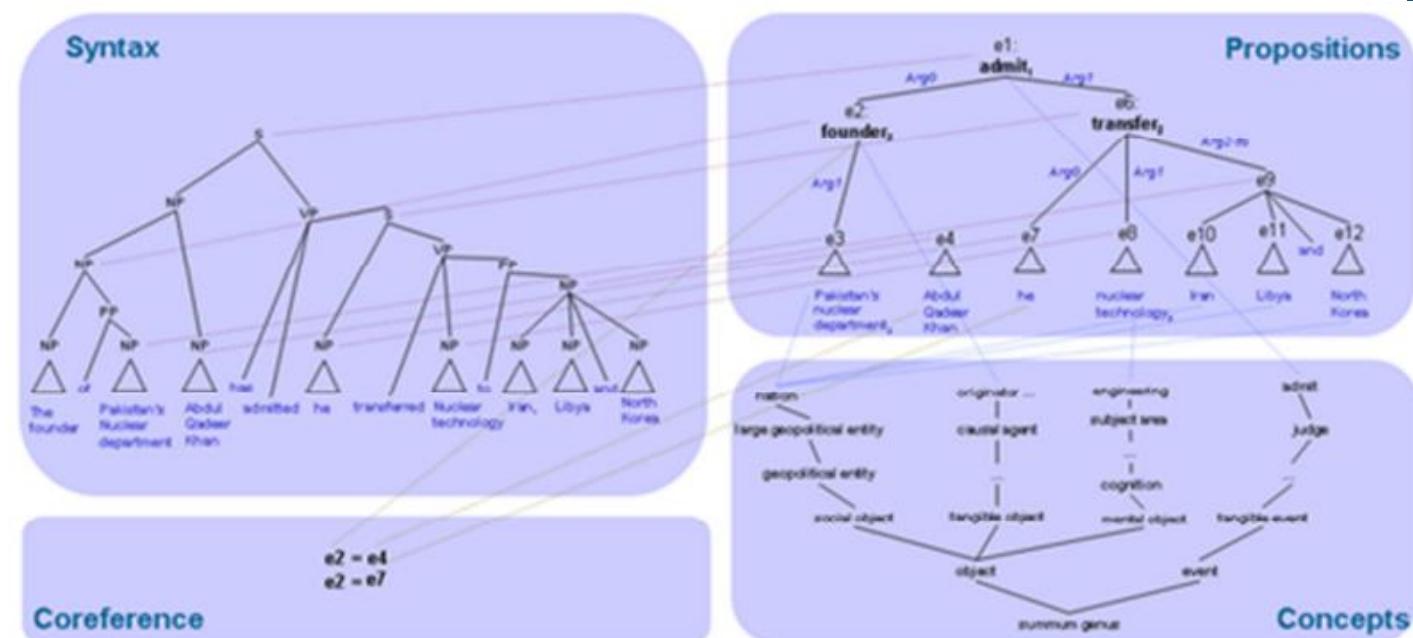
# OntoNotes 5.0

<https://catalog.ldc.upenn.edu/LDC2013T19>

**Data Source:** news, telephone conversations, blogs, talk shows, etc.

**Languages:** English, Chinese, Arabic

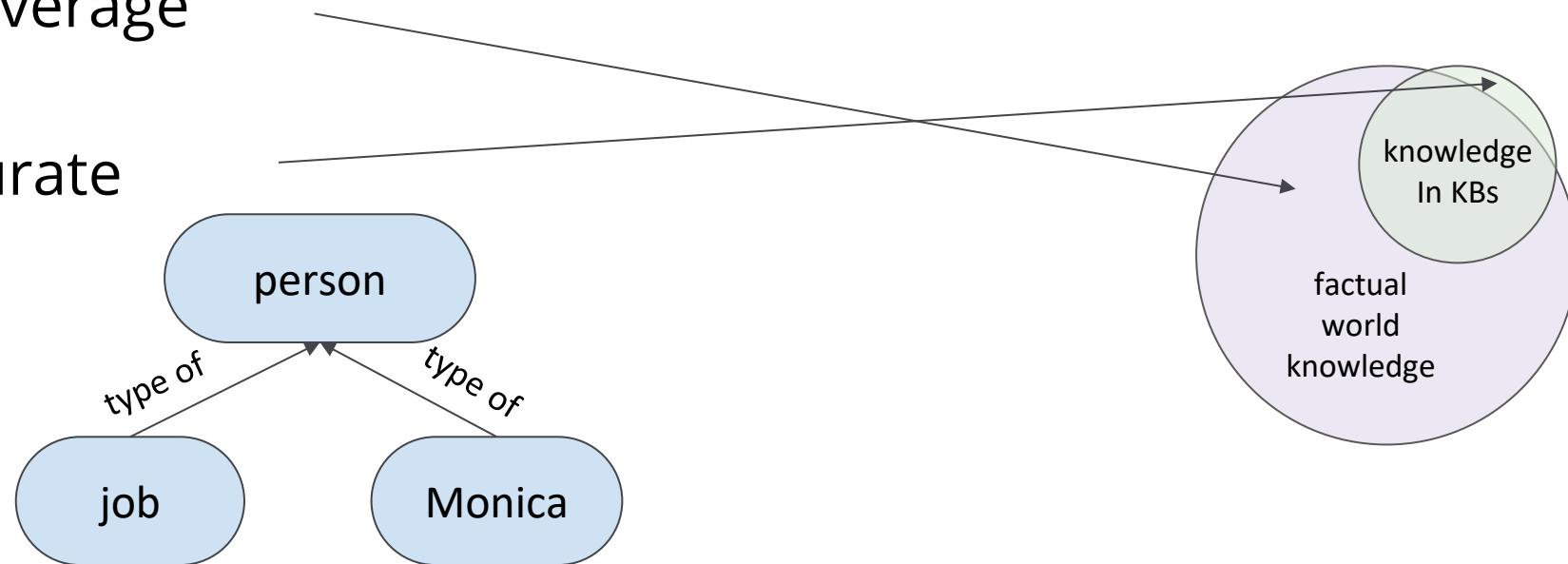
**Use:** raw data (same link)



S. S. Pradhan, E. Hovy, M. Marcus, M. Palmer, L. Ramshaw and R. Weischedel, "OntoNotes: A Unified Relational Semantic Representation," International Conference on Semantic Computing (ICSC 2007), 2007, pp. 517-526, doi: 10.1109/ICSC.2007.83.

# Limitations

- Insufficient Coverage
- Not 100% accurate



- Easy to incorporate simple resources with stationary facts (ConceptNet) but they are limited in expressiveness:

