

Commonsense Reasoning

Lara J. Martin (she/they)

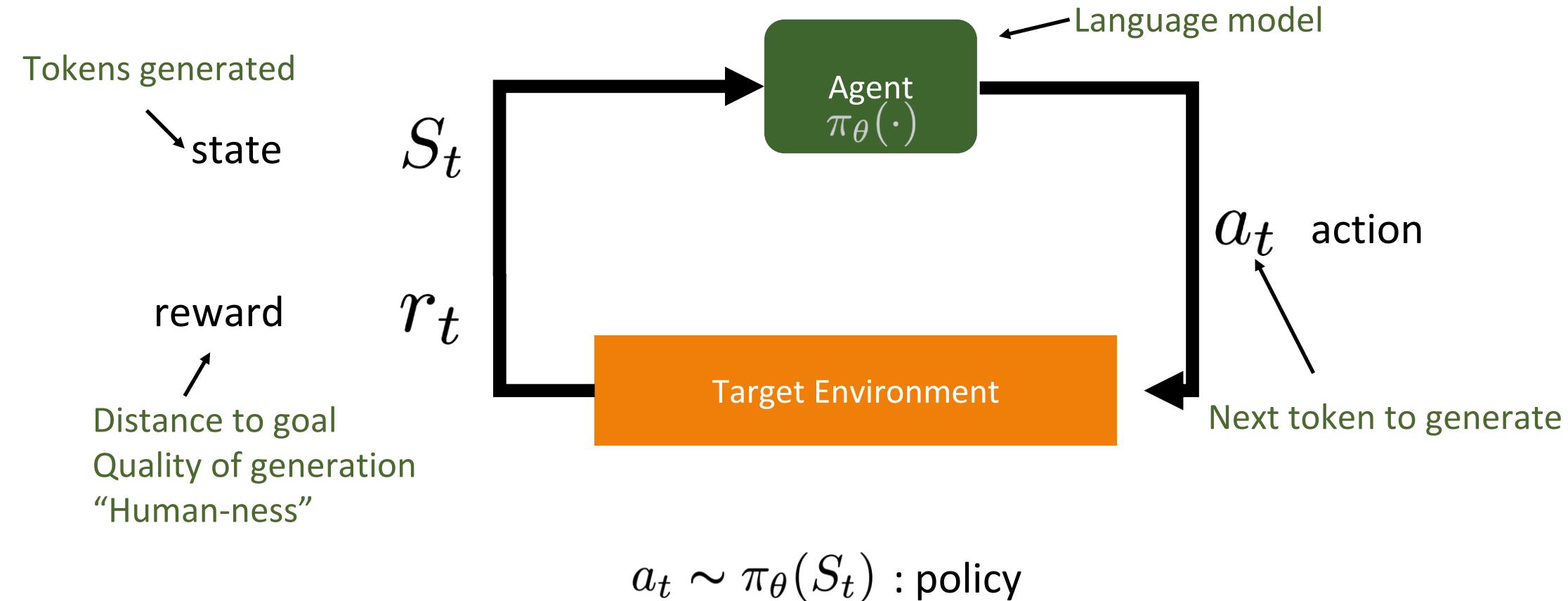
<https://laramartin.net/interactive-fiction-class>

Modified from slides by Chris Callison-Burch

Learning Objectives

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

Review: RL in the Context of Language Models...



Review: REINFORCE

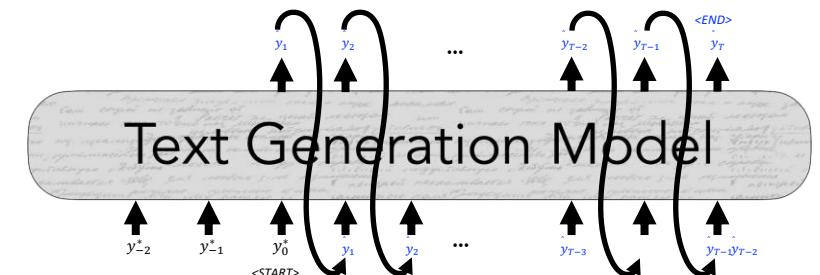
- Sample a sequence from your model, score the sequence, and use the score to train the model.

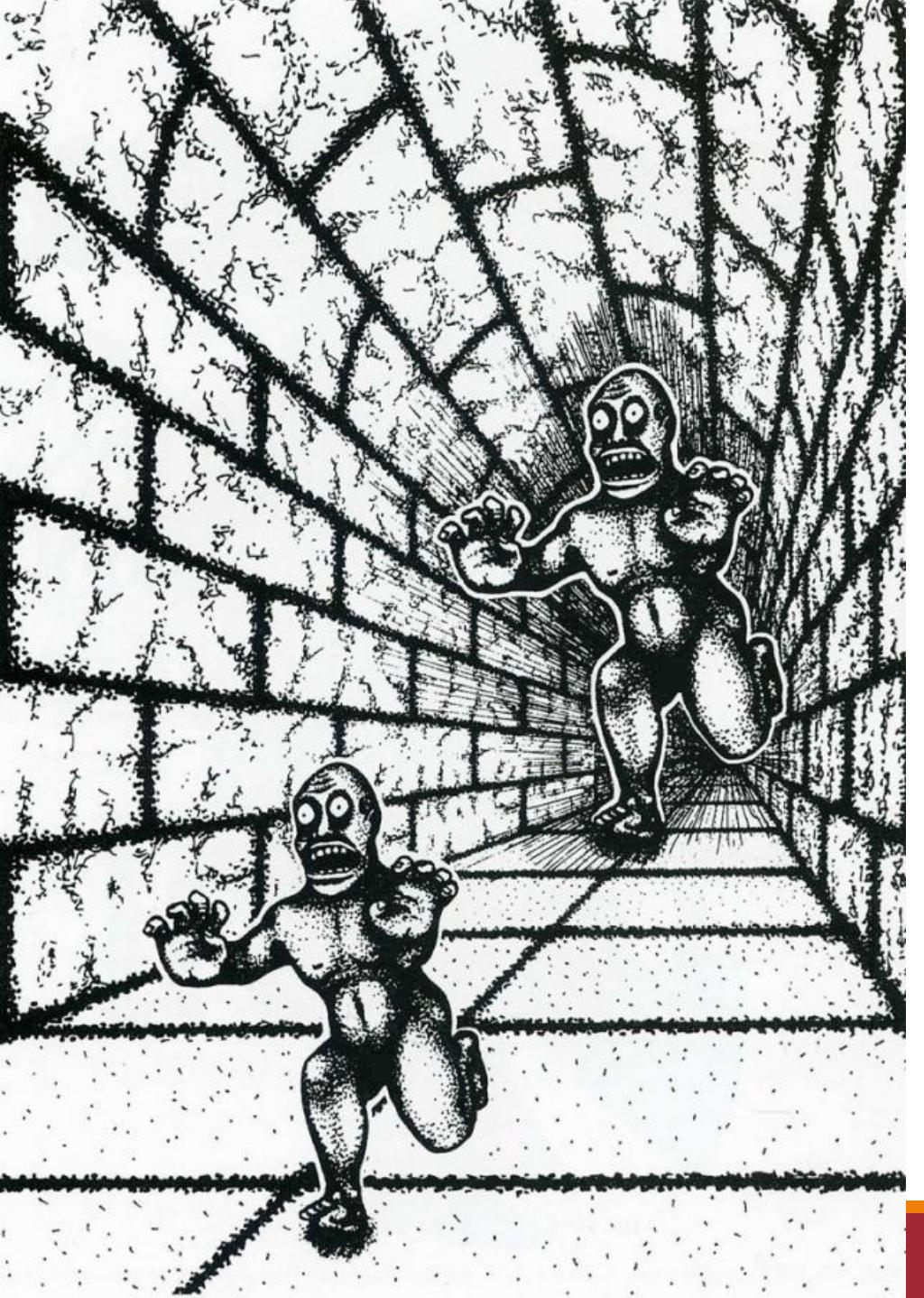
$$L_{RL} = - \sum_{t=1}^T r(\hat{y}_t) \log P(\hat{y}_t | \{\hat{y}^*\}; \{y\}_{<t})$$

Next time, increase the probability of this sampled token in the same context.

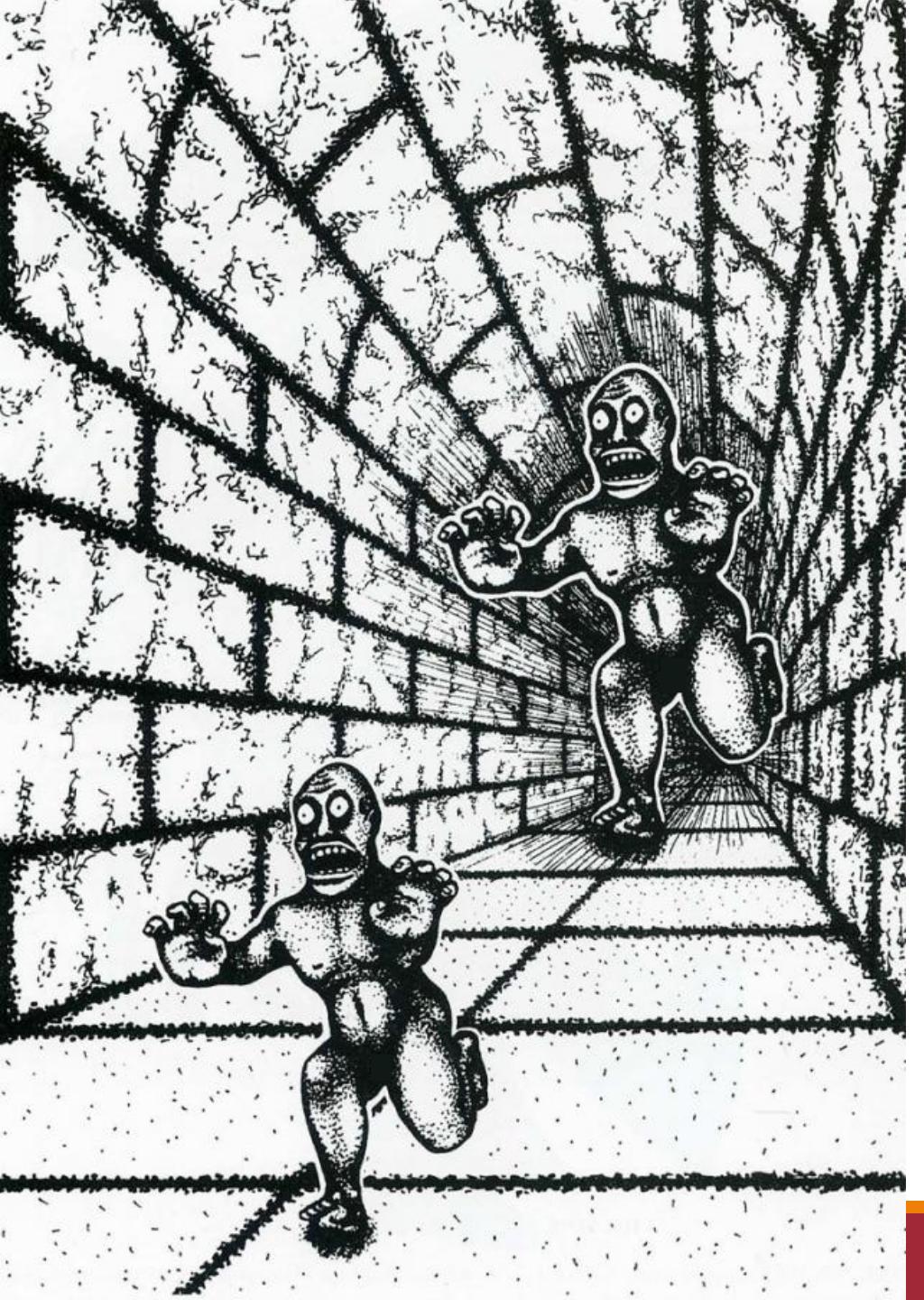
... but increase it more if I get a higher reward from the reward function.

- $r(\cdot)$: Your reward model
- \hat{y}^* : Input sequence given to the model
- y : The sequence sampled from the model given y^*





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”

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

CADE METZ BUSINESS MAY 22, 2017 3:12 PM

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.

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

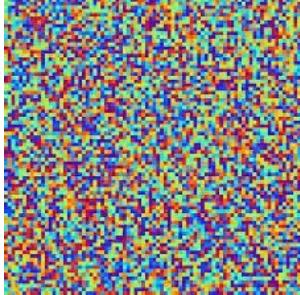
Who Is Joe Rogan Voting For? We Asked ChatGPT

Published Oct 15, 2024 at 6:38 AM EDT

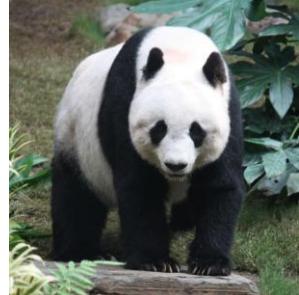
Updated Oct 15, 2024 at 6:07 PM EDT



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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

We may be "solving" datasets
rather than the underlying "task"

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

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

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"

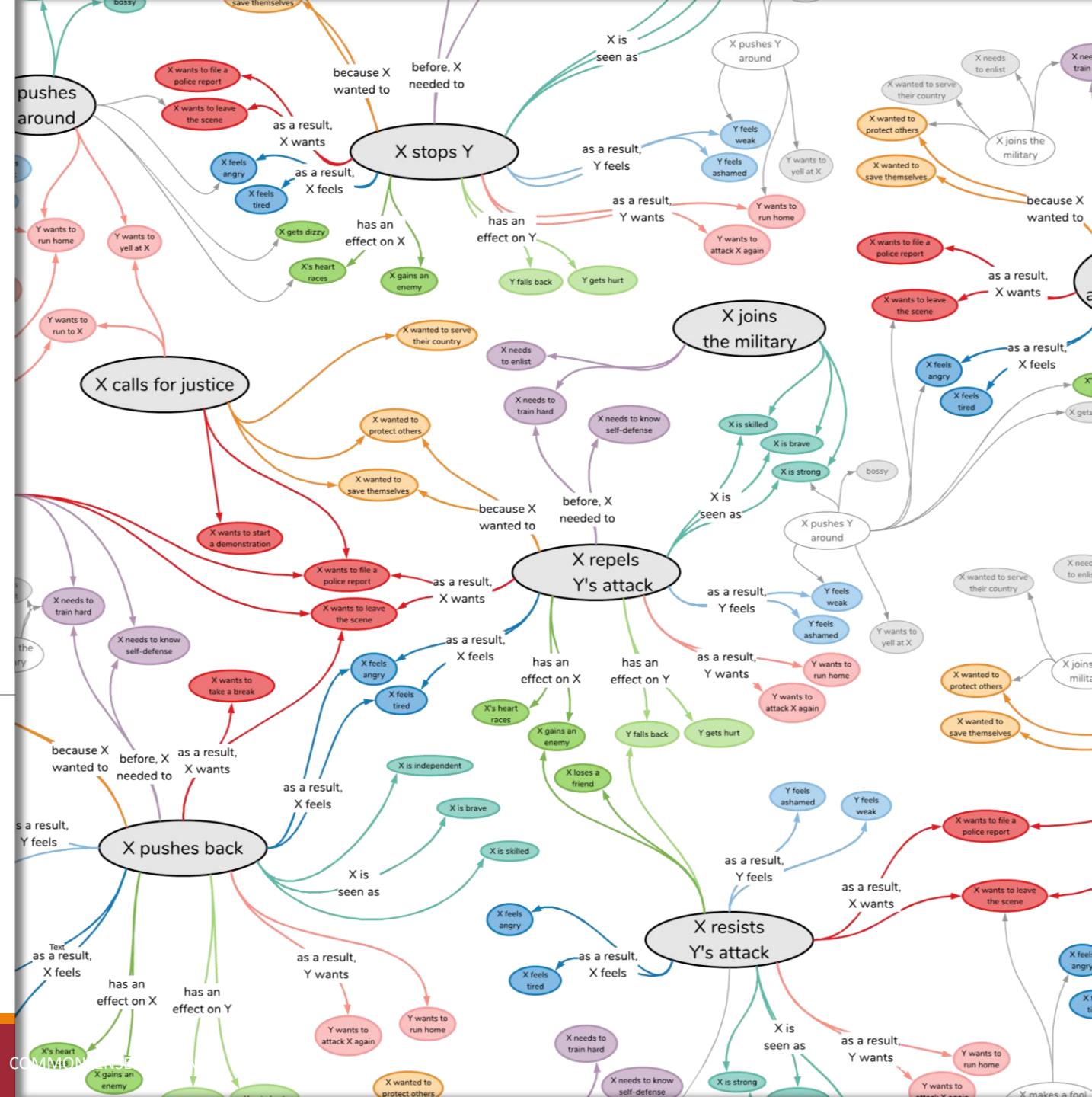
1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with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

- Isaac Asimov, 1942 short story "Runaround"



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

Commonsense resources





Grandma's glasses

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

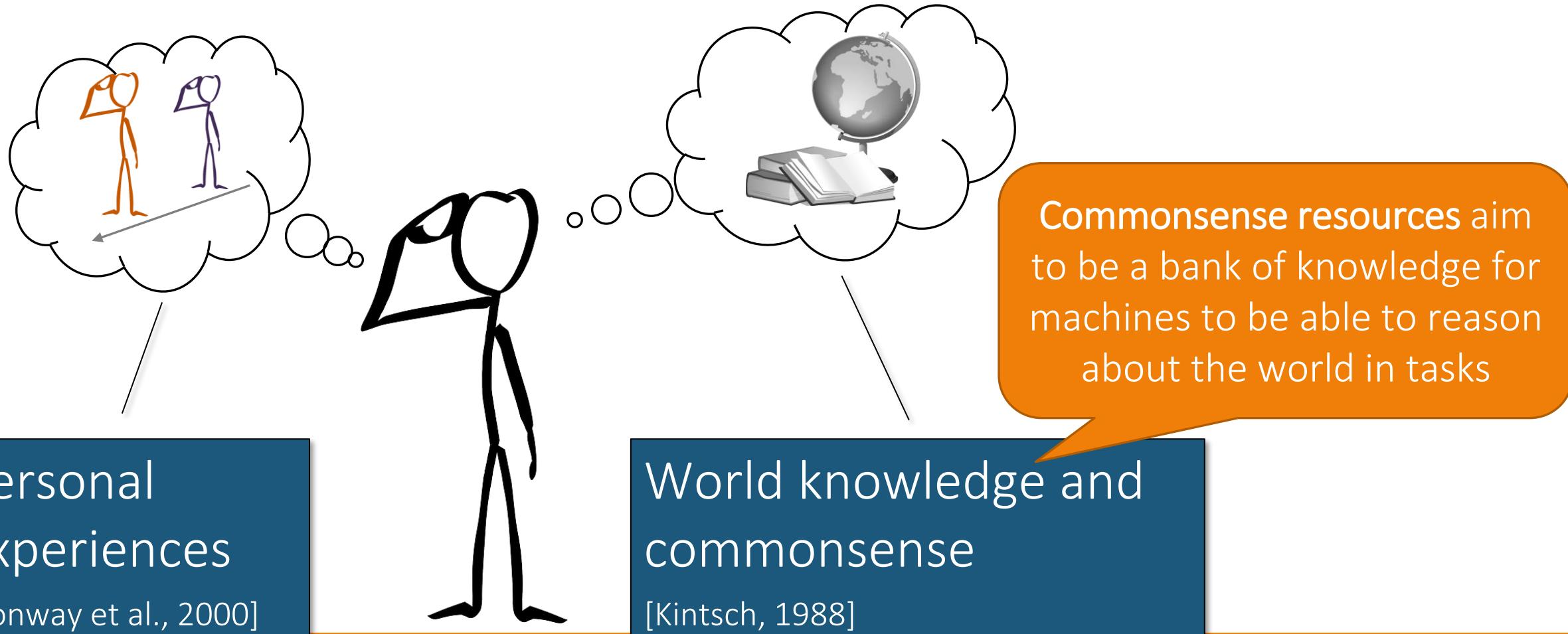
She couldn't pick them up, so she called Tom for help.

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]



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.

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ConceptNet

ATOMIC

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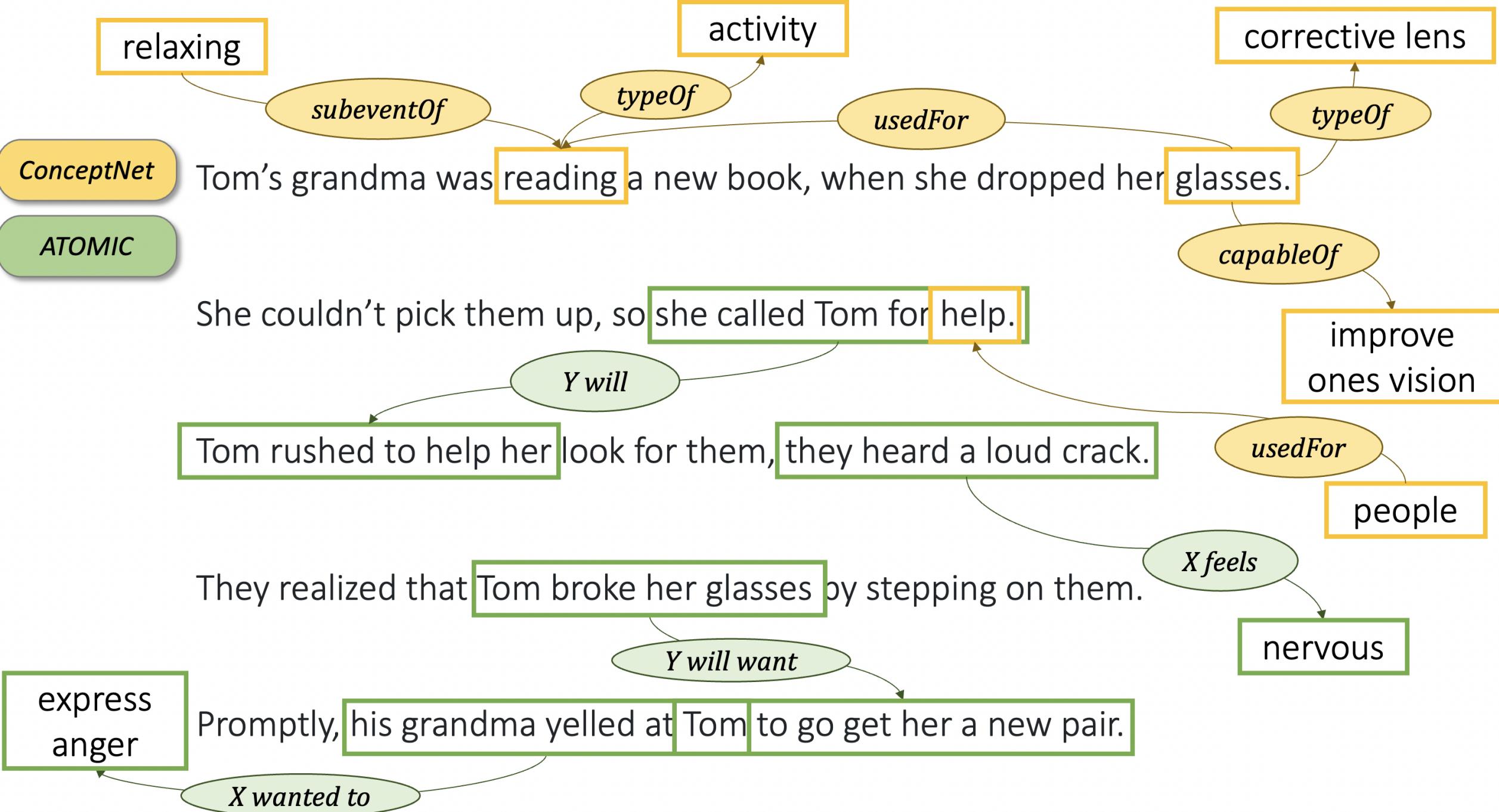
```
graph LR; reading[reading] -- usedFor --> glasses[glasses]
```

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.

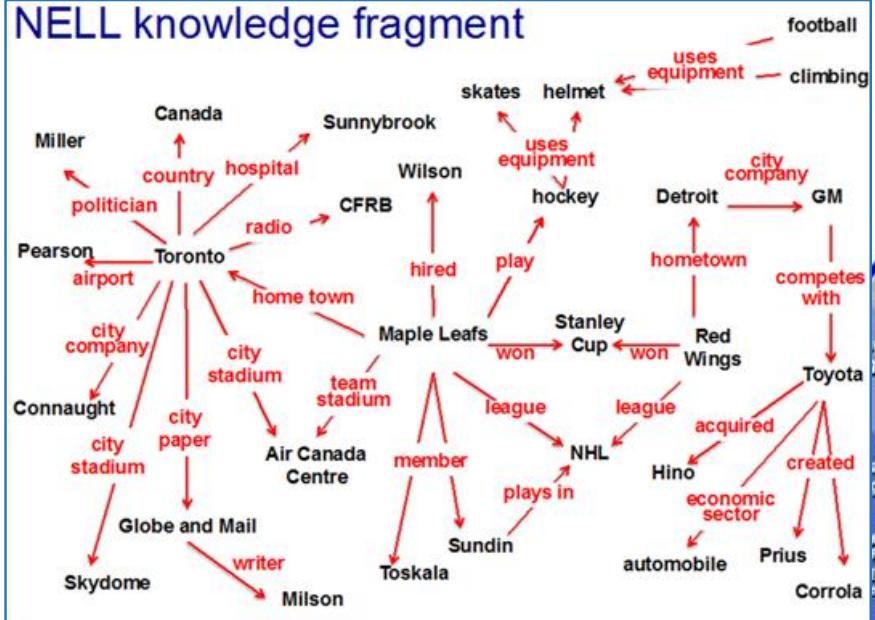
They realized that Tom broke her glasses by stepping on them.

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Some important resources

NELL knowledge fragment

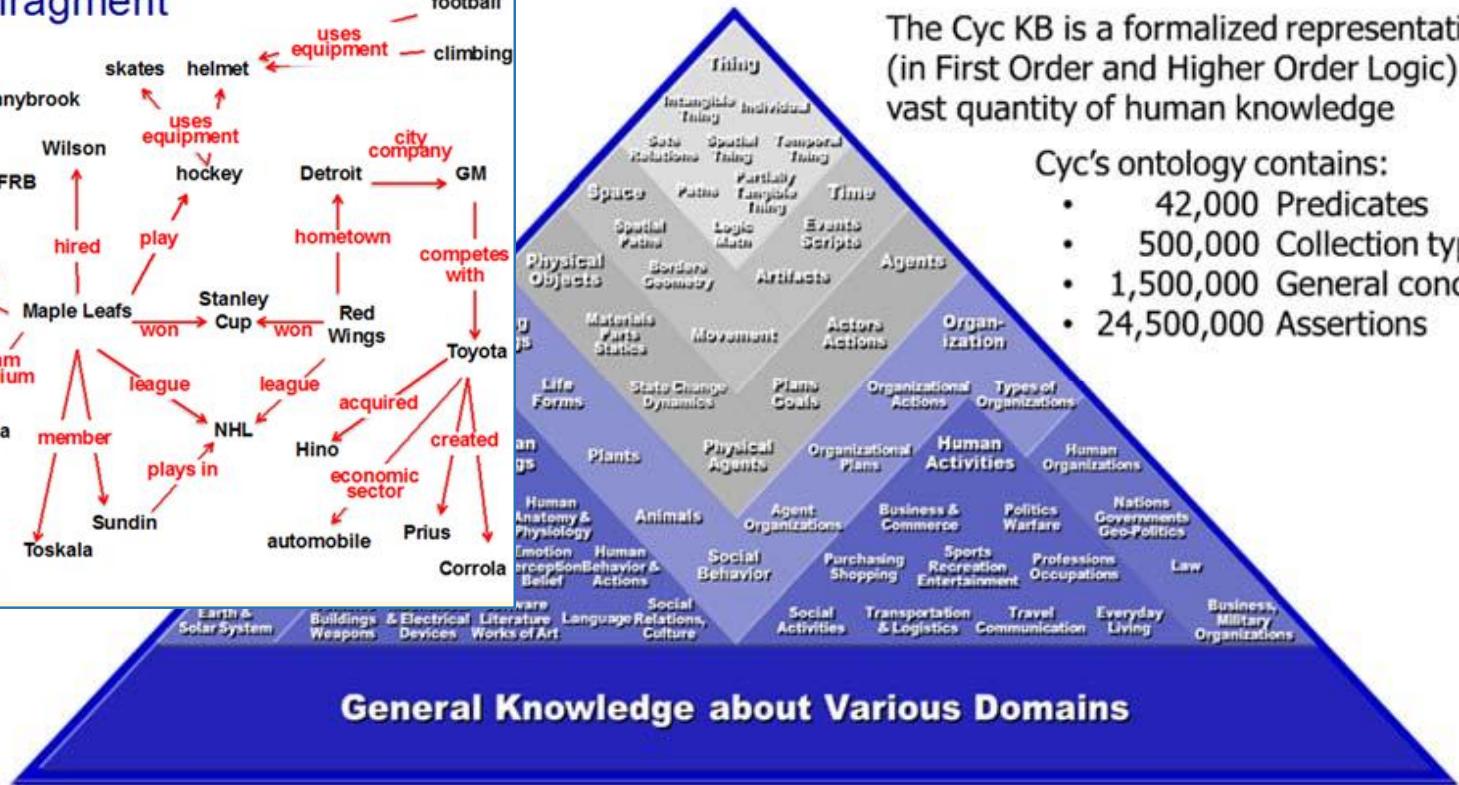


*Open Mind Comm
(Minsky, Singh & Ha*

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



ATOMIC
(ap et al., 2019)

ild 2.0
(al., 2017)

Net 5.5
(al., 2017)

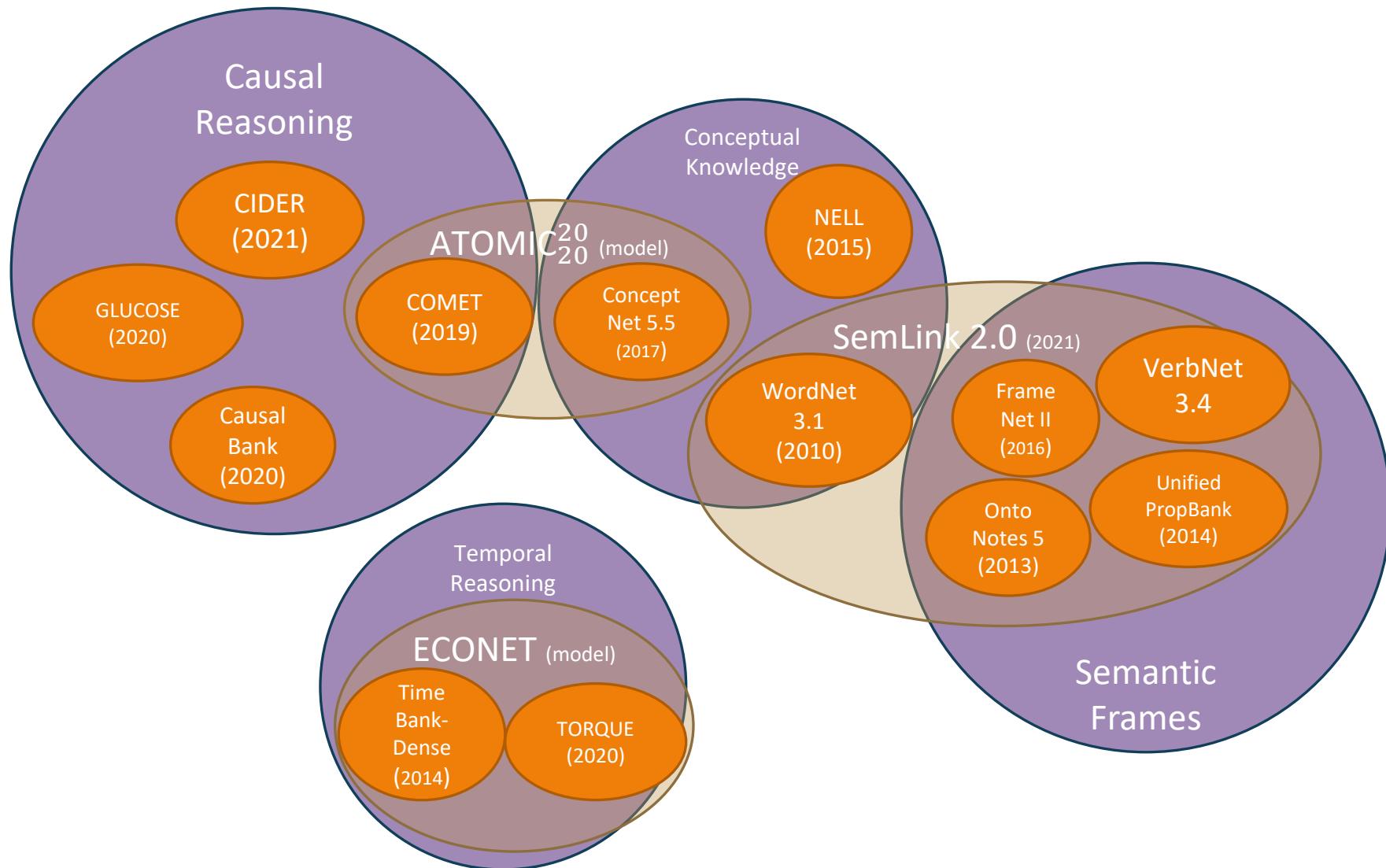
Cyc
(Lenat et al., 1984)

OpenCyc
(Lenat, 2004)

ResearchCyc
(Lenat, 2006)

OpenCyc 4.0
(Lenat, 2012)

today



How do you create a commonsense resource?

Desirable properties for a commonsense resource

COVERAGE

Large scale

Diverse knowledge types

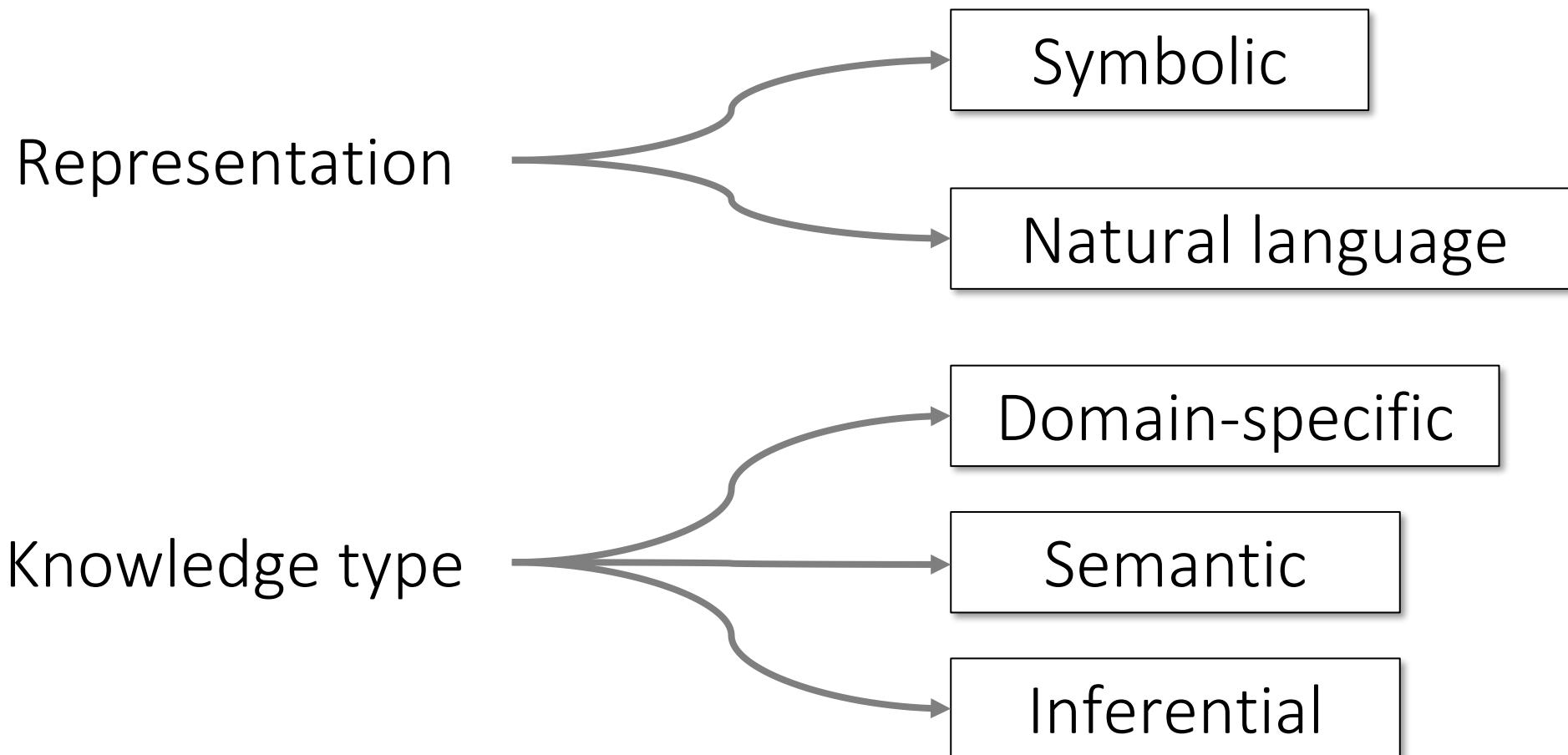
USEFUL

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

<http://conceptnet.io/>

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

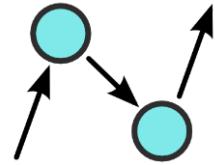
- [en] article →
- [en] a library →
- [en] literature →
- [en] a paper page →

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

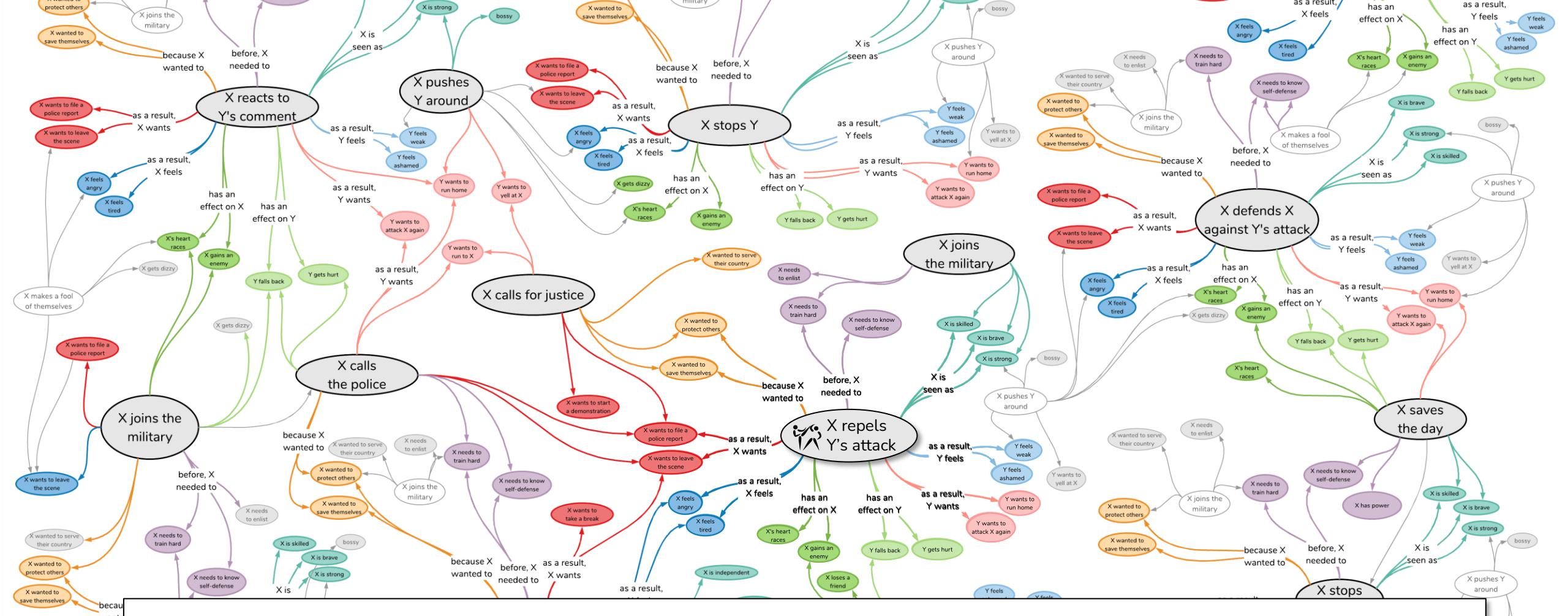
Knowledge covered:

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

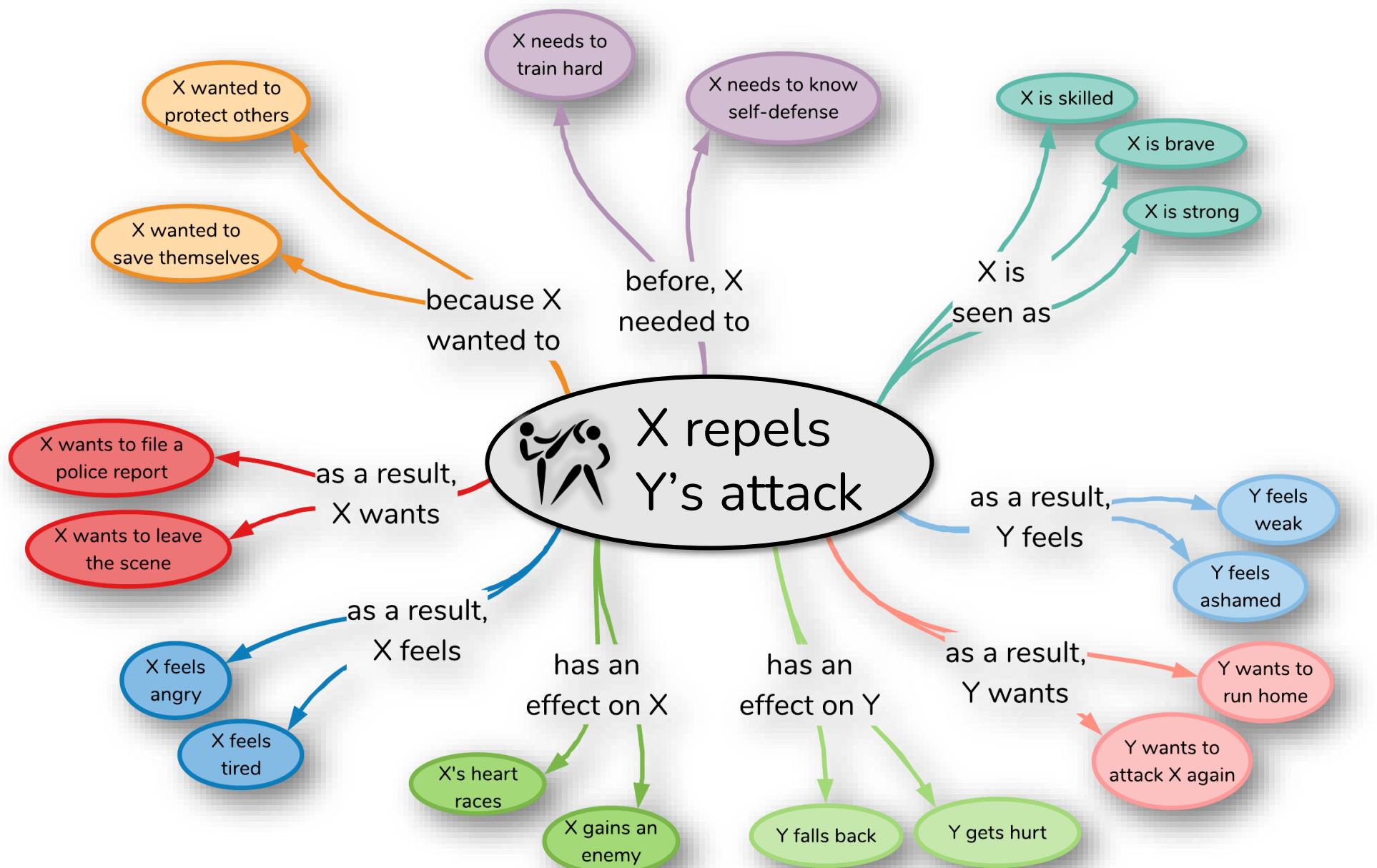
ATOMIC:

inferential knowledge in natural language form

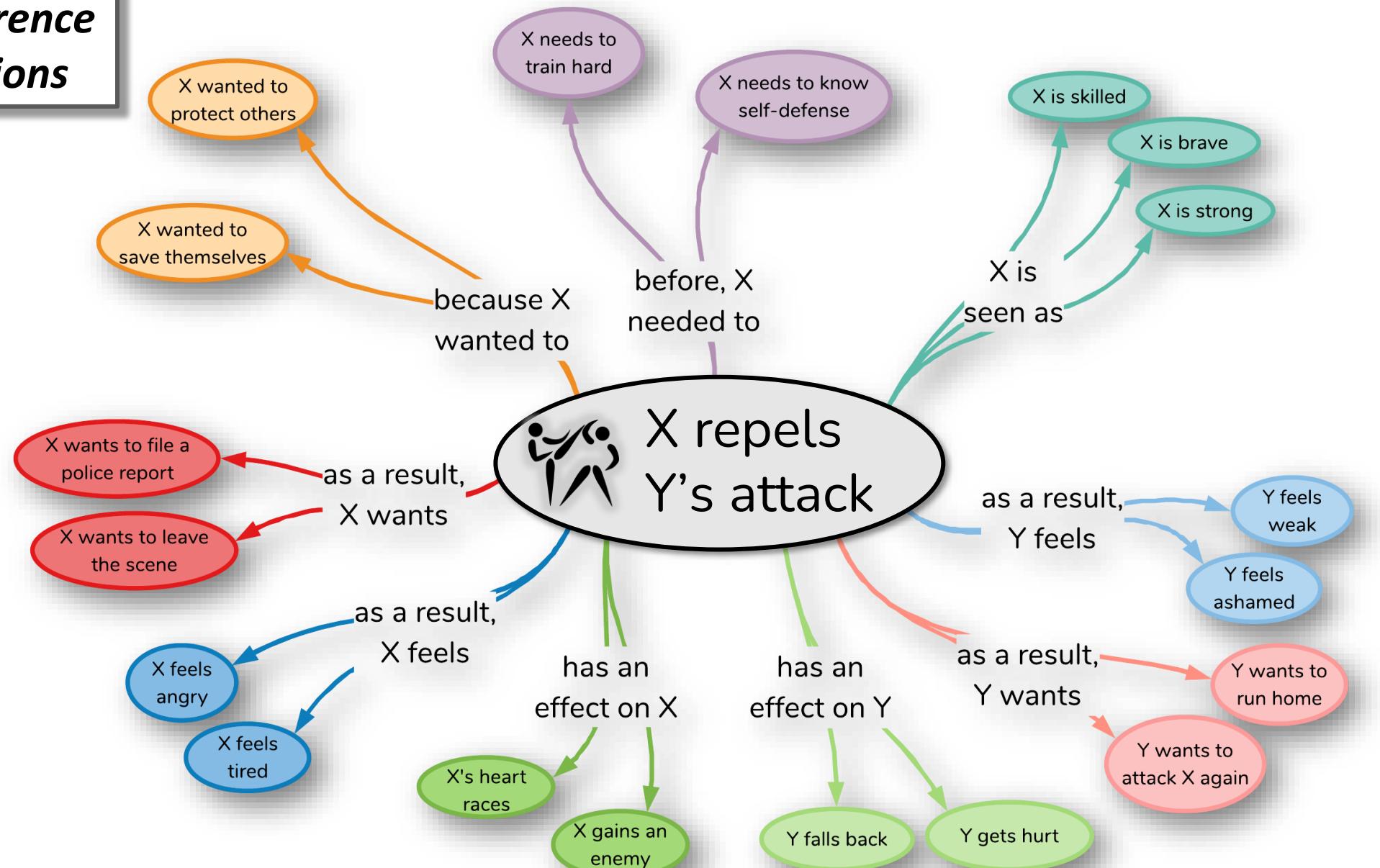
<https://github.com/allenai/comet-atomic-2020>



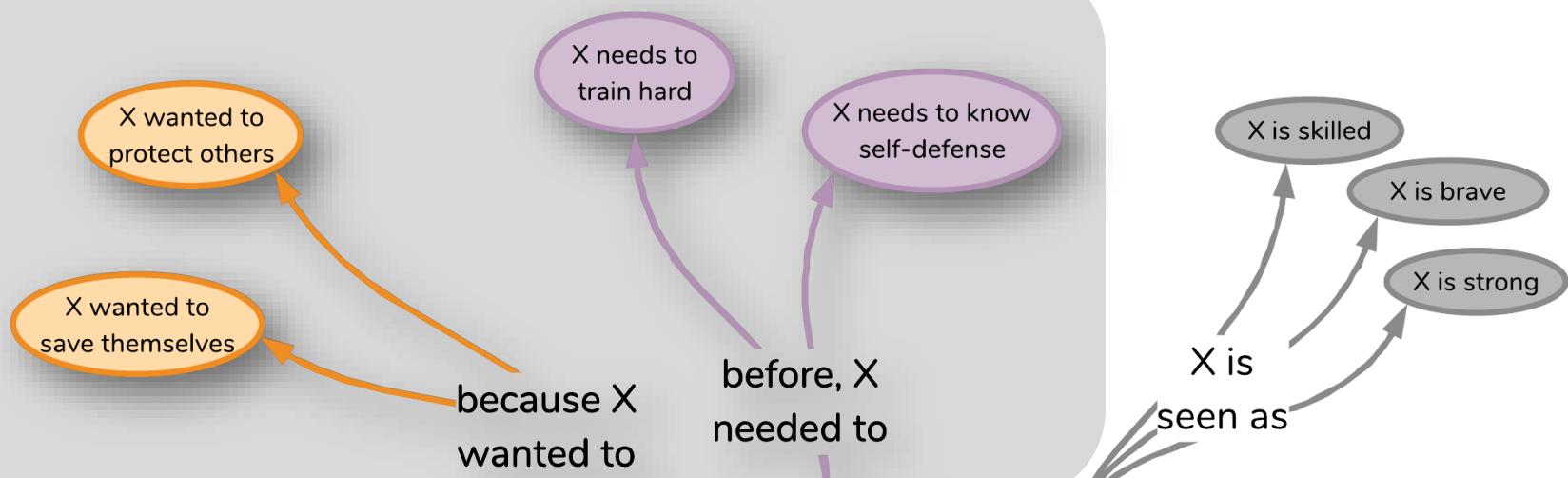
ATOMIC: 880,000 triples for AI systems to reason about *causes* and *effects* of everyday situations



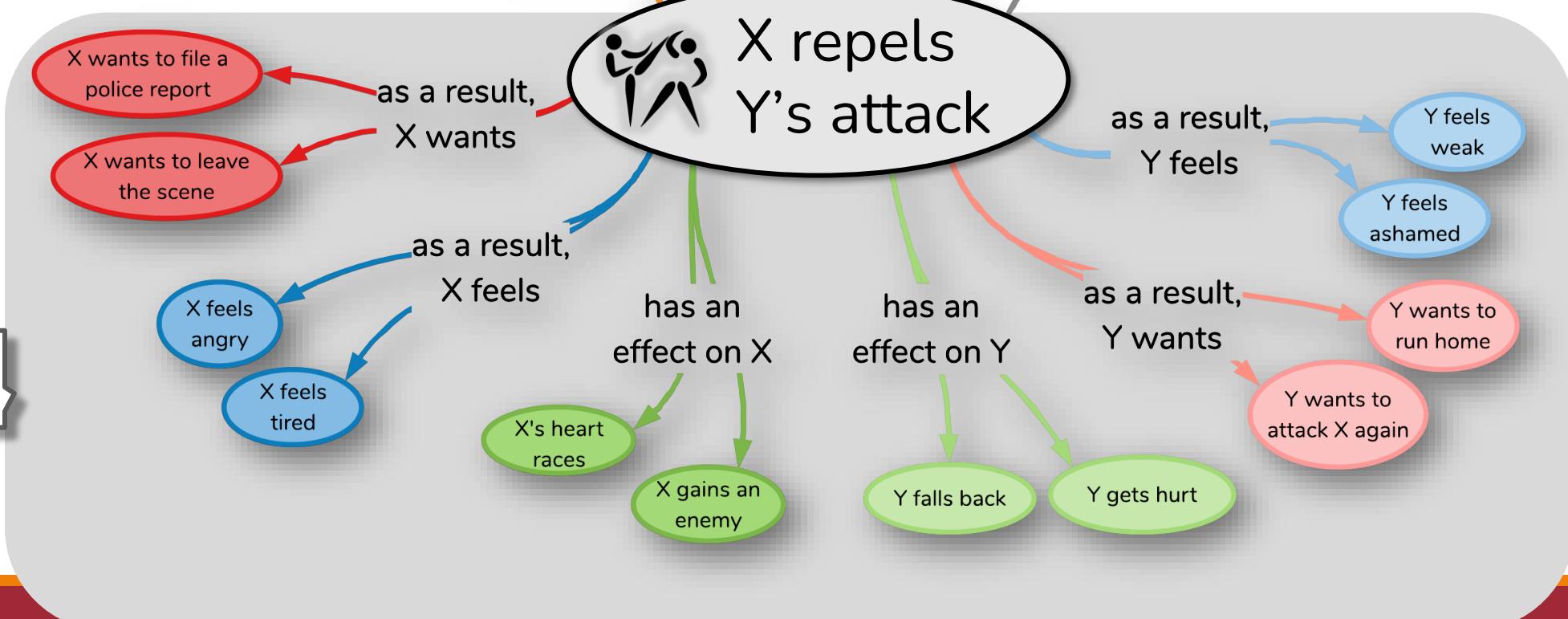
nine inference dimensions



Causes

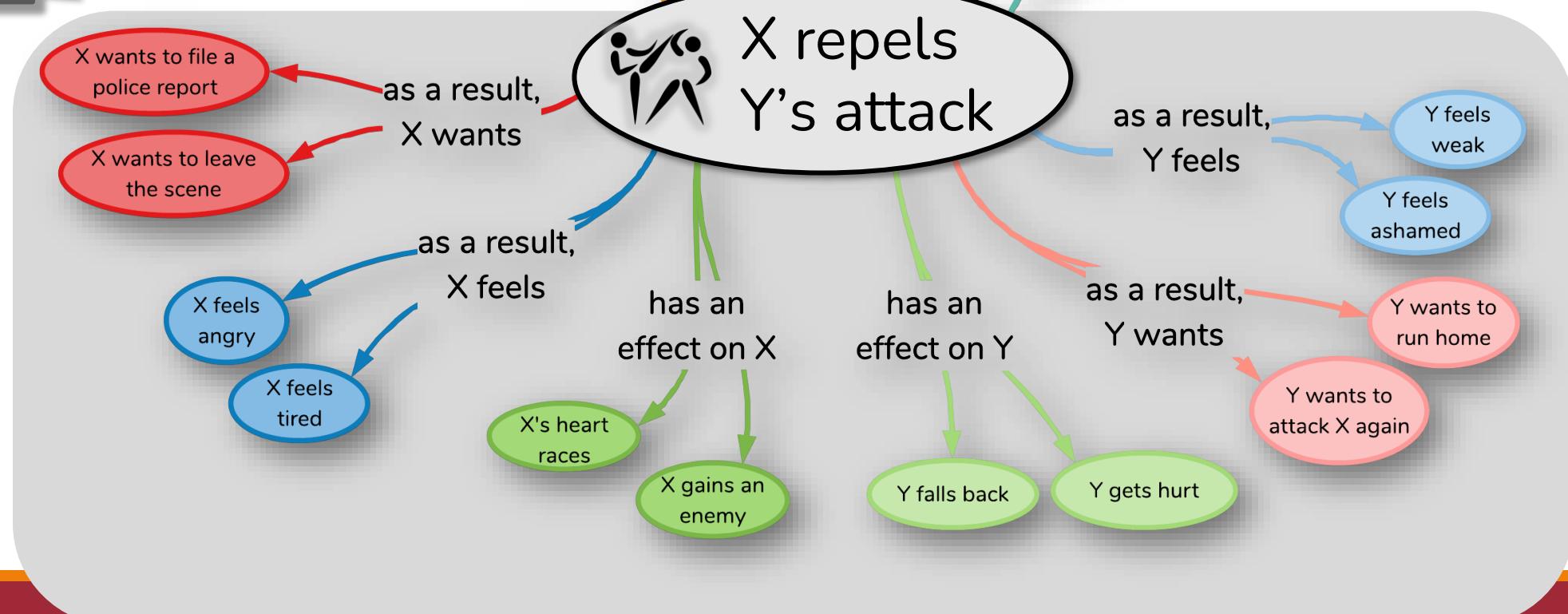


Effects

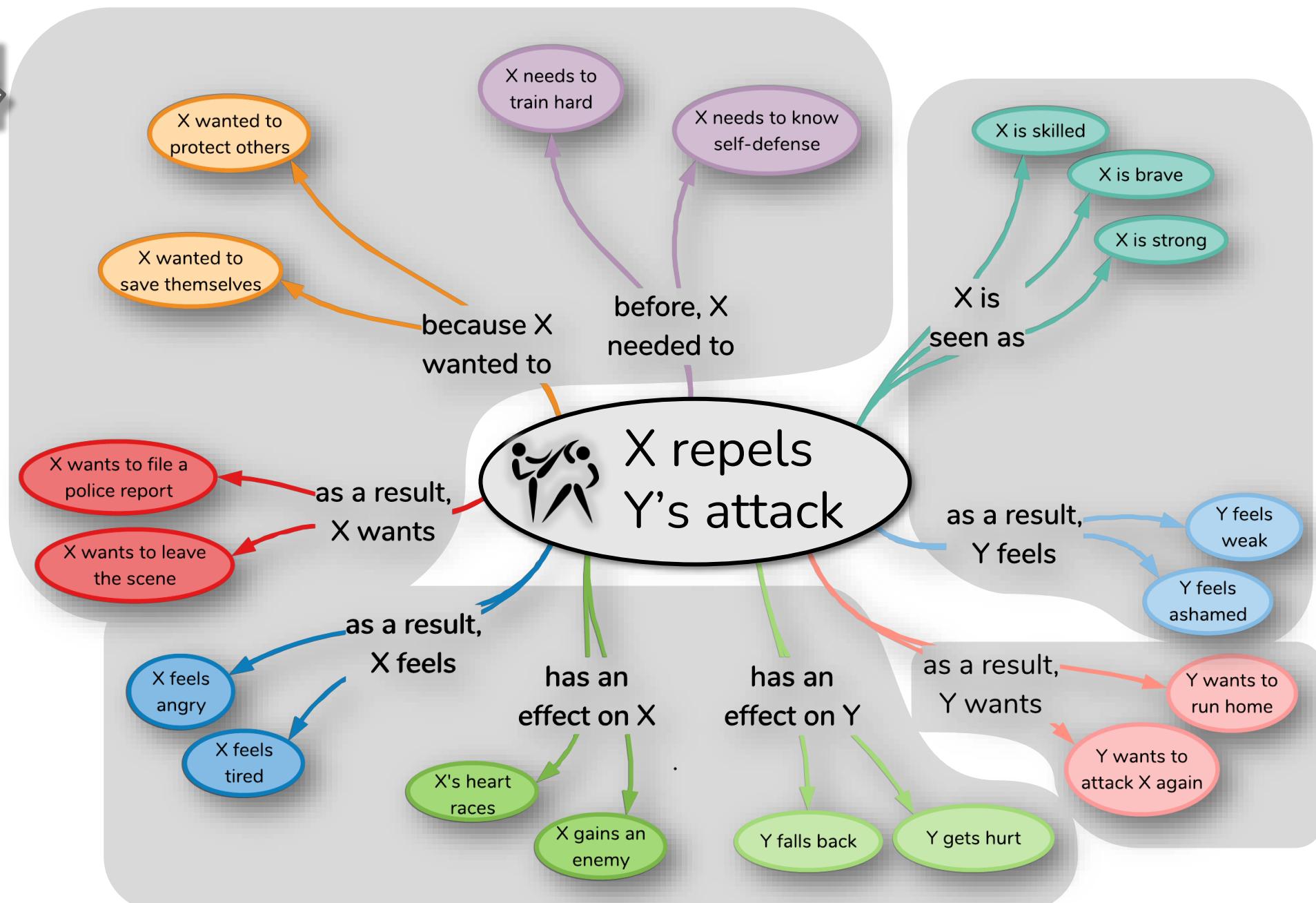


Static

Dynamic



Voluntary



Involuntary

Agent

X wants to file a police report
X wants to leave the scene

X feels angry
X feels tired

as a result,
X wants

as a result,
X feels

Y's attack

X repels
Y's attack

Theme

Y feels weak
Y feels ashamed

Y wants to run home

Y wants to attack X again

as a result,
Y feels

as a result,
Y wants

Y falls back
Y gets hurt

X needs to know self-defense

X needs to train hard

X wanted to protect others

X wanted to save themselves

because X
wanted to

before, X
needed to

X is skilled

X is brave

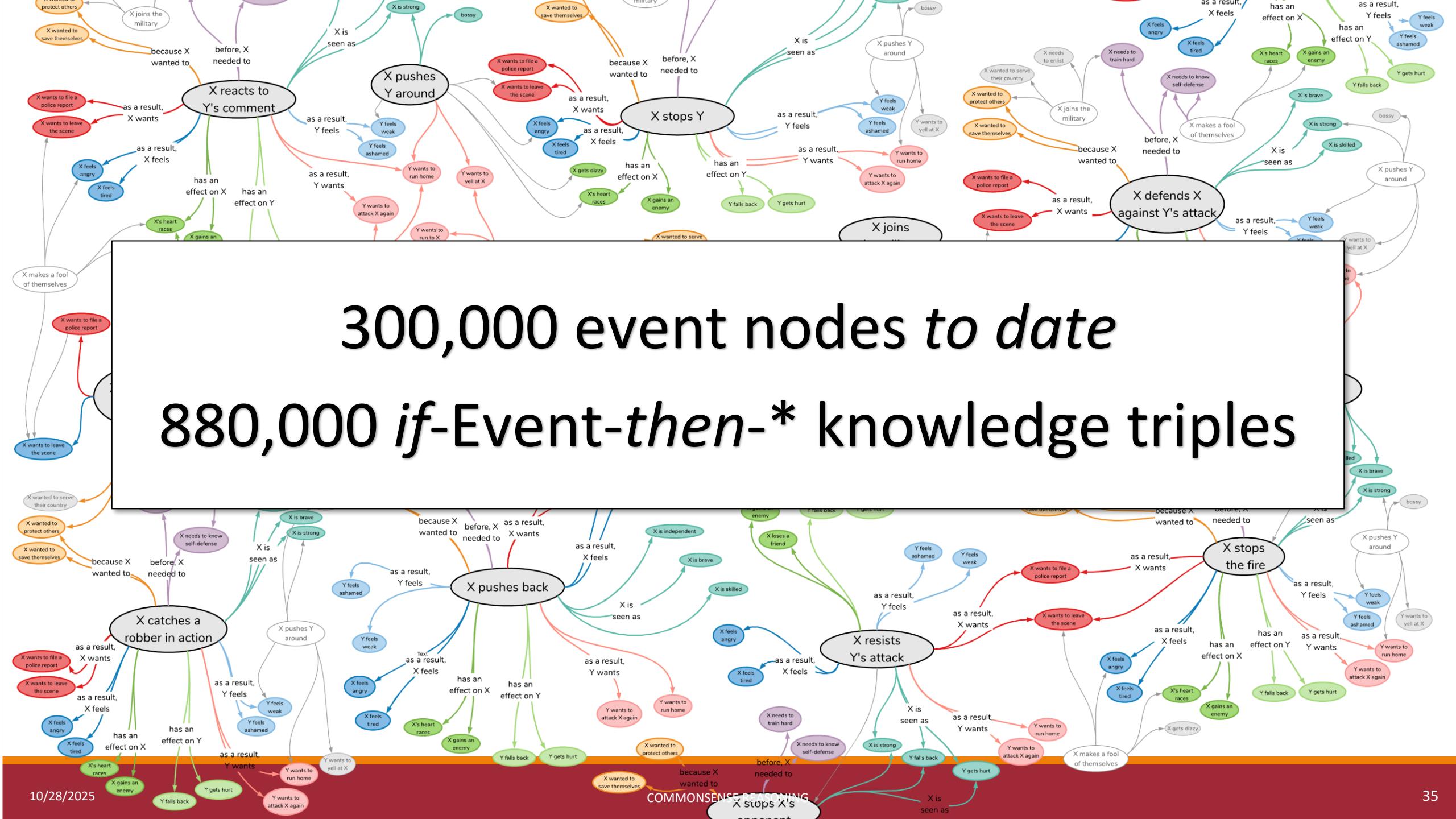
X is strong

X is
seen as

X's heart races
X gains an enemy

300,000 event nodes to date

880,000 if-Event-then-* knowledge triples



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

THE
BOOK OF
WHY

$\alpha \rightarrow \beta$

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)

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

NELL
(Mitchell et al., 2015)

OpenCyc 4.0
(Lenat, 2012)

ConceptNet 5.5
(Speer et al., 2017)

ATOMIC
(Sap et al., 2019)

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

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NELL
(Mitchell et al., 2015)

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(Lenat, 2012)

ConceptNet 5.5
(Speer et al., 2017)

When would you want
to use a taxonomic
knowledge base?

How about an
inferential?

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

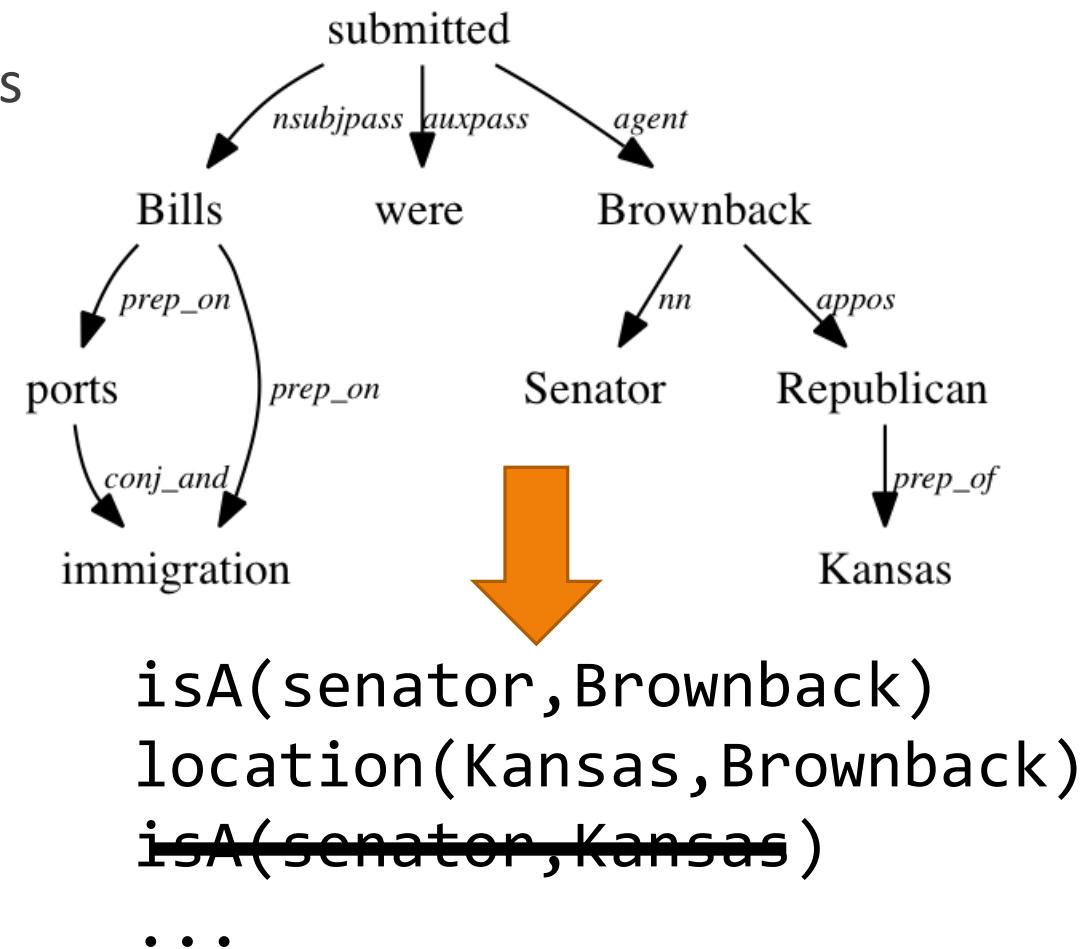
Extracting commonsense from text

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)



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

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



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

Eliciting commonsense from humans

EXPERTS CREATE KNOWLEDGE BASE

What is an “expert”
in this case?

NON-EXPERTS WRITE KNOWLEDGE IN
NATURAL LANGUAGE PHRASES

OpenCyc 4.0
(Lenat, 2012)

WordNet
(Miller et al.,
1990)

ATOMIC
(Sap et al., 2019)

ConceptNet 5.5
(Speer et al., 2017)

When poll is
active respond
at

**PollEv.com/
laramartin527**

Send **laramartin527** and your
message to **22333**



Knowledge bases and mitigating biases

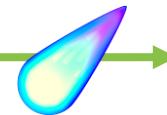
PersonX clutches a gun

ATOMIC (Sap et al., 2019)

because X
wanted to

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

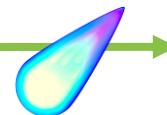
Jaquain clutches a gun



because X
wanted to

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

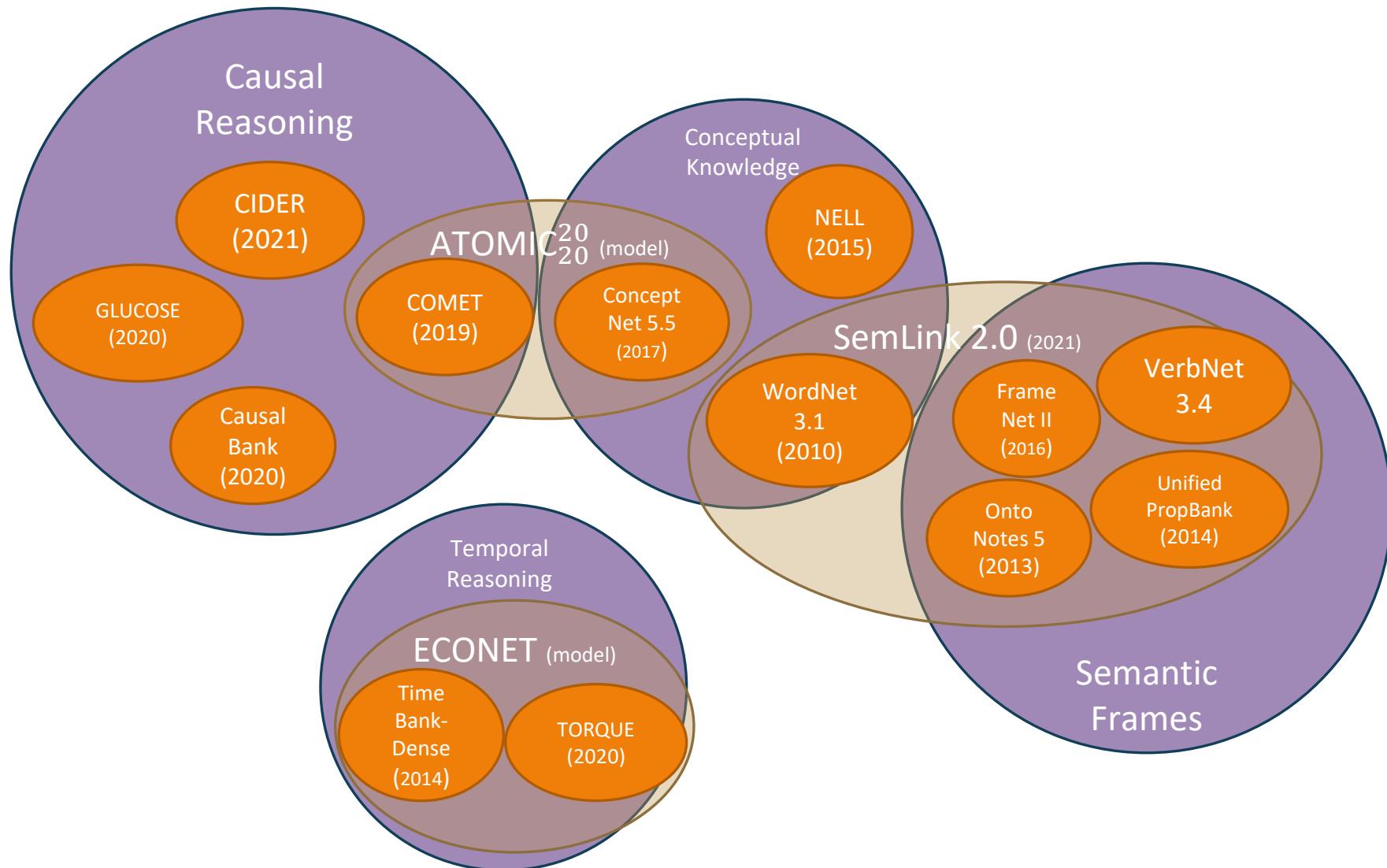
Karen clutches a gun



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

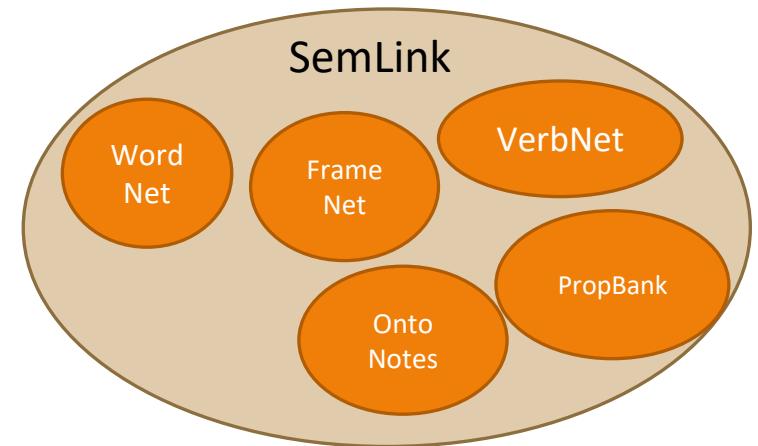


SemLink/Unified Verb Index 2.0

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

Combines 5 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.

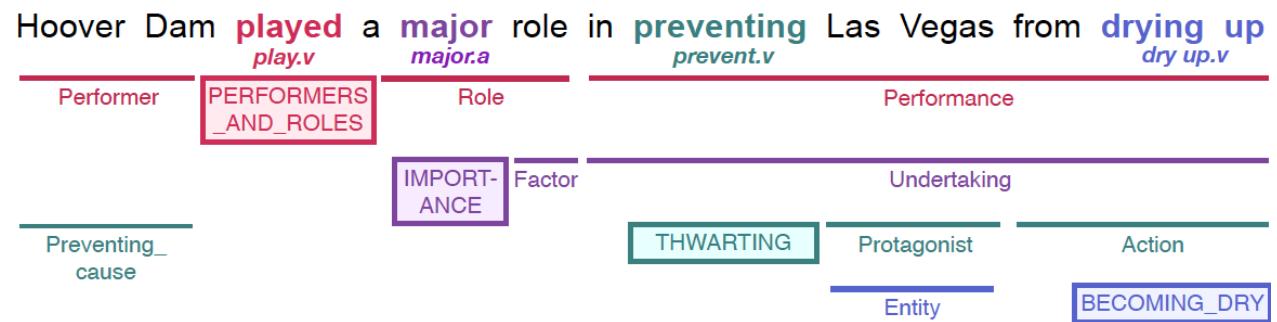
FrameNet II

<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 Petrucc, 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

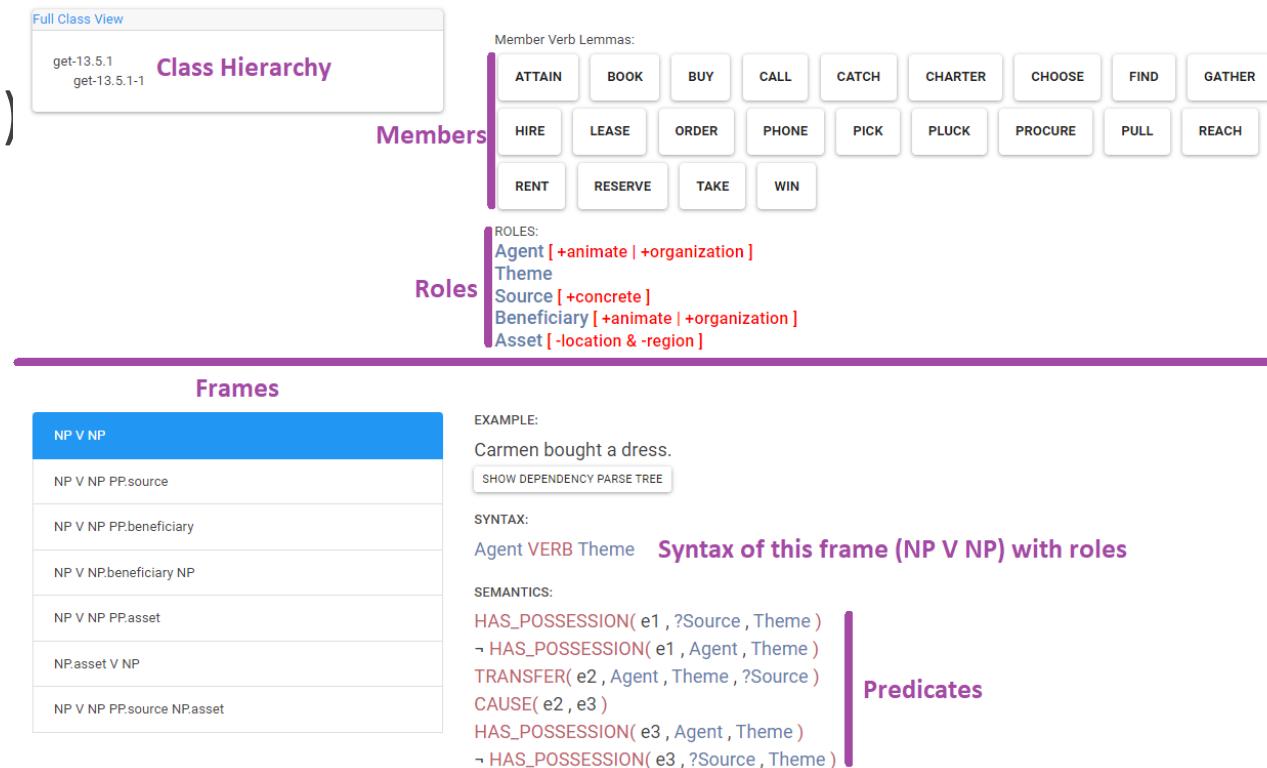
Use: [raw data](#)

Demo:

https://uvi.colorado.edu/uvi_search

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
(Plus a way to map English to different languages)

Use: [raw data](#)

*semantic propositions regardless of part of speech (e.g. cre

Event relation: Offer

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)))
```

Martha Palmer, Dan Gildea, Paul Kingsbury, The Proposition Bank: A Corpus Annotated with Semantic Roles *Computational Linguistics Journal*, 31:1, 2005.

Claire Bonial, Julia Bonn, Kathryn Conger, Jena Hwang and Martha Palmer (2014) PropBank: Semantics of New Predicate Types. *The 9th edition of the Language Resources and Evaluation Conference*. Reykjavik, Iceland.

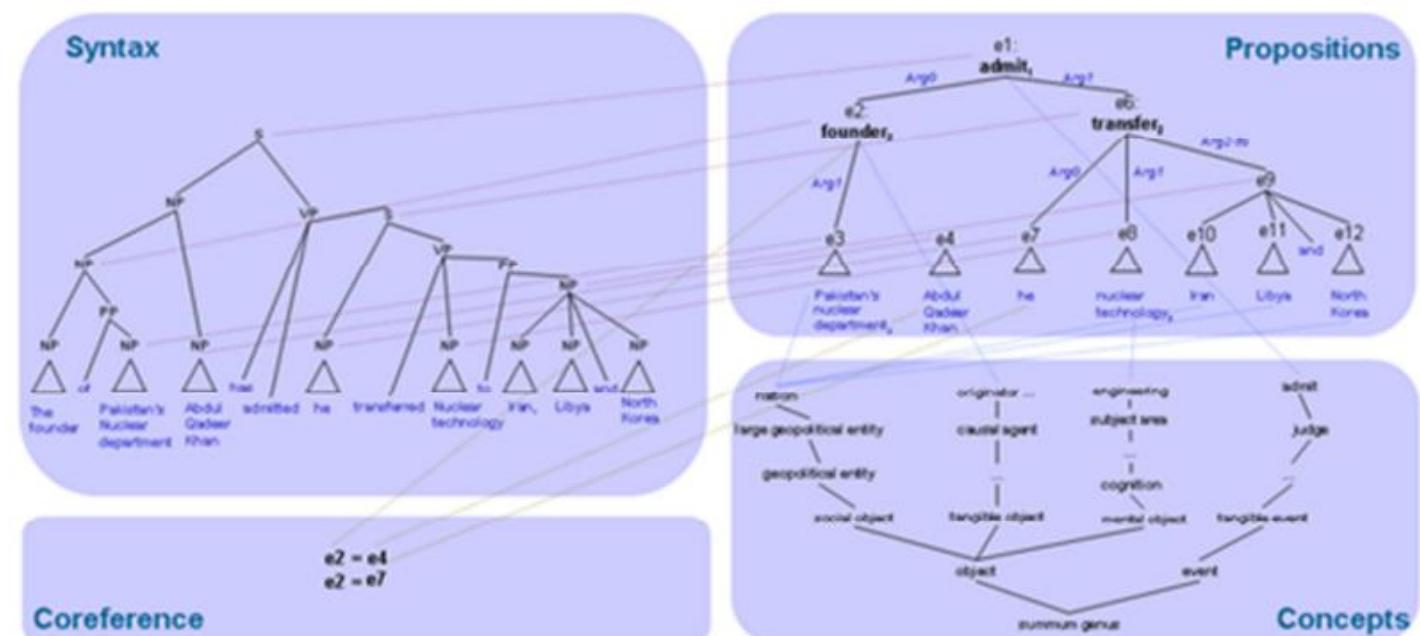
OntoNotes 5.0

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

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

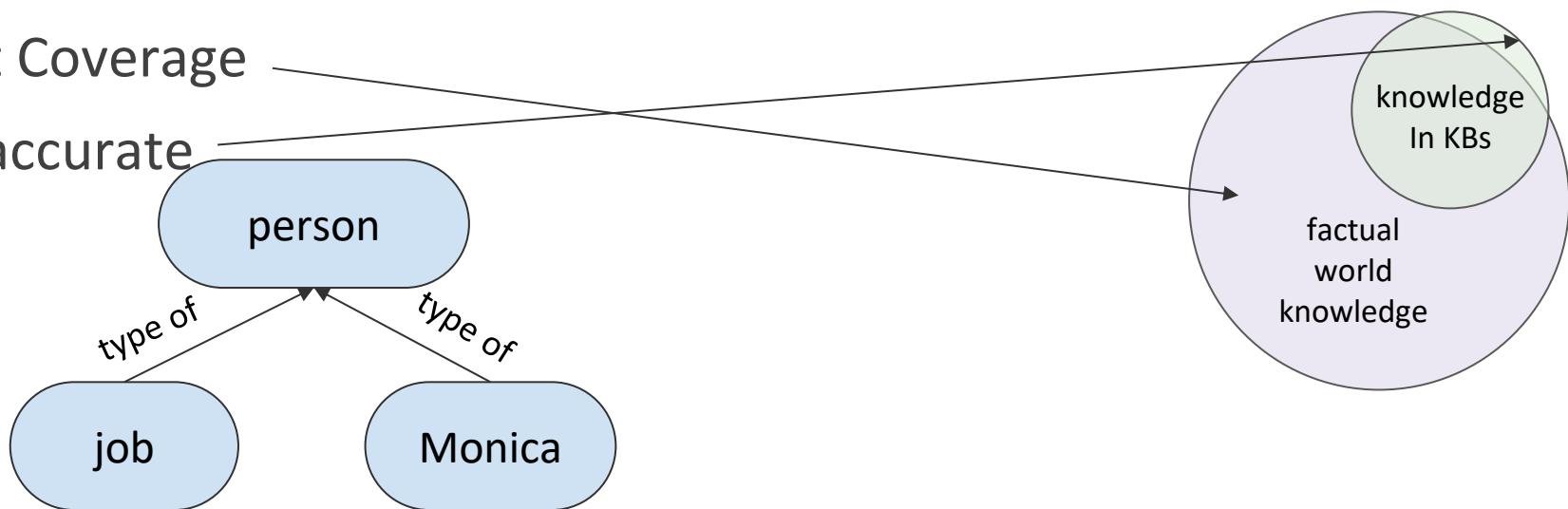
Languages: English, Chinese, Arabic

Use: raw data (same link)

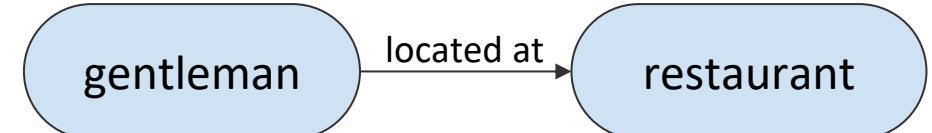


Limitations

- Insufficient Coverage
- Not 100% accurate



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



Think-Pair-Share

How might you use a knowledge base in a planning-based system?

