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

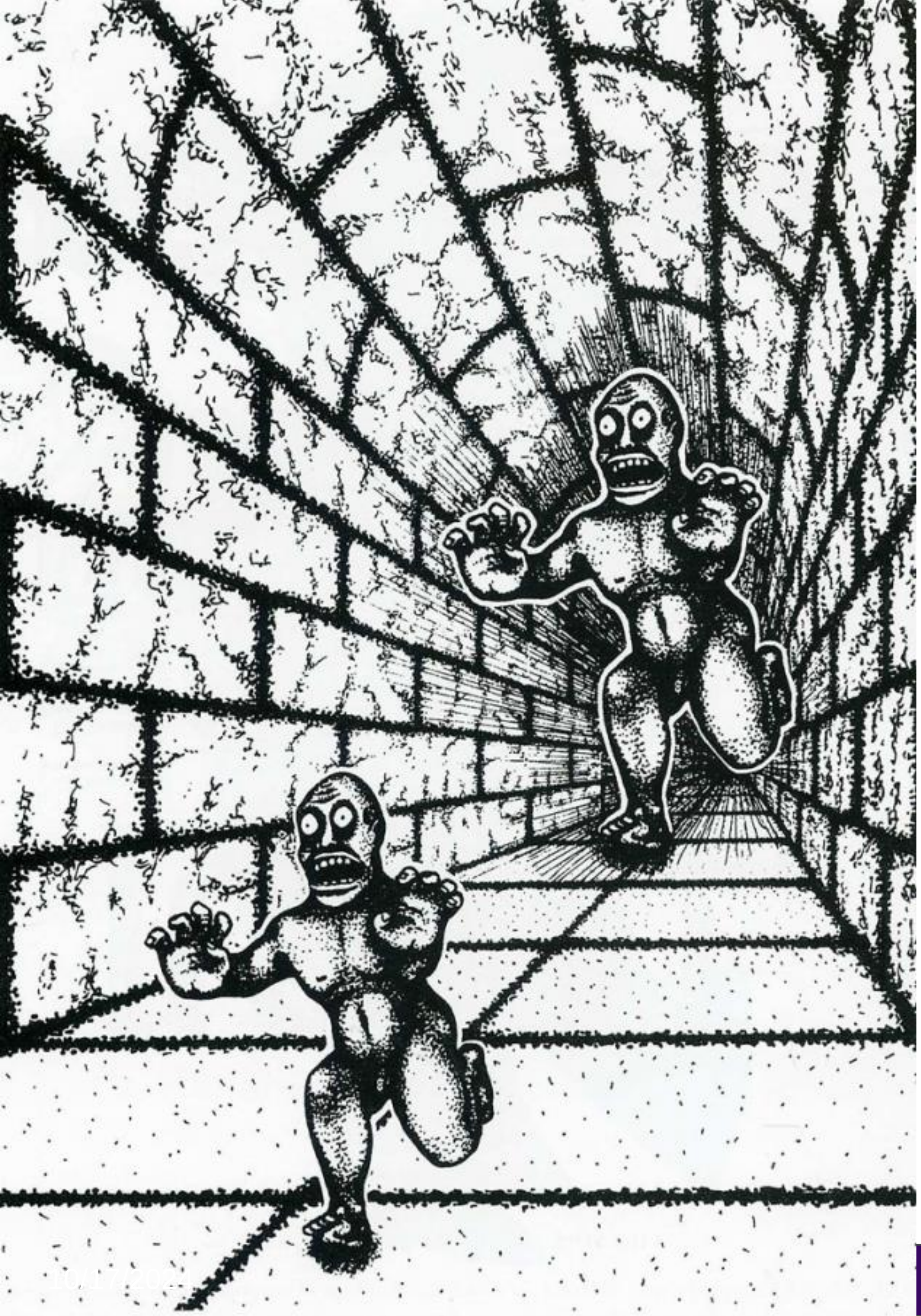
Announcements

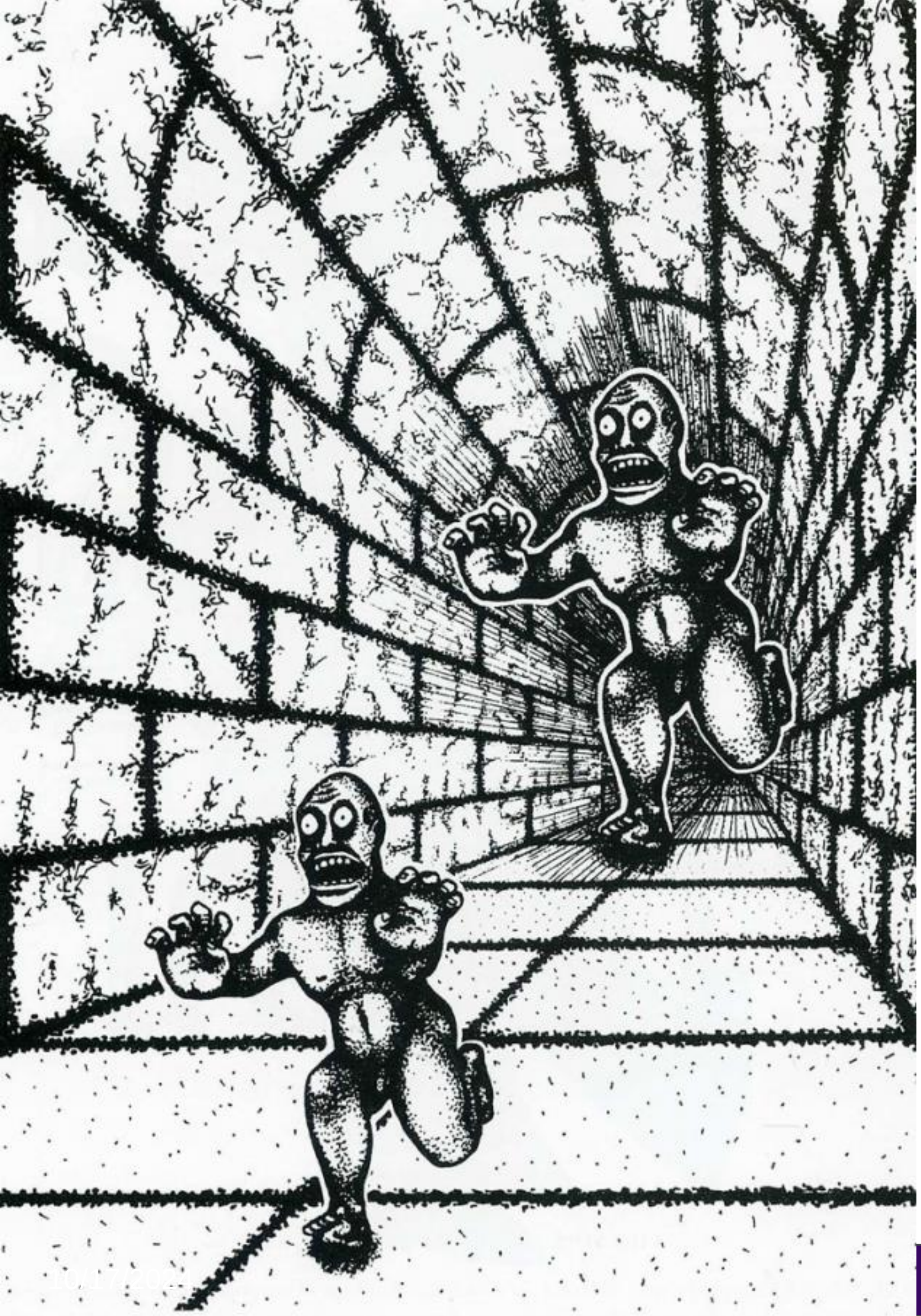
- HW 3
  - Due 10/28 (same day as project milestone)
- Next Tuesday will be grad paper presentations
- Midpoint feedback due 10/22 – hard deadline
  - knowledge check point
- All homeworks are up 2% (most are 12% now, HW1 is 7%)
- Final presentations will be in SHER 150 on 12/12

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

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.

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

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

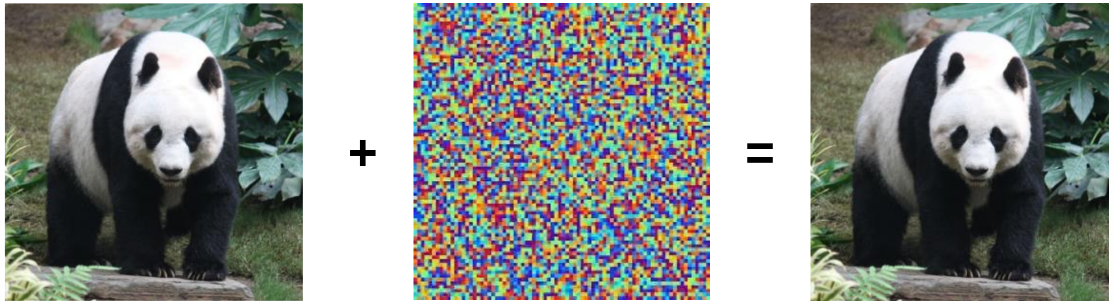
Newsweek SUBSCRIBE FOR $1 Login

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



Giant panda

Gibbon

Object Recognition

Szegedy et al, 2014….

VQA

Jabri et al, 2017

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

A horse standing in the grass.

Captioning

MacLeod et al, 2017

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

Where did Tesla move in 1880? Chicago

QA

Jia et al, 2017

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

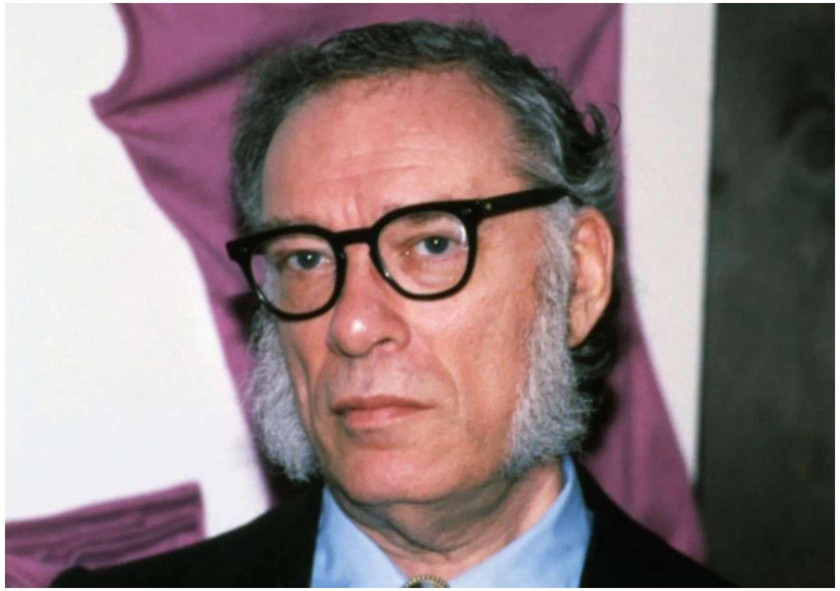
The basic level of **practical knowledge** and **reasoning**
concerning **everyday situations** and events
that are **commonly shared** among **most** people.

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.

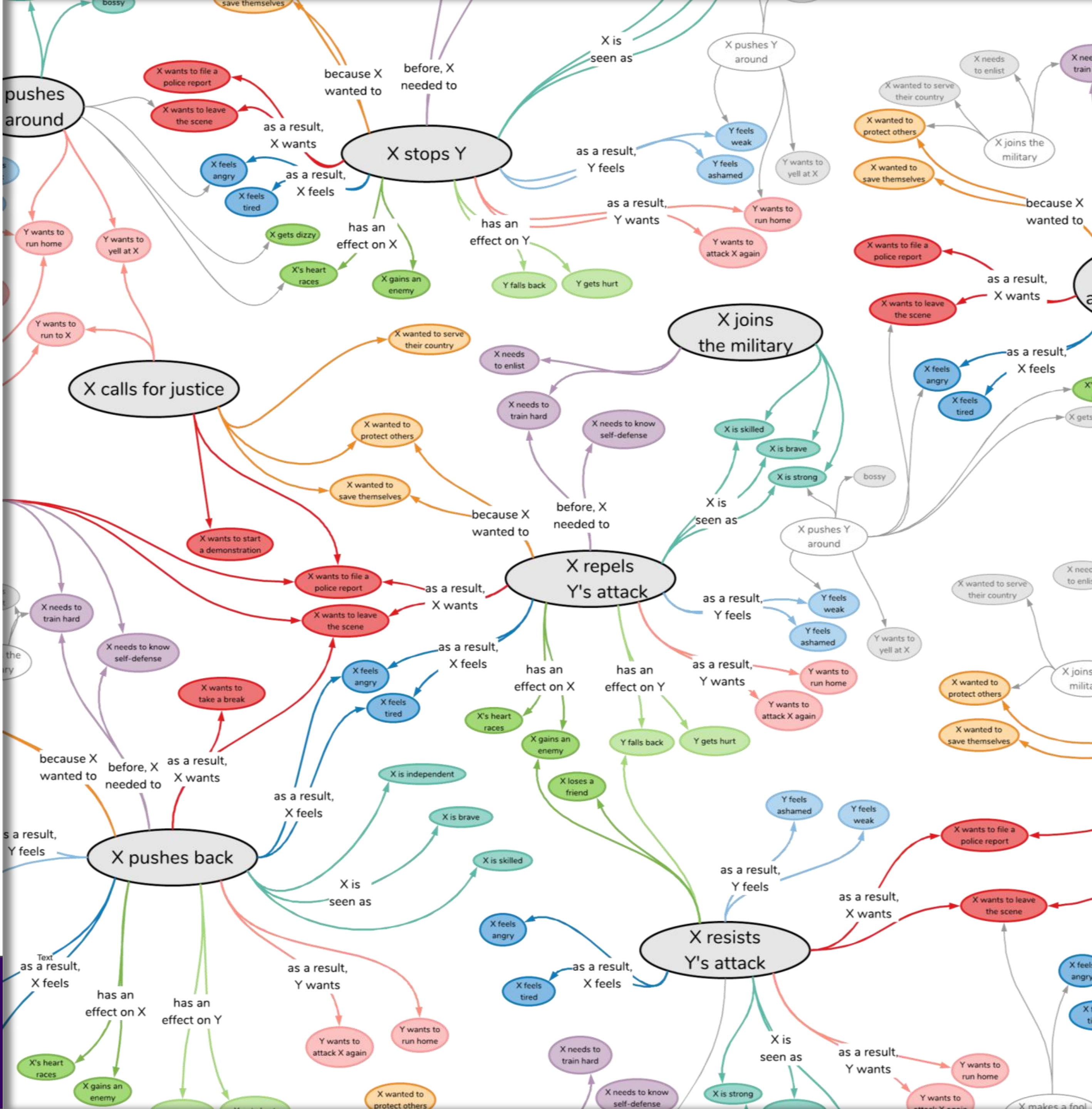
- Isaac Asimov, 1942 short story "Runaround"



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.

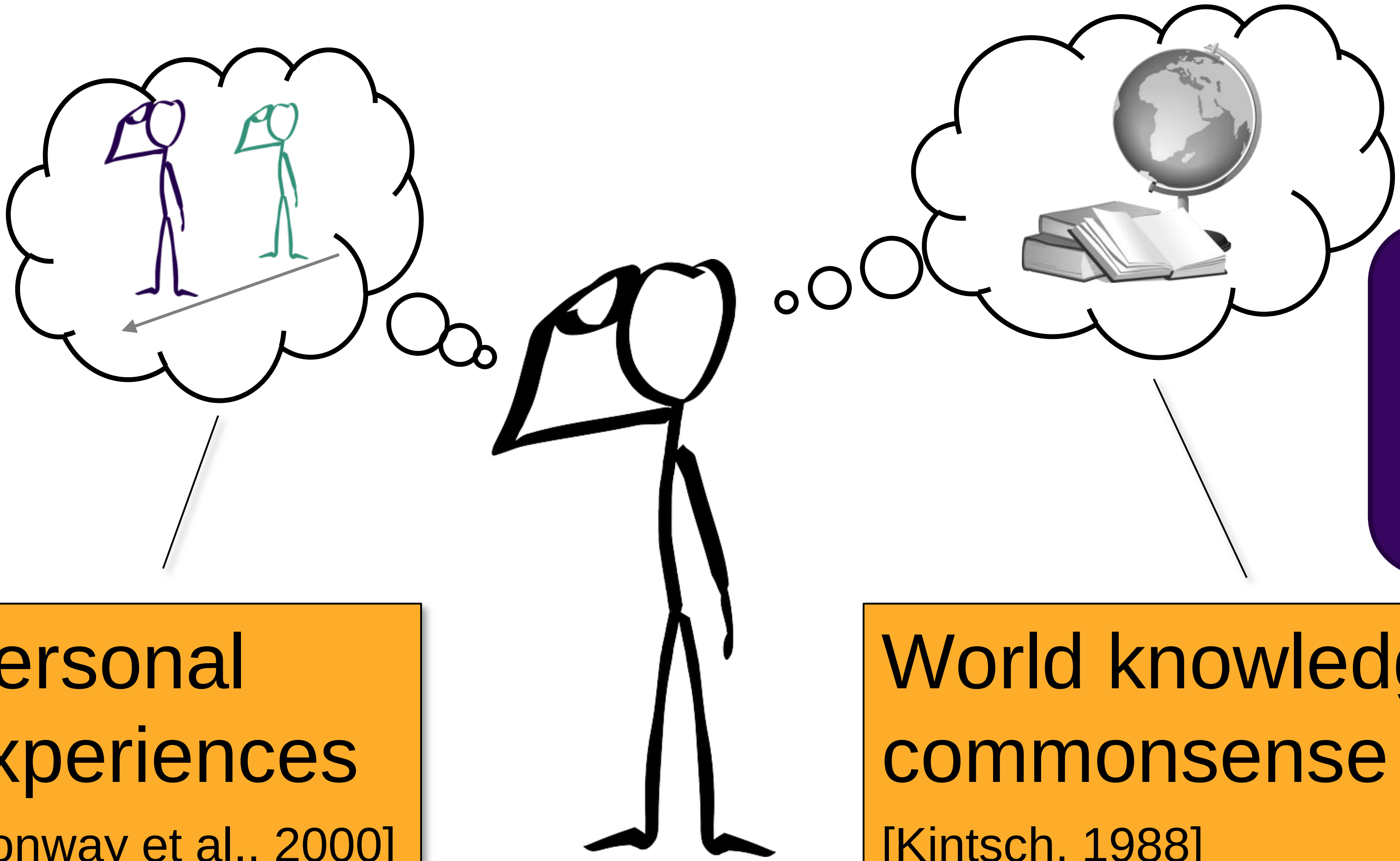
Tom rushed to help her look for them, they heard a loud crack.

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]

Commonsense resources aim to be a bank of knowledge for machines to be able to reason about the world in tasks

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

usedFor

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.

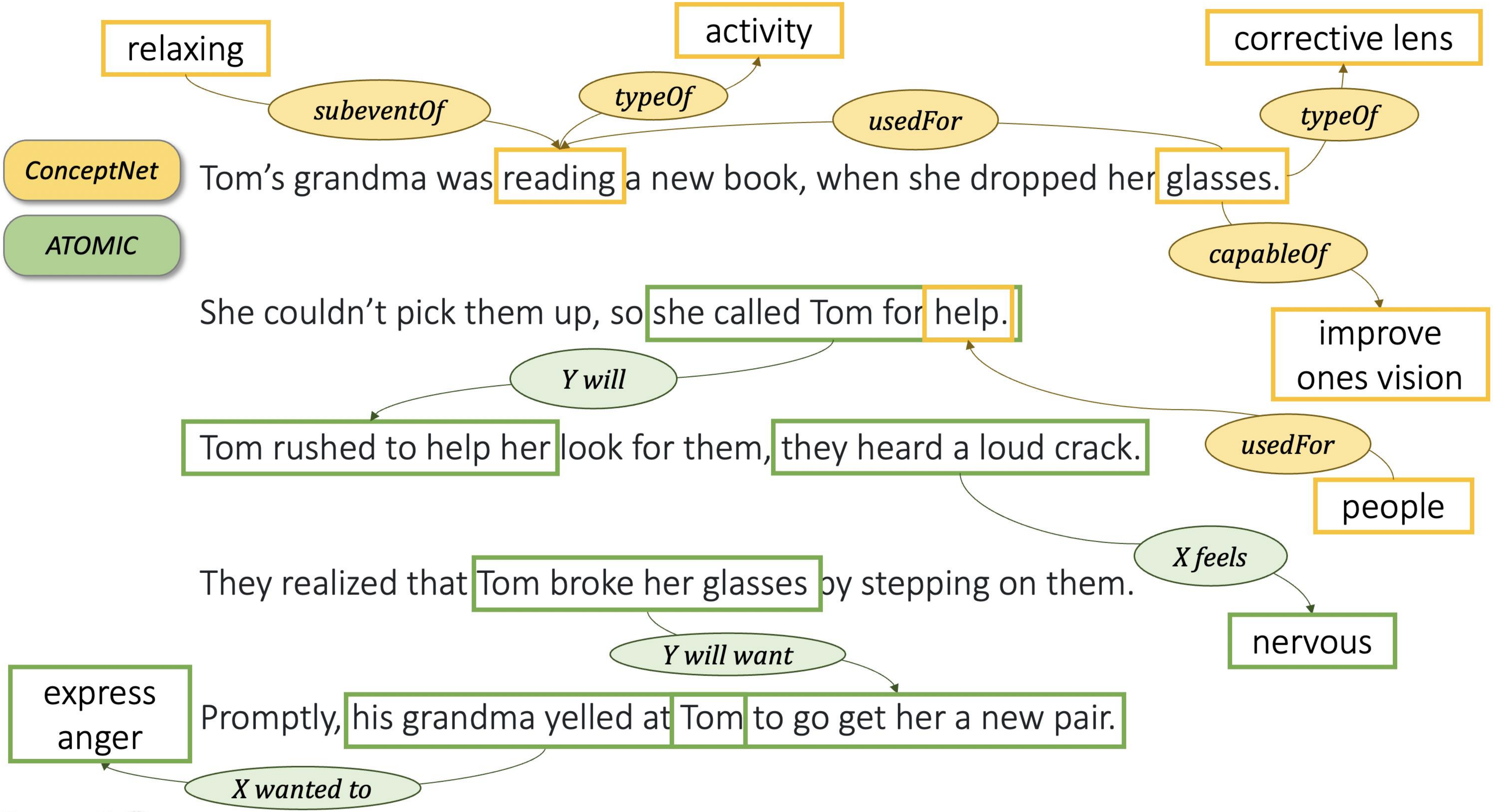
Y will

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

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

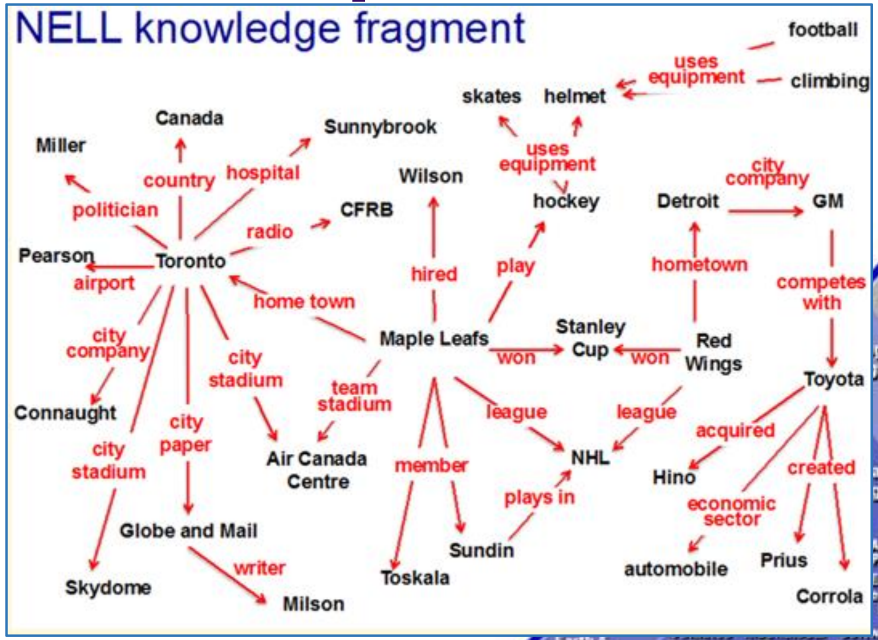
Y will want

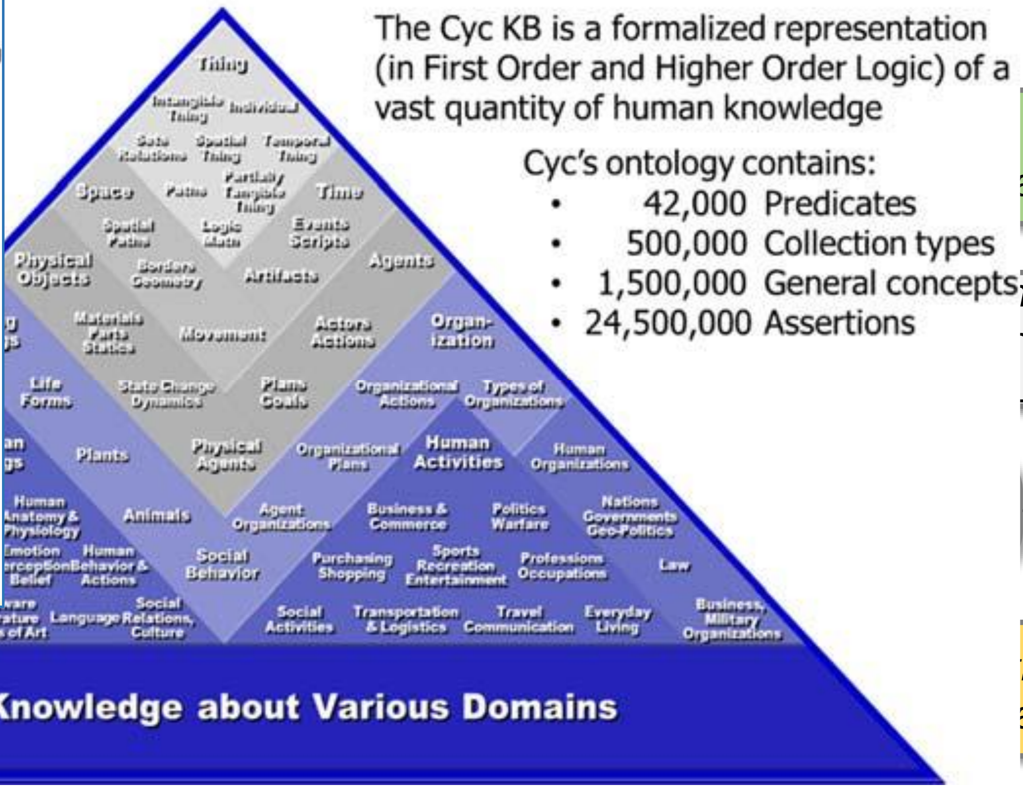
Promptly, his grandma yelled at Tom to go get her a new pair.



ConceptNet
ATOMIC
relaxing
subeventOf
typeOf
activity
usedFor
corrective lens
typeOf
Tom's grandma was reading a new book, when she dropped her glasses.
capableOf
improve ones vision
She couldn't pick them up, so she called Tom for help.
Y will
usedFor
Tom rushed to help her look for them, they heard a loud crack.
people
X feels
They realized that Tom broke her glasses by stepping on them.
nervous
Y will want
express anger
Promptly, his grandma yelled at Tom to go get her a new pair.
X wanted to

Some important resources





ATOMIC
ap et al., 2019)

ild 2.0
n et al.,
.7)

Net 5.5
al., 2017)

Open Mind Comm
(Minsky, Singh &
1999)

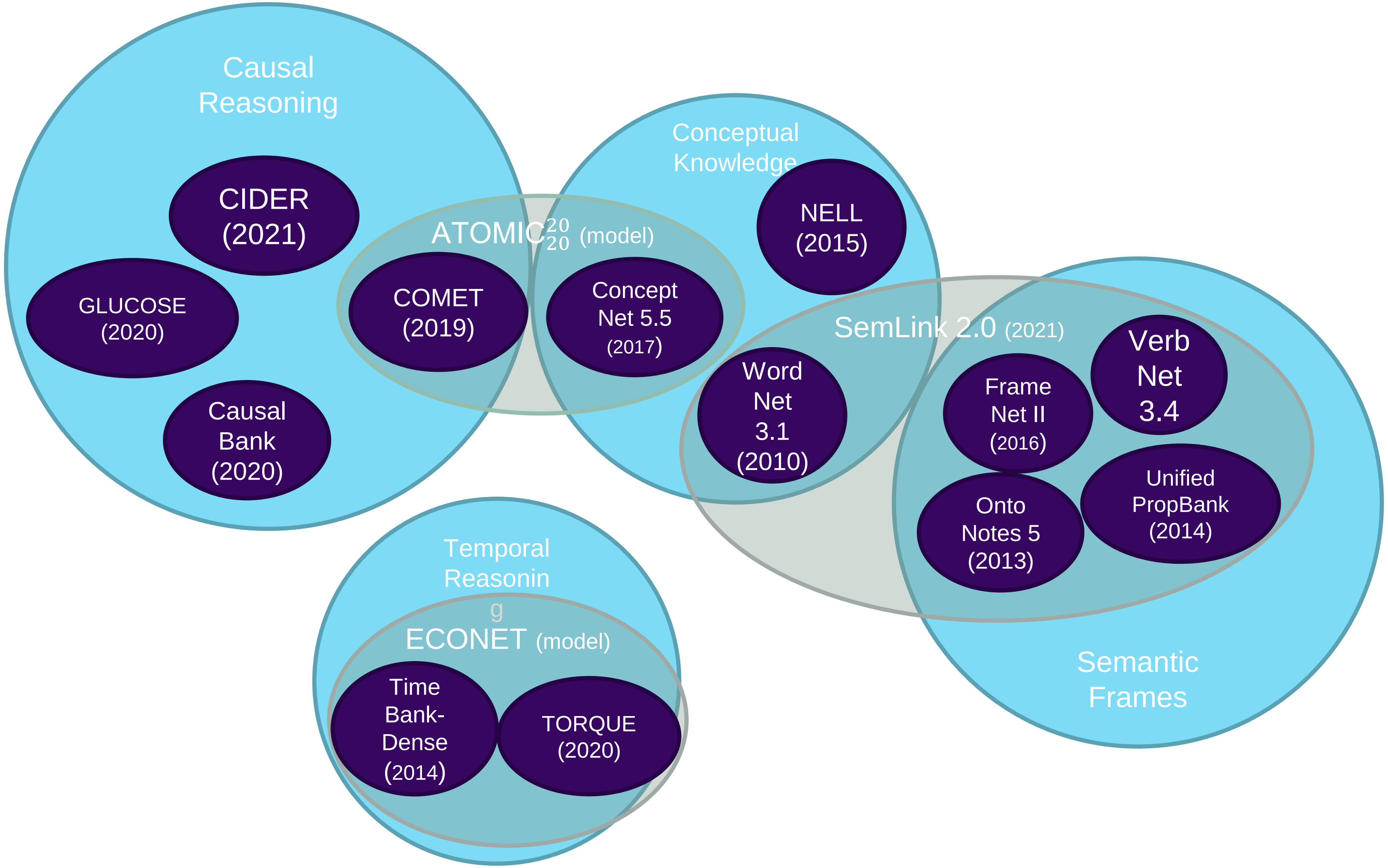
Cyc
(Lenat et al.,
1984)

OpenCyc
(Lenat,
2004)

ResearchCyc
(Lenat, 2006)

OpenCyc 4.0
(Lenat, 2012)

today


Causal Reasoning
CIDER (2021)
GLUCOSE (2020)
Causal Bank (2020)
ATOMIC$^{20}_{20}$ (model)
COMET (2019)
Concept Net 5.5 (2017)
Conceptual Knowledge
NELL (2015)
SemLink 2.0 (2021)
Word Net 3.1 (2010)
Frame Net II (2016)
Verb Net 3.4
Onto Notes 5 (2013)
Unified PropBank (2014)
Semantic Frames
Temporal Reasonin
g
ECONET (model)
Time Bank-Dense (2014)
TORQUE (2020)

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

- Representation
  - Symbolic
  - Natural language
- Knowledge type
  - Domain-specific
  - Semantic
  - Inferential

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 Petruck, 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 type of...

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

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 →

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)

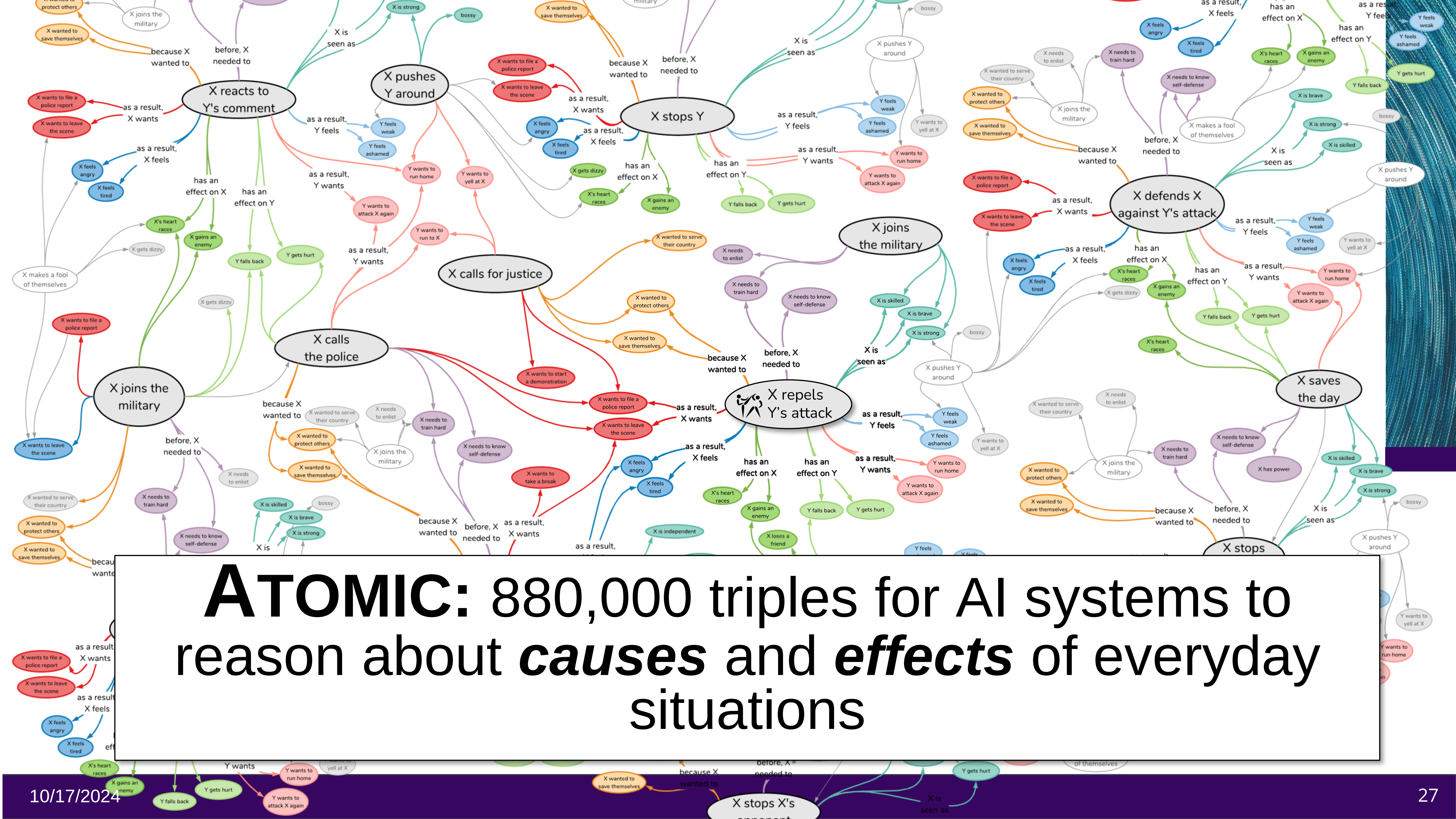
- Over 85 languages
- In English: over 1.5 million nodes

Knowledge covered:

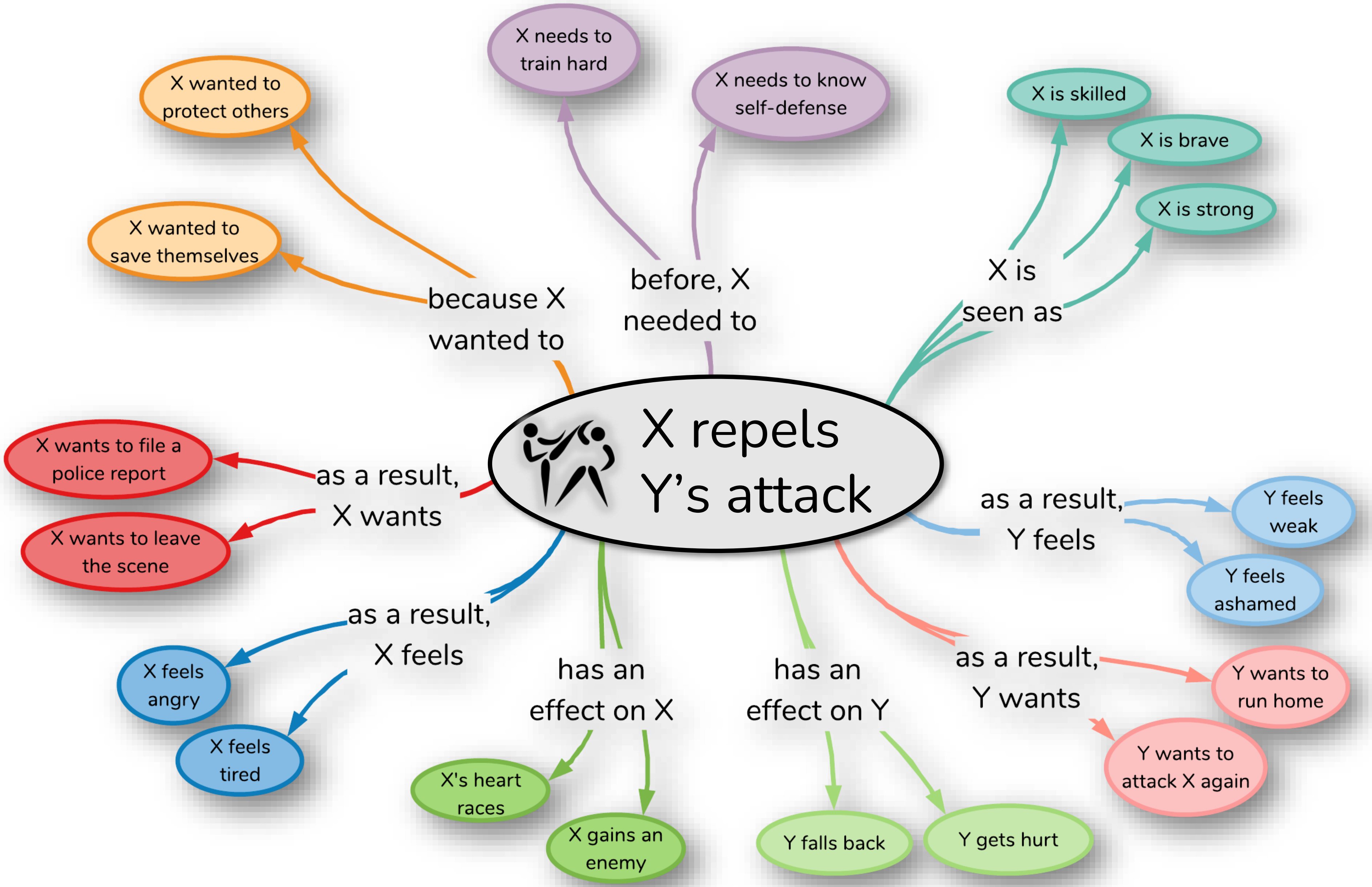
- Open Mind Commonsense assertions
- Wikipedia/Wiktionary semantic knowledge
- WordNet, Cyc ontological knowledge

ATOMIC:
inferential knowledge in *natural language* form

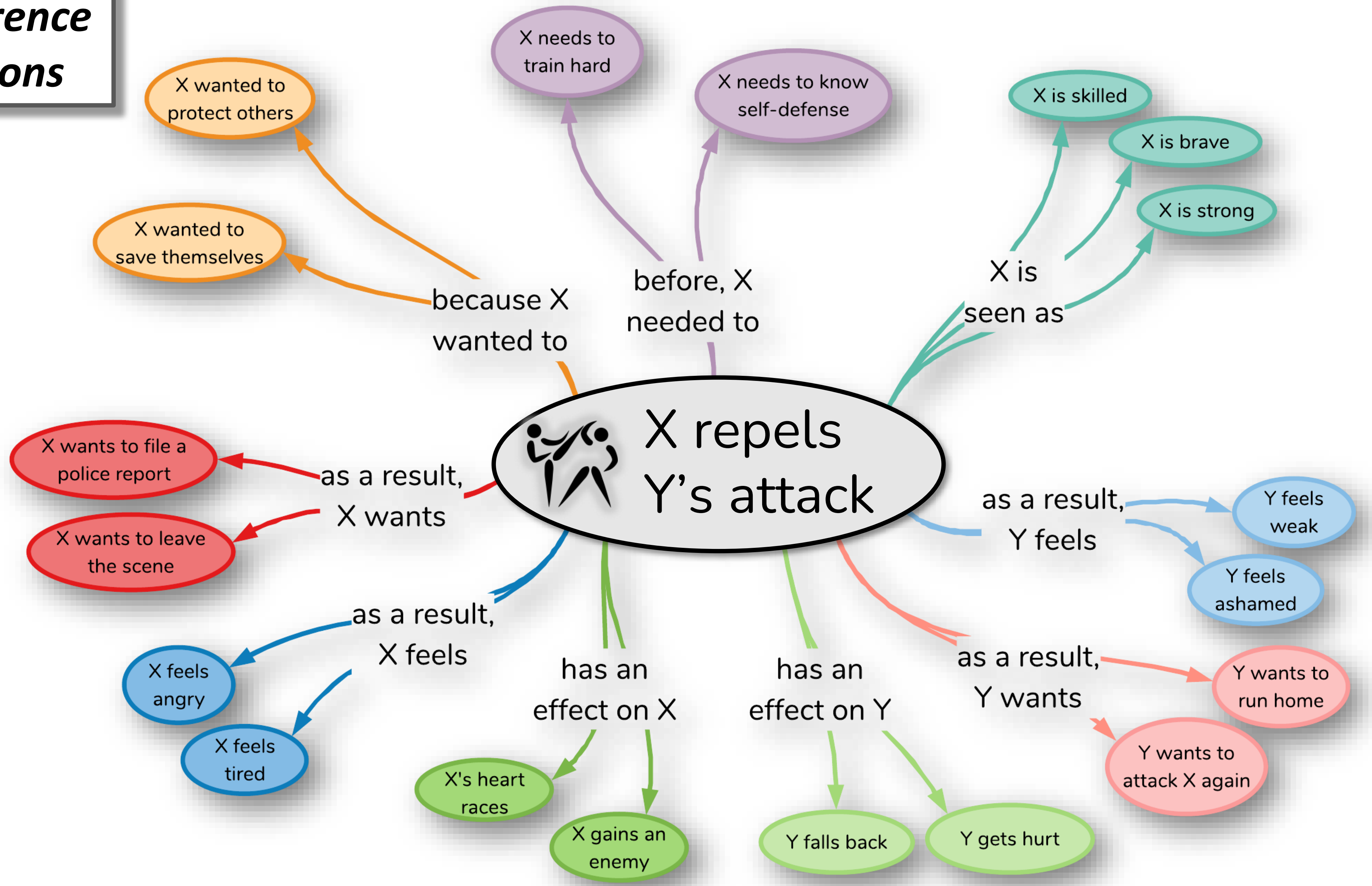
https://github.com/allenai/comet-atomic-2020

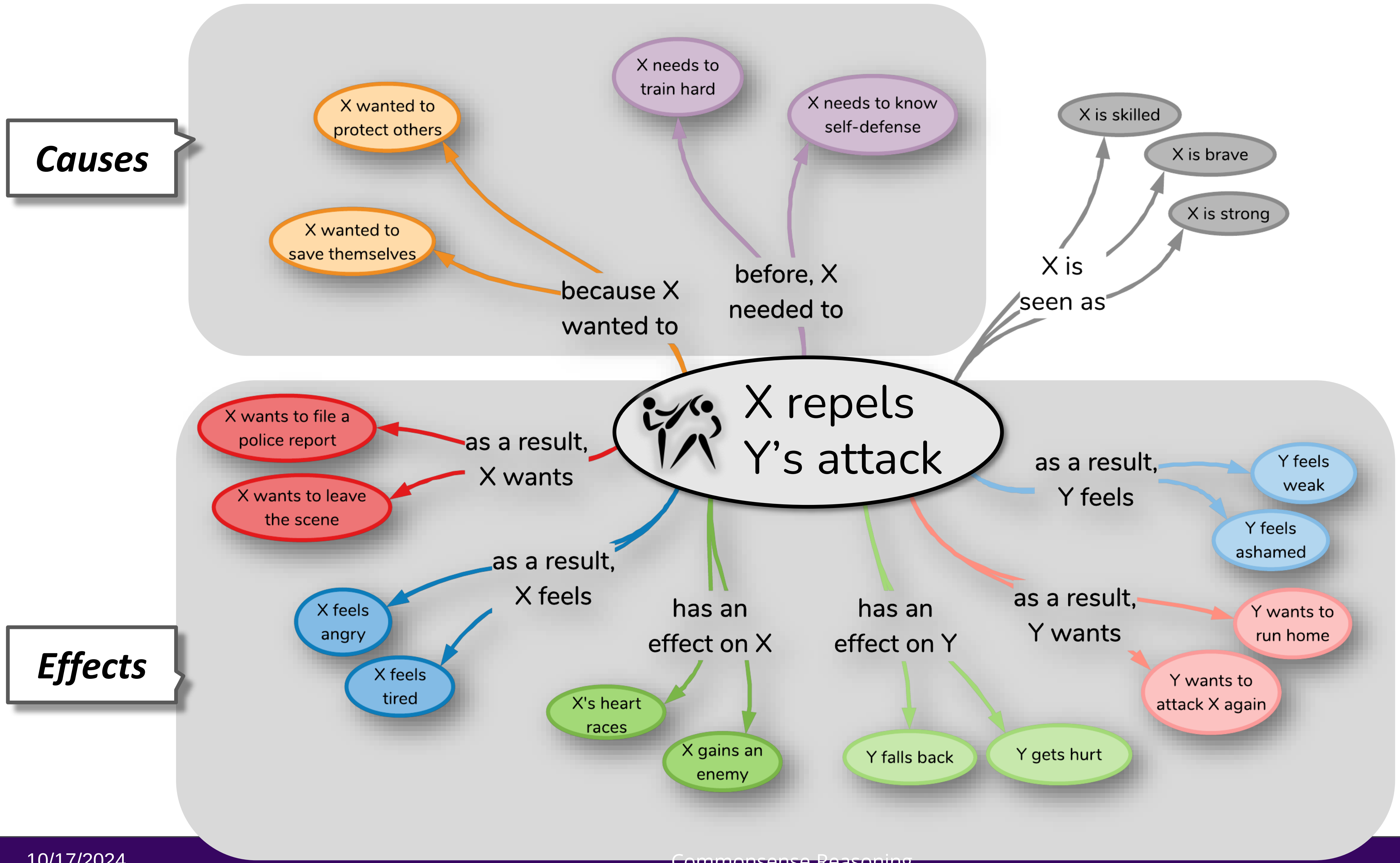


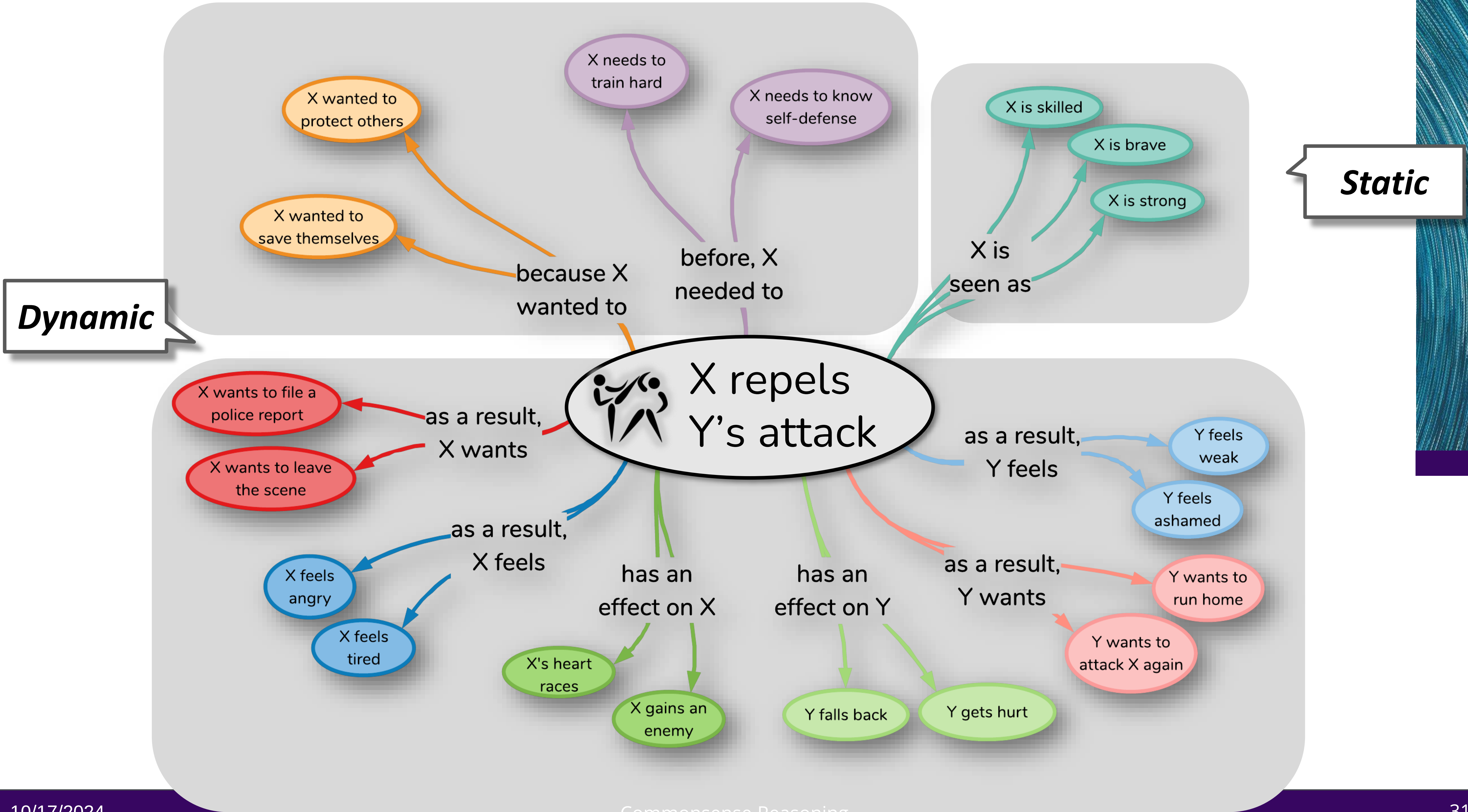
ATOMIC: 880,000 triples for AI systems to reason about ***causes*** and ***effects*** of everyday situations

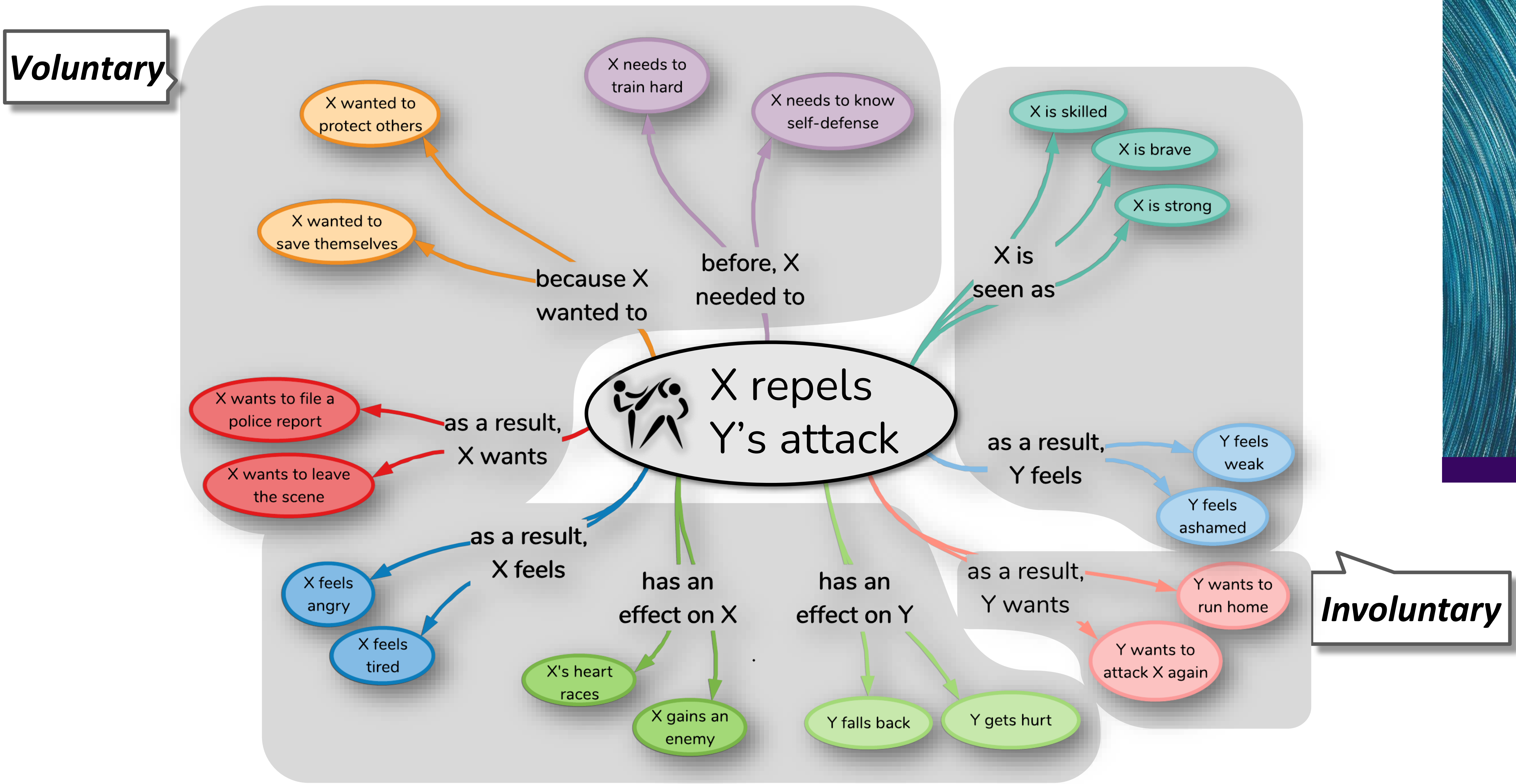

X repels Y's attack
because X wanted to
X wanted to protect others
X wanted to save themselves
before, X needed to
X needs to train hard
X needs to know self-defense
X is seen as
X is skilled
X is brave
X is strong
as a result, X wants
X wants to file a police report
X wants to leave the scene
as a result, Y feels
Y feels weak
Y feels ashamed
as a result, X feels
X feels angry
X feels tired
has an effect on X
X's heart races
X gains an enemy
has an effect on Y
Y falls back
Y gets hurt
as a result, Y wants
Y wants to run home
Y wants to attack X again

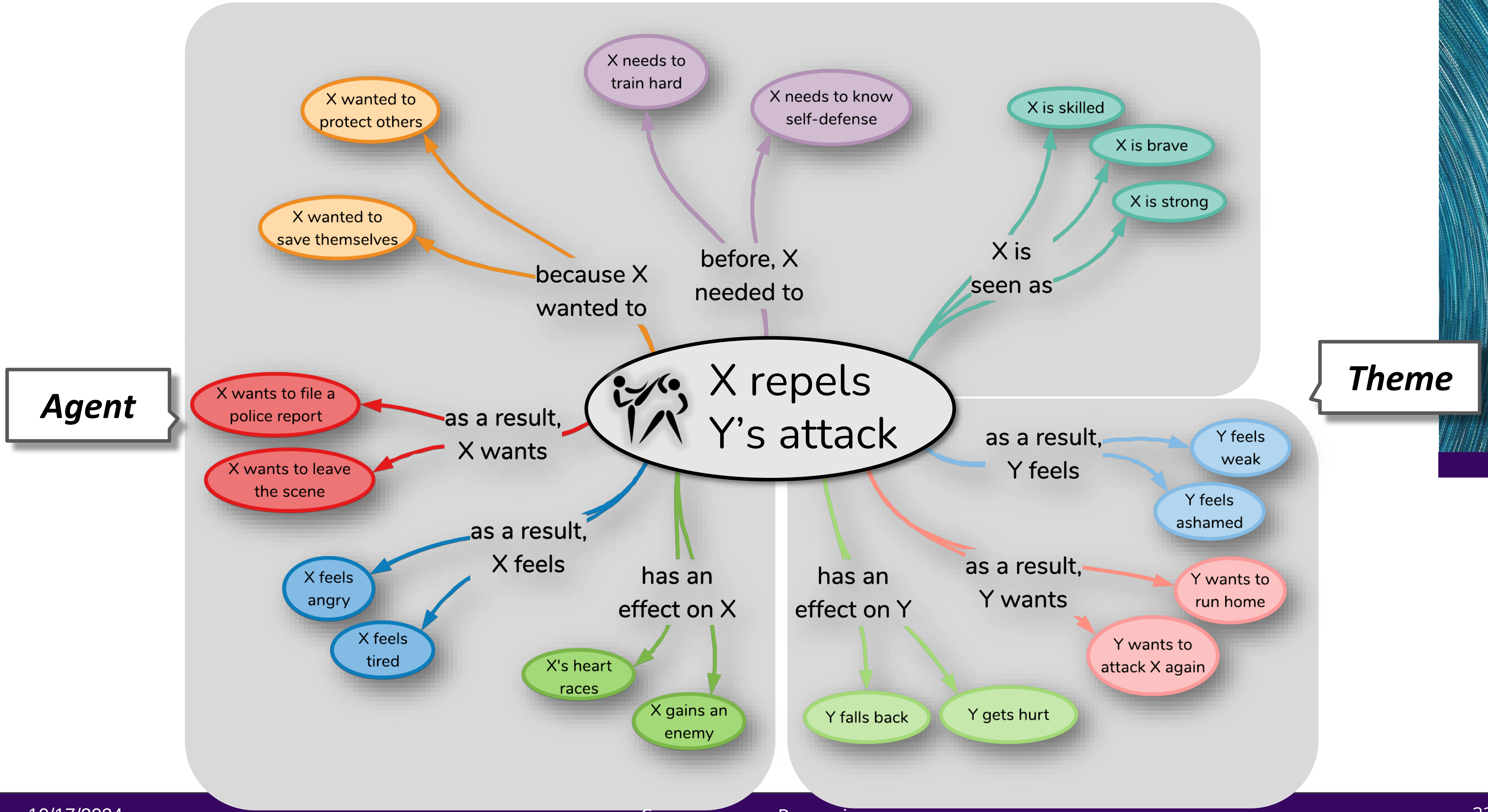
nine inference dimensions



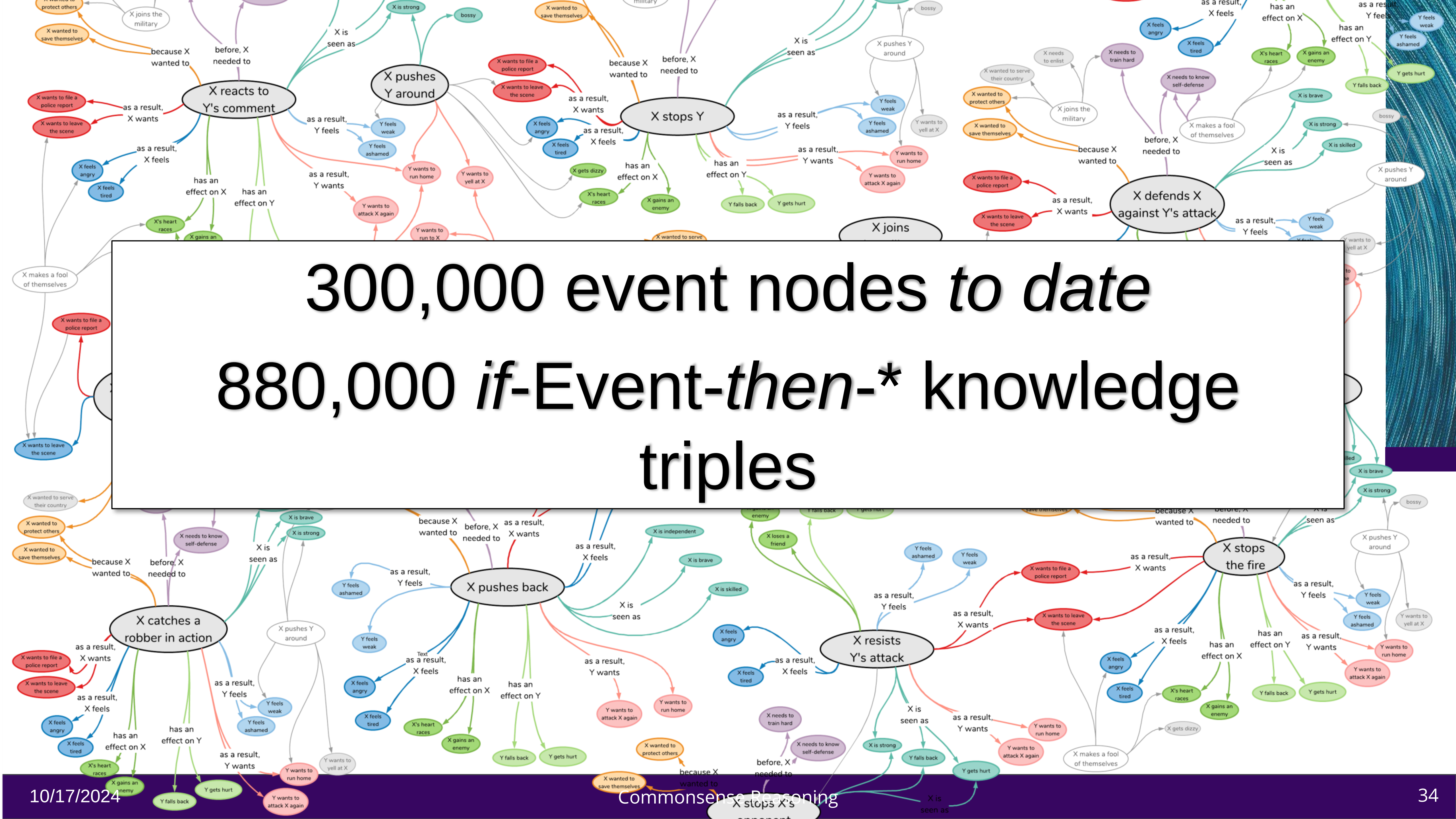

Causes
X wanted to protect others
X wanted to save themselves
X needs to train hard
X needs to know self-defense
because X wanted to
before, X needed to
X is skilled
X is brave
X is strong
X is seen as
X repels Y's attack
Effects
X wants to file a police report
X wants to leave the scene
as a result, X wants
as a result, X feels
X feels angry
X feels tired
has an effect on X
X's heart races
X gains an enemy
has an effect on Y
Y falls back
Y gets hurt
as a result, Y wants
Y wants to run home
Y wants to attack X again
as a result, Y feels
Y feels weak
Y feels ashamed


Static
Dynamic
X repels Y's attack
because X wanted to
X wanted to protect others
X wanted to save themselves
before, X needed to
X needs to train hard
X needs to know self-defense
X is seen as
X is skilled
X is brave
X is strong
as a result, X wants
X wants to file a police report
X wants to leave the scene
as a result, X feels
X feels angry
X feels tired
has an effect on X
X's heart races
X gains an enemy
has an effect on Y
Y falls back
Y gets hurt
as a result, Y wants
Y wants to run home
Y wants to attack X again
as a result, Y feels
Y feels weak
Y feels ashamed


Voluntary
X wanted to protect others
X wanted to save themselves
X needs to train hard
X needs to know self-defense
because X wanted to
before, X needed to
X is skilled
X is brave
X is strong
X is seen as
X repels Y's attack
as a result, X wants
X wants to file a police report
X wants to leave the scene
as a result, Y feels
Y feels weak
Y feels ashamed
as a result, X feels
X feels angry
X feels tired
has an effect on X
X's heart races
X gains an enemy
has an effect on Y
Y falls back
Y gets hurt
as a result, Y wants
Y wants to run home
Y wants to attack X again
Involuntary



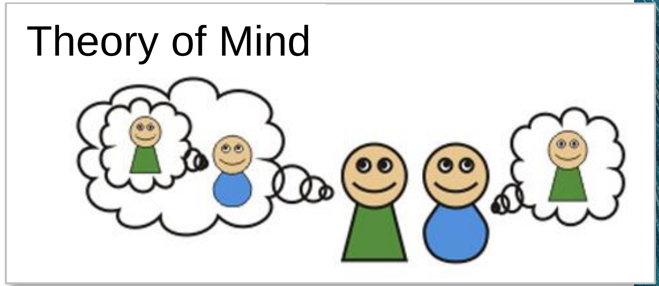
X repels Y's attack
because X wanted to
X wanted to protect others
X wanted to save themselves
before, X needed to
X needs to train hard
X needs to know self-defense
X is seen as
X is skilled
X is brave
X is strong
as a result, X wants
X wants to file a police report
X wants to leave the scene
as a result, X feels
X feels angry
X feels tired
has an effect on X
X's heart races
X gains an enemy
has an effect on Y
Y falls back
Y gets hurt
as a result, Y wants
Y wants to run home
Y wants to attack X again
as a result, Y feels
Y feels weak
Y feels ashamed
Agent
Theme



300,000 event nodes *to date*

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

Atomic: knowledge of *cause* and *effect*



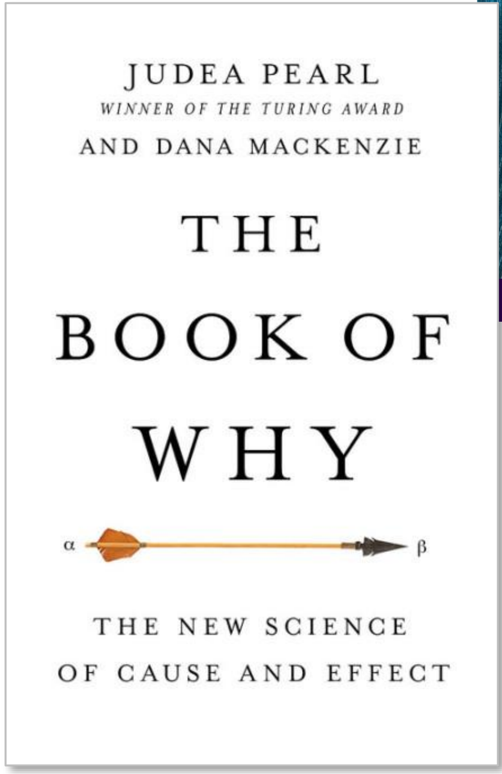
Humans have **theory of mind**, allowing us to

- 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)



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))
```

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)

Knowledge of "***what***"
(taxonomic: `A isA B`)

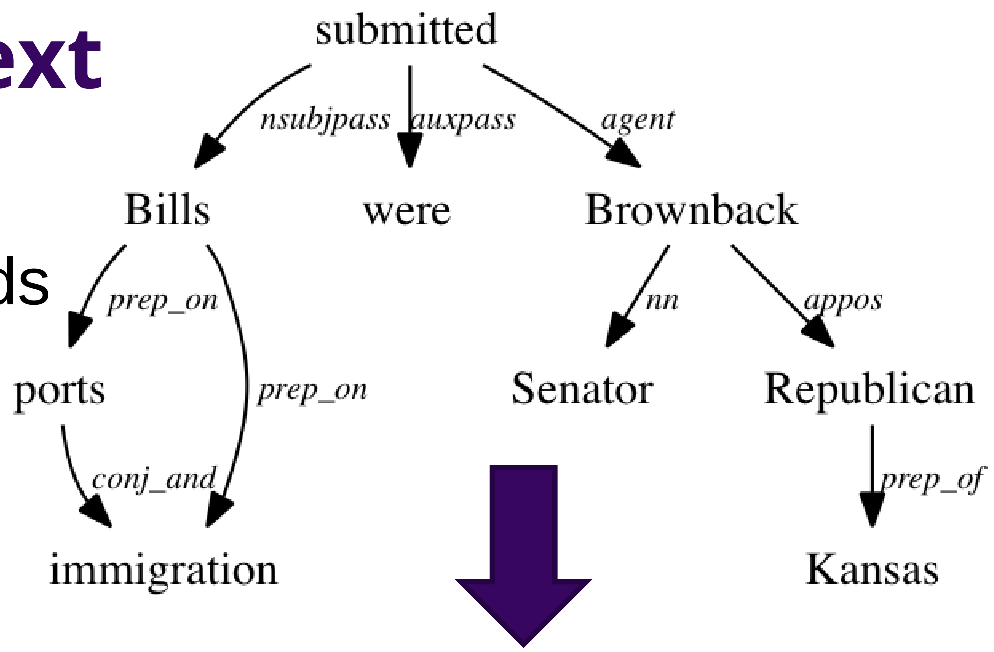
Knowledge of "***why***" and "***how***"
(inferential: *causes* and *effects*)

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

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

...

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

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

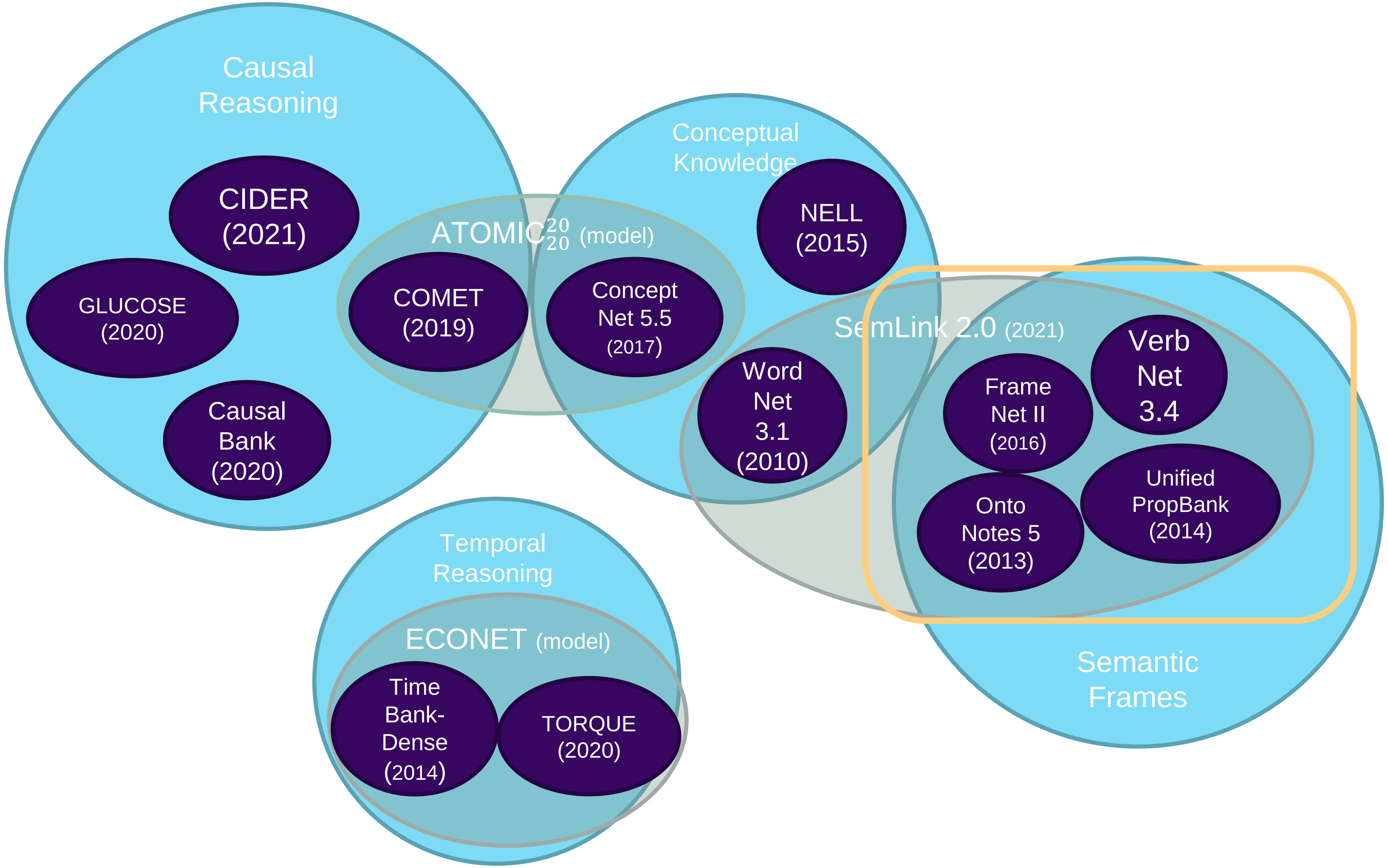
PersonX clutches a gun → because X wanted to
- to be safe
- to protect himself
- to protect themselves
- to defend themselves
- to defend himself

ATOMIC (Sap et al., 2019)

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


Causal Reasoning
CIDER (2021)
GLUCOSE (2020)
Causal Bank (2020)
ATOMIC$^{20}_{20}$ (model)
COMET (2019)
Concept Net 5.5 (2017)
Conceptual Knowledge
NELL (2015)
Word Net 3.1 (2010)
SemLink 2.0 (2021)
Frame Net II (2016)
Verb Net 3.4
Onto Notes 5 (2013)
Unified PropBank (2014)
Semantic Frames
Temporal Reasoning
ECONET (model)
Time Bank-Dense (2014)
TORQUE (2020)

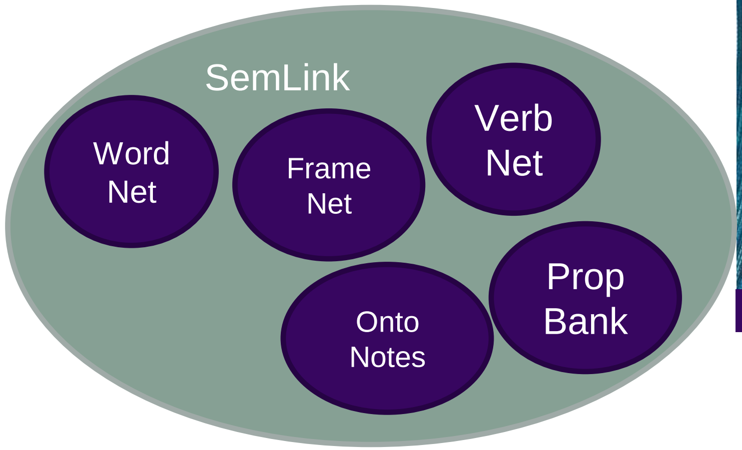
SemLink/Unified Verb Index 2.0

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.

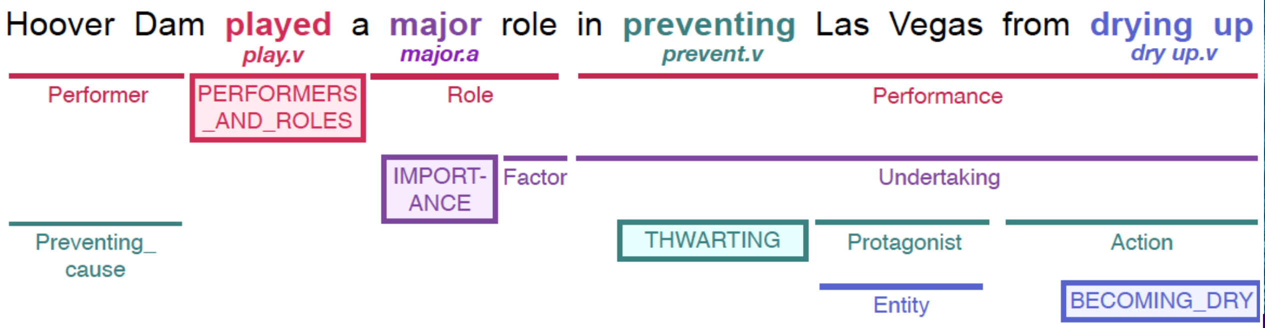
FrameNet II

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 Petruck, 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/

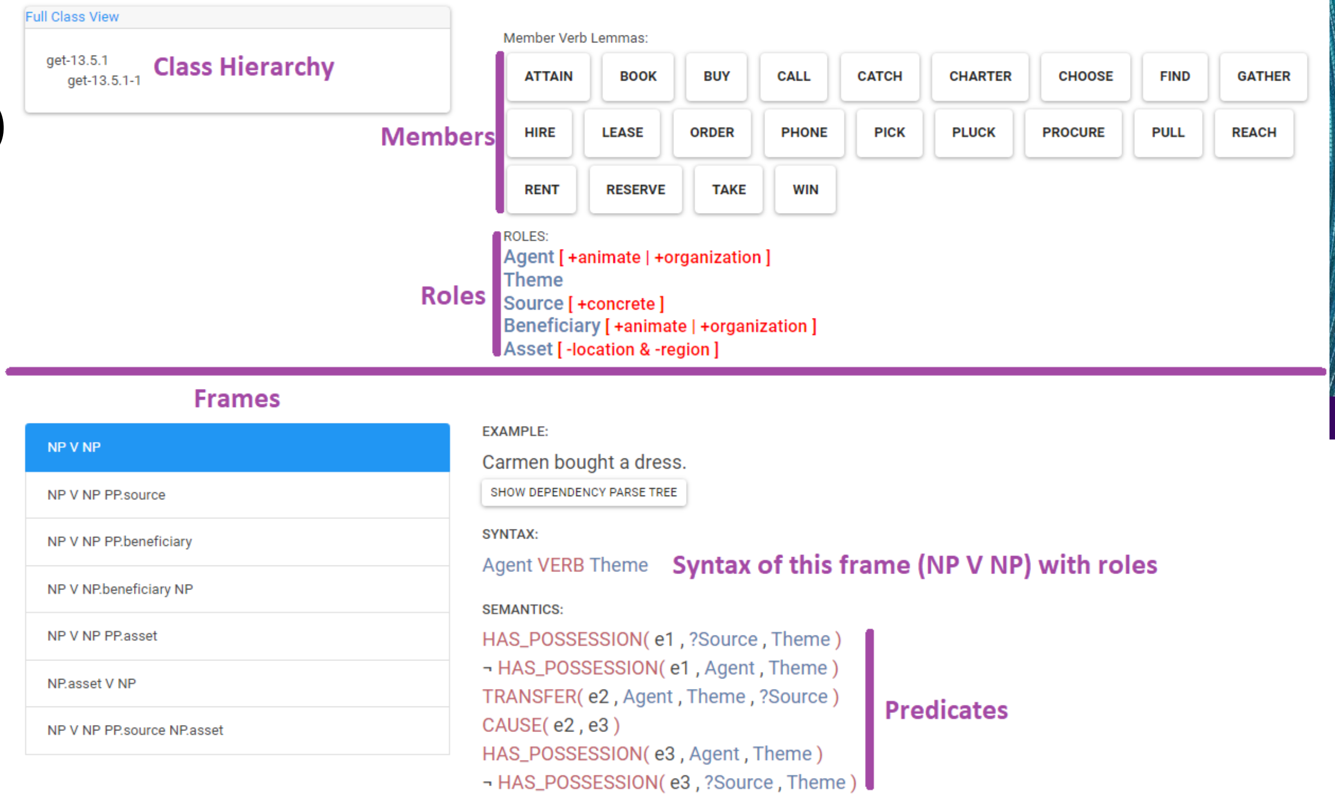
Verb classes based on Beth Levin (1993)

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, 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)

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.

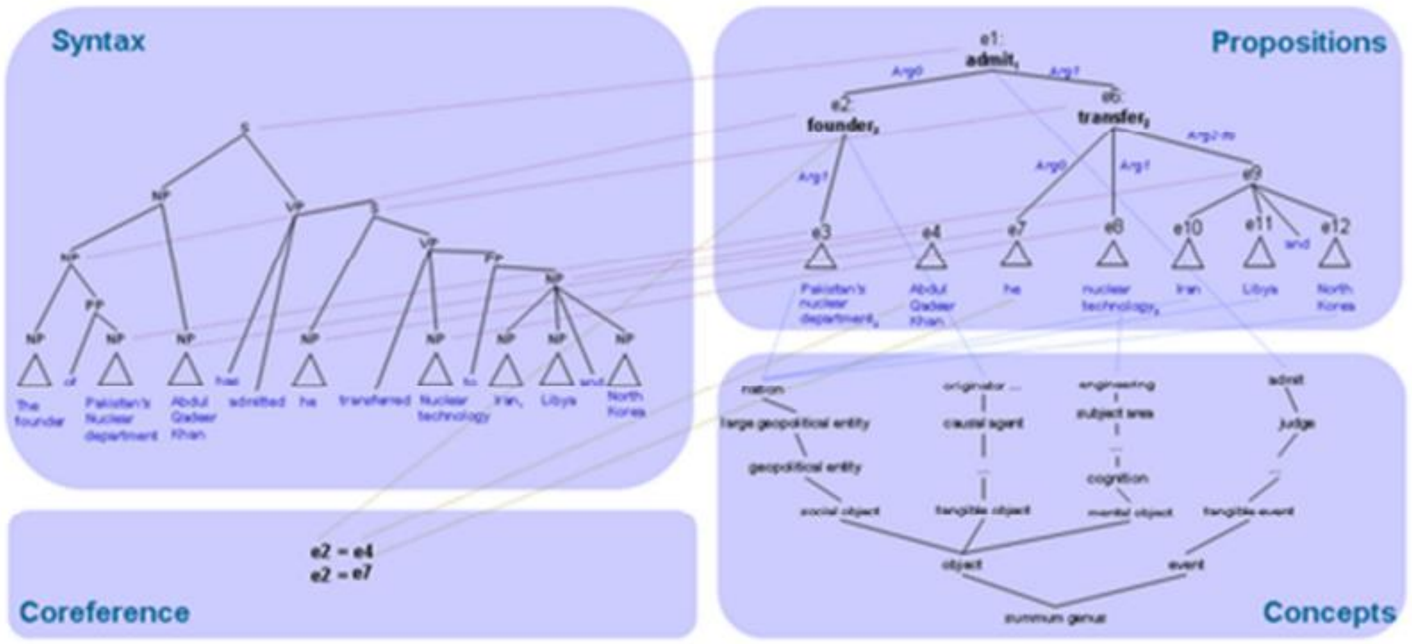
OntoNotes 5.0

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

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

Languages: English, Chinese, Arabic

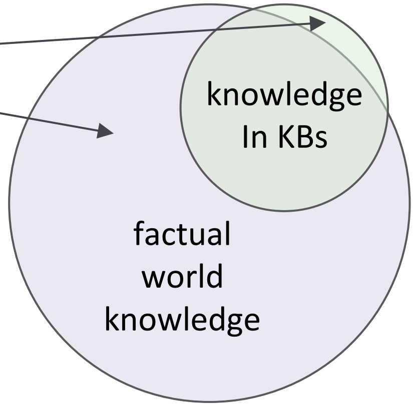
Use: raw data (same link)

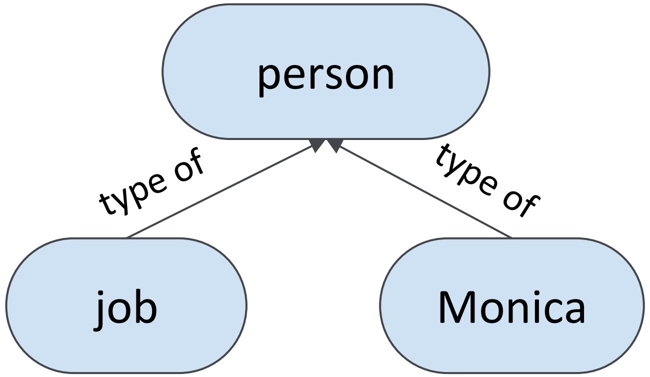


S. S. Pradhan, E. Hovy, M. Marcus, M. Palmer, L. Ramshaw and R. Weischedel, "OntoNotes: A Unified Relational Semantic Representation," International Conference on Semantic Computing (ICSC 2007), 2007, pp. 517-526, doi: 10.1109/ICSC.2007.83.

Limitations

- Insufficient Coverage
- Not 100% accurate





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