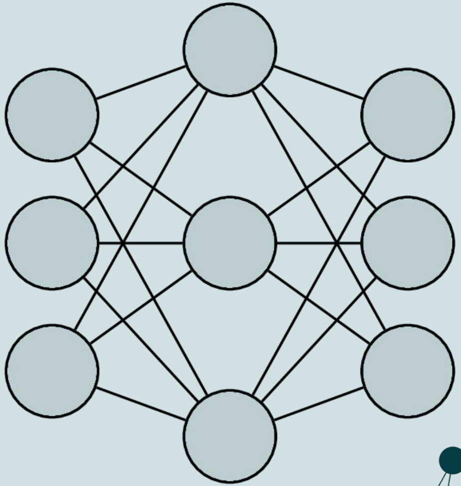
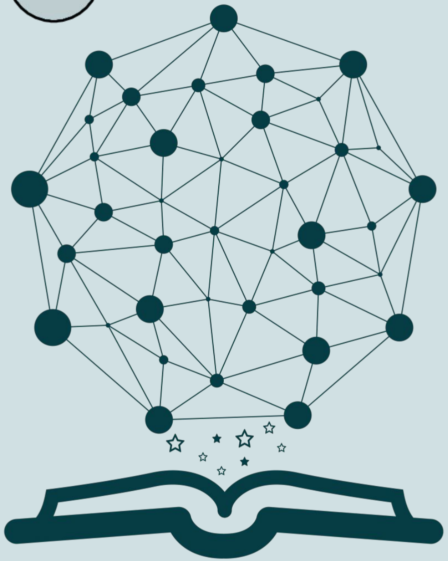
Neural and Symbolic Models of Commonsense Reasoning

Vered Shwartz

July 5th, 2020





Katrina had the financial means to afford a new car while Monica did not, since ____ had a high paying job.

Modern Neural Architecture

[CLS] Katrina had the financial means to afford a new car while Monica did not, since [SEP] Katrina had a high paying job.

[CLS] Katrina had the financial means to afford a new car while Monica did not, since [SEP] Monica had a high paying job.

0.51
0.49

Sentence:

Katrina had the financial means to afford a new car while Monica did not, since [MASK] had a high paying job.

Predictions:

11.8%	↵
8.8%	She
6.3%	I
6.2%	So
5.2%	Monica
	← Undo

https://demo.allennlp.org/masked-lm

Sentence:

Katrina had the financial means to afford a new car while Monica did not, since [MASK] had a high paying job.

Predictions:

- 11.8% ↵
- 8.8% She
- 6.3% I
- 6.2% So
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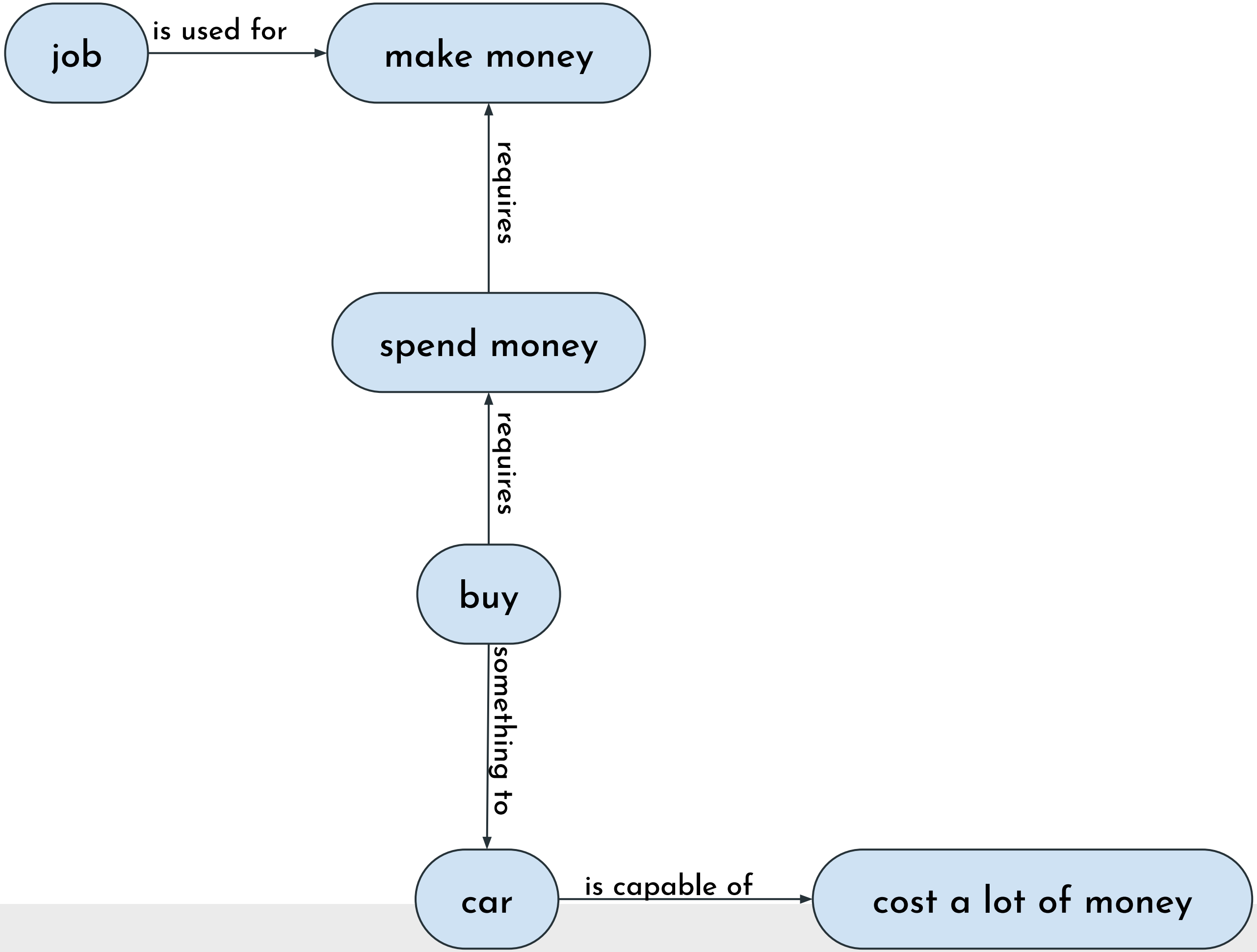
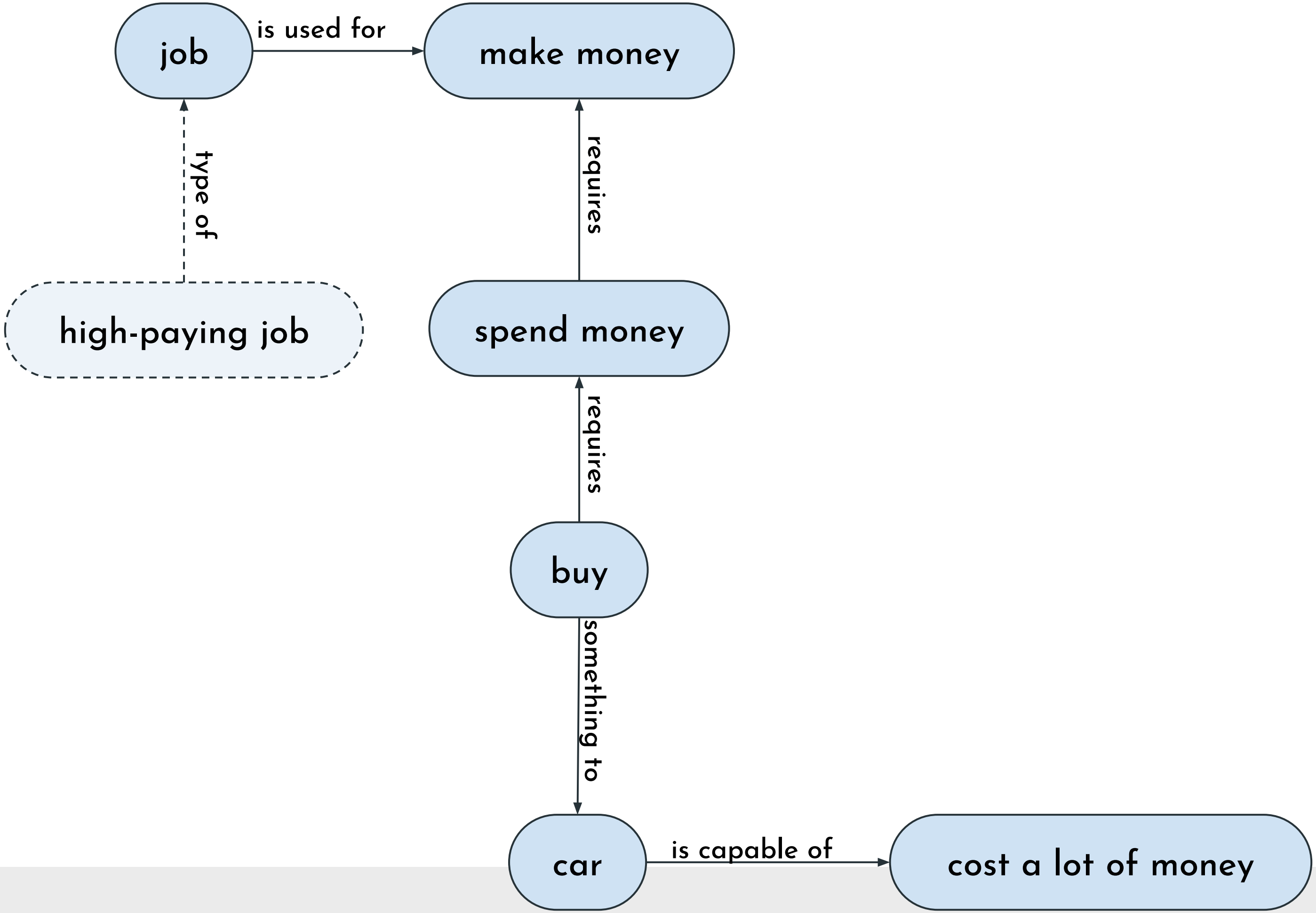


http://conceptnet5.media.mit.edu/



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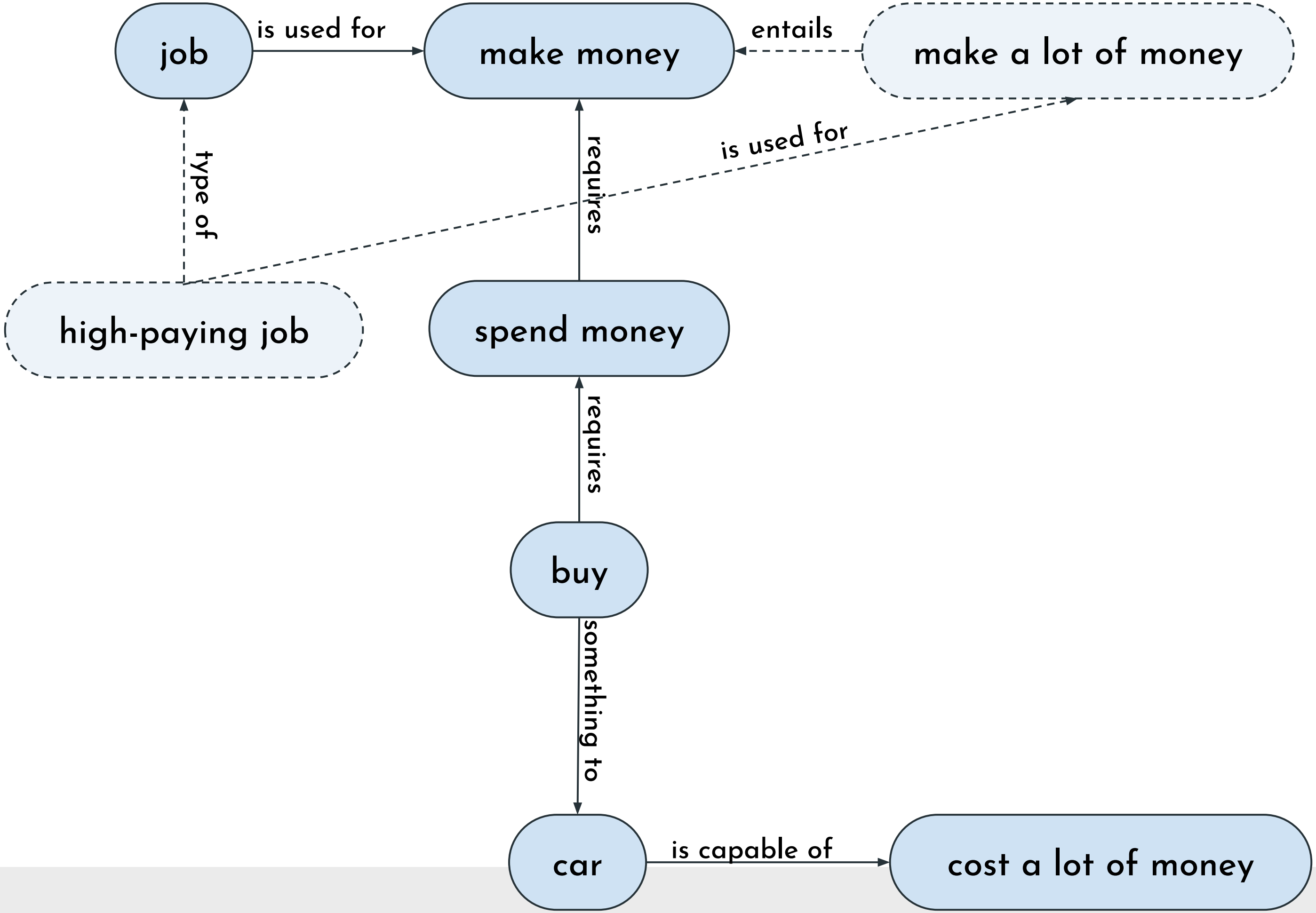

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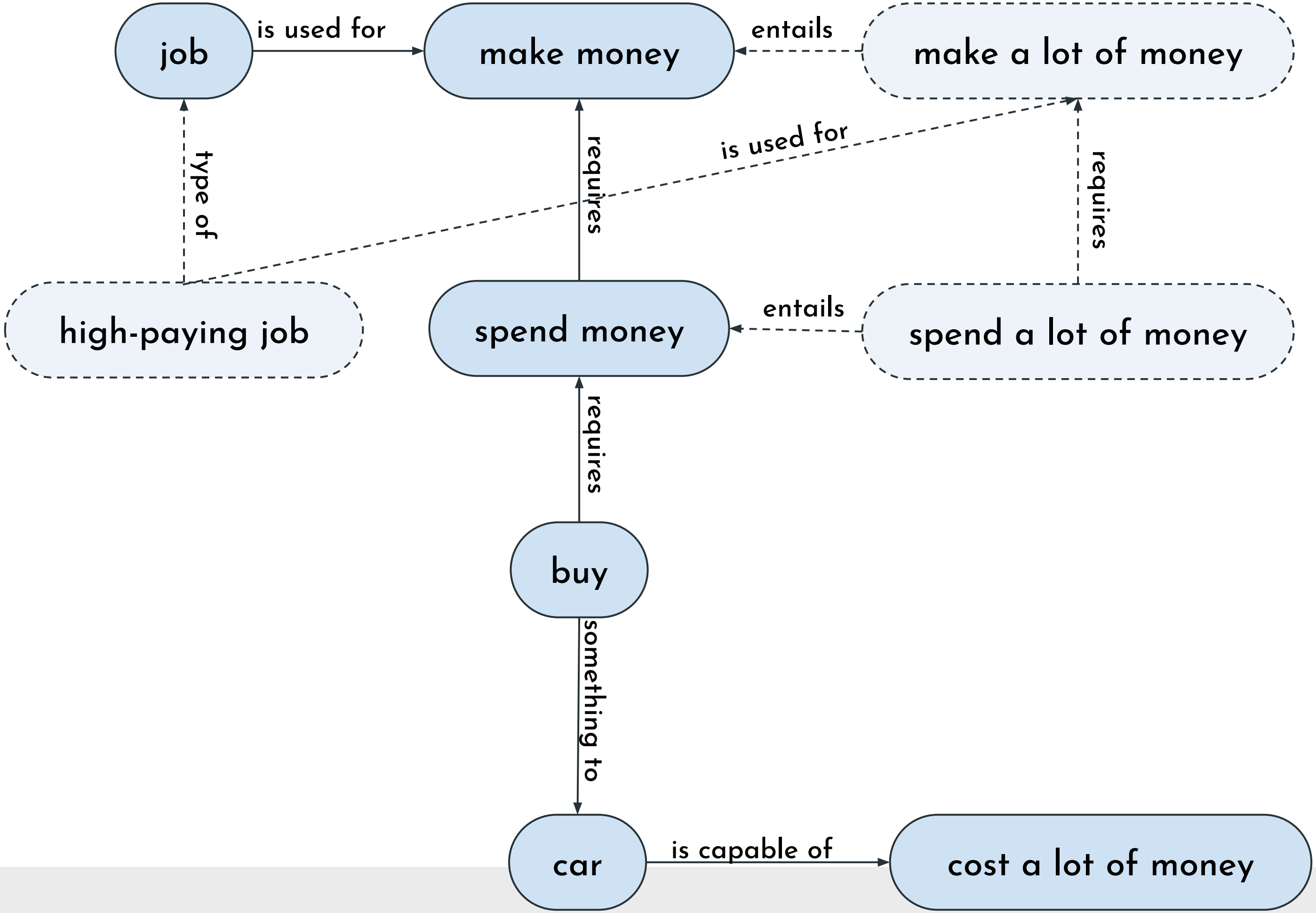

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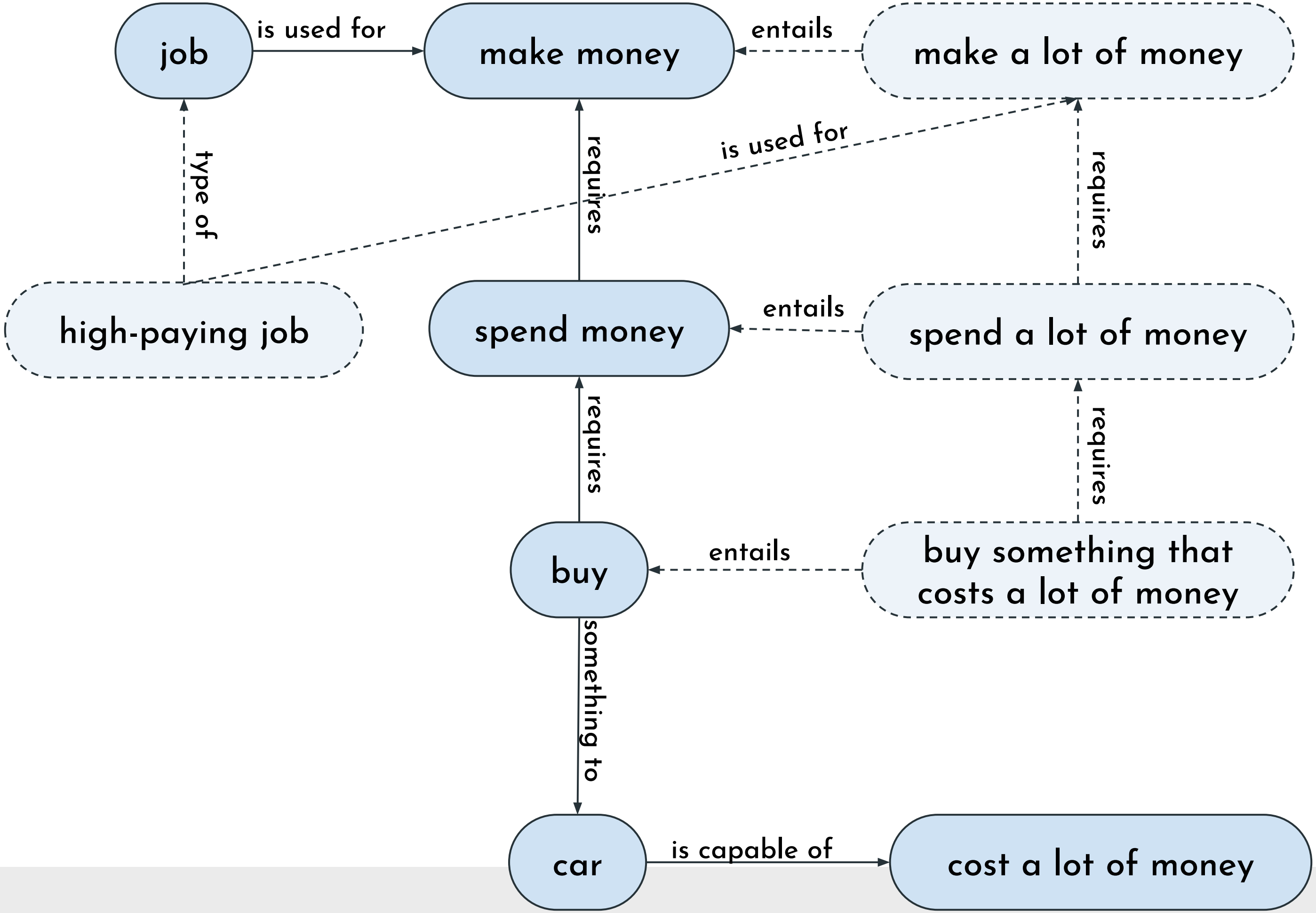

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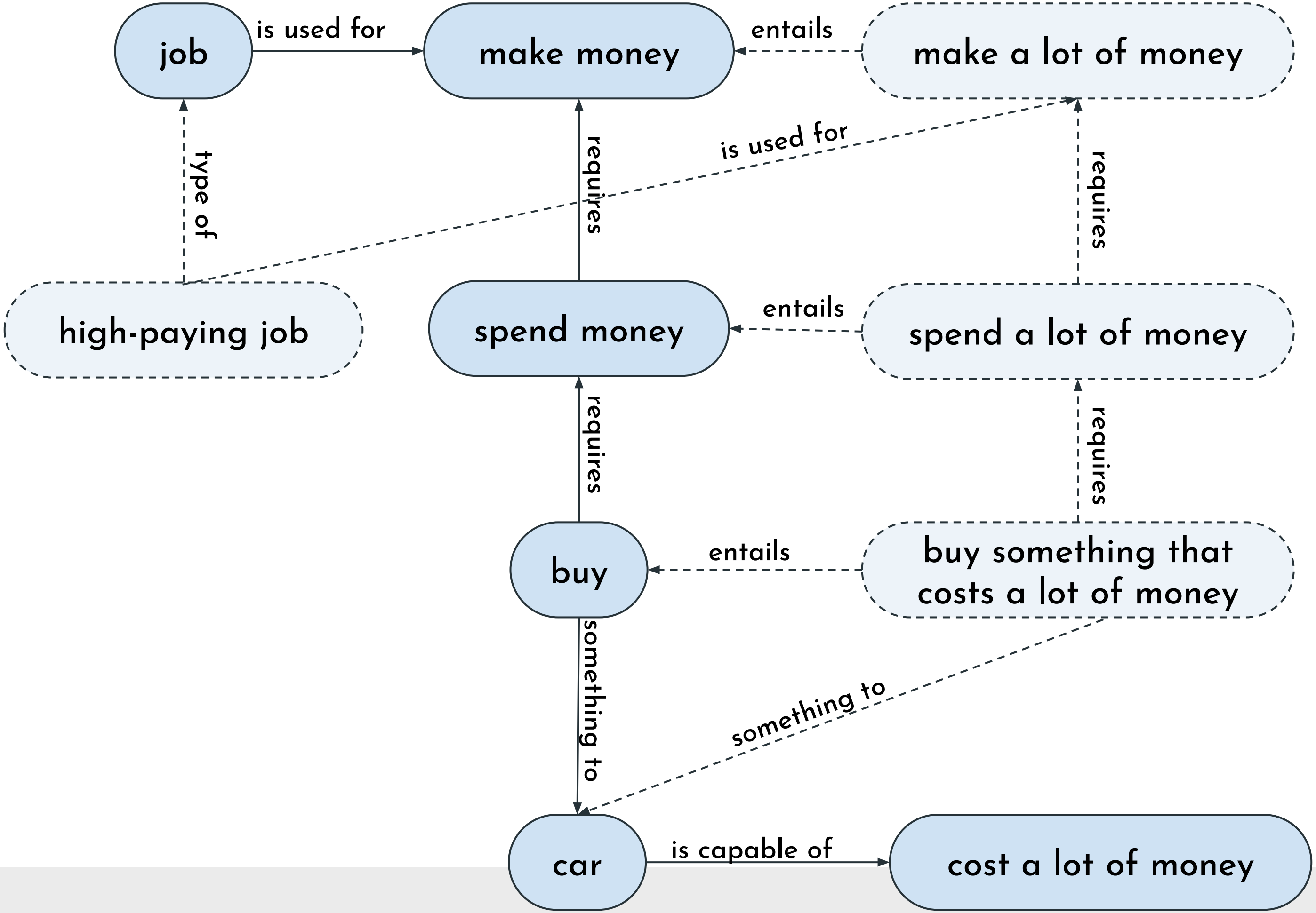

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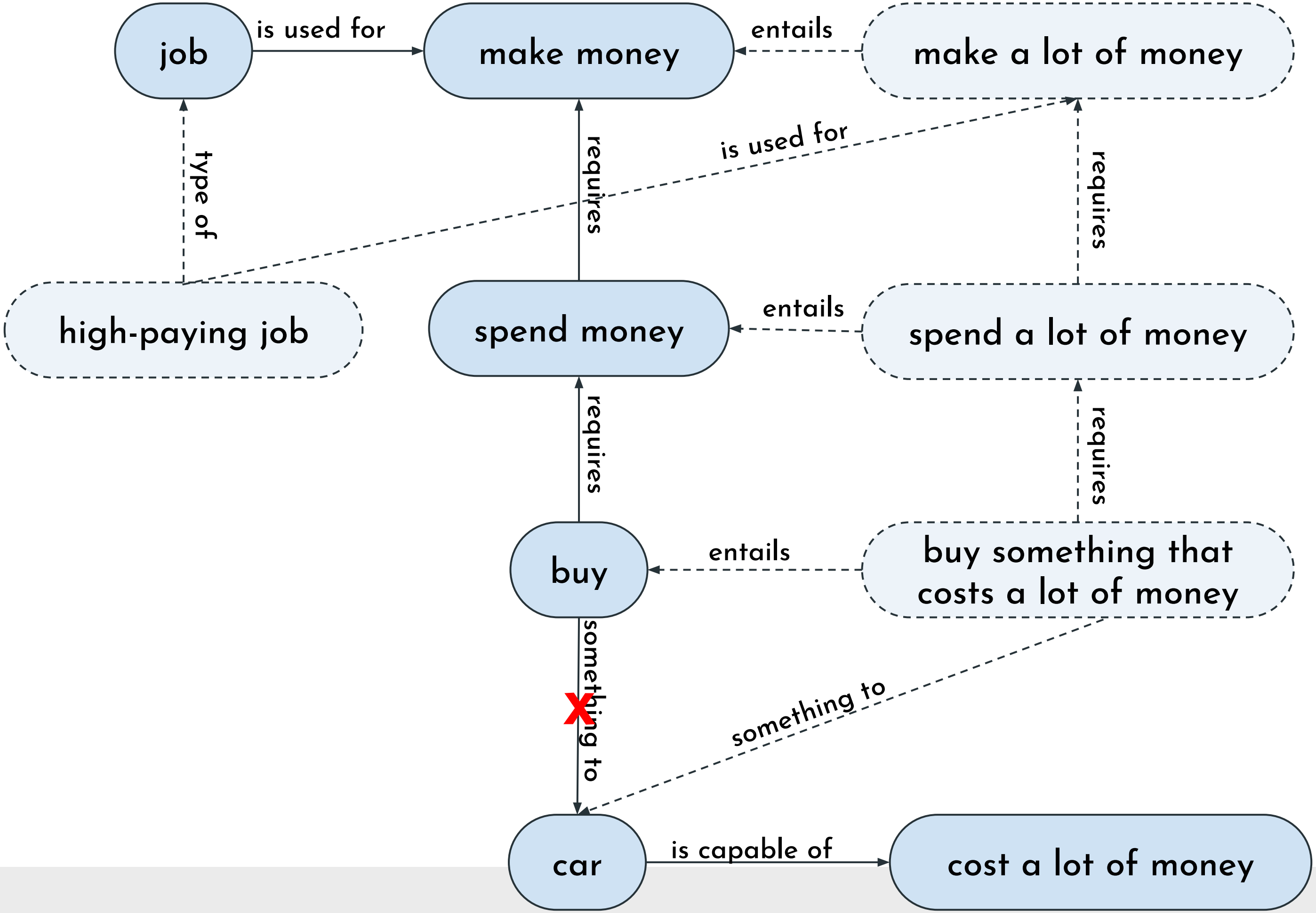
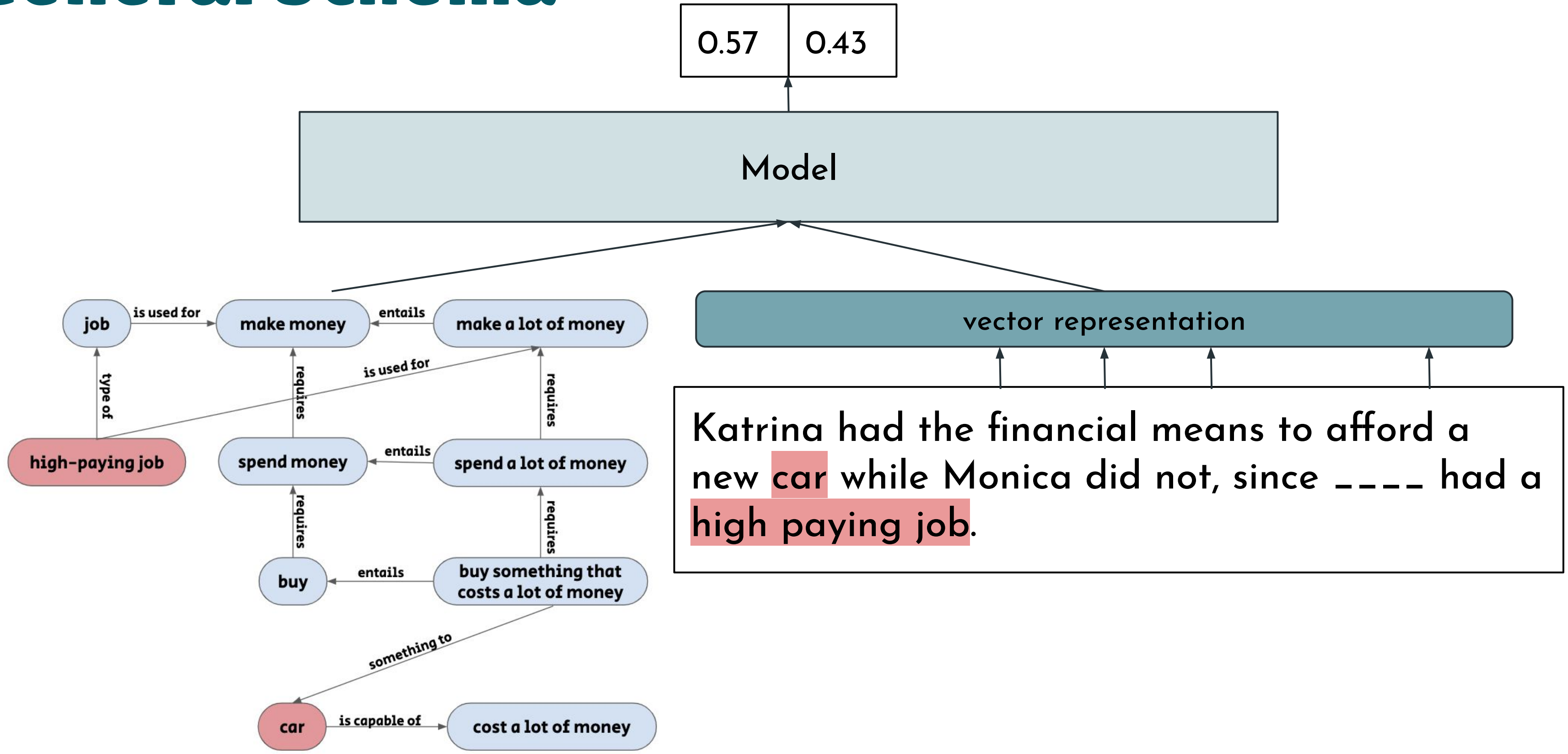

job
is used for
make money
entails
make a lot of money
type of
requires
is used for
requires
high-paying job
spend money
entails
spend a lot of money
requires
requires
buy
entails
buy something that costs a lot of money
something to
something to
car
is capable of
cost a lot of money

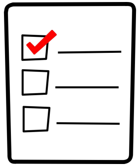
General Schema



Recipe

Task

Story ending,
Machine Comprehension
Social common sense
NLI



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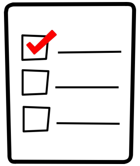

Story ending,
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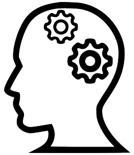
Knowledge Source



Knowledge bases,
extracted from text,
hand-crafted rules

Incorporating External Knowledge into Neural Models

Recipe

Task

Story ending,
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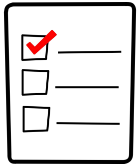
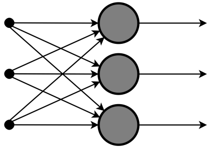


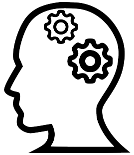


Neural Component

Pre/post pre-trained
language models

Knowledge Source

Knowledge bases,
extracted from text,
hand-crafted rules



Recipe

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Story ending,
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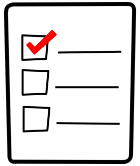

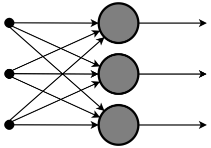

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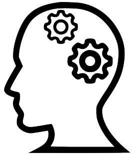

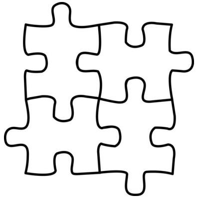

Combination Method

Attention, pruning, word
embeddings, multi-task
learning

Story Ending (RocStories)

Agatha had always wanted pet birds.
So one day she purchased two pet finches.
Soon she couldn't stand their constant noise.
And even worse was their constant mess.

Agatha decided to buy two more. (Wrong)
Agatha decided to return them. (Right)

Task

A Corpus and Cloze Evaluation for Deeper Understanding of Commonsense Stories. *Nasrin Mostafazadeh, Nathanael Chambers, Xiaodong He, Devi Parikh, Dhruv Batra, Lucy Vanderwende, Pushmeet Kohli, and James Allen.* NAACL 2016.

Machine Comprehension

ProPara

		Participants:				
Paragraph (seq. of steps):		**water**	**light**	**CO2**	**mixture**	**sugar**
	state0	**soil**	**sun**	**?**	**-**	**-**
Roots absorb water from soil						
	state1	**roots**	**sun**	**?**	**-**	**-**
The water flows to the leaf.						
	state2	**leaf**	**sun**	**?**	**-**	**-**
Light from the sun and CO2 enter the leaf.						
	state3	**leaf**	**leaf**	**leaf**	**-**	**-**
The light, water, and CO2 combine into a mixture.						
	state4	**-**	**-**	**-**	**leaf**	**-**
Mixture forms sugar.						
	state5	**-**	**-**	**-**	**-**	**leaf**

Time

Task

Machine Comprehension

ProPara

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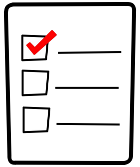
Time

NarrativeQA

Question: How is Oscar related to Dana?
Answer: her son
Snippet: [...] She continues digging in her purse while Frank leans over the buggy and makes funny faces at the baby, OSCAR, a very cute nine-month old boy. [...]

Task



Machine Comprehension

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Time

MCScript

T I wanted to plant a tree. I went to the home and garden store and picked a nice oak. Afterwards, I planted it in my garden.

Q1 What was used to dig the hole?
a. a shovel b. his bare hands

Q2 When did he plant the tree?
a. after watering it b. after taking it home

NarrativeQA

Question: How is Oscar related to Dana?
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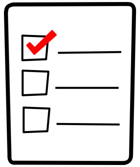

Machine Comprehension

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Mixture forms su						

Participants:

Time

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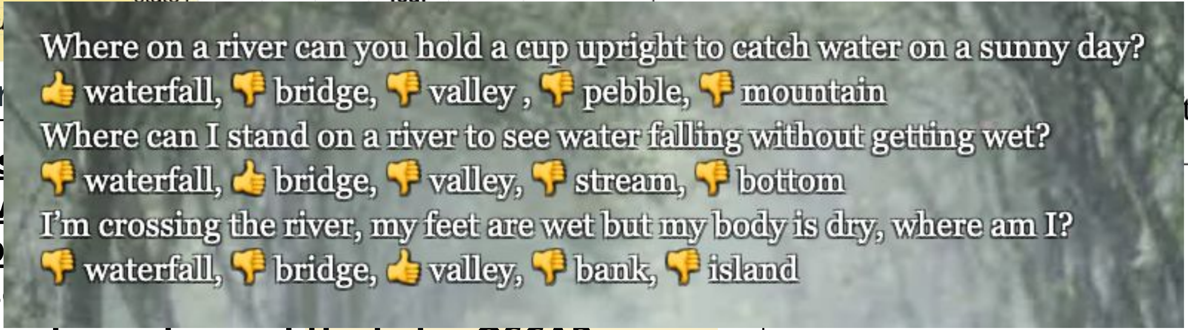
CommonsenseQA



Nar

Ques
Answ
Snip
purs
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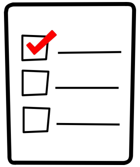

Machine Comprehension

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The light, water, and CO2 combine into a mixture.						
	state4	-	-	-	leaf	-
Mixture forms su						

Time

ARC

Which property of a mineral can be determined just by looking at it?

(A) luster
(B) mass
(C) weight
(D) hardness

MCScript

T I wa
and g
ward

Q1 What was used to dig the hole?
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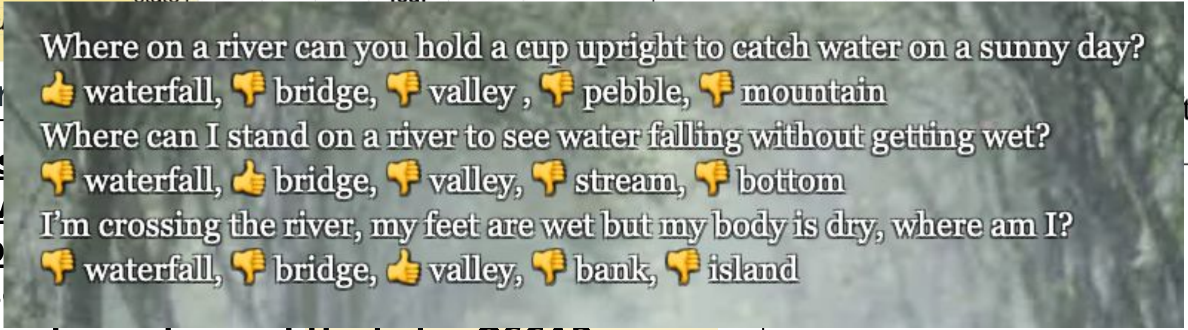
ter taking it home

CommonsenseQA



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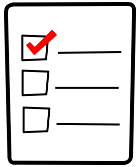
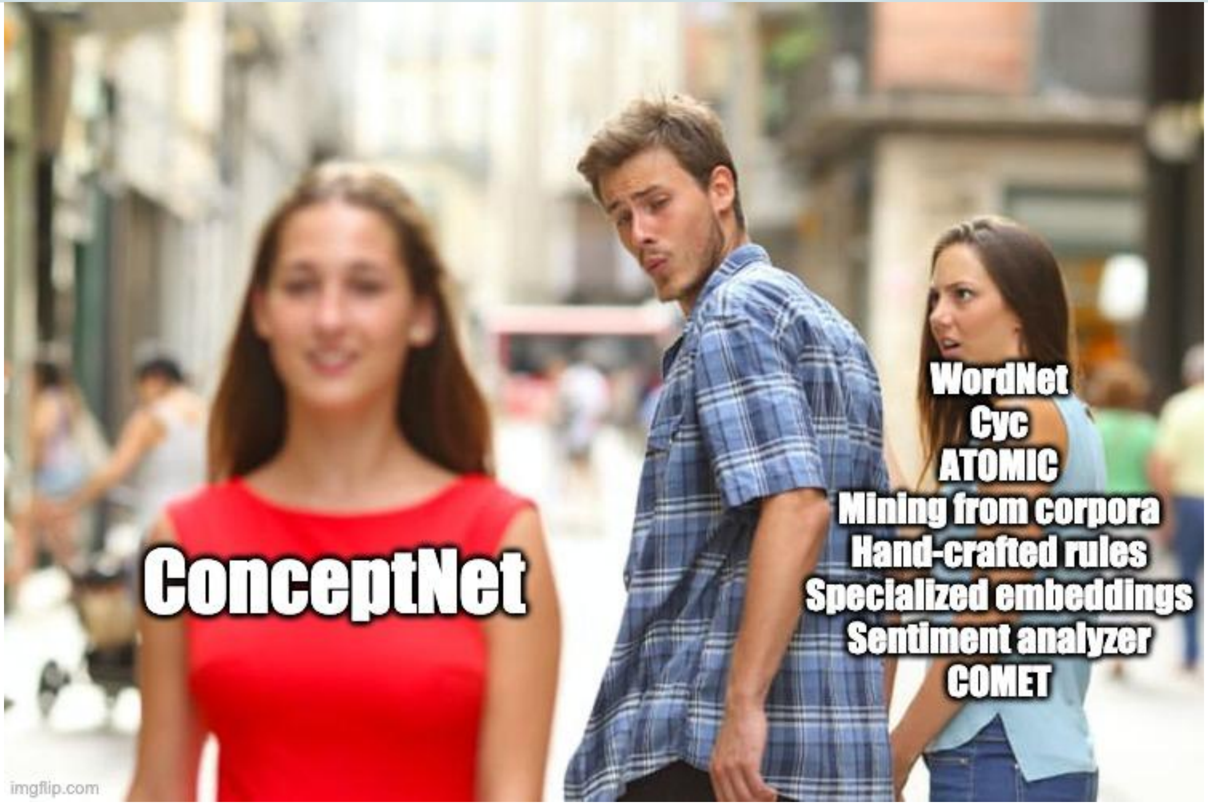
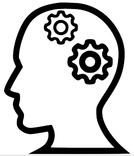
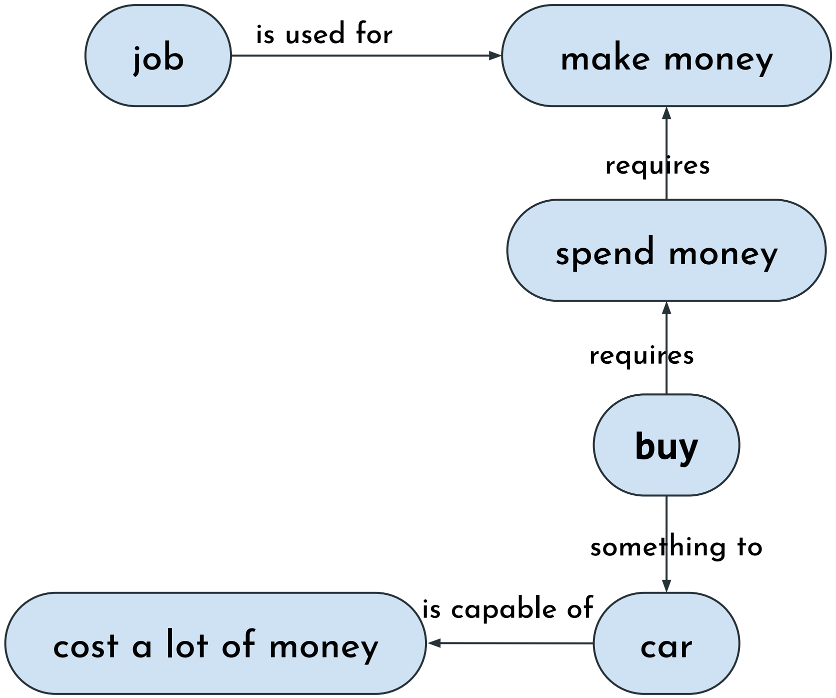


Knowledge Source



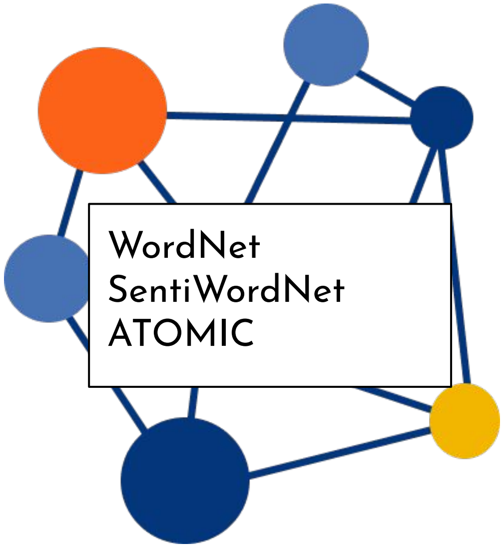


ConceptNet



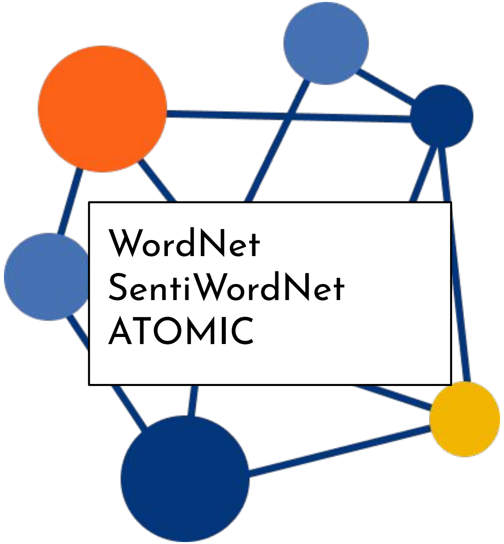
Conceptnet 5.5: An open multilingual graph of general knowledge. *Robyn Speer, Joshua Chin, and Catherine Havasi.* AAAI 2017.

Other Knowledge Sources



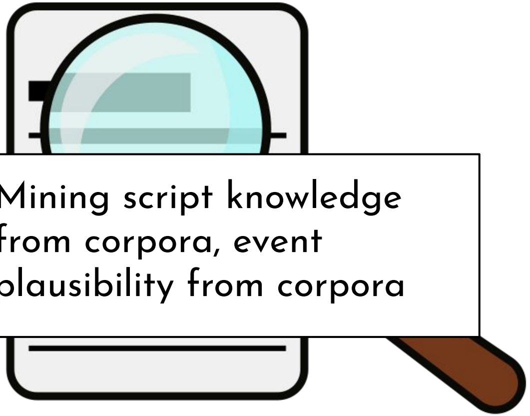
Knowledge Bases

Other Knowledge Sources



WordNet
SentiWordNet
ATOMIC

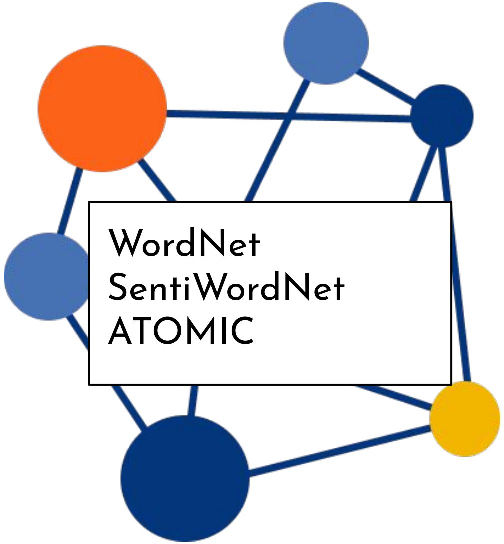
Knowledge Bases



Mining script knowledge from corpora, event plausibility from corpora

Mining from Text

Other Knowledge Sources



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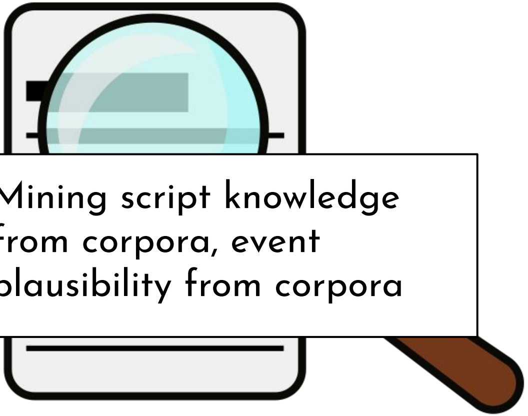

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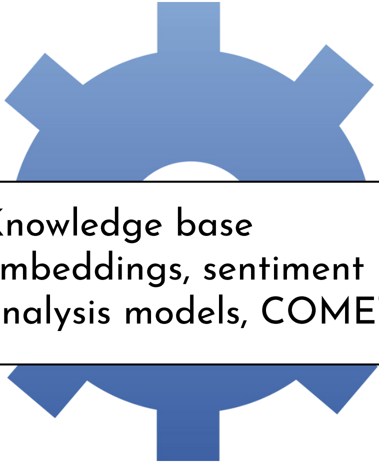
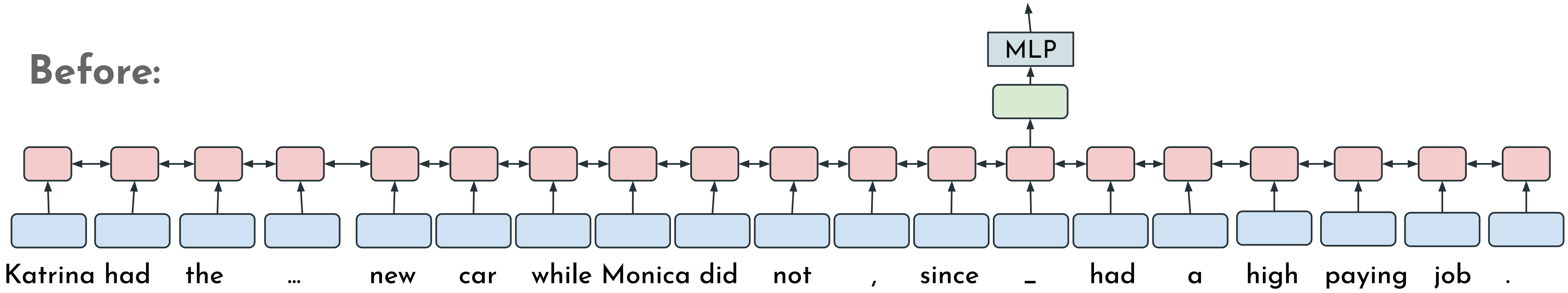


Knowledge base embeddings, sentiment analysis models, COMET

Tools

Neural Component

Before:



Neural Component

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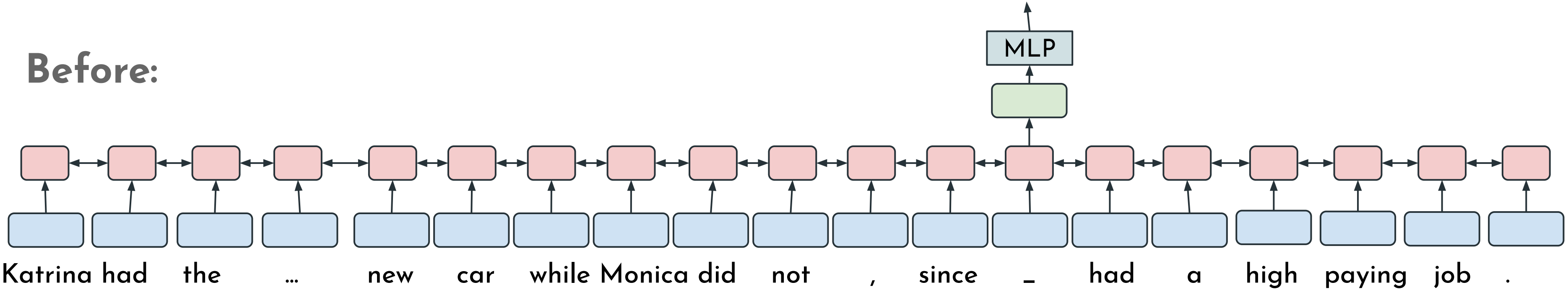

After:

[CLS] Katrina had the financial means to afford a new car while Monica did not, since [SEP] Katrina had a high paying job.

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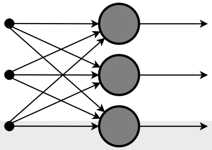
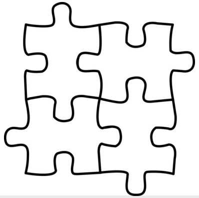


Combination Method

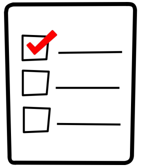
1. Incorporate into scoring function

2. Symbolic → vector representation
   - (+attention)

3. Multi-task learning



Example #1



RocStories

Reasoning with Heterogeneous Knowledge for Commonsense Machine Comprehension. *Hongyu Lin, Le Sun, and Xianpei Han.* EMNLP 2017

Example #1

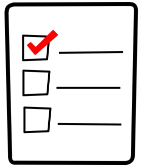
RocStories

Inference Rules (with costs)

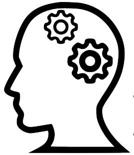
WordNet: restaurant→eatery (1.0)
Wikipedia: restaurant→business (1.0)
Script knowledge:
X went to a restaurant→*X ate* (0.32)
Relatedness: restaurant→food (0.71)
Hand-crafted negation rules
Sentiment
...

Incorporating External Knowledge into Neural Models

Example #1



RocStories



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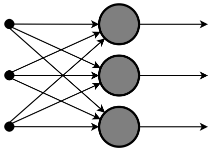
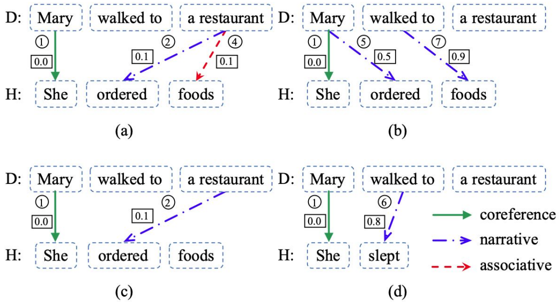
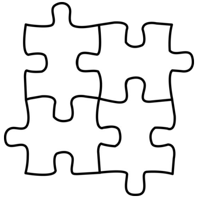
Sentiment
...

1. For each sentence in the story (premise), find a set of inference rules that "cover" a story ending (hypothesis): **reason**.







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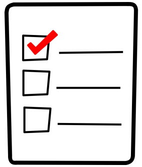
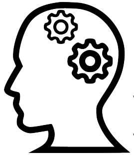


RocStories



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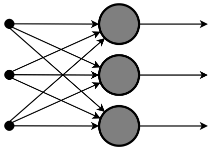
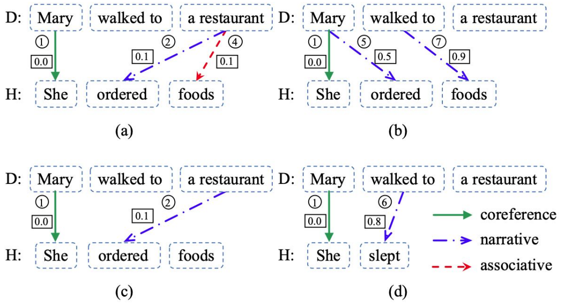
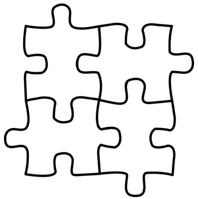


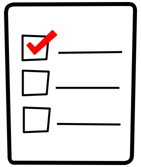




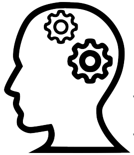
2. Learn to score a reason according to costs, inference types, and relatedness between the involved words, using **attention mechanism**.

Reasoning with Heterogeneous Knowledge for Commonsense Machine Comprehension. *Hongyu Lin, Le Sun, and Xianpei Han.* EMNLP 2017

Example #1



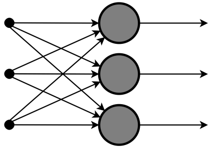
RocStories

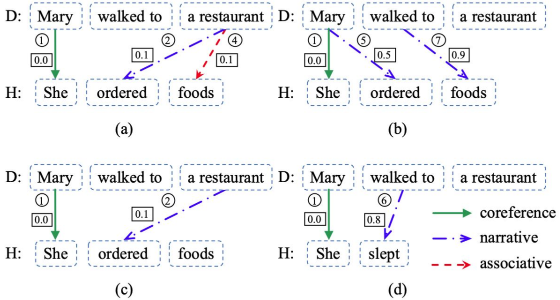


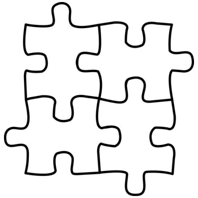
Inference Rules (with costs)

WordNet: restaurant→eatery (1.0)
Wikipedia: restaurant→business (1.0)
Script knowledge:
X went to a restaurant→*X ate* (0.32)
Relatedness: restaurant→food (0.71)
Hand-crafted negation rules
Sentiment
...

1. For each sentence in the story (premise), find a set of inference rules that “cover” a story ending (hypothesis): **reason**.



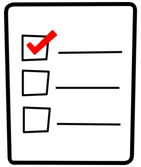




2. Learn to score a reason according to costs, inference types, and relatedness between the involved words, using **attention mechanism**.

3. Aggregate across all the sentences in the story.

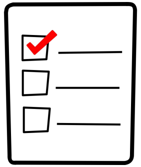
Example #2



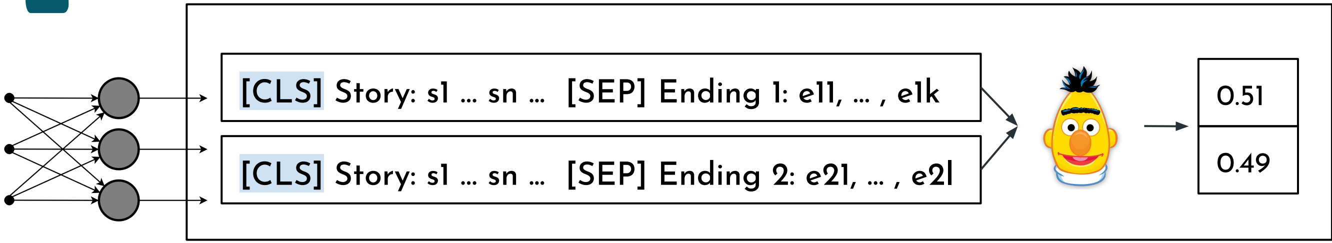
RocStories
MCScript

Incorporating Relation Knowledge into Commonsense Reading Comprehension with Multi-task Learning.
Jiangnan Xia, Chen Wu, and Ming Yan. CIKM 2019.

Example #2

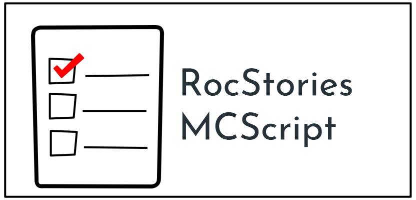


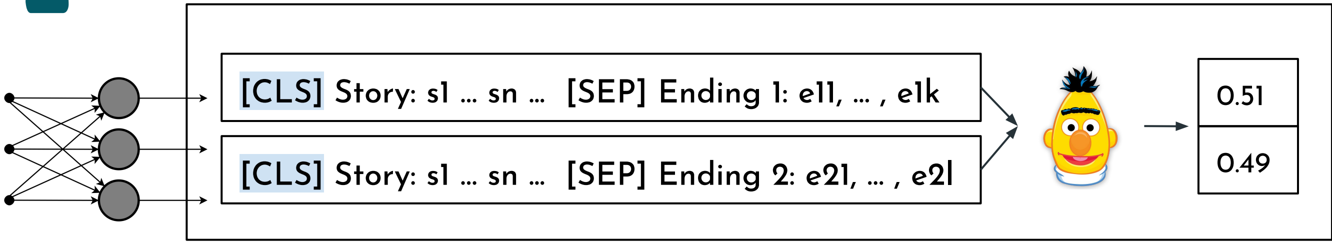
RocStories
MCScript

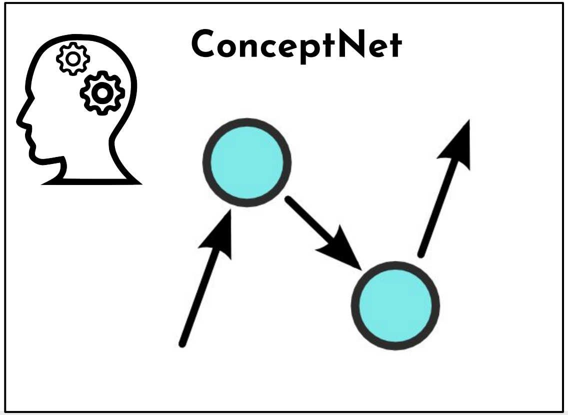


Incorporating External Knowledge into Neural Models

Example #2







Incorporating External Knowledge into Neural Models

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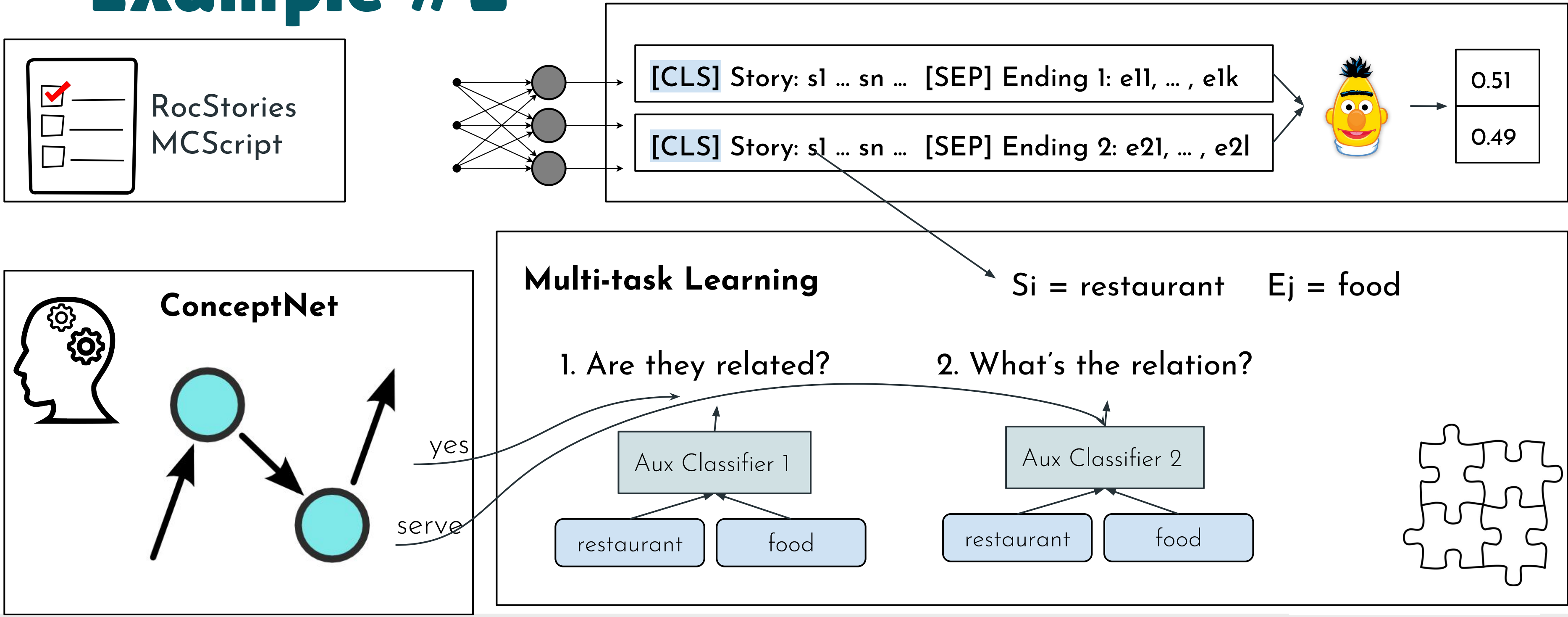

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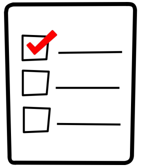
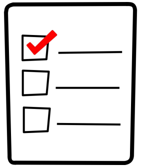
Example #3



CommonsenseQA

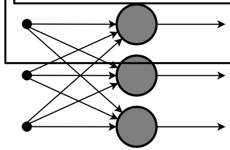
KagNet: Knowledge-Aware Graph Networks for Commonsense Reasoning. *Bill Yuchen Lin, Xinyue Chen, Jamin Chen, Xiang Ren.* EMNLP 2019.

Example #3



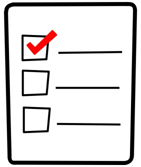
CommonsenseQA

[CLS] Where do adults use glue sticks? [SEP] office



Statement Vector

Example #3



CommonsenseQA

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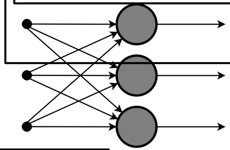
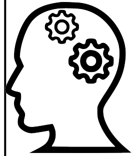
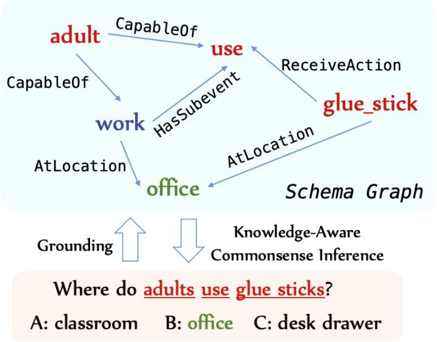
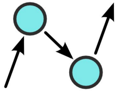




ConceptNet





1. Retrieving subgraphs. 2. Pruning

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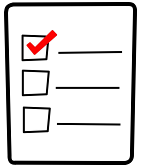
Incorporating External Knowledge into Neural Models

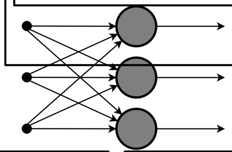
Example #3

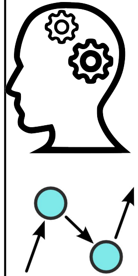


CommonsenseQA

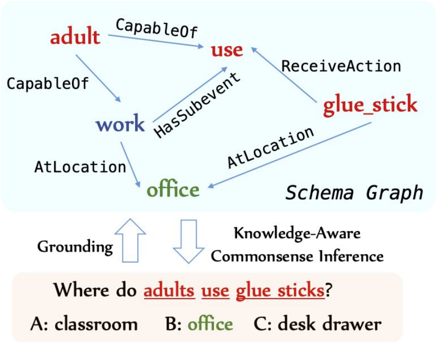
[CLS] Where do adults use glue sticks? [SEP] office →

→ Statement Vector





ConceptNet



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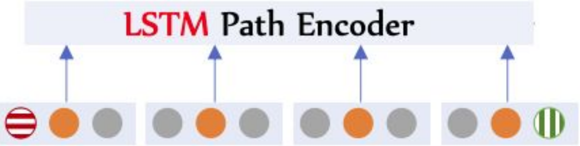
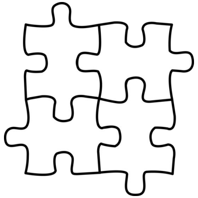


+ Attention → Graph Vector



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Incorporating External Knowledge into Neural Models

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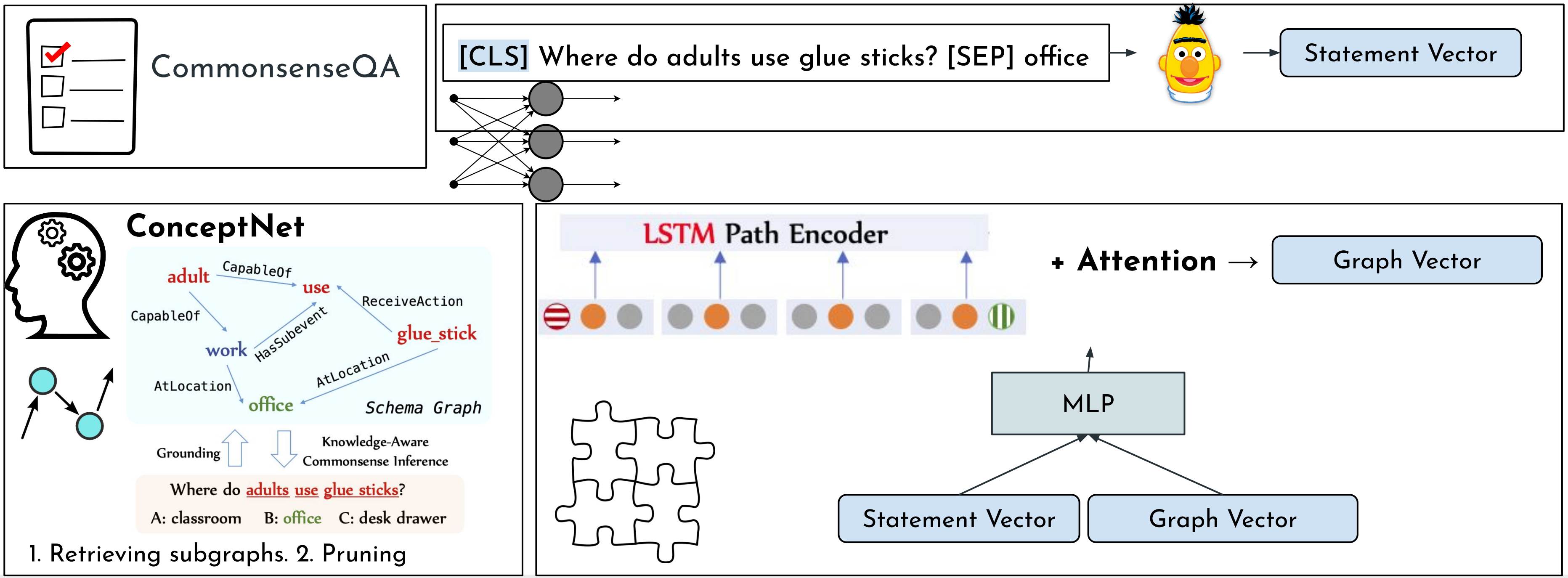

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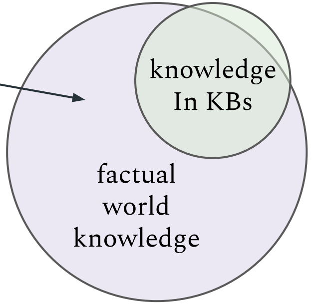
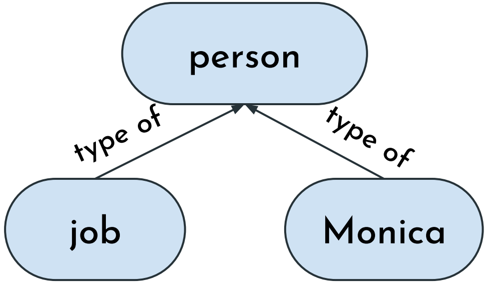
Limitations

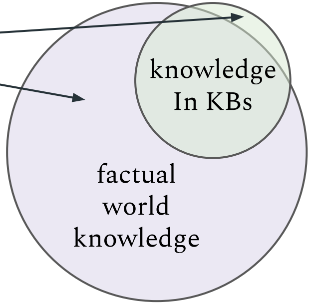
- Insufficient Coverage



Limitations

- Insufficient Coverage
- Not 100% accurate





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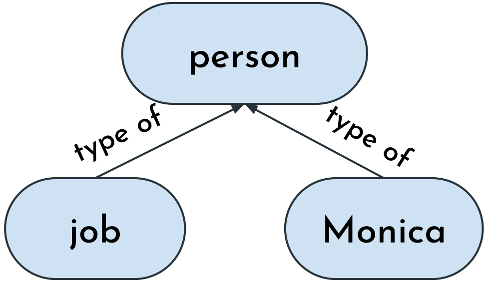

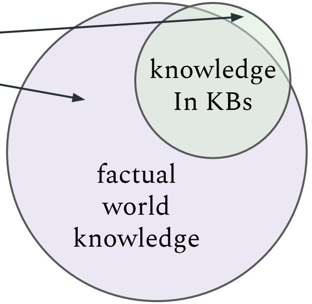

- Easy to incorporate simple resources with stationary facts (ConcpetNet) but they are limited in expressiveness:

Thank you!

vereds@allenai.org

References + Additional Reading

[1] Reasoning with Heterogeneous Knowledge for Commonsense Machine Comprehension. Hongyu Lin, Le Sun, and Xianpei Han. EMNLP 2017.
[2] Reasoning about Actions and State Changes by Injecting Commonsense Knowledge. Niket Tandon, Bhavana Dalvi, Joel Grus, Wen-tau Yih, Antoine Bosselut, and Peter Clark. EMNLP 2018.
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