Agenda

08:30 PST	10 mins	**Introduction to commonsense knowledge (Filip)**
08:40 PST	25 min	**Part I - Axiomatization of commonsense knowledge (Mayank)**
09:05 PST	40 min	**Part II - Consolidating commonsense knowledge (Filip)**
09:45 PST	15 min	Break
10:00 PST	45 min	**Part III - Extracting and contextualizing commonsense knowledge (Simon)**
10:45 PST	45 min	**Part IV - Language models, QA, and evaluation challenges (Antoine)**
11:30 PST	15 min	**Way forward: KGs+LMs+axioms? (Filip)**

Consolidating Commonsense Knowledge

Filip Ilievski

Overview of CSK sources

Category	Source	Relations	Example 1	Example 2
Commonsense KGs	ConceptNet*	34	*food - capable of - go rotten*	*eating - is used for - nourishment*
	ATOMIC	9	*Person X bakes bread - xEffect - eat food*	*PersonX is eating dinner - xEffect - satisfies hunger*
	GLUCOSE	10	*Someone$_A$ makes Something$_A$ (that is food)*	*Causes/Enables Someone$_A$ eats Something$_A$*
	WebChild	4 (groups)	*restaurant food - quality#n#1 - expensive*	*eating - type of - consumption*
	Quasimodo	78,636	*pressure cooker - cook faster - food*	*herbivore - eat - plants*
	SenticNet	4	*cold_food - polarity - negative*	*eating breakfast - polarity - positive*
	HasPartKB	1	*dairy food - has part - vitamin*	*n/a*
Common KGs	Wikidata	6.7k	*food - has quality - mouthfeel*	*eating - subclass of - ingestion*
	YAGO4	116	*banana chip - rdf:type - food*	*eating - rdfs:label - feeding*
	DOLCE*	1	*n/a*	*n/a*
	SUMO*	1,614	*food - hyponym - food_product*	*process - subsumes - eating*
Lexical resources	WordNet	10	*food - hyponym - comfort food*	*eating - part-meronym - chewing*
	Roget	2	*dish - synonym - food*	*eating - synonym - feeding*
	FrameNet	8 (f2f)	*Cooking_creation - has frame element - Produced_food*	*eating - evoke - Ingestion*
	MetaNet	14 (f2f)	*Food - has role - food_consumer*	*consuming_resources - is - eating*
	VerbNet	36 (roles)	*feed.v.01 - Arg1-PPT - food*	*eating - hasPatient - comestible*
Visual sources	Visual Genome	42,374	*food - on - plate*	*boy - is eating - treat*
	Flickr30k	1	*a food buffet - corefers with - a food counter*	*a eating place - corefers with - their kitchen*
Corpora & LMs	GenericsKB	n/a	*Aardvarks search for food.*	*Animals receive nitrogen by eating plants.*
	GPT-2	n/a	*Food causes a person to be hungry and a person to eat.*	*Eating at home will not lead to weight gain.*

Consolidation Hypothesis

Integrating multiple knowledge sources in CSKG is beneficial for downstream reasoning tasks.

On stage, a woman takes a seat at the piano. She

1.   sits on a bench as her sister plays with the doll.
2.   smiles with someone as the music plays.
3.   is in the crowd, watching the dancers.
4.   <u>nervously sets her fingers on the keys.</u>

piano is used for...

en performing music →
en music →
en accompanying an orchestra →

Things located at piano

en keys →
en black keys →
en hammers →
en a keyboard →

ConceptNet: pianos have keys, are used to perform music

On stage, a woman takes a seat at the **piano**. She

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ConceptNet: pianos have keys, are used to perform music

- S: (n) **piano**, pianoforte, forte-piano (a keyboard instrument that is played by depressing keys that cause hammers to strike tuned strings and produce sounds)

WordNet: pianos are played by pressing keys

On stage, a woman takes a seat at the ==piano==. She

1. sits on a bench as her sister plays with the doll.
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Visual Genome: person can play a piano while sitting, his hands are on the keyboard

man plays piano
keys ON piano
woman watches man
pillow ON couch
light ON wall
window IN room
person playing piano
guy ON bench
hands ON keyboard

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piano is used for...

en performing music →
en music →
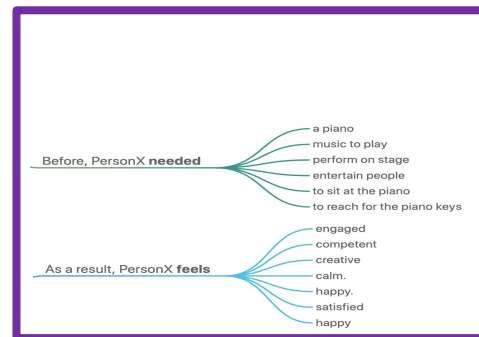en accompanying an orchestra →

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en black keys →
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WordNet: pianos are played by pressing keys

Before, PersonX **needed**
- a piano
- music to play
- perform on stage
- entertain people
- to sit at the piano
- to reach for the piano keys

As a result, PersonX **feels**
- engaged
- competent
- creative
- calm.
- happy.
- satisfied
- happy

ATOMIC: to play piano, a person needs to sit at it, on stage and reach for the keys; feelings

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Things located at piano
- en keys →
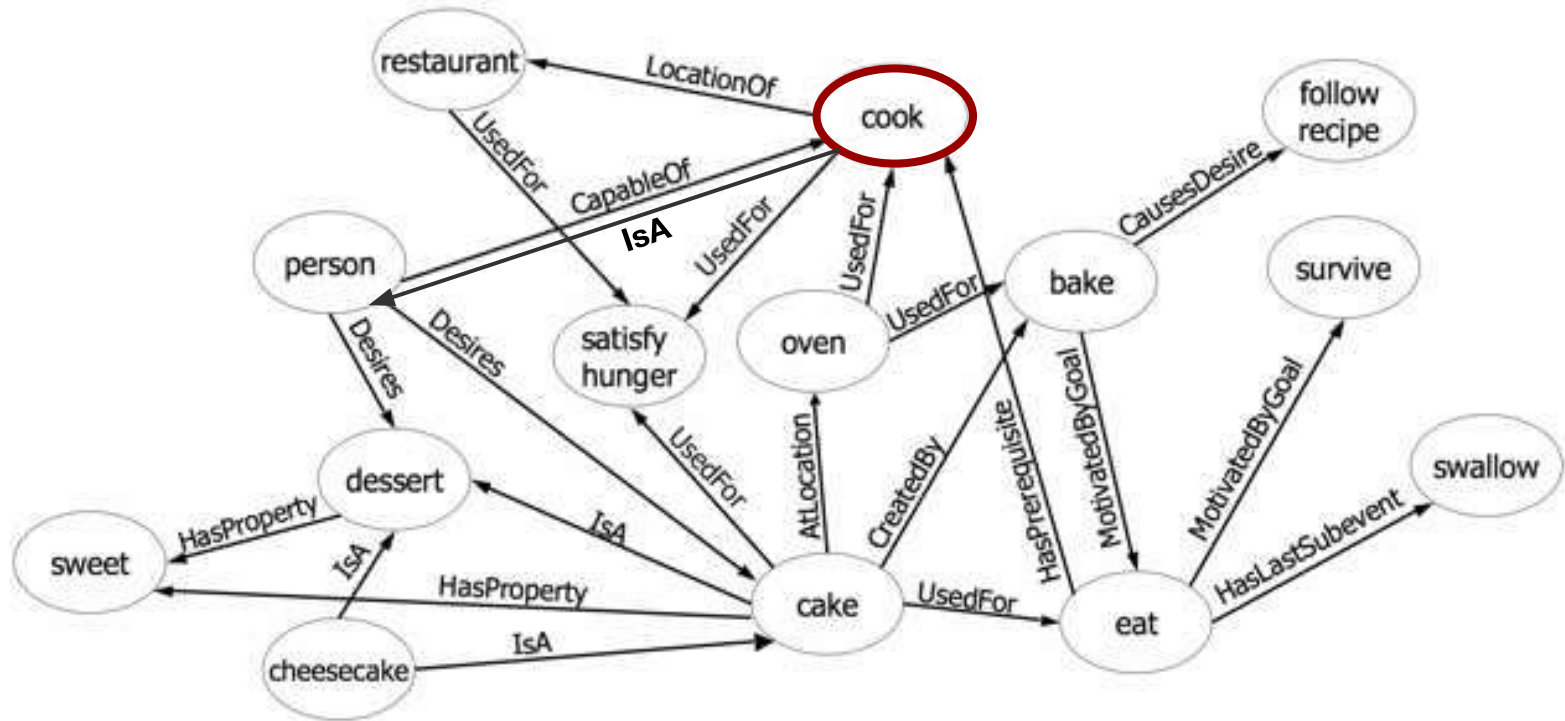- en black keys →
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FrameNet:
performer entertains audience

Audience [Aud]	The Audience experiences the Performance.
Medium [Medium]	Medium is the physical entity or channel used by the Performer to transmit the Performance to the Audience.
Performance [Perance]	The Performers generates the Performance which the Audience perceives.
Performer [Perfer]	The Performer provides an experience for the Audience.

Visual Genome: person can play a piano while sitting, his hands are on the keyboard

- man plays piano
- keys ON piano
- woman watches man
- pillow ON couch
- light ON wall
- window IN room
- person playing piano
- guy ON bench
- hands ON keyboard

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Challenge: Knowledge granularity

	size	examples

Concept Net	36 relations, 8M nodes, 21M edges	`/c/en/piano`
		`/c/en/piano/n`
		`/c/en/piano/n/wn`
		`/r/relatedTo`

Web Child	4 relation groups, 2M nodes, 18M edges	`hasTaste` `fasterThan`
ATOMIC	9 relations, 300k nodes, 877k edges	`wanted-to` `impressed`
Wikidata	1.2k relations, 75M objects, 900M edges	`wd:Q1234 wdt:P31`
CEO	121 properties, 223 events	`ceo:Damaging` `hasPostSituation`
WordNet	10 relations, 155k words, 176k synsets	`dog.n.01` `hypernymy`
Roget	2 relations, 72k words, 1.4M edges	`truncate` `antonym`
VerbNet	273 top classes 23 roles, 5.3k senses	`perform-v` `performance-26.7-1`

FrameNet	1.9k edges, 1.2k frames, 12k roles, 13k lexical units	`Activity`
		`Change_of_leadership`
		`New_leader`

Visual Genome	42k relations, 3.8M nodes, 2.3M edges, 2.8M attributes	`fire hydrant` `white dog`

Challenge: Imprecise descriptions

Challenge: Sparse overlap and mappings

	mappings
Concept Net	WordNet, DBpedia, OpenCyc, Wiktionary
Web Child	WordNet
ATOMIC	ConceptNet, Cyc
Wikidata	various
CEO	FrameNet, SUMO
WordNet	
Roget	
VerbNet	FrameNet, WordNet
FrameNet	
Visual Genome	WordNet

Other source	Both	Wikidata-CS only	Other source only
ConceptNet	2,386	97,473 (97.6%)	3,320,935 (99.9%)
Roget	299	99,560 (99.7%)	1,403,162 (99.9%)
WordNet	1,613	98,246 (98.4%)	419,103 (99.6%)

Challenge: Modeling of relations

ConceptNet

Web Child

/r/HasProperty ⟷

-	quality#n#1
ability#n#1	sensitivity#n#2
age#n#1	shape#n#2
appearance#n#1	size#n#1
beauty#n#1	sound#n#1
color#n#1	state#n#2
disposition#n#4	strength#n#1
emotion#n#1	structure#n#2
feeling#n#1	sustainability#n#1
length#n#1	tactile_property#n#1
manner#n#1	taste_property#n#1
motion#n#4	temperature#n#1
personality#n#1	trait#n#1
physical_property#n#1	weight#n#1

Challenge: Acquisition methods and quality

	creation
Concept Net	crowd-sourcing
Web Child	curated automatic extraction
ATOMIC	crowd-sourcing
Wikidata	crowd-sourcing
CEO	manual
WordNet	manual
Roget	manual
VerbNet	manual
FrameNet	manual
Visual Genome	crowd-sourcing

Consolidation of <u>nodes</u>

P1. Embrace heterogeneity of nodes

objects, classes, words, actions, frames, states

P2. Leverage external links

many sources map to WordNet

**P3. Generate high-quality probabilistic links**

many facts not explicitly stated

Overview of node mappings

251,517 mw:SameAs

45,659 mw:HasInstance

Mapping from	Mapping to	Relation	Resource used
WordNet 3.0 senses	WordNet 3.1 senses	mw:SameAs	Interlingual Index (ILI)
lexical nodes in ConceptNet	lexical nodes in ATOMIC and ROGET	mw:SameAs	/
ConceptNet nodes	FrameNet LUs	mw:SameAs	Predicate matrix
ConceptNet concepts	FrameNet FEe	mw:HasInstance	rule-based system
Wikidata Qnodes	WordNet senses	mw:SameAs	XLNet-based description similarity

Consolidated Knowledge Graphs

ConceptNet (Speer, Chin and Havasi 2017)
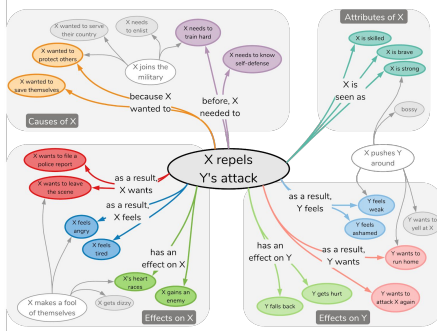
ATOMIC (Sap et al. 2019)

CSKG (Ilievski et al. 2020)
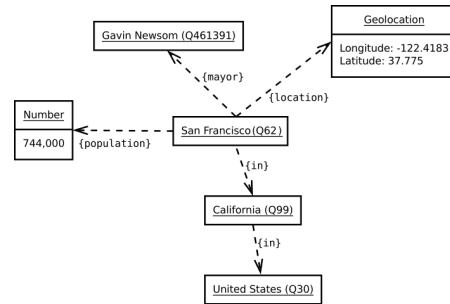
Wikidata (Vrandecic and Krotzsch 2014)
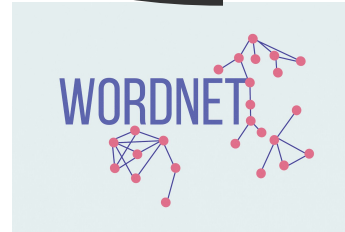
WordNet (Miller 1995)
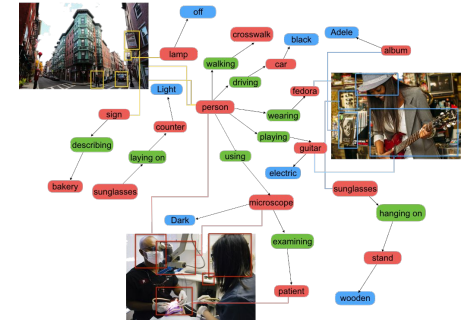
Visual Genome (Krishna et al. 2017)

CSKG snippet
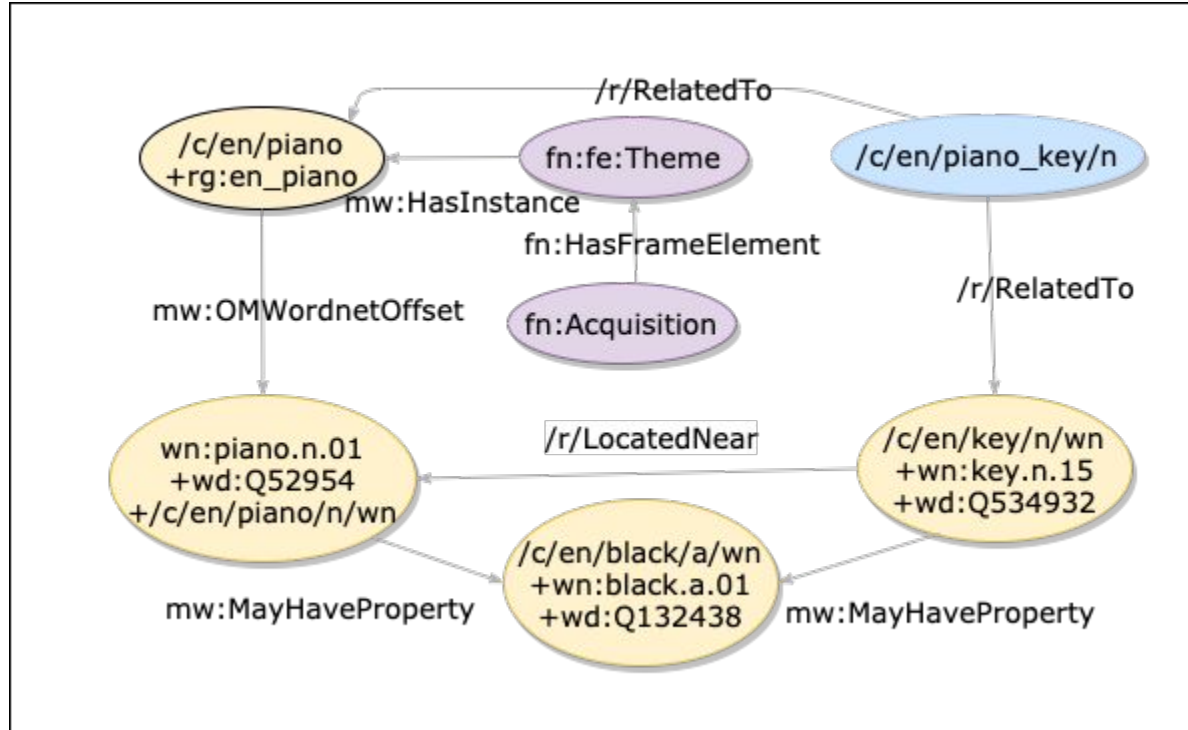
The effect of node resolution
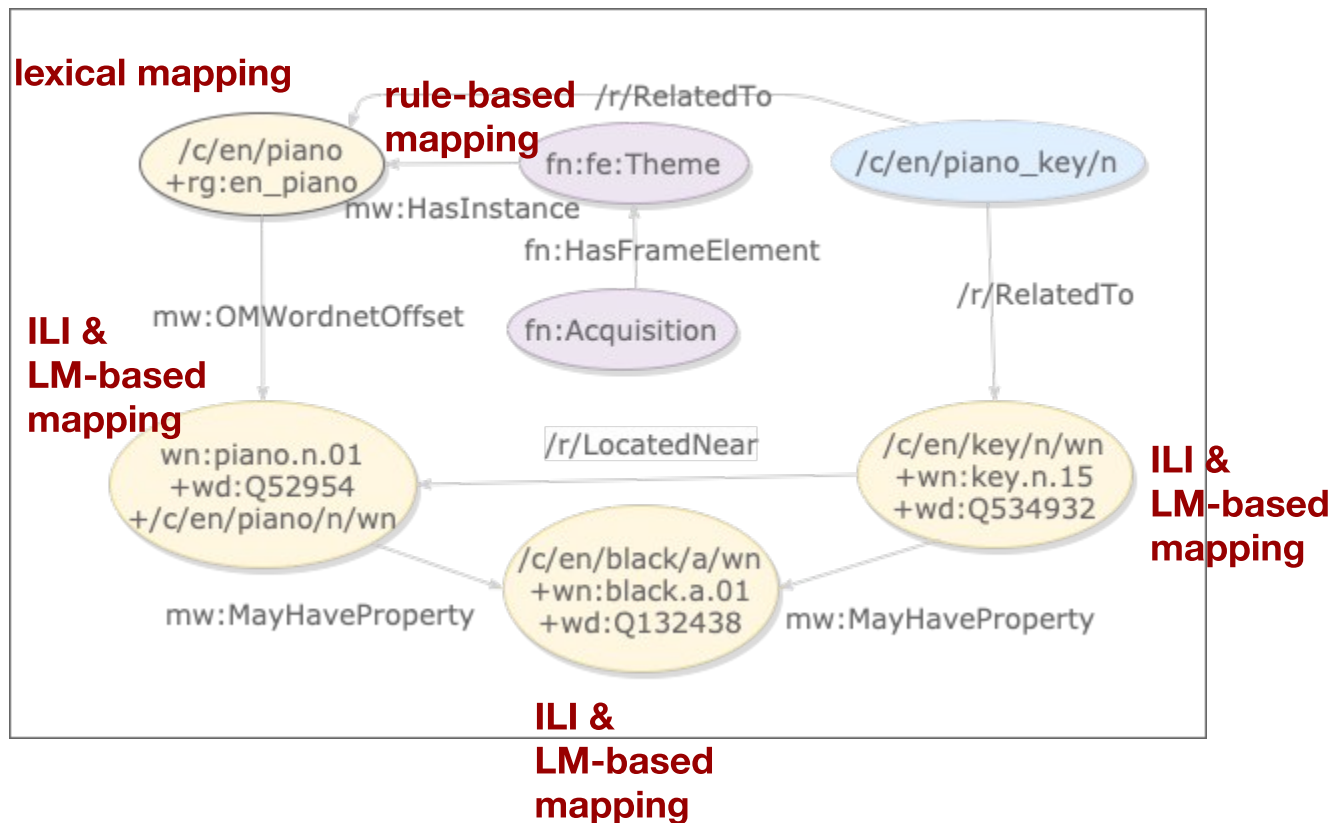
Consolidation of <u>relations</u>

P1. Reuse edge types across resources   -> 58 relations

/r/LocatedNear from ConceptNet applicable for attributes in Visual Genome

Integration statistics

	AT	CN	FN	RG	WN	WD	VG	CSKG (concat)	CSKG
#nodes	304,909	1787373	15,652	71,804	91,294	71,243	11,264	2,414,813	2,160,968
#edges	732,723	3,423,004	54,109	1,403,955	111,276	101,771	2,587,623	6,349,731	6,001,531
#relations	9	34	23	2	3	15	3	59	58
mean degree	4.81	3.83	6.91	39.1	2.44	2.44	459.45	5.26	5.55

Top PageRank nodes

1. **/c/en/chemical_compound/n**

2. **/c/en/change/n/wn/artifact**

3. **/c/en/natural_science/n/wn/cognition**

4. **/c/en/chromatic/a/wn**

5. **/c/en/organic_compound**

Zero-shot QA with CSKG

Method

(Ma et al., 2021)

Pretrain LMs with artificial QA sets generated from CSKG

Answer commonsense questions on unseen datasets
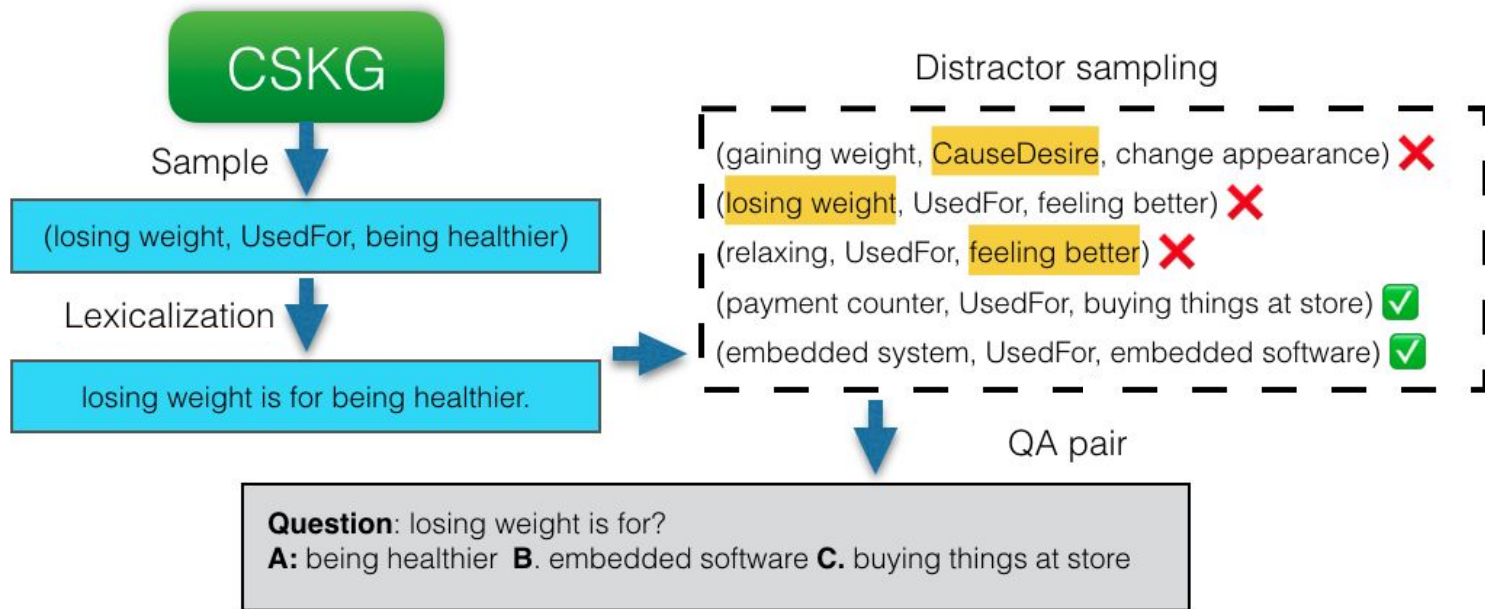
Main Results

- Pretraining on artificial QA sets helps accuracy
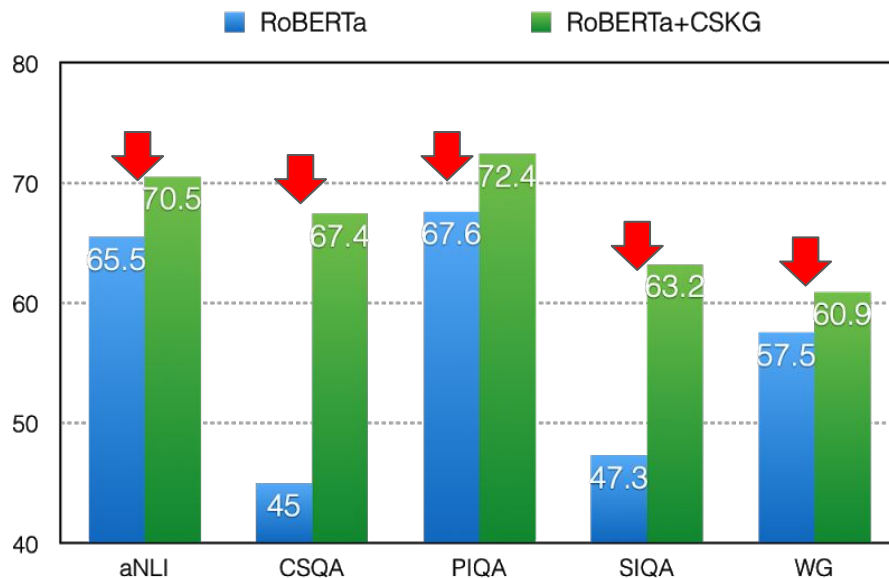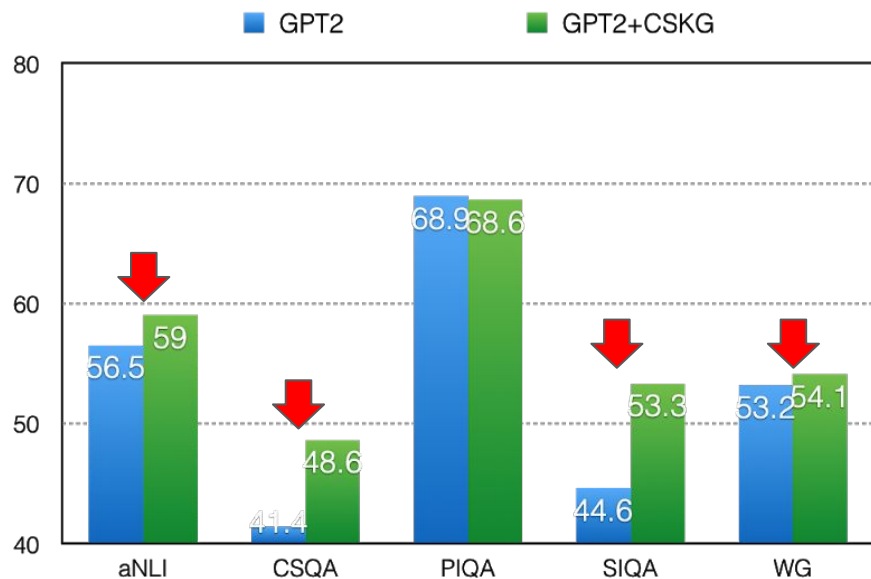
Main Results

- The impact of knowledge depends on KG-task alignment
- Adding knowledge improves accuracy
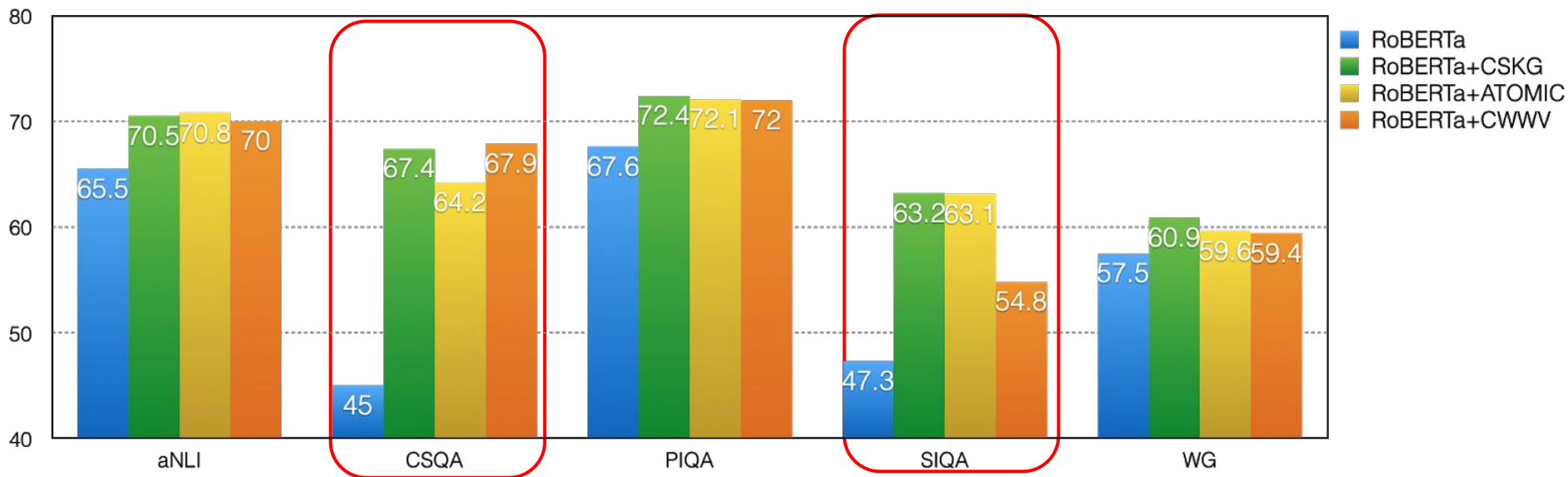
Consolidation of <u>relations</u>

P1. Reuse edge types across resources

/r/LocatedNear from ConceptNet applicable for attributes in Visual Genome

P2. Group relations into high-level dimensions

Causes, HasSubevent and precedes all express temporal knowledge

Dimensions

	ATOMIC	ConceptNet	WebChild	Other	Wikidata
taxonomic		IsA InstanceOf MannerOf	hasHypernymy	perspective_on (FN) inheritance (FN) hypernym (WN)	subClassOf instanceOf description
part-whole		PartOf HasA MadeOf AtLocation*	physicalPartOf memberOf substanceOf	HasPart (HP) meronym (WN) holonym (WN)	has part member of material used
spatial		AtLocation* LocatedNear	location spatial		location anatomical location
creation		CreatedBy			creator
utility		ReceivesAction UsedFor CapableOf ¬NotCapableOf	hassynsetmember activity participant	using (FN)	used by use uses
desire/goal	xIntent xWant oWant	CausesDesire MotivatedByGoal Desires ¬NotDesires ObstructedBy			
quality			shape size		
		HasProperty ¬NotHasProperty	color taste_property	frame_element (FN)	color
	xAttr	SymbolOf	temperature		has quality
comparative			*6.3k relations*		
temporal	xNeed xEffect oEffect xReact oReact	HasFirstSubevent HasLastSubevent HasSubevent HasPrerequisite Causes Entails	time emotion prev next	subframe (FN) precedes (FN) inchoative_of (FN) causative_of (FN)	has cause has effect

Dimensions of Commonsense Knowledge

lexical

similarity

distinctness

taxonomic

part-whole

spatial

creation

utility

desire/goal

quality

comparative

temporal

relational-other

Coverage of dimensions in sources

Dimension	ATOMIC	ConceptNet	WebChild	ROGET	Wikidata-CS	WordNet	FrameNet
lexical		704			0.5	207	14
similarity		255	343	1,023	1	152	0.4
distinctness		22		381	7	4	
taxonomic		244	783		73	89	23
part-whole		19	5,752		8	22	
spatial		28	660		0.5		
creation		0.3			0.2		
utility		69	2,843		2		1
desire/goal	244	20					
quality	143	9	6,510		1		11
comparative			813				
temporal	346	71	2,135		3		0.6
relational-other		1,969	291		6		0.7

Little overlap of knowledge

Sources	part-whole	taxonomic	lexical	distinctness	similarity	quality	utility	creation	temporal	rel-other
CN-RG	-	-	-	4,639	69,353	-	-	-	-	-
	-	-	-	(1.17)	(5.79)	-	-	-	-	-
CN-WD	68	1,888	20	266	102	0	14	0	1	264
	(0.25)	(0.62)	(0.00)	(1.00)	(0.04)	(0.00)	(0.02)	(0.00)	(0.00)	(0.01)
CN-WN	4,710	73,123	-	1,053	19,060	-	-	-	-	-
	(4.10)	(15.19)	-	(4.65)	(5.05)	-	-	-	-	-
RG-WD	-	-	-	206	127	-	-	-	-	-
	-	-	-	(0.05)	(0.01)	-	-	-	-	-
RG-WN	-	-	-	3,300	71,725	-	-	-	-	-
	-	-	-	(0.87)	(6.50)	-	-	-	-	-
WD-WN	82	1,533	-	63	26	-	-	-	-	-
	(0.07)	(0.39)	-	(0.62)	(0.02)	-	-	-	-	-

Zero-shot QA with CSKG dimensions

Method

(Ma et al., 2021)

Pretrain LMs with artificial QA sets generated from CSKG

Answer commonsense questions on unseen datasets

One dimension at a time to measure their impact on a task

dimension → CSKG

Sample
(losing weight, UsedFor, being healthier)

Lexicalization
losing weight is for being healthier.

Distractor sampling
(gaining weight, CauseDesire, change appearance) ❌
(losing weight, UsedFor, feeling better) ❌
(relaxing, UsedFor, feeling better) ❌
(payment counter, UsedFor, buying things at store) ✅
(embedded system, UsedFor, embedded software) ✅

QA pair

Question: losing weight is for?
A: being healthier **B**. embedded software **C**. buying things at store

Slicing CSKG questions along dimensions

Dimensions	Train	Dev
part-whole	87,765	4,620
taxonomic	340,609	17,927
lexical	107,861	5,677
distinctness	20,286	1,068
similarity	166,575	8,768
quality	116,593	12,492
utility	63,862	3,362
creation	304	17
temporal	312,628	31,587
relational-other	242,759	12,777
spatial	21,726	1,144
desire/goal	194,906	20,912

Pre-training language models with dimensions

CSQA = Commonsense QA

SIQA = SocialIQA

Dimensions	CSQA	SIQA
Baseline	45.0	47.3
+part-whole	63.0($\pm$1.4)	52.6($\pm$1.9)
+taxonomic	62.6($\pm$1.4)	52.2($\pm$1.6)
+lexical	49.9($\pm$2.9)	49.0($\pm$0.4)
+distinctness	57.2($\pm$0.5)	50.2($\pm$1.5)
+similarity	61.4($\pm$0.8)	53.5($\pm$0.6)
+quality	65.7($\pm$0.5)	60.0($\pm$0.7)
+utility	**67.4($\pm$1.0)**	54.8($\pm$0.7)
+creation	49.9($\pm$1.1)	47.8($\pm$0.2)
+temporal	67.3($\pm$0.3)	**62.6($\pm$0.9)**
+relational-other	58.2($\pm$1.7)	51.3($\pm$1.7)
+spatial	63.3($\pm$0.2)	53.1($\pm$0.3)
+desire/goal	65.0($\pm$1.8)	60.0($\pm$0.6)
+all	66.2($\pm$1.4)	61.0($\pm$0.7)

Accuracy per question type (CSQA)

	AtL.(595)	Cau.(193)	Cap.(108)	Ant.(88)	H.Pre.(46)	H.Sub.(38)	C.Des.(28)	Des.(27)	P.Of(22)	M.Goal(21)	H.Pro.(20)
Baseline	0.41	0.58	0.37	0.44	0.46	0.47	0.5	0.56	0.41	0.57	0.4
+creation	0.46	0.62	0.47	0.49	0.43	0.52	0.52	0.67	0.47	0.59	0.45
+distinctness	0.56	0.62	0.53	0.58	0.52	0.54	0.58	0.72	0.47	0.59	0.58
+lexical	0.47	0.61	0.44	0.48	0.51	0.46	0.51	0.65	0.39	0.51	0.52
+quality	0.64	0.72	0.65	0.57	0.72	0.58	0.64	0.8	0.68	0.75	0.62
+similarity	0.59	0.68	0.6	0.66	0.65	0.58	0.51	0.78	0.56	0.65	0.65
+taxonomic	0.6	0.7	0.58	0.6	0.67	0.64	0.57	0.77	0.53	0.73	0.62
+utility	0.66	0.7	0.62	0.71	0.75	0.69	0.61	0.83	0.62	0.71	0.67
+desire/goal	0.63	0.71	0.62	0.64	0.73	0.54	0.65	0.81	0.48	0.71	0.72
+part-whole	0.62	0.66	0.58	0.62	0.67	0.6	0.62	0.8	0.58	0.65	0.63
+relational-other	0.57	0.64	0.59	0.56	0.62	0.49	0.55	0.77	0.38	0.65	0.6
+spatial	0.63	0.66	0.61	0.55	0.69	0.67	0.64	0.74	0.56	0.6	0.63
+temporal	0.65	0.72	0.73	0.64	0.72	0.58	0.71	0.79	0.5	0.71	0.77
+all	0.66	0.68	0.69	0.6	0.67	0.61	0.62	0.81	0.52	0.75	0.65

Novelty per dimension

Can 'vanilla' RoBERTa answer the questions without pretraining?

Dimensions	Dev
part-whole	67.5
taxonomic	57.0
lexical	90.1
distinctness	77.3
similarity	65.6
quality	45.5
utility	67.9
creation	82.4
temporal	47.2
relational-other	37.6
spatial	56.9
desire/goal	48.0

Findings

Consolidation is not trivial but beneficial

- **nodes: improve the graph connectivity**

- **relations: align the knowledge types**

Findings

Consolidation is not trivial but beneficial

- **nodes: improve the graph connectivity**

- **relations: align the knowledge types**

The knowledge dimensions allow us to study the knowledge-task alignment

- **lexical and distinctness knowledge is largely redundant**

- **spatial knowledge is novel but not useful for current tasks**

- **temporal and desire/goal knowledge is both novel and useful**

Findings

Consolidation is not trivial but beneficial

- nodes: improve the graph connectivity

- relations: align the knowledge types

The knowledge dimensions allow us to study the knowledge-task alignment

- lexical and distinctness knowledge is largely redundant

- spatial knowledge is novel but not useful for current tasks

- temporal and desire/goal knowledge is both novel and useful

*We are only starting to understand the coverage/gaps of knowledge sources and evaluation!*

Open challenge: Node resolution

Node label: scene

fn:lu:sensation:scene	FN	/c/en/scene/n/wn/cognition	CN, WN
fn:lu:locale_by_event:scene	FN	/c/en/scene/n/wn/artifact	CN, WN
fn:fe:scene	FN	/c/en/scene/n/wn/state	CN, WN
Q7430735	WD	/c/en/scene/n/opencyc/scene_dramatic	CN
Q67943498	WD	/c/en/scene/n/opencyc/image_space	CN
Q16675888	WD	/c/en/picture/n/wn/state	CN, WN
Q1185607	WD	/c/en/scene/n	CN
Q282939	WD	/c/en/scene	CN
/c/en/scene/n/wn/location	CN, WN	/c/en/scenery/n/wn/artifact	CN, WN
/c/en/scene/n/wn/event	CN, WN		

Open challenge: Ambiguity of nodes
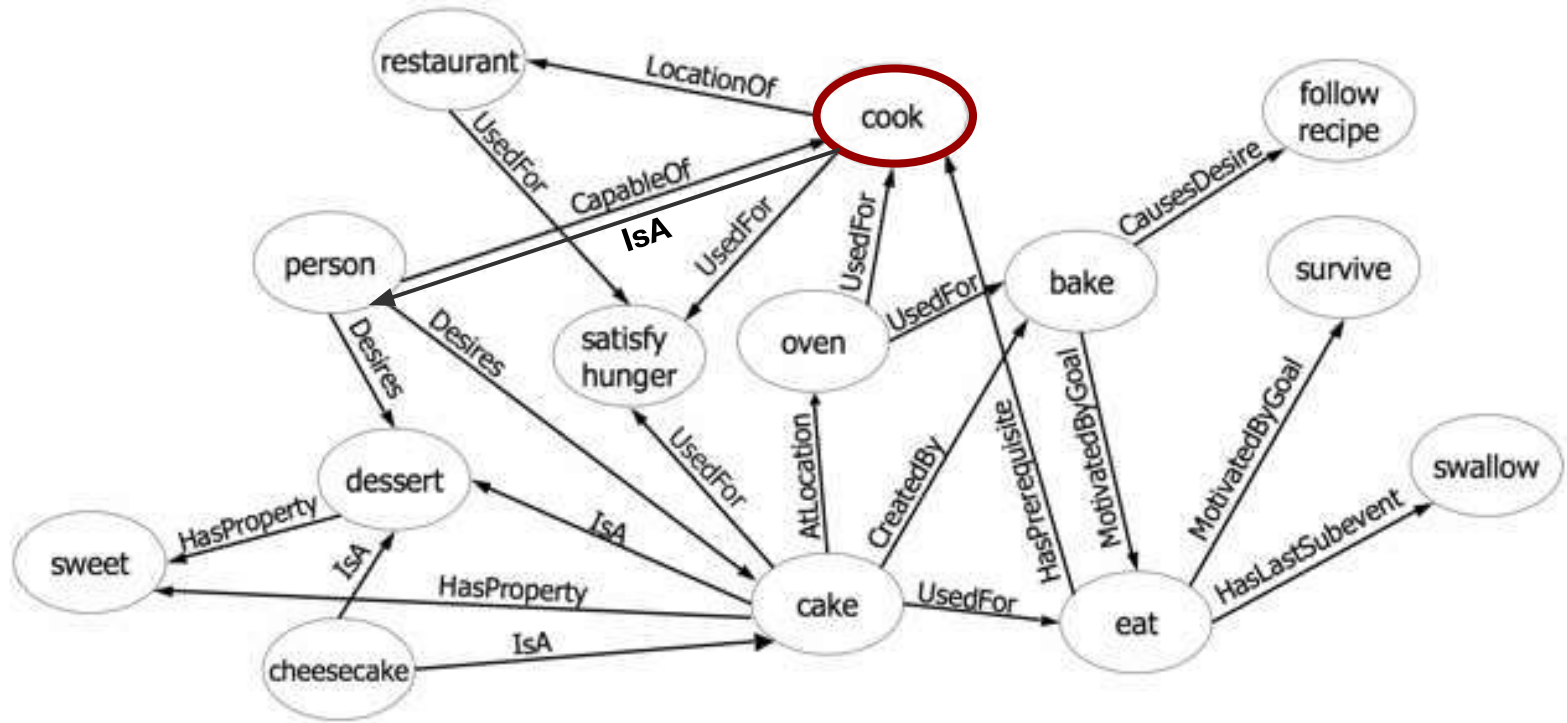
Open challenge: Variance of nodes

coffee has...

en caffeine →
en caffein →
en the active ingredient caffeine →
en caffeine which raises brain reaction
    time →
en caffiene →
en caffiene in it →
en caffine →
en large amounts of caffeine →
en a slightly bitter taste ➜
en a stimulant drug: caffeine →

Open challenge: Relation granularity

ConceptNet

Web Child

/r/HasProperty ⟷

-
ability#n#1
age#n#1
appearance#n#1
beauty#n#1
color#n#1
disposition#n#4
emotion#n#1
feeling#n#1
length#n#1
manner#n#1
motion#n#4
personality#n#1
physical_property#n#1

quality#n#1
sensitivity#n#2
shape#n#2
size#n#1
sound#n#1
state#n#2
strength#n#1
structure#n#2
sustainability#n#1
tactile_property#n#1
taste_property#n#1
temperature#n#1
trait#n#1
weight#n#1

Open challenge: Knowledge filtering

en **noma**

An English term in ConceptNet 5.8

Sources: DBPedia 2015, JMDict 1.07, English Wiktionary, and Open Multilingual WordNet
View this term in the API

Synonyms

- fi vesikuolio (n, state) →
- fr noma (n, state) →
- id noma (n, state) →
- ja 水癌 (n) →
- ja 野間 (n, state) →
- pt Noma (n, state) →
- ja 水癌 →

Related terms

- en destruction →
- en disease →
- en gangrenous →
- en tissue ➡
- en noma pudendi (n) →
- ja 水癌 (n) →
- pt noma (n) →

Etymological roots of "noma"

- grc voµη →
- la noma →
- la nome →

noma is a type of...

- en ulcer (n, state) →
- en disease (n) →
- en restaurant (n) →

Open challenge: Missing facts

Location of barbecue

en austrailia →
en Australia →
en Detroit →
en a garage →
en a Michigan park →
en a retail store →

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