

# Semi-Automated Construction of Complex Knowledge Base Question Answering Dataset using Large Language Model (Supplementary)

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In this supplementary, we provide more details of our constructed KG (iMKG) and KBQA dataset (MCQA). Please find the lists of tables and figures below. (Due to having long tables, the tables and figures might be placed not in order)

## Tables:

- Table 1 shows the list of genre entities in MovieKG and the corresponding Wikidata URI.
- Table 2 shows a sample prompt for generating SPARQL template.
- Table 3 showcases examples when  $NSM_h$  tends to return neighbors of topic entities as answers.
- Table 4 shows the list of question types, together with their number of questions, number of question templates, and examples.
- Table 5 shows the broad category and corresponding question types of CR.
- Table 6 shows the performance of  $NSM_h$  for each question type.
- Table 7 shows the performance of QGG for each question type.

## Figures:

- Figure 1 shows the distribution of the question types in train, development, and test sets.
- Figure 2 plots the precision and recall scores of  $NSM_h$  for AC questions.
- Figure 3 shows the examples of data points in MCQA with their corresponding subgraphs.

**Table 1.** The genre entities in MovieKG and its mapped Wikidata URI.

Genre	Wikidata URI
Horror	<a href="https://www.wikidata.org/entity/Q200092">https://www.wikidata.org/entity/Q200092</a>
Adventure	<a href="https://www.wikidata.org/entity/Q319221">https://www.wikidata.org/entity/Q319221</a>
Biography	<a href="https://www.wikidata.org/entity/Q645928">https://www.wikidata.org/entity/Q645928</a>
Sci-Fi	<a href="https://www.wikidata.org/entity/Q471839">https://www.wikidata.org/entity/Q471839</a>
Action	<a href="https://www.wikidata.org/entity/Q188473">https://www.wikidata.org/entity/Q188473</a>
Thriller	<a href="https://www.wikidata.org/entity/Q2484376">https://www.wikidata.org/entity/Q2484376</a>
Short	<a href="https://www.wikidata.org/entity/Q24862">https://www.wikidata.org/entity/Q24862</a>
Family	<a href="https://www.wikidata.org/entity/Q2143665">https://www.wikidata.org/entity/Q2143665</a>
Musical	<a href="https://www.wikidata.org/entity/Q842256">https://www.wikidata.org/entity/Q842256</a>
History	<a href="https://www.wikidata.org/entity/Q1196408">https://www.wikidata.org/entity/Q1196408</a>
Sport	<a href="https://www.wikidata.org/entity/Q1339864">https://www.wikidata.org/entity/Q1339864</a>
Western	<a href="https://www.wikidata.org/entity/Q172980">https://www.wikidata.org/entity/Q172980</a>
Fantasy	<a href="https://www.wikidata.org/entity/Q157394">https://www.wikidata.org/entity/Q157394</a>
War	<a href="https://www.wikidata.org/entity/Q369747">https://www.wikidata.org/entity/Q369747</a>
Music	<a href="https://www.wikidata.org/entity/Q842256">https://www.wikidata.org/entity/Q842256</a>
Crime	<a href="https://www.wikidata.org/entity/Q959790">https://www.wikidata.org/entity/Q959790</a>
Romance	<a href="https://www.wikidata.org/entity/Q1054574">https://www.wikidata.org/entity/Q1054574</a>
Documentary	<a href="https://www.wikidata.org/entity/Q93204">https://www.wikidata.org/entity/Q93204</a>
Animation	<a href="https://www.wikidata.org/entity/Q202866">https://www.wikidata.org/entity/Q202866</a>
Drama	<a href="https://www.wikidata.org/entity/Q130232">https://www.wikidata.org/entity/Q130232</a>
Comedy	<a href="https://www.wikidata.org/entity/Q157443">https://www.wikidata.org/entity/Q157443</a>
News	<a href="https://www.wikidata.org/entity/Q93204">https://www.wikidata.org/entity/Q93204</a>
Mystery	<a href="https://www.wikidata.org/entity/Q1200678">https://www.wikidata.org/entity/Q1200678</a>

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
<b>Total</b>	<b>157,764</b>	<b>4,135</b>	
actor_to_movie _constraint_actor	1,997	170	Which films are acted by [Akira Kubo] and [Yoshio Tsuchiya]?
actor_to_movie _constraint_director	1,999	128	What films does [Richard Dormer] appear in that were directed by [Lisa Barros D'Sa]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
actor_to_movie _constraint_genre	1,898	371	What movies did [Inger Stevens] star in and has genre [Western film]?
actor_to_movie _constraint_language	2,000	20	Which [Cantonese] language movies had [Eddy Ko] as an actor?
actor_to_movie _constraint_tag	2,000	46	What does [Chris Cooper] appear in and has the classification [chris cooper]?
actor_to_movie _constraint_writer	2,000	30	[Sam Raimi] wrote which movies that [Colin Friels] appears in?
actor_to_movie _constraint_year	2,000	20	What films featuring [Sarah Polley] were released in [2009]?
actor_to_movie_to_actor _constraint_movie	1,979	32	who else appeared in the same movie as [David Duchovny] and also acted in [Places in the Heart]?
actor_to_movie_to_writer _constraint_movie	2,000	16	who are the writers of the films that [Chevy Chase] starred in, as well as for [The Best Little Whorehouse in Texas]?
actor_year_movie	1,986	19	Could you inform me about the films that had [V́ctor Israel] in the cast in [1965]?
actor_year_num_movies	2,000	20	Can you tell me how many movies [Henry Nielsen] starred in during [1954]?
compare_directors_num_movies	2,000	17	Which of these two directors, [Karsten Krause] or [Ray Nowosielski], has more films to their name?
director_movie_not_actor	1,999	19	Can you provide a list of movies directed by [Věra Plívová-Šimková] without [David Saudek]?
director_num_movies	2,000	20	Discover how many movies [José Mojica Marins] has directed.
director_to_movie _constraint_actor	2,000	53	What films did [William Dear] direct and [George Lopez] act in?
director_to_movie _constraint_director	2,000	24	What films did [Jim Fall] direct in addition to [Rusty Cundieff]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
director_to_movie _constraint_genre	1,971	99	What movies did [Will Speck] direct that have the [comedy film] genre?
director_to_movie _constraint_language	2,000	142	What movies in [English] was the director on of [Gregory Hatanaka]?
director_to_movie _constraint_tag	2,000	277	What movies did [Craig R. Baxley] direct that have the tag [action]?
director_to_movie _constraint_writer	2,000	221	Do you have any information on movies that were both directed by [Phillip Borsos] and written by [John Hunter]?
director_to_movie _constraint_year	2,000	232	What was [Martin Provost] the director of and released in [2008]?
director_to_movie_to _actor_constraint_movie	1,988	41	who acted in the films directed by [Susannah Grant] and also acted in [Catch and Release]?
director_to_movie_to _writer_constraint_movie	2,000	23	which writer from [Cherry Town] has penned the screenplay for the films helmed by [Roman Tikhomirov]?
director_year_movie	1,822	20	Find out the cast members of films directed by [Natalia Meta] and released in [2014].
genre_num_movies	549	20	I'd like to find out how many films are categorized under the [crime film] genre.
language_genre_movie	1,978	20	Discover the movies that are in [Malay] and fall under the [true crime] genre.
language_num_movies	585	19	What's the film count for movies in [Kashmiri]?
movie_num_actors	2,000	20	Determine the number of performers in the movie [The Junkman].
movie_release_first	2,000	16	Can you tell me which one was released first, [Senti Aur Mental] or [Bhakti Mein Shakti]?
movie_to_actor _constraint_movie	2,000	20	What actor starred in both [The Buddy Holly Story] and [Surviving the Game]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
movie_to_actor_to_movie _constraint_actor	1,742	37	can you name any movies that have the same actor as [Escape from Alcatraz] and starred [Pat Hingle]?
movie_to_actor_to_movie _constraint_director	1,988	18	what are the films that have the same actor as [Pascali's Island] and were directed by [Brad Anderson]?
movie_to_actor_to_movie _constraint_genre	705	19	what are the films that have an actor in common with [Bengazi] and are in the [adventure film] genre?
movie_to_actor_to_movie _constraint_language	2,000	23	what movies have the same actor as [The Whiskey Bandit] and are in [Hungarian] language?
movie_to_actor_to_movie _constraint_tag	1,959	34	which films share the same actor as [Gold Diggers of 1937] and have the tag [william dieterle]?
movie_to_actor_to_movie _constraint_writer	1,998	22	which movies have the actor from [GoldenEye] and were written by [Daniel Defoe]?
movie_to_actor_to_movie _constraint_year	1,787	17	which films have an actor in common with [Bye Bye Birdie] and came out in [1966]?
movie_to_director_to _movie_constraint_actor	1,999	37	what movies have the same director as [A Breed Apart] and starred [Ronny Cox]?
movie_to_director_to _movie_constraint_genre	1,865	27	what movies have the same director as [Ice Soldiers] and have the genre of [drama]?
movie_to_director_to _movie_constraint_language	2,000	38	what movies share the same director as [Disorganized Crime] and are [Dutch]?
movie_to_director_to _movie_constraint_tag	2,000	24	what movies have the same director as [The Last Dragon] and have tag [joel schumacher]?
movie_to_director_to _movie_constraint_writer	1,994	35	what films share the same director as [Ernest Saves Christmas] and were penned by [John R. Cherry III]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
movie_to_director_to _movie_constraint_year	2,000	35	can you think of any films that have the same director as [The Seven-Per-Cent Solution] and were released in [1984]?
movie_to_tag _constraint_movie	2,000	53	Of all the tags for [Fire Birds], which ones are also the tags of [Left Behind]?
movie_to_writer _constraint_movie	2,000	16	Who wrote the screenplay for [The Adventures of Tintin] and also wrote for [Hot Fuzz]?
movie_to_writer_to _movie_constraint_actor	2,000	39	what are the films that have the same screenwriter as [Independence Day] and [Steven Strait] starred in the films?
movie_to_writer_to_movie _constraint_director	1,990	38	what films share the same screenwriter as [Best Friends] and were directed by [Barry Levinson]?
movie_to_writer_to_movie _constraint_genre	1,861	39	which films have the same screenwriter as [Shakes the Clown] and have genre [comedy film]?
movie_to_writer_to_movie _constraint_language	2,000	69	Are there any films in [Bengali] that share the same screenwriter as [Tiger]?
movie_to_writer_to_movie _constraint_tag	2,000	65	which movies have the same screenwriter as [Ten Thousand Saints] and have the tag [paul giamatti]
movie_to_writer_to_movie _constraint_year	1,999	44	what are the films that share the same screenwriter as [Gold] and were released in [1968]?
same_director_writer_actors	1,112	19	Who are the actors that have acted in films both written and directed by [Šarūnas Bartas]?
tag_to_movie _constraint_actor	2,000	96	I'd like to know what movies are about [sport] and have [Evan Rachel Wood] as the actor?
tag_to_movie _constraint_director	2,000	23	Are there any [lukas moodysson] films that were directed by [Lukas Moodysson]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
tag_to_movie _constraint_genre	2,000	35	What movies are about [nicolas roeg] and are in the [LGBT-related film] movies section?
tag_to_movie _constraint_language	2,000	30	What [English] language films are about [sets]?
tag_to_movie _constraint_tag	2,000	21	What movies can be utilized to describe [roger moore] and [007]?
tag_to_movie _constraint_writer	2,000	20	Can you tell me some [cédric klapisch] movies written by [Cédric Klapisch]?
tag_to_movie _constraint_year	1,912	38	Are there any [dc] films from [2004]?
writer_director_movie	1,998	20	What are the films where [Walde- mar Young] is the writer and [John Francis Dillon] is the director?
writer_num_movies	2,000	20	Can you provide me with the num- ber of films written by [Thomas Knauf]?
writer_to_movie _constraint_actor	2,000	295	[Mike Leigh] wrote which movies that are acted by [Alison Stead- man]?
writer_to_movie _constraint_director	2,000	139	Which flick did [Charles Shyer] write and direct by [Nancy Mey- ers]?
writer_to_movie _constraint_genre	1,993	40	For which film of genre [adventure film] did [Lyle Saxon] write the story?
writer_to_movie _constraint_language	2,000	28	What [Hindi] films did [Uday Shankar] write?
writer_to_movie _constraint_tag	2,000	17	What movies was [Bernard Rose] the writer of that have tag [leo tol- stoy]?
writer_to_movie _constraint_writer	2,000	25	Do you know which movies [Leon Uris] and [Dalton Trumbo] wrote?
writer_to_movie _constraint_year	2,000	17	In [1999], which films were written by [Garry Marshall]?
writer_to_movie_to_actor _constraint_movie	1,978	53	who played a starring role in the movies written by [Richard Rich] and also acted in [Frankenstein Must Be Destroyed]?

Table 4: Showing all the question types, the number of questions (#Qs), the number of question templates (#Ts), and the example of question for each question type.

Question Type	#Qs	#Ts	Example
writer_to_movie_to_writer _constraint_movie	2,000	36	which screenwriters co-wrote films with [Gina Kaus] and also wrote for [Three Brave Men] the movie?
writer_year_num_movies	2,000	20	Can you provide the count of movies written by [Stéphane Ben Lahcene] in [2013]?
year_genre_movie	1,986	20	I'd like to know which movies in [1972] and has genre [anthology film].
year_num_movies	147	19	I'd like to find out how many films premiered in [1920].
yesno_actor_director	2,000	20	Tell me if [Carlos Moreno] and [Tonino Caputo] have shared any film credits.
yesno_actor_genre	2,000	20	Tell me if [Bruno F. Apitz] has acted in any films of the [Euro War] genre.
yesno_actor_movie	2,000	20	I'd like to know if [Sue Hodge] had a role in [Stadtlandliebe].
yesno_movie_director	2,000	20	Did [Nagisa Ōshima] direct [The Pleasures of the Flesh]?
yesno_movie_genre	2,000	20	Tell me if [Calamity, a Childhood of Martha Jane Cannary] is part of the [children's film] genre.
yesno_movie_language	2,000	20	I'm curious, is [AHA!] spoken in the [Makassarese] language?
yesno_movie_multi_genres	2,000	20	Can you tell me if [The Feud and the Turkey] is categorized under multiple genres?
yesno_movie_same_director _writer	2,000	20	Discover if [Our Miss Brooks] was a project where the writer and director are one and the same.
yesno_movie_writer	2,000	19	Can you inform me if [Peter Lynch] wrote [Birdland]?
yesno_movie_year	2,000	21	Find out if [Trail of Courage] hit theaters in [1928].



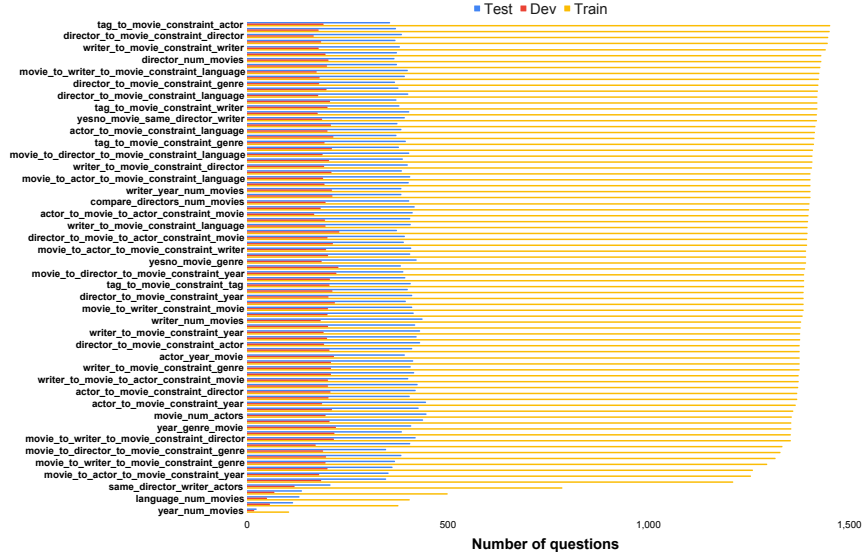


Fig. 1. MCQA training, development, and test data distribution by question type.

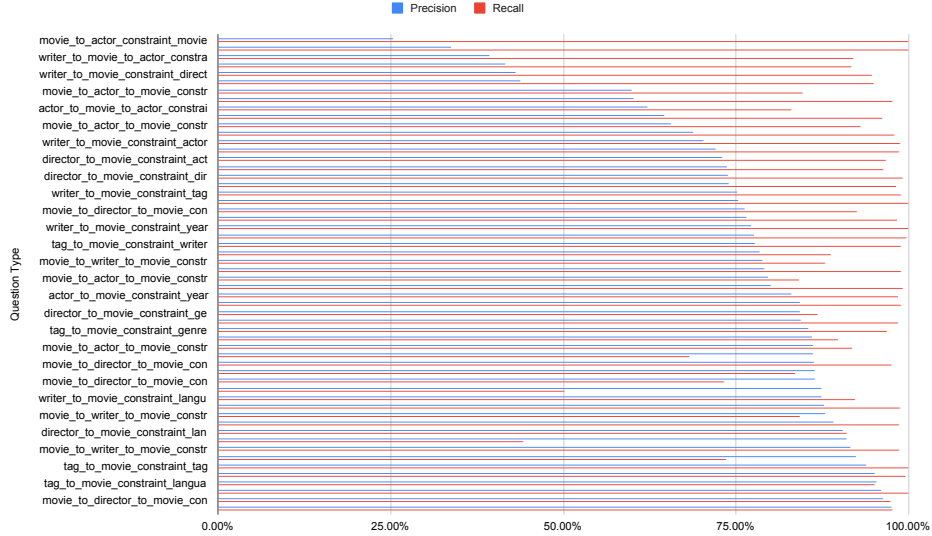


Fig. 2. Precision and recall score of  $NSM_h$  for MCQA-AC questions.  $NSM_h$ 's recall on MCQA-AC is very high, but the precision is not as good because it tends to return answer entities from the neighbors of both topic entity and constraint.

Table 6:  $NSM_h$  performance by question type on MCQA. The questions on count and yes-no category cannot be processed as  $NSM_h$  requires the answers to exist in a form of KB entity.

qtype	Precision	Recall	F1	H1
movie_to_tag_constraint_movie	96.04	100.00	97.16	100.00

movie_to_writer_to_movie_constraint_tag	97.53	97.67	96.74	98.21
tag_to_movie_constraint_year	95.07	99.48	96.25	97.79
movie_to_director_to_movie_constraint_tag	96.25	97.35	95.74	98.12
tag_to_movie_constraint_tag	93.90	100.00	95.42	100.00
tag_to_movie_constraint_language	95.34	95.09	94.15	97.57
movie_to_writer_to_movie_constraint_year	91.56	98.65	93.75	96.63
movie_to_director_to_movie_constraint_year	89.18	98.64	92.07	93.83
actor_to_movie_constraint_tag	87.80	98.69	90.65	98.51
director_to_movie_constraint_language	90.41	91.07	89.23	93.53
movie_to_director_to_movie_constraint_actor	86.26	97.48	88.44	99.49
movie_to_writer_to_movie_constraint_actor	84.44	98.42	87.93	97.62
writer_to_movie_constraint_language	87.39	92.26	87.86	94.61
tag_to_movie_constraint_genre	85.50	96.87	87.70	96.46
tag_to_movie_constraint_actor	84.18	98.81	87.68	99.44
actor_to_movie_constraint_year	83.00	98.46	87.64	95.07
actor_to_movie_constraint_language	85.98	89.74	85.83	89.87
movie_to_actor_to_movie_constraint_tag	86.08	91.79	84.92	95.34
director_to_movie_constraint_tag	80.07	99.17	84.57	99.75
movie_to_writer_to_movie_constraint_language	87.91	84.20	83.86	88.75
actor_to_movie_constraint_actor	79.14	98.92	83.77	99.47
director_to_movie_to_writer_constraint_movie	77.59	99.69	83.18	98.66
writer_to_movie_constraint_year	77.25	100.00	83.17	97.68
movie_to_director_to_movie_constraint_language	86.37	83.54	82.90	87.13
tag_to_movie_constraint_writer	77.76	98.86	82.70	99.74
director_to_movie_constraint_year	75.30	99.89	81.69	96.84
tag_to_movie_constraint_director	76.57	98.32	81.39	99.76
director_to_movie_constraint_genre	84.30	86.83	80.86	94.57
writer_to_movie_constraint_tag	75.18	98.84	80.83	99.77
director_to_movie_constraint_director	73.87	99.12	79.94	97.15
writer_to_movie_to_writer_constraint_movie	73.89	98.19	79.83	93.38
actor_to_movie_constraint_director	73.64	96.23	79.40	84.52
actor_to_movie_to_writer_constraint_movie	72.06	98.62	78.99	95.92
movie_to_actor_to_movie_constraint_language	79.59	84.05	78.88	86.00
actor_year_movie	83.82	79.65	78.82	83.97
director_to_movie_constraint_actor	72.95	96.72	78.66	85.61
movie_to_director_to_movie_constraint_writer	76.27	92.54	77.93	99.51
writer_to_movie_constraint_genre	78.47	88.67	77.34	94.85
writer_to_movie_constraint_actor	70.24	98.70	77.17	92.12
movie_to_writer_to_movie_constraint_genre	92.37	73.54	76.84	94.04
movie_to_writer_to_movie_constraint_director	78.81	87.86	75.87	98.33
actor_to_movie_constraint_writer	68.74	97.93	75.78	87.47
language_genre_movie	74.64	87.42	74.38	88.89
movie_to_director_to_movie_constraint_genre	86.43	73.28	73.17	94.51
writer_to_movie_constraint_writer	64.64	96.12	70.62	99.74
movie_to_actor_to_movie_constraint_director	65.58	92.99	69.68	97.21
actor_to_movie_constraint_genre	86.15	68.31	69.48	93.49
movie_to_actor_to_movie_constraint_writer	60.08	97.62	68.35	98.78
year_genre_movie	74.96	65.22	63.77	78.24
actor_to_movie_to_actor_constraint_movie	62.15	83.07	60.58	95.40

writer_director_movie	51.49	84.14	60.06	74.69
same_director_writer_actors	86.94	51.57	58.67	90.87
movie_to_actor_to_movie_constraint_actor	59.85	84.67	58.63	97.11
director_movie_not_actor	82.28	53.88	57.73	87.10
movie_to_actor_to_movie_constraint_year	87.37	50.19	57.72	92.90
director_to_movie_constraint_writer	43.80	94.90	54.53	81.45
writer_to_movie_constraint_director	43.09	94.70	53.96	77.06
movie_to_actor_to_movie_constraint_genre	90.95	44.16	53.01	94.16
director_year_movie	84.87	41.81	52.42	90.61
director_to_movie_to_actor_constraint_movie	41.61	91.63	48.44	96.69
movie_to_writer_constraint_movie	33.71	100.00	47.99	99.76
writer_to_movie_to_actor_constraint_movie	39.24	92.01	46.06	96.77
movie_to_actor_constraint_movie	25.29	99.89	38.24	100.00
yesno_movie_director	0.00	0.00	0.00	0.00
actor_year_num_movies	0.00	0.00	0.00	0.00
compare_directors_num_movies	0.00	0.00	0.00	0.00
director_num_movies	0.00	0.00	0.00	0.00
genre_num_movies	0.00	0.00	0.00	0.00
language_num_movies	0.00	0.00	0.00	0.00
movie_num_actors	0.00	0.00	0.00	0.00
movie_release_first	0.00	0.00	0.00	0.00
writer_num_movies	0.00	0.00	0.00	0.00
writer_year_num_movies	0.00	0.00	0.00	0.00
year_num_movies	0.00	0.00	0.00	0.00
yesno_actor_director	0.00	0.00	0.00	0.00
yesno_actor_genre	0.00	0.00	0.00	0.00
yesno_actor_movie	0.00	0.00	0.00	0.00
yesno_movie_genre	0.00	0.00	0.00	0.00
yesno_movie_language	0.00	0.00	0.00	0.00
yesno_movie_multi_genres	0.00	0.00	0.00	0.00
yesno_movie_same_director_writer	0.00	0.00	0.00	0.00
yesno_movie_writer	0.00	0.00	0.00	0.00
yesno_movie_year	0.00	0.00	0.00	0.00

Table 7: QGG performance by question type on MCQA. QGG performs best on simpler question types involving fewer graph traversal steps. Poor performance of QGG on multi-hop questions can be attributed to logical fallacy where the model mistakenly predicts 1-hop query paths for a number of multi-hop questions.

qtype	Precision	Recall	F1	H1
actor_to_movie_constraint_language	59	71.58	60.94	58.44
writer_to_movie_constraint_language	60.94	60.96	56.58	63.48
director_to_movie_constraint_language	61.85	52.27	50.78	61.69
tag_to_movie_constraint_tag	36.36	85.85	47.43	38.97
tag_to_movie_constraint_actor	32.11	89.09	42.75	35.39
tag_to_movie_constraint_writer	31.58	82.9	40.22	30.08

tag_to_movie_constraint_year	26.43	78.87	37.24	23.83
movie_to_director_to_movie_constraint_tag	30.99	78.2	36.54	31.90
director_to_movie_constraint_director	33.72	39.22	33.68	35.23
director_to_movie_constraint_tag	28.41	76.2	33.19	27.18
movie_to_writer_to_movie_constraint_tag	25.22	81.76	32.04	25.32
movie_to_actor_to_movie_constraint_tag	24.28	78.14	31.45	22.54
actor_to_movie_constraint_tag	24.03	78.4	30.07	22.03
writer_to_movie_constraint_tag	23.42	73.45	29.65	22.95
director_to_movie_constraint_writer	27.28	34.08	28.32	26.75
writer_to_movie_constraint_genre	28.76	41.17	28.25	28.68
writer_to_movie_constraint_writer	25.94	36.84	27.09	24.41
actor_to_movie_constraint_genre	21.19	62.72	24.69	19.53
director_movie_not_actor	40.87	21.58	23.64	39.95
actor_to_movie_constraint_writer	21.9	32.87	23	22.40
writer_director_movie	23.19	25.46	21.29	23.10
director_to_movie_constraint_genre	27.08	25.81	20.96	27.99
language_genre_movie	16.27	78.54	19.51	17.53
actor_to_movie_to_writer_constraint_movie	20.38	16.66	17.71	20.38
actor_year_movie	10.84	68.58	16.47	11.45
writer_to_movie_constraint_actor	12.43	28.9	14.91	12.07
writer_to_movie_constraint_year	11.52	29.58	14.66	9.28
writer_to_movie_constraint_director	13.59	19.88	14.52	12.97
director_to_movie_constraint_actor	12.54	20.1	13.27	11.83
actor_to_movie_constraint_director	12.46	19.99	13.12	11.67
director_to_movie_to_writer_constraint_movie	11.83	11.47	11.56	11.83
director_to_movie_constraint_year	8.55	21.9	10.97	8.76
tag_to_movie_constraint_director	10.72	13.47	9.66	10.50
writer_to_movie_to_writer_constraint_movie	10.87	9.07	9.57	10.87
actor_to_movie_constraint_actor	7.28	35.36	8.85	6.63
movie_to_writer_constraint_movie	8.98	8.5	8.66	8.98
actor_to_movie_constraint_year	5.52	32.58	7.33	3.36
movie_to_director_to_movie_constraint_writer	6.68	4.78	4.88	6.57
movie_to_actor_to_movie_constraint_writer	4.73	5.04	4.24	5.38
year_genre_movie	2.23	93.8	4.13	2.44
movie_to_writer_to_movie_constraint_director	5.88	4.12	3.61	5.48
movie_to_actor_to_movie_constraint_director	3.98	3.31	3.15	4.06
movie_to_writer_to_movie_constraint_actor	1.27	2.4	1.49	1.59
movie_to_tag_constraint_movie	1.34	1.34	1.34	1.34
actor_to_movie_to_actor_constraint_movie	2.66	0.92	1.08	2.66
movie_to_director_to_movie_constraint_actor	1.28	1.13	0.95	1.02
movie_to_actor_constraint_movie	1.01	0.89	0.93	1.01
movie_to_actor_to_movie_constraint_actor	1.75	0.72	0.87	1.45
writer_to_movie_to_actor_constraint_movie	0.75	0.52	0.54	0.75
movie_to_director_to_movie_constraint_year	0.4	0.73	0.47	0.77
movie_to_writer_to_movie_constraint_genre	0.76	0.62	0.28	1.08
movie_to_writer_to_movie_constraint_language	0.25	1.25	0.25	0.25
movie_to_actor_to_movie_constraint_year	1.14	0.14	0.25	1.14
director_to_movie_to_actor_constraint_movie	0.51	0.17	0.24	0.51
movie_to_director_to_movie_constraint_genre	0.65	0.33	0.2	0.58

movie_to_actor_to_movie_constraint_genre	0.73	0.11	0.18	0.73
tag_to_movie_constraint_language	0.1	81.35	0.16	0.27
tag_to_movie_constraint_genre	0.08	76.71	0.15	0.00
movie_to_actor_to_movie_constraint_language	0.13	0.55	0.09	0.25
movie_to_director_to_movie_constraint_language	0	0.5	0	0.00
actor_year_num_movies	0	0	0	0.00
compare_directors_num_movies	0	0	0	0.00
director_num_movies	0	0	0	0.00
director_year_movie	0	0	0	0.00
genre_num_movies	0	0	0	0.00
language_num_movies	0	0	0	0.00
movie_num_actors	0	0	0	0.00
movie_release_first	0	0	0	0.00
movie_to_writer_to_movie_constraint_year	0	0	0	0.00
same_director_writer_actors	0	0	0	0.00
writer_num_movies	0	0	0	0.00
writer_year_num_movies	0	0	0	0.00
year_num_movies	0	0	0	0.00
yesno_actor_director	0	0	0	0.00
yesno_actor_genre	0	0	0	0.00
yesno_actor_movie	0	0	0	0.00
yesno_movie_director	0	0	0	0.00
yesno_movie_genre	0	0	0	0.00
yesno_movie_language	0	0	0	0.00
yesno_movie_multi_genres	0	0	0	0.00
yesno_movie_same_director_writer	0	0	0	0.00
yesno_movie_writer	0	0	0	0.00
yesno_movie_year	0	0	0	0.00

**Table 2.** Sample ChatGPT prompt for SPARQL generation and ChatGPT response retrieved on 6 Oct 2023. While this sample includes one question type, to generate the complete set of SPARQL queries, we add all 27 question types to the input prompt.

<b>Prompt for SPARQL generation</b>
Given a knowledge graph that includes the following relations: starred_actors, directed_by, written_by, release_year, in_language, has_tags, has_genre, has_imdb_votes, has_imdb_rating And given the following questions: 1. Which movie was released first, Titanic or Top Gun? Write a SPARQL query to retrieve the answer from the knowledge graph.
<b>ChatGPT 3.5 response</b>
To answer the given questions using SPARQL queries with the provided knowledge graph, you can construct queries as follows: 1. Which movie was released first, Titanic or Top Gun? <pre> SELECT ?movie ?releaseDate WHERE {?movie1 a :Movie ; :released_in ?releaseDate . FILTER (?movie1 = :Titanic    ?movie1 = :TopGun)} ORDER BY ?releaseDate LIMIT 1 </pre> Please note that you should replace :Titanic, :TopGun, :director with the actual URIs or values from your knowledge graph. Additionally, make sure your knowledge graph is properly loaded into a SPARQL-compatible system for these queries to work.

**Table 3.** CR question examples and their final answers when tested on NSM<sub>h</sub>. It was observed that NSM<sub>h</sub> tends to return answer entities from the neighbors of both topic entity and constraint.

Question, Groundtruth Answer, Question Type	NSM Final Answers	Neighbor of Topic Entity	Neighbor of Constraint
Which actor was in both [The Wolf of Wall Street] and in [The Aviator]?  Groundtruth Answer: Leonardo DiCaprio Question Type: movie_to_actor_constraint_movie	Leonardo DiCaprio Jordan Belfort Putini Sam Wanamaker Kenneth Welsh Yves Jacques	Leonardo DiCaprio Jordan Belfort Putini	Leonardo DiCaprio Sam Wanamaker Kenneth Welsh Yves Jacques
What actor starred in both [White Lightning] and [100 Rifles]?  Groundtruth Answer: Burt Reynolds Question Type: movie_to_actor_constraint_movie	Burt Reynolds Akim Tamiroff Jennifer Billingsley Diane Ladd Raquel Welch	Burt Reynolds Jennifer Billingsley Diane Ladd	Burt Reynolds Akim Tamiroff Raquel Welch
For which film did [Nicholas Ray] write the story and [Ida Lupino] direct it? Groundtruth Answer: On Dangerous Ground Question Type: writer_to_movie_constraint_director	On Dangerous Ground Rebel Without a Cause Bigger Than Life They Live by Night Bitter Victory	On Dangerous Ground Rebel Without a Cause Bigger Than Life They Live by Night Bitter Victory	On Dangerous Ground
What films did [David Cronenberg] write and directed that were [Don DeLillo]?  Groundtruth Answer: Cosmopolis Question Type: writer_to_movie_constraint_director	Cosmopolis The Dead Zone Crash Naked Lunch The Fly	Cosmopolis The Dead Zone Crash Naked Lunch The Fly	Cosmopolis
What films did [Jeff Schaffer] write and [Sacha Baron Cohen] star in?  Groundtruth Answer: Brüno Question Type: writer_to_movie_constraint_actor	Brüno The Dictator Ali G Indahouse Grimsby Borat	Brüno The Dictator	Brüno The Dictator Ali G Indahouse Grimsby, Borat
What is the name of the movie that [Jennifer Jason Leigh] wrote and [Greta Gerwig] acted in?  Groundtruth Answer: Greenberg Question Type: writer_to_movie_constraint_actor	Greenberg Frances Ha Mistress America Nights and Weekends The Anniversary Party	Greenberg The Anniversary Party	Greenberg Frances Ha Mistress America Nights and Weekends

## Example 1

**Q:** Can you help me remember who starred in both [Edge of Tomorrow] and [Rain Man]?

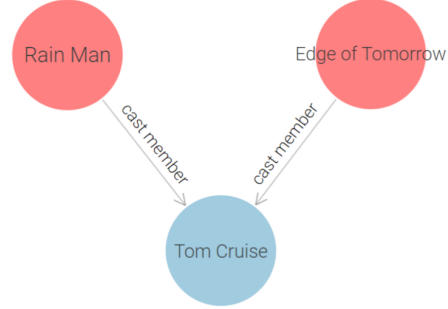
**QT:** movie\_to\_actor\_constraint\_movie

**TE:** Edge of Tomorrow, Rain Man

**A:** Tom Cruise

**SPARQL:**

```
SELECT DISTINCT ?label ?uri WHERE {
  ?e1 ?rel ?uri; rdfs:label "Edge of Tomorrow" .
  ?e3 ?rel ?uri; rdfs:label "Rain Man" .
  ?rel rdfs:label "starred_actors" .
  ?uri rdfs:label ?label . }
```



## Example 2

**Q:** Find out the total number of movies featuring [Brian Cox] in [2000].

**QT:** actor\_year\_num\_movies

**TE:** Brian Cox, 2000

**A:** 6

**SPARQL:**

**PREFIX**

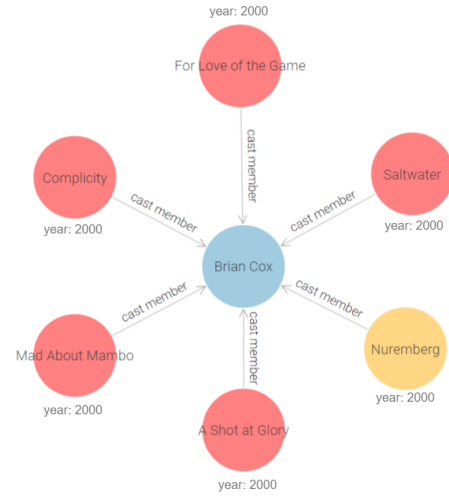
**wd:** <https://www.wikidata.org/entity/>

```
SELECT (COUNT(?movie) AS ?count)
```

```
WHERE { ?movie wd:P161 ?actor .
```

```
?actor rdfs:label "Brian Cox".
```

```
?movie wd:publication_year "2000" . }
```



## Example 3

**Q:** which films have the same screenwriter as [The Last Airbender] and are in the genre of [fantasy film]?

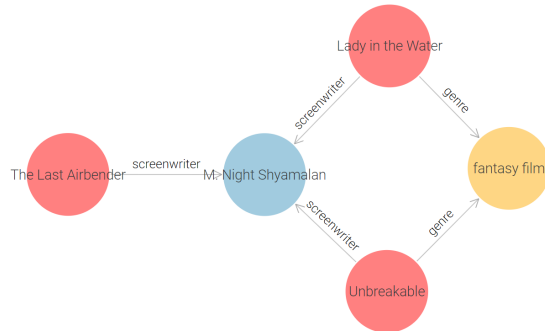
**QT:** movie\_to\_writer\_to\_movie\_constraint\_genre

**TE:** The Last Airbender, fantasy film

**A:** Lady in the Water, Unbreakable

**SPARQL:**

```
SELECT DISTINCT ?label ?uri WHERE {
  ?rel1 rdfs:label "written_by" .
  ?e1 ?rel1 ?e2 ;
  rdfs:label "The Last Airbender" .
  ?uri ?rel1 ?e2 ; ?rel4 ?e4 ; rdfs:label ?label .
  FILTER (?label != "The Last Airbender")
  ?rel4 rdfs:label "has_genre" .
  ?e4 rdfs:label "fantasy film" . }
```



**Fig. 3.** The visual subgraph and its corresponding SPARQL query for sample question in MCQA.

**Table 5.** Complex Reasoning question categories and question types. One question type may belong to multiple categories, like `director_year_movie` belonging to both ‘constraint-temporal’ and ‘multi-hop’ category.

Question Category	Question Type
comparative	<code>compare_directors_num_movies</code>
difference	<code>director_movie_not_actor</code>
constraint-entity	<code>language_genre_movie</code> <code>same_director_writer_actors</code> <code>writer_director_movie</code>
constraint-temporal	<code>actor_year_movie</code>
constraint-temporal, multi-hop	<code>director_year_movie</code> <code>year_genre_movie</code>
constraint-temporal, multi-hop, count	<code>year_num_movies</code>
count	<code>actor_year_num_movies</code> <code>director_num_movies</code> <code>genre_num_movies</code> <code>language_num_movies</code> <code>movie_num_actors</code> <code>writer_num_movies</code> <code>writer_year_num_movies</code>
superlative/rank	<code>movie_release_first</code>
yes-no	<code>yesno_actor_director</code> <code>yesno_actor_genre</code> <code>yesno_actor_movie</code> <code>yesno_movie_director</code> <code>yesno_movie_genre</code> <code>yesno_movie_language</code> <code>yesno_movie_multi_genres</code> <code>yesno_movie_same_director_writer</code> <code>yesno_movie_writer</code> <code>yesno_movie_year</code>