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MultiSpider: Towards Benchmarking Multilingual Text-to-SQL Semantic Parsing

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Work done during the internship of Microsoft Research Asia

Overview

[Benchmark]

MultiSpider: the largest **text-to-SQL multilingual** dataset covering 7 languages.

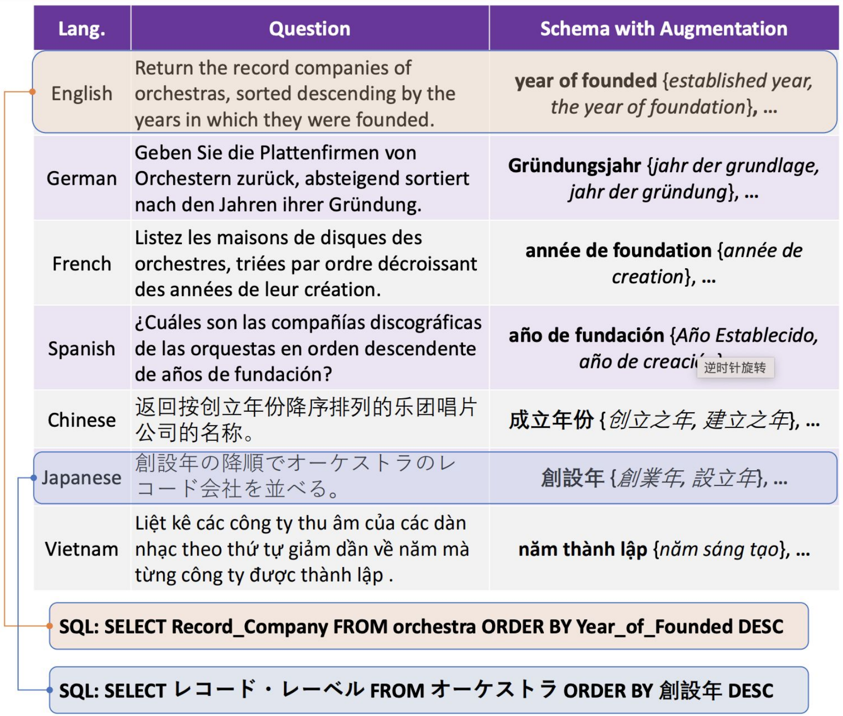
[Analysis&Experiments]

Identify the specific **lexical** challenge and **structural** challenge of MultiSpider.

[Data Augmentation]

SAVe: a data-augmentation method from the **perspective of schema**.

MultiSpider Benchmark



Lang.	Question	Schema with Augmentation
English	Return the record companies of orchestras, sorted descending by the years in which they were founded.	**year of founded** {*established year, the year of foundation*}, …
German	Geben Sie die Plattenfirmen von Orchestern zurück, absteigend sortiert nach den Jahren ihrer Gründung.	**Gründungsjahr** {*jahr der grundlage, jahr der gründung*}, …
French	Listez les maisons de disques des orchestres, triées par ordre décroissant des années de leur création.	**année de foundation** {*année de creation*}, …
Spanish	¿Cuáles son las compañías discográficas de las orquestas en orden descendente de años de fundación?	**año de fundación** {*Año Establecido, año de creaci*逆时针旋转
Chinese	返回按创立年份降序排列的乐团唱片公司的名称。	**成立年份** {*创立之年, 建立之年*}, …
Japanese	創設年の降順でオーケストラのレコード会社を並べる。	**創設年** {*創業年, 設立年*}, …
Vietnam	Liệt kê các công ty thu âm của các dàn nhạc theo thứ tự giảm dần về năm mà từng công ty được thành lập .	**năm thành lập** {*năm sáng tạo*}, …

SQL: SELECT Record_Company FROM orchestra ORDER BY Year_of_Founded DESC

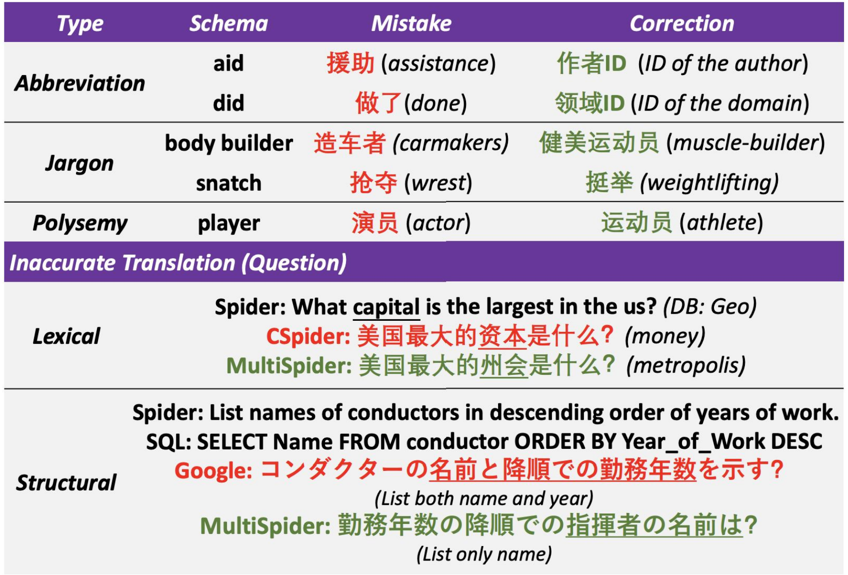
SQL: SELECT レコード・レーベル FROM オーケストラ ORDER BY 創設年 DESC

- Built on the top of **challenging** multi-table cross-database English Spider.

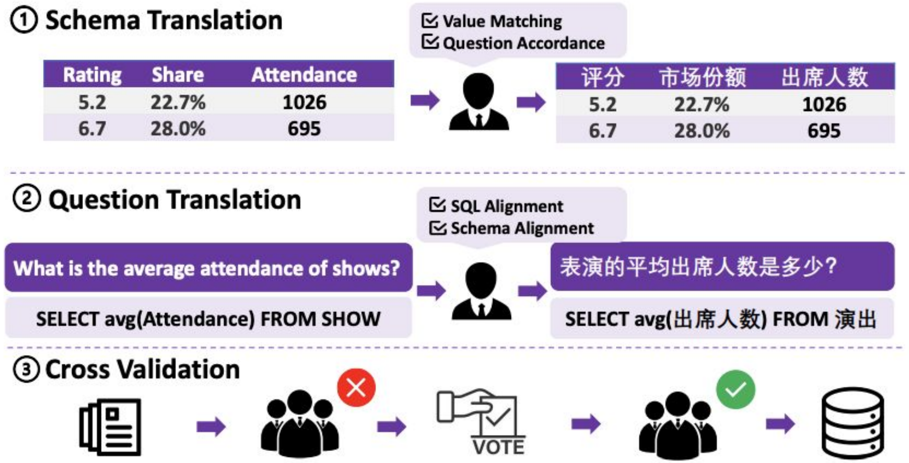
- **Largest** and **high-quality** multilingual text-to-SQL dataset, including **seven** mainstream languages.

- Translate both **question&schema**.

Benchmark Construction



Type	*Schema*	*Mistake*	*Correction*
Abbreviation	**aid**	援助 (*assistance*)	**作者ID** (*ID of the author*)
	did	做了 (*done*)	**领域ID** (*ID of the domain*)
Jargon	**body builder**	造车者 (*carmakers*)	健美运动员 (*muscle-builder*)
	snatch	抢夺 (*wrest*)	挺举 (*weightlifting*)
Polysemy	**player**	演员 (*actor*)	运动员 (*athlete*)
Inaccurate Translation (Question)			
Lexical	**Spider: What capital is the largest in the us?** *(DB: Geo)* **CSpider:** 美国最大的资本是什么? *(money)* **MultiSpider:** 美国最大的州会是什么? *(metropolis)*		
Structural	**Spider: List names of conductors in descending order of years of work.** **SQL: SELECT Name FROM conductor ORDER BY Year_of_Work DESC** **Google:** コンダクターの名前と降順での勤務年数を示す? *(List both name and year)* **MultiSpider:** 勤務年数の降順での指揮者の名前は? *(List only name)*		



① Schema Translation

☑ Value Matching
☑ Question Accordance

Rating	Share	Attendance
5.2	22.7%	1026
6.7	28.0%	695

评分	市场份额	出席人数
5.2	22.7%	1026
6.7	28.0%	695

② Question Translation

☑ SQL Alignment
☑ Schema Alignment

What is the average attendance of shows?

SELECT avg(Attendance) FROM SHOW

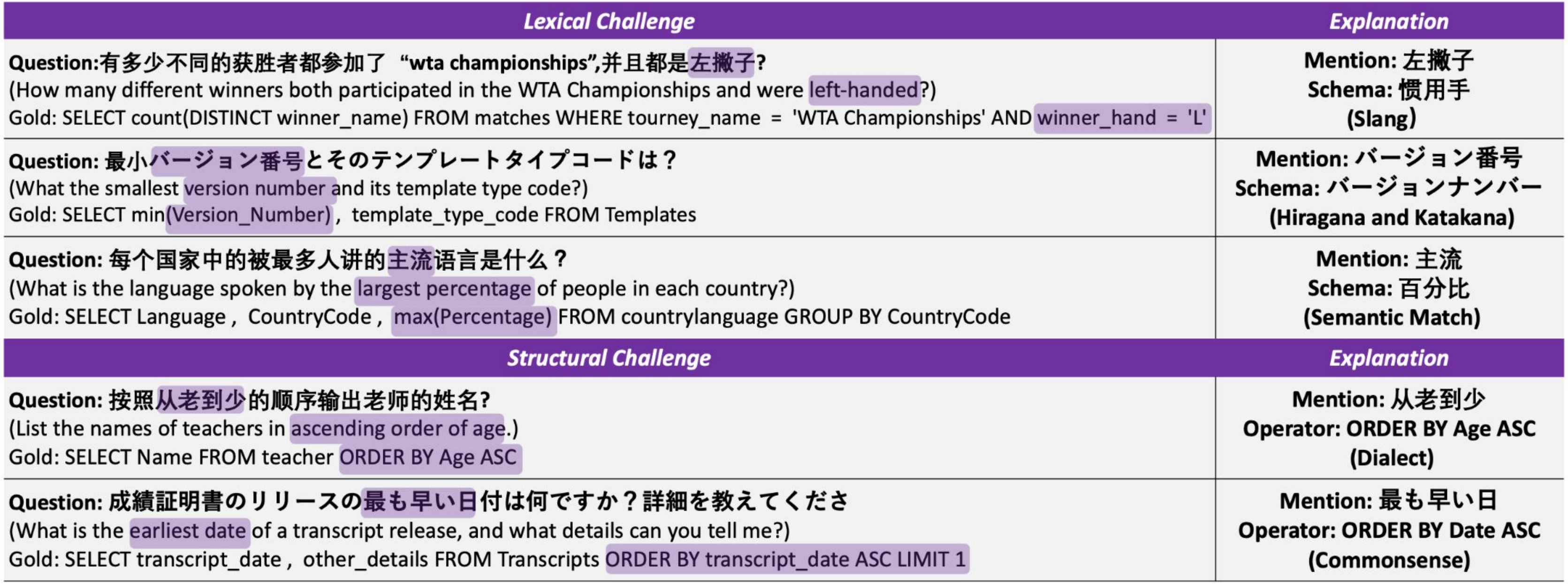
表演的平均出席人数是多少?

SELECT avg(出席人数) FROM 演出

③ Cross Validation

- To ensure the dataset quality, we identify five **typical translation mistakes**.
- Organize the construction pipeline consisting of **multi-round translation**.

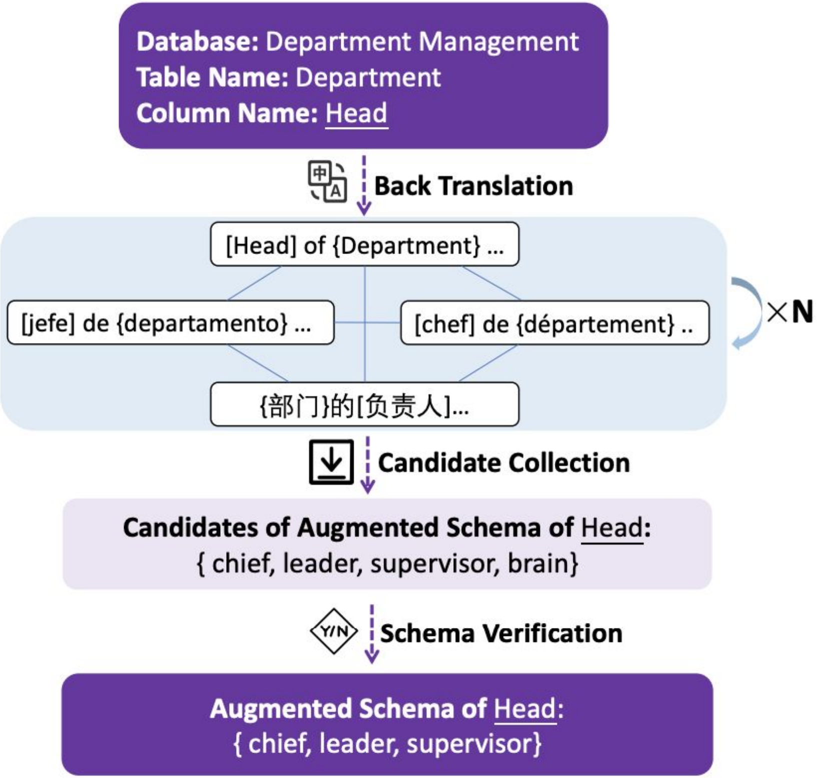
Analysis: More Challenging



Lexical Challenge	*Explanation*
Question:有多少不同的获胜者都参加了 “wta championships”,并且都是左撇子? (How many different winners both participated in the WTA Championships and were left-handed?) Gold: SELECT count(DISTINCT winner_name) FROM matches WHERE tourney_name = 'WTA Championships' AND winner_hand = 'L'	Mention: 左撇子 Schema: 惯用手 (Slang)
Question: 最小バージョン番号とそのテンプレートタイプコードは？ (What the smallest version number and its template type code?) Gold: SELECT min(Version_Number) , template_type_code FROM Templates	Mention: バージョン番号 Schema: バージョンナンバー (Hiragana and Katakana)
Question: 每个国家中的被最多人讲的主流语言是什么？ (What is the language spoken by the largest percentage of people in each country?) Gold: SELECT Language , CountryCode , max(Percentage) FROM countrylanguage GROUP BY CountryCode	Mention: 主流 Schema: 百分比 (Semantic Match)
Structural Challenge	***Explanation***
Question: 按照从老到少的顺序输出老师的姓名? (List the names of teachers in ascending order of age.) Gold: SELECT Name FROM teacher ORDER BY Age ASC	Mention: 从老到少 Operator: ORDER BY Age ASC (Dialect)
Question: 成績証明書のリリースの最も早い日付は何ですか？詳細を教えてくださ (What is the earliest date of a transcript release, and what details can you tell me?) Gold: SELECT transcript_date , other_details FROM Transcripts ORDER BY transcript_date ASC LIMIT 1	Mention: 最も早い日 Operator: ORDER BY Date ASC (Commonsense)

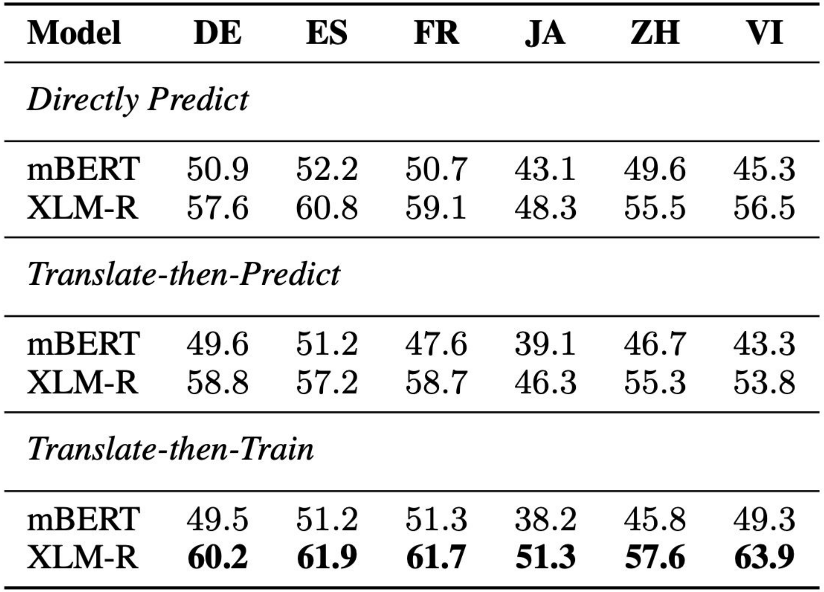
- The **specific language properties** like Hiragana and Katakana (Japanese).
- The **morphologically rich** language (German and French).
- The **dialect and slang sayings** require further commonsense reasoning.

SAVe: Schema Augmentation


Database: Department Management
Table Name: Department
Column Name: Head
Back Translation
[Head] of {Department} ...
[jefe] de {departamento} ...
[chef] de {département} ..
{部门}的[负责人]...
×N
Candidate Collection
Candidates of Augmented Schema of Head:
{ chief, leader, supervisor, brain}
Y/N
Schema Verification
Augmented Schema of Head:
{ chief, leader, supervisor}

- Schema Augmentation-with-Verification
- Back Translation with Machine Translation tools (e.g., Google NMT, M100)
- Schema Verification with Natural Language Inference (e.g., XNLI)

Experiments: Zero-shot Setting



Model	**DE**	**ES**	**FR**	**JA**	**ZH**	**VI**
Directly Predict						
mBERT	50.9	52.2	50.7	43.1	49.6	45.3
XLM-R	57.6	60.8	59.1	48.3	55.5	56.5
Translate-then-Predict						
mBERT	49.6	51.2	47.6	39.1	46.7	43.3
XLM-R	58.8	57.2	58.7	46.3	55.3	53.8
Translate-then-Train						
mBERT	49.5	51.2	51.3	38.2	45.8	49.3
XLM-R	**60.2**	**61.9**	**61.7**	**51.3**	**57.6**	**63.9**

- **Better model** enables better zero-shot transfer (XLM-R > mBERT).

- Directly predict receives better performance about 1.6% (MT creates mistakes) compared with translate-then-predict.

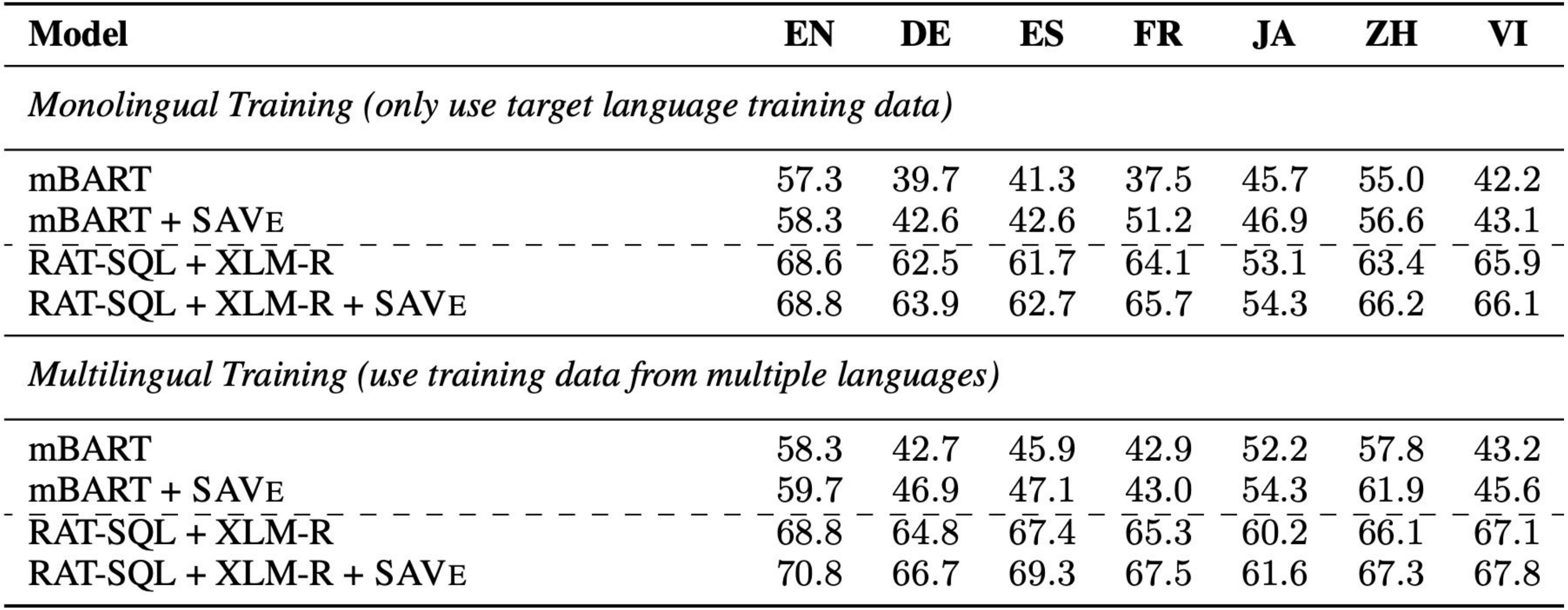
- Strong PLM with Strong MT yields **promising zero-shot** performance.

- Directly Predict (Train: English, Test: Target)

- Translate-then-Predict (Train: English, Test: Target to English)

- Translate-then-Train (Train: English to Target, Test: Target)

Experiments: Monolingual & Multilingual Setting

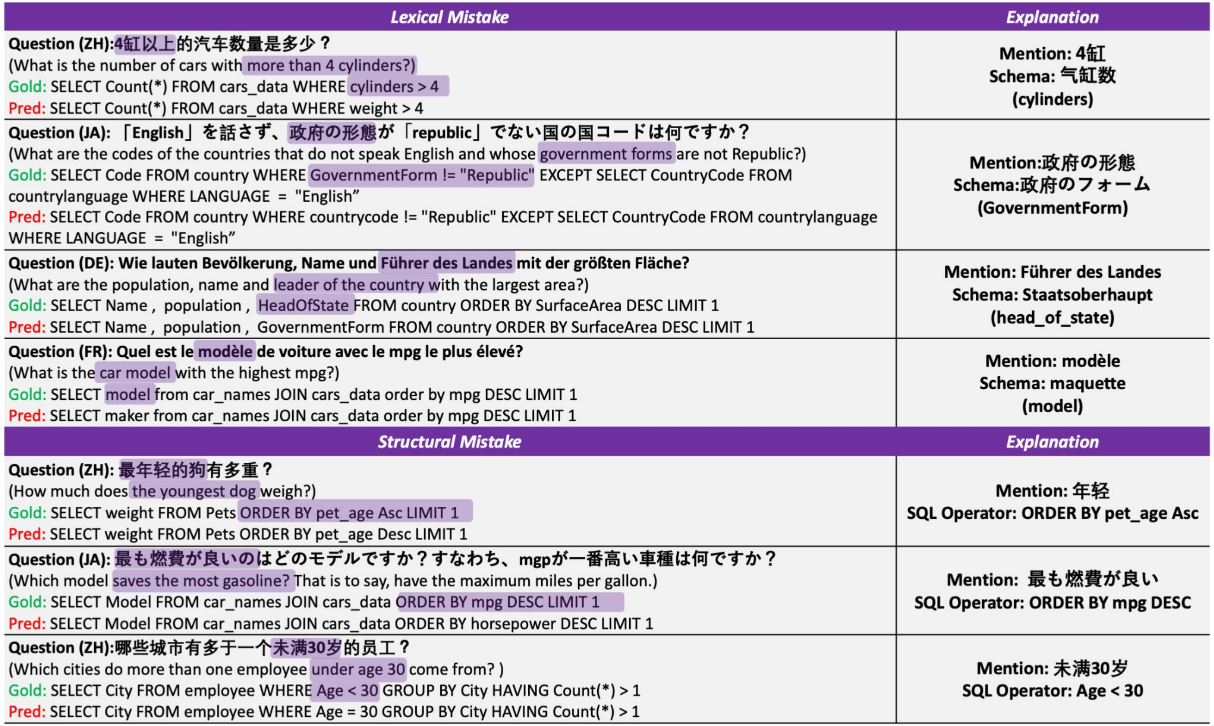


Model	EN	DE	ES	FR	JA	ZH	VI
Monolingual Training (only use target language training data)							
mBART	57.3	39.7	41.3	37.5	45.7	55.0	42.2
mBART + SAVE	58.3	42.6	42.6	51.2	46.9	56.6	43.1
RAT-SQL + XLM-R	68.6	62.5	61.7	64.1	53.1	63.4	65.9
RAT-SQL + XLM-R + SAVE	68.8	63.9	62.7	65.7	54.3	66.2	66.1
Multilingual Training (use training data from multiple languages)							
mBART	58.3	42.7	45.9	42.9	52.2	57.8	43.2
mBART + SAVE	59.7	46.9	47.1	43.0	54.3	61.9	45.6
RAT-SQL + XLM-R	68.8	64.8	67.4	65.3	60.2	66.1	67.1
RAT-SQL + XLM-R + SAVE	70.8	66.7	69.3	67.5	61.6	67.3	67.8

- The performance of **Japanese** is significantly behind other languages.
- The absolute **drop** of accuracy in **non-English** languages is about **6.1%**.
- **SAVe** significantly **improves** the non-English languages **(1.4%-1.9%)**.

Discussion

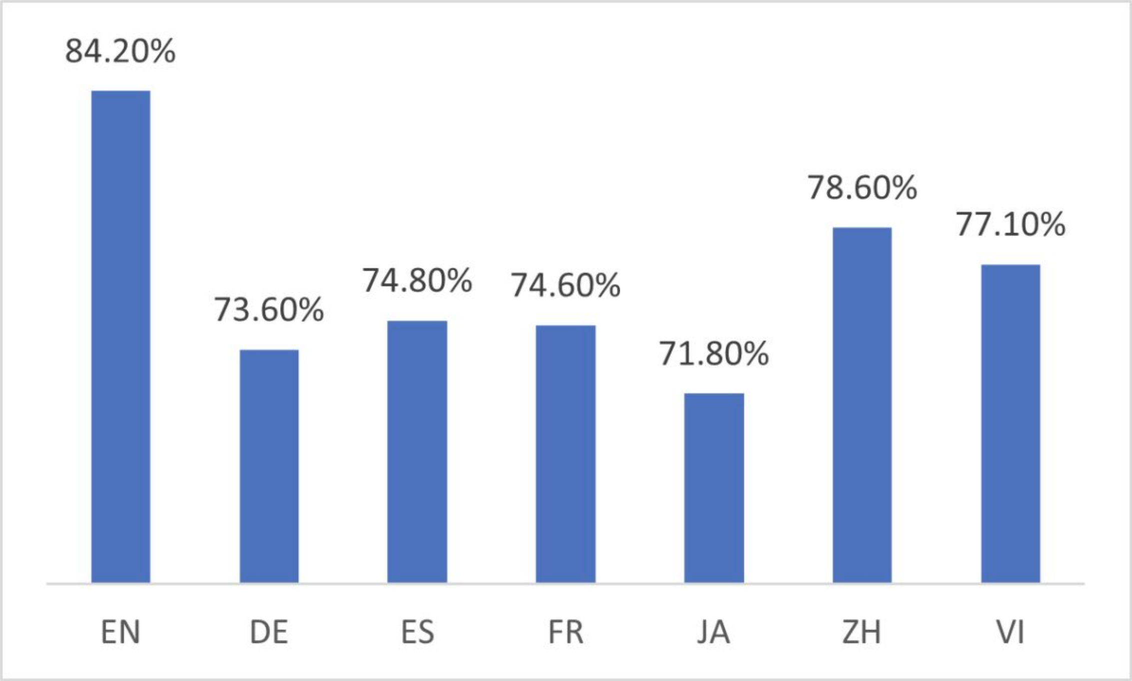
- What causes the performance drop in non-English languages?
  - **Specific language properties** and the **dialect sayings** lead to the performance drop in non-English languages.



Lexical Mistake	*Explanation*
Question (ZH):4缸以上的汽车数量是多少？ (What is the number of cars with more than 4 cylinders?) Gold: SELECT Count(*) FROM cars_data WHERE cylinders > 4 Pred: SELECT Count(*) FROM cars_data WHERE weight > 4	**Mention: 4缸** **Schema: 气缸数** **(cylinders)**
Question (JA): 「English」を話さず、政府の形態が「republic」でない国の国コードは何ですか？ (What are the codes of the countries that do not speak English and whose government forms are not Republic?) Gold: SELECT Code FROM country WHERE GovernmentForm != "Republic" EXCEPT SELECT CountryCode FROM countrylanguage WHERE LANGUAGE = "English" Pred: SELECT Code FROM country WHERE countrycode != "Republic" EXCEPT SELECT CountryCode FROM countrylanguage WHERE LANGUAGE = "English"	**Mention:政府の形態** **Schema:政府のフォーム** **(GovernmentForm)**
Question (DE): Wie lauten Bevölkerung, Name und Führer des Landes mit der größten Fläche? (What are the population, name and leader of the country with the largest area?) Gold: SELECT Name , population , HeadOfState FROM country ORDER BY SurfaceArea DESC LIMIT 1 Pred: SELECT Name , population , GovernmentForm FROM country ORDER BY SurfaceArea DESC LIMIT 1	**Mention: Führer des Landes** **Schema: Staatsoberhaupt** **(head_of_state)**
Question (FR): Quel est le modèle de voiture avec le mpg le plus élevé? (What is the car model with the highest mpg?) Gold: SELECT model from car_names JOIN cars_data order by mpg DESC LIMIT 1 Pred: SELECT maker from car_names JOIN cars_data order by mpg DESC LIMIT 1	**Mention: modèle** **Schema: maquette** **(model)**
Structural Mistake	***Explanation***
Question (ZH): 最年轻的狗有多重？ (How much does the youngest dog weigh?) Gold: SELECT weight FROM Pets ORDER BY pet_age Asc LIMIT 1 Pred: SELECT weight FROM Pets ORDER BY pet_age Desc LIMIT 1	**Mention: 年轻** **SQL Operator: ORDER BY pet_age Asc**
Question (JA): 最も燃費が良いのはどのモデルですか？すなわち、mgpが一番高い車種は何ですか？ (Which model saves the most gasoline? That is to say, have the maximum miles per gallon.) Gold: SELECT Model FROM car_names JOIN cars_data ORDER BY mpg DESC LIMIT 1 Pred: SELECT Model FROM car_names JOIN cars_data ORDER BY horsepower DESC LIMIT 1	**Mention: 最も燃費が良い** **SQL Operator: ORDER BY mpg DESC**
Question (ZH):哪些城市有多于一个未满30岁的员工？ (Which cities do more than one employee under age 30 come from?) Gold: SELECT City FROM employee WHERE Age < 30 GROUP BY City HAVING Count(*) > 1 Pred: SELECT City FROM employee WHERE Age = 30 GROUP BY City HAVING Count(*) > 1	**Mention: 未满30岁** **SQL Operator: Age < 30**

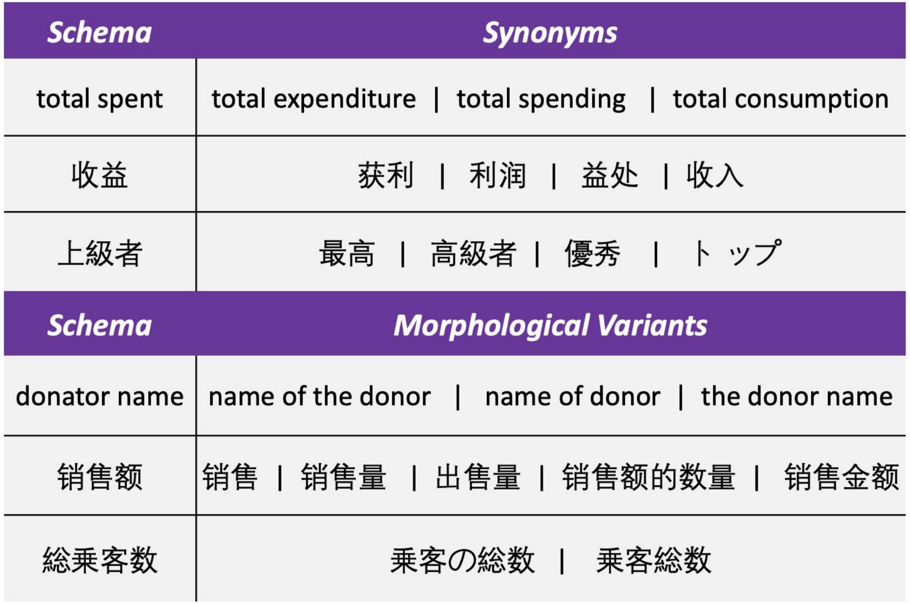
Discussion

- What causes the performance drop in non-English languages?
  - **Schema-linking** becomes more **challenging** in non-English languages.



Discussion

- How schema augmentation SAVE improves the model?
  - **Synonyms** that semantically identical with the original schema but with different lemmas.
  - **Morphological variants** that change the forms of schema syntactically.



Schema	*Synonyms*
total spent	total expenditure | total spending | total consumption
收益	获利 | 利润 | 益处 | 收入
上級者	最高 | 高級者 | 優秀 | ト ップ

Schema	*Morphological Variants*
donator name	name of the donor | name of donor | the donor name
销售额	销售 | 销售量 | 出售量 | 销售额的数量 | 销售金额
総乗客数	乗客の総数 | 乗客総数

Future Work

(1) Developing a multilingual text-to-SQL system and apply it in the real **globalization scenario**.

(2) Leveraging better pretrained model and advancing **architecture design** to address the lexical challenge and structural challenge in multilingual settings.

(3) **Expanding SAVe** to other table-related task (e.g., TabFact) and further improve the schema verification accuracy.

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Thanks!

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Paper/Slides/Code in https://longxudou.github.io/