Learning to Ask Unanswerable Questions for Machine Reading Comprehension

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Machine Reading Comprehension (MRC)

- Answering questions about the given paragraph

Paragraph: "*… Public schools, also known as state or government schools, are funded and run directly by the Victoria Department of Education . Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools …*"

Question1: "***What organization runs the public schools in Victoria?***"

Answer: "***Victoria Department of Education***"

MRC with Unanswerable Questions

- Answering questions about the given paragraph
- **Abstain from answering unanswerable questions**

Paragraph: "*… Public schools, also known as state or government schools, are funded and run directly by the Victoria Department of Education . Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools …*"

Question1: "*What organization runs the public schools in Victoria?*"

Answer: "*Victoria Department of Education*"

Question2: "***What organization runs the waste management in Victoria?***"

Answer: **<No-Answer>**

Related Work

- Machine reading comprehension

  Wang and Jiang, (2017); Seo et al., (2017); Wang et al., (2017); Hu et al., (2018); Huang et al., (2018); Liu et al., (2018); Yu et al., (2018); Wang et al., (2018); ...

Related Work

- Machine reading comprehension

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- Question generation

  Du et al. (2017); Yuan et al., (2017); Zhou et al., (2018); Du and Cardie, (2018); Sun et al., (2018); Song et al. (2018); Yao et al. (2018); Kim et al. (2019); Dong et al., (2019);

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- Adversarial examples

  Jia and Liang (2017); Clark and Gardner (2018); Tan et al. (2018); Rajpurkar et al. (2018);

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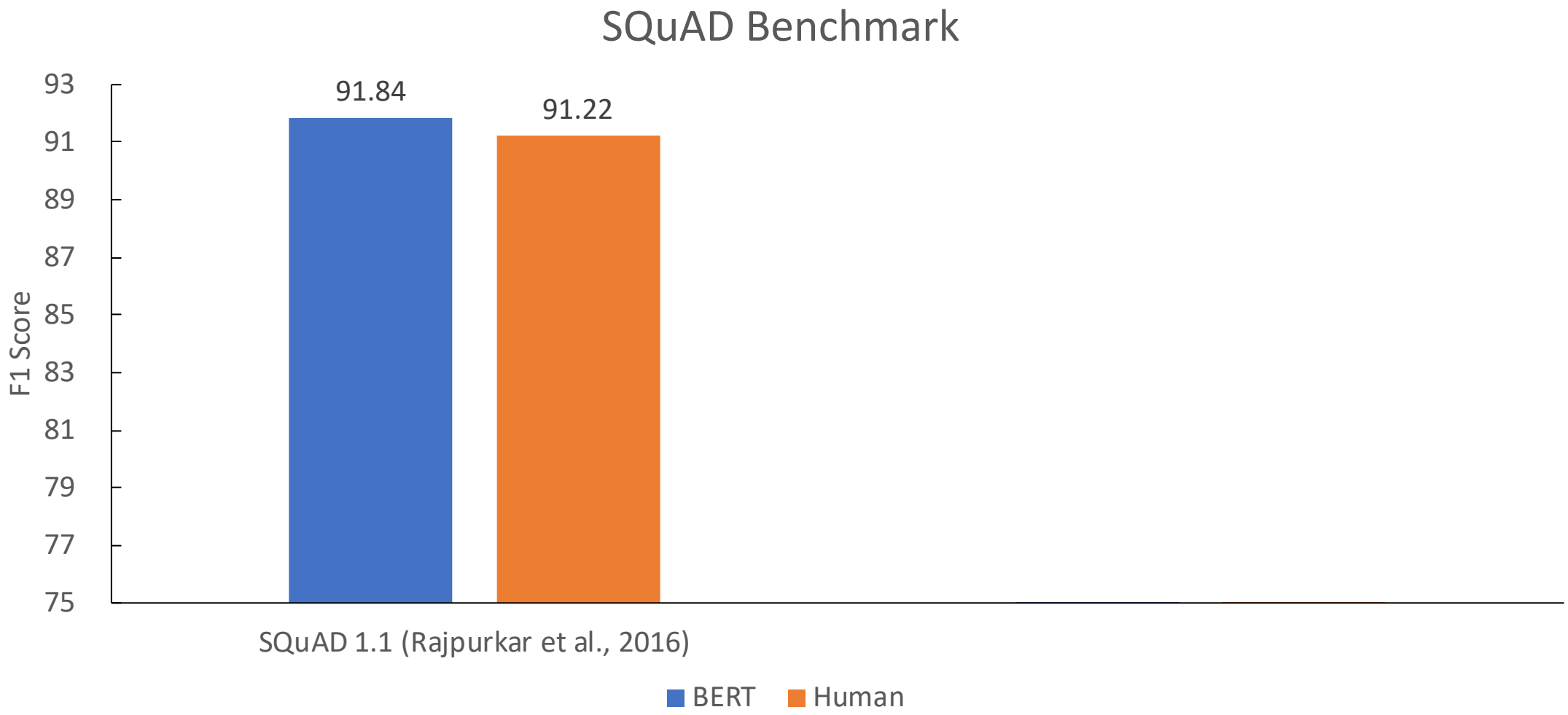
- Adversarial examples

  Jia and Liang (2017); Clark and Gardner (2018); Tan et al. (2018); Rajpurkar et al. (2018);

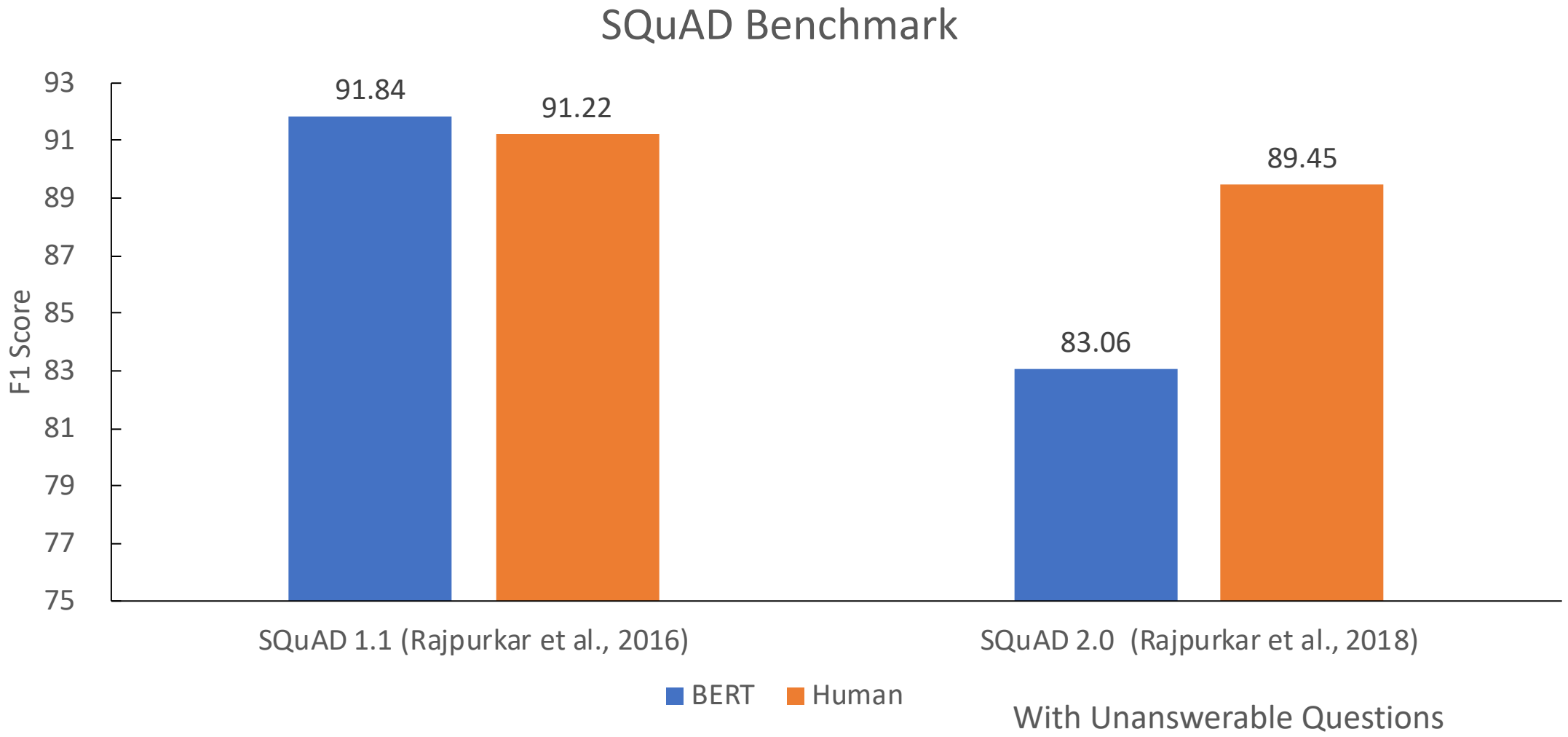
- Data augmentation

  Yu et al. (2018); Devlin et al. (2019); Yang et al. (2017); Sun et al. (2019);

Motivation


SQuAD Benchmark
93
91
89
87
85
83
81
79
77
75
F1 Score
91.84
91.22
SQuAD 1.1 (Rajpurkar et al., 2016)
BERT
Human

Motivation


SQuAD Benchmark
F1 Score
93
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91.84
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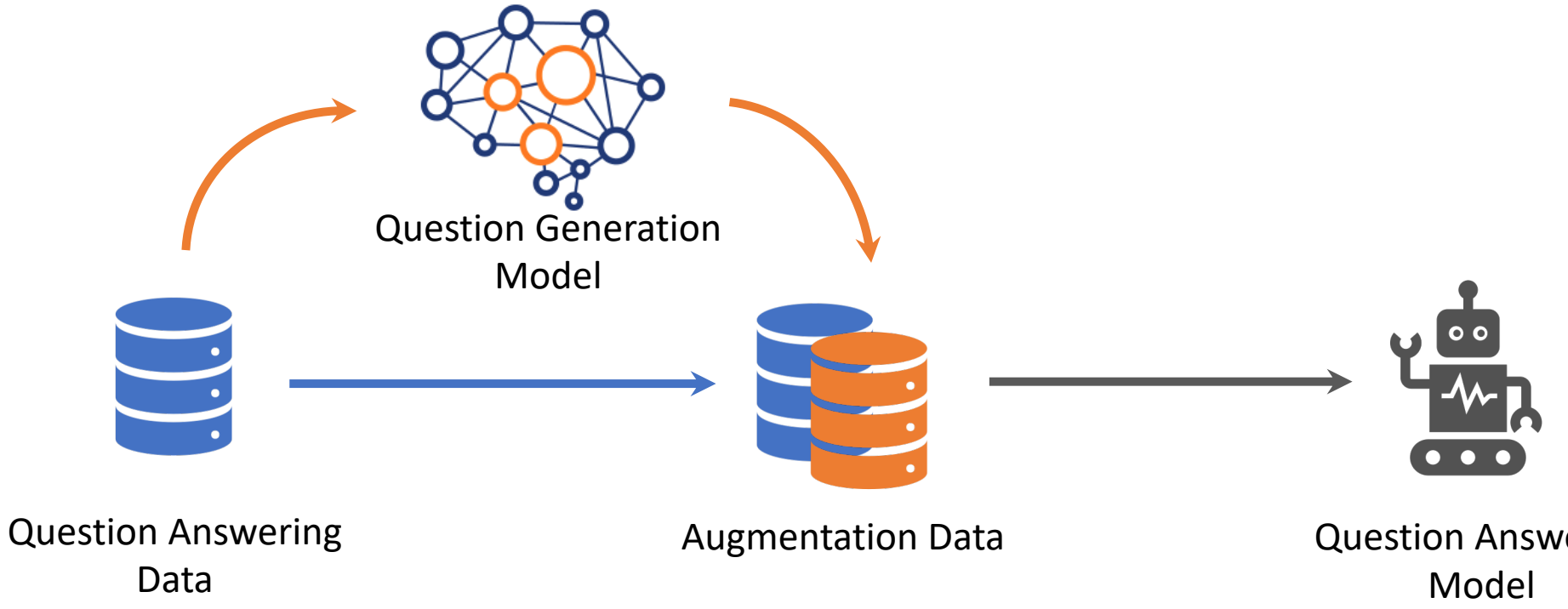
83.06
89.45
SQuAD 1.1 (Rajpurkar et al., 2016)
SQuAD 2.0 (Rajpurkar et al., 2018)
BERT
Human
With Unanswerable Questions

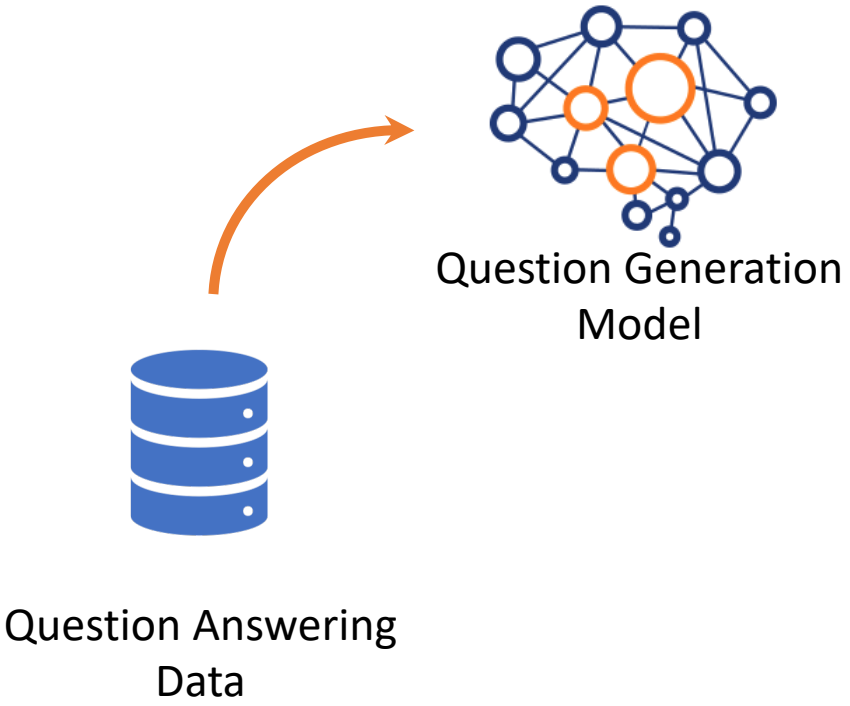
This Work

Generate **unanswerable questions** for **data augmentation** to improve question answering models



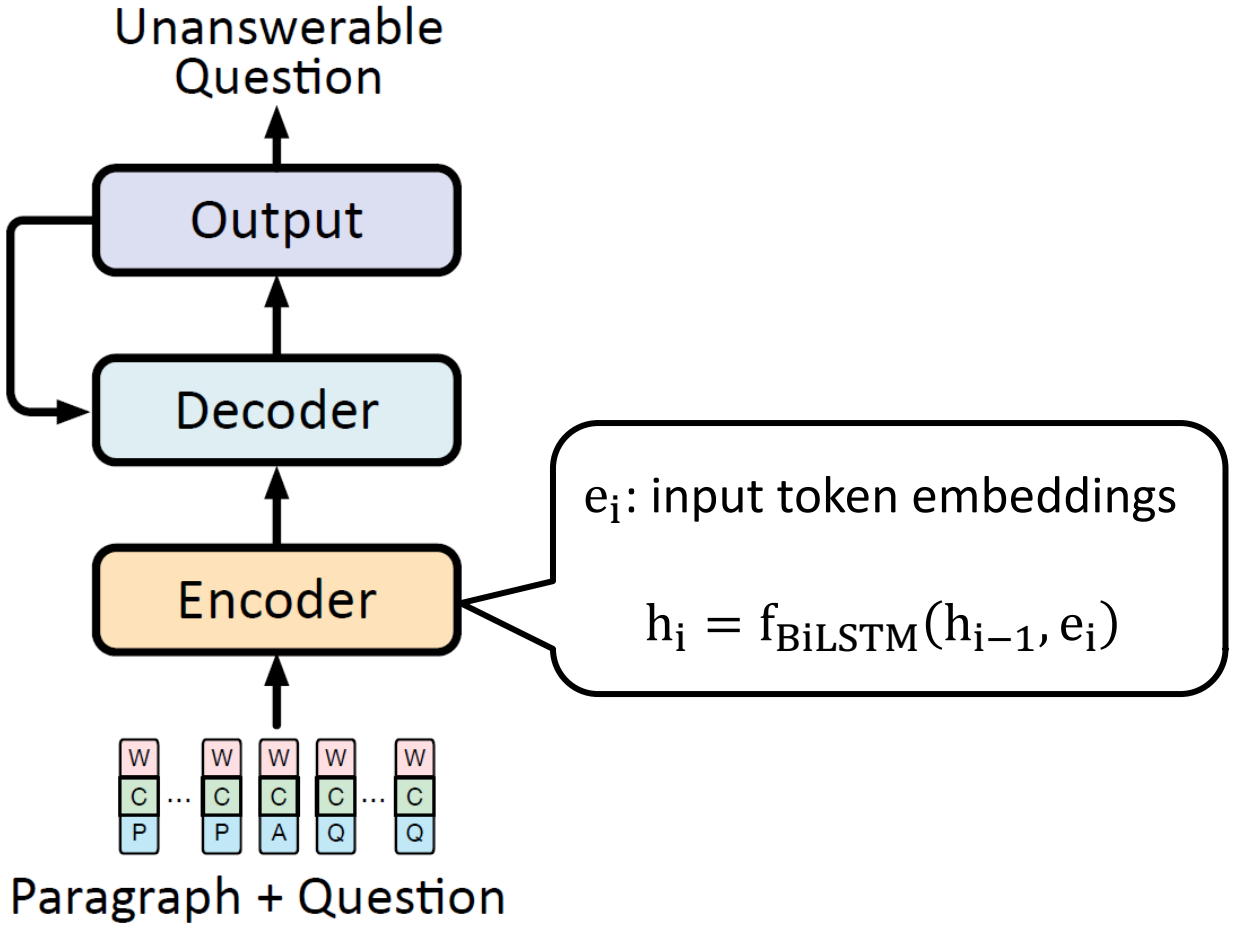
Question Generation

- Question Generation Model
- Question Generation Training Data Construction



Question Generation Model

Seq2Seq: Encode the paragraph and the question sequentially



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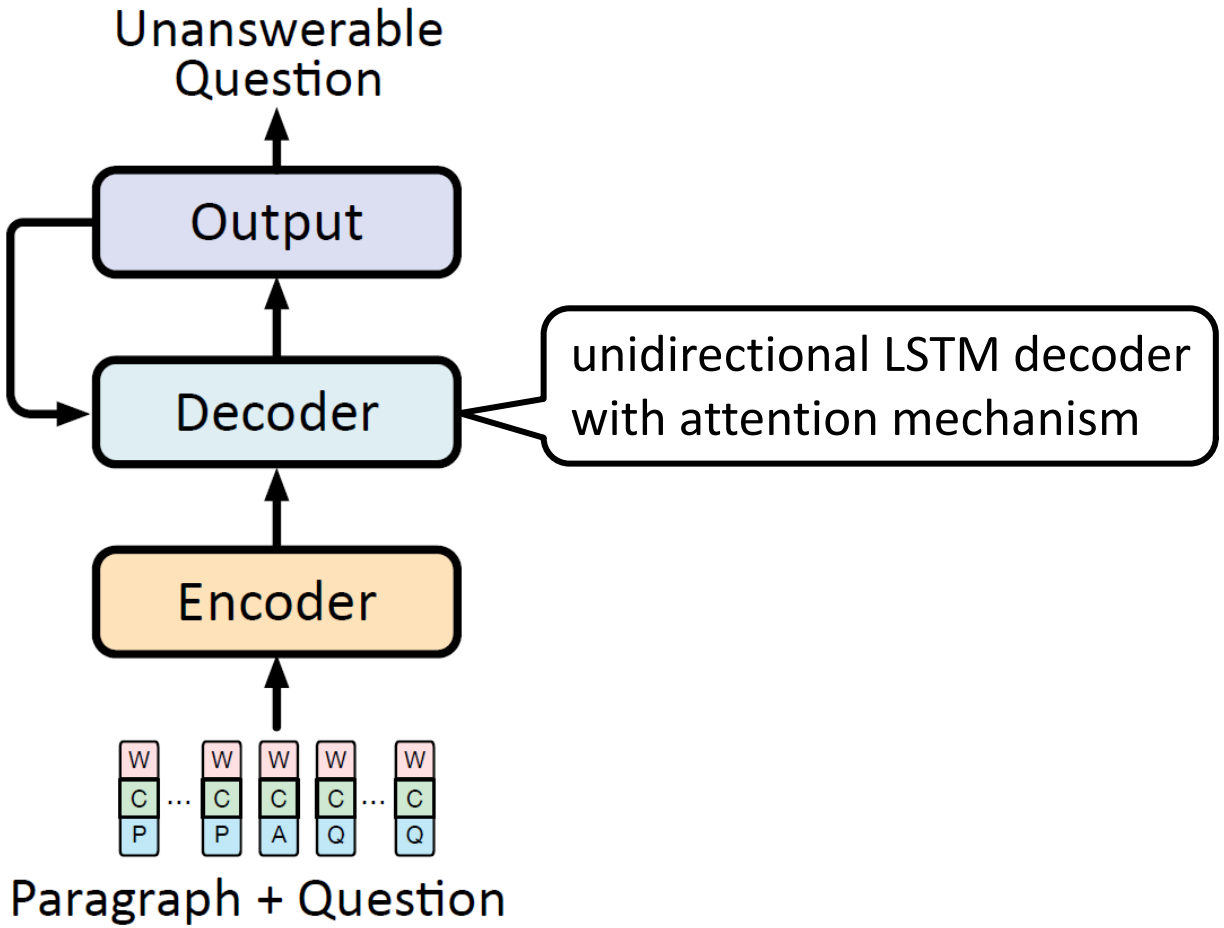

Question Generation Model

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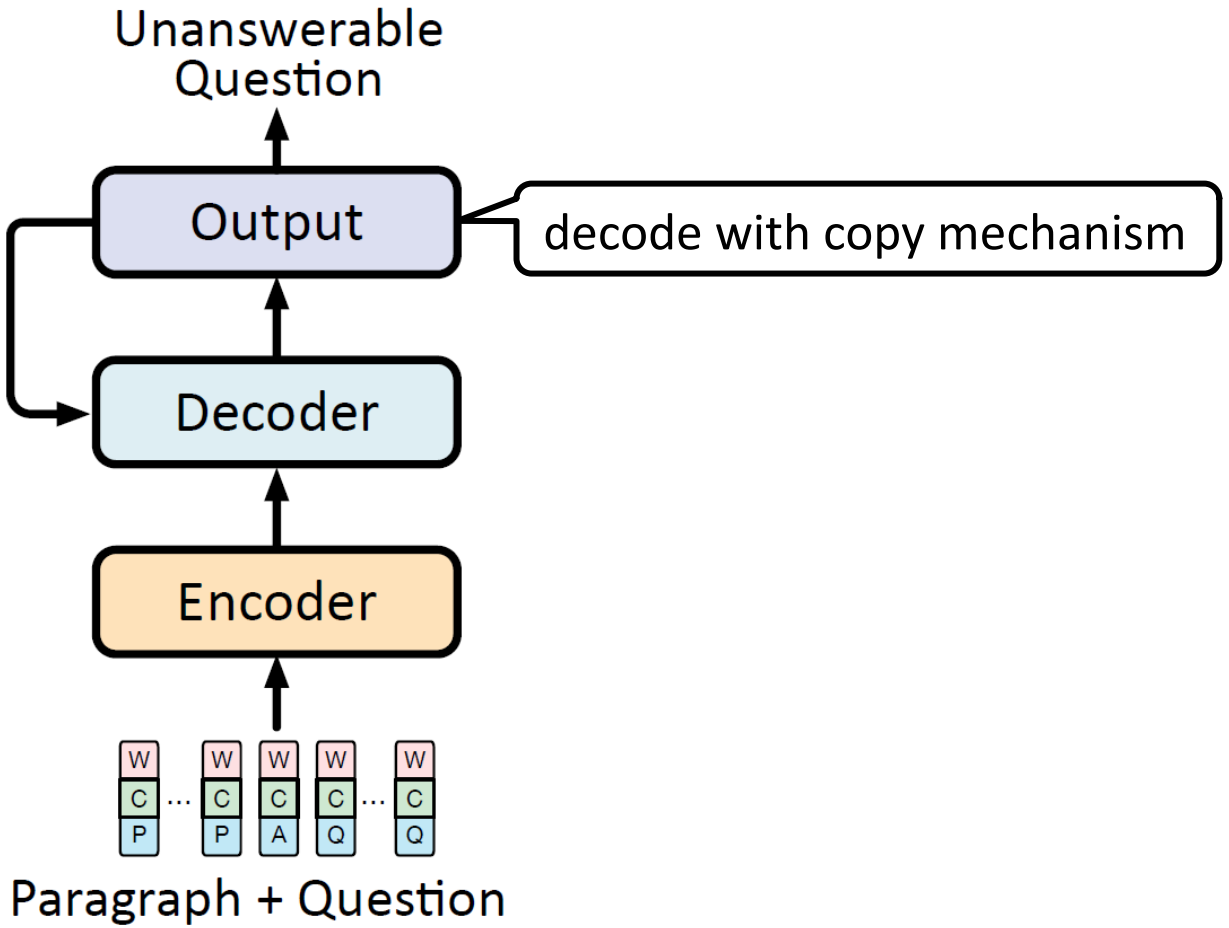
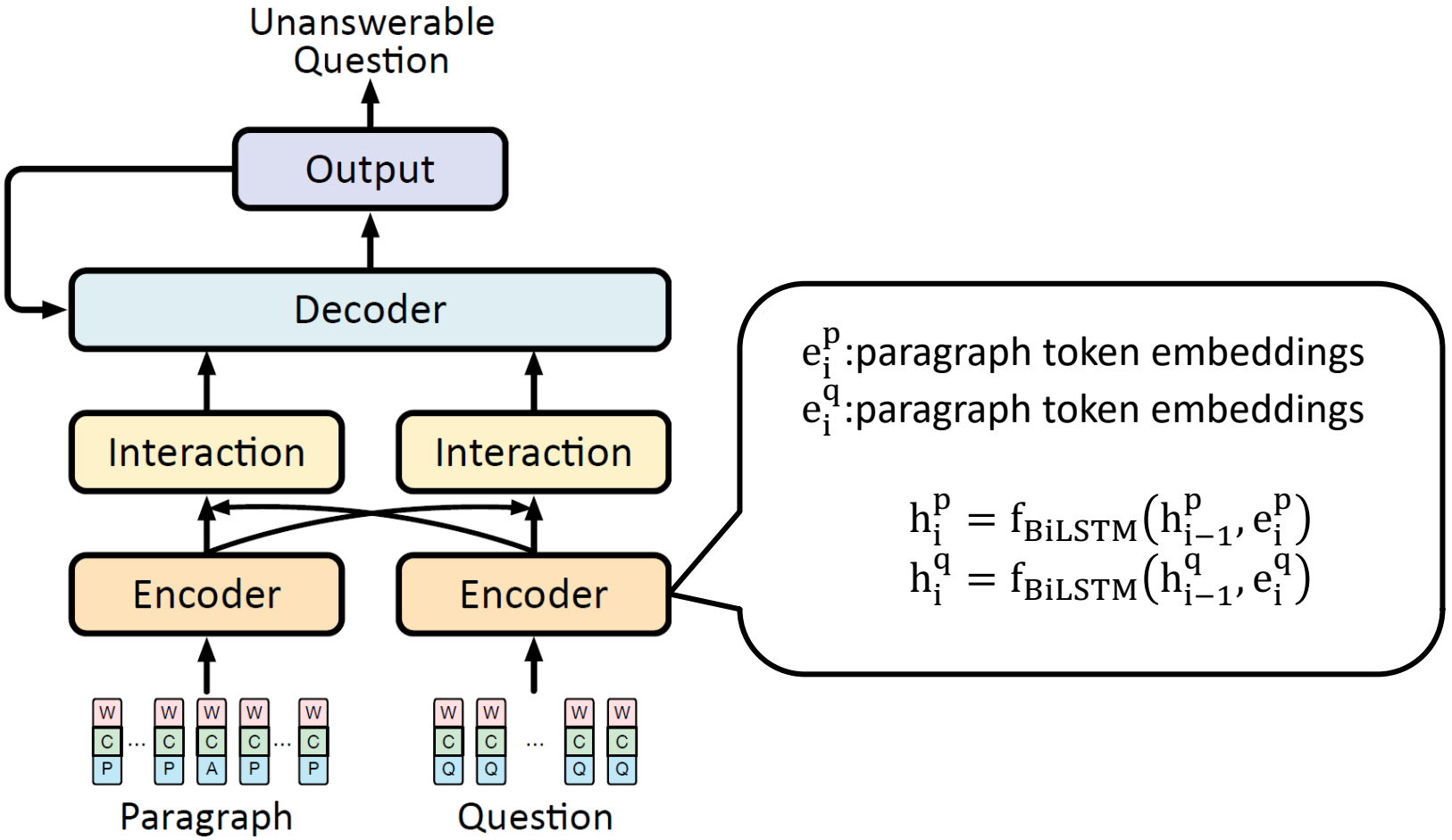


Question Generation Model

Pair2Seq: Capture the **interactions** between the question and the paragraph



Question Generation Model

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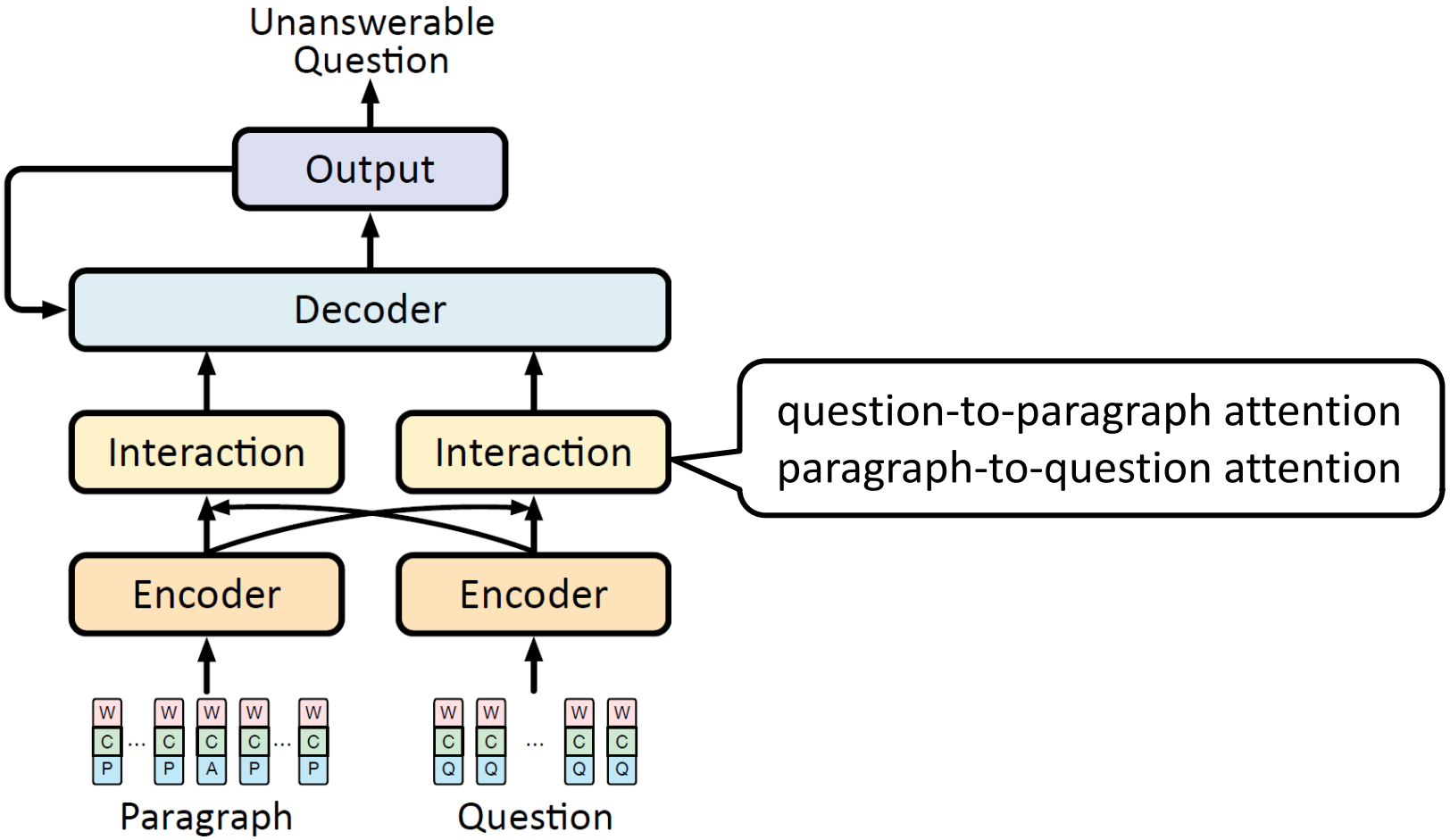


Question Generation Training Data Construction

Example from SQuAD 2.0

Paragraph: *"… Public schools, also known as state or government schools, are funded and run directly by the* ***Victoria Department of Education*** *. Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools …"*

Ans. Question: *"What organization runs the public schools in Victoria?"*

Answer: *"****Victoria Department of Education****"*

UnAns. Question: *"What organization runs the waste management in Victoria?"*

Plausible Answer: *"****Victoria Department of Education****"*

Question Generation Training Data Construction

Question generation example

Paragraph + Ans. Question + Answer → UnAns. Question

Paragraph: *"… Public schools, also known as state or government schools, are funded and run directly by the Victoria Department of Education . Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools …"*

Ans. Question: *"What organization runs the public schools in Victoria?"*

Answer: *"Victoria Department of Education"*

UnAns. Question: *"What organization runs the waste management in Victoria?"*

Training and Inference

- $\boldsymbol{p}$:paragraph, $\boldsymbol{q}$:ans. question, $\boldsymbol{a}$:answer, $\tilde{\boldsymbol{q}}$:unans. question

- Training: maximize the log likelihood

$$\max \sum_{(\tilde{q},q,p,a)\in D} \log P(\tilde{q}|q,p,a;\theta)$$

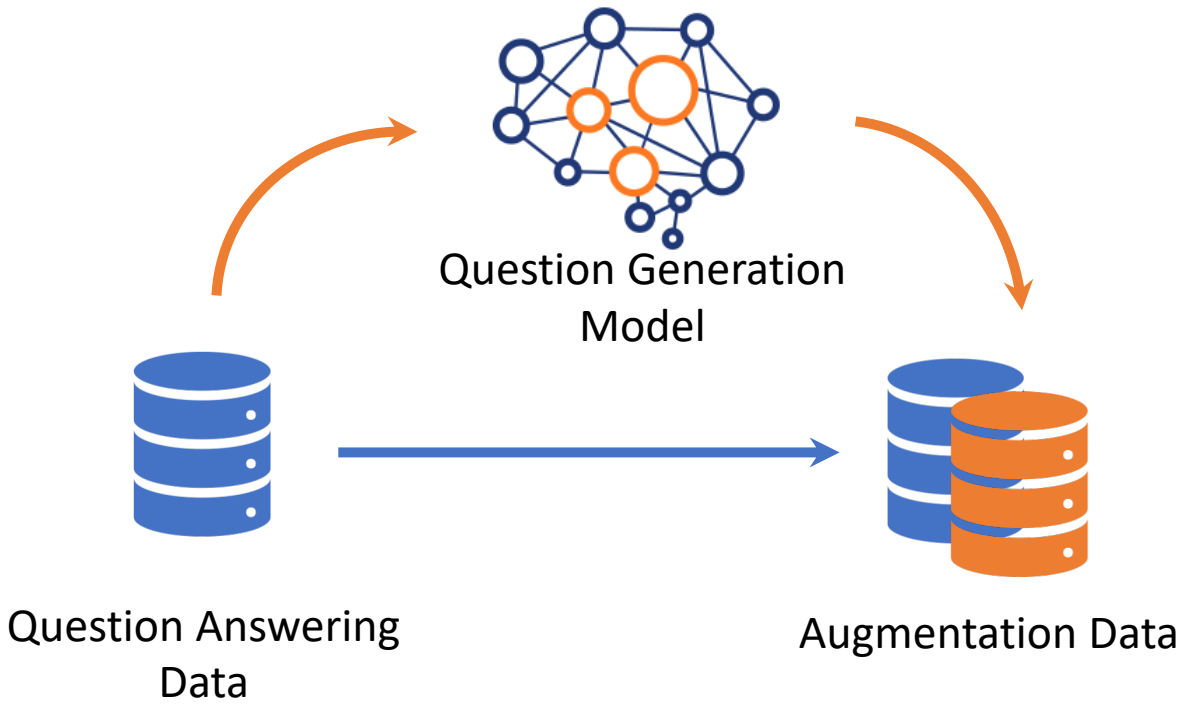
- Inference: beam search

$$\underset{q'}{\operatorname{argmax}}\, P(q'|q,p,a)$$

Data Augmentation Setup

- Unanswerable example generation

  Use trained **generation model** and **answerable** examples to generate **unanswerable** examples



Data Augmentation Setup

- Unanswerable example generation

  Use trained generation model and answerable examples to generate unanswerable examples

- Two-stage training scheme
  - **First stage**: train on **answerable** examples and **generated unanswerable** examples
  - Second stage: fine-tune model parameters on original dataset

Augmentation Data

Question Answering Model

Data Augmentation Setup

- Unanswerable example generation

  Use trained generation model and answerable examples to generate unanswerable examples

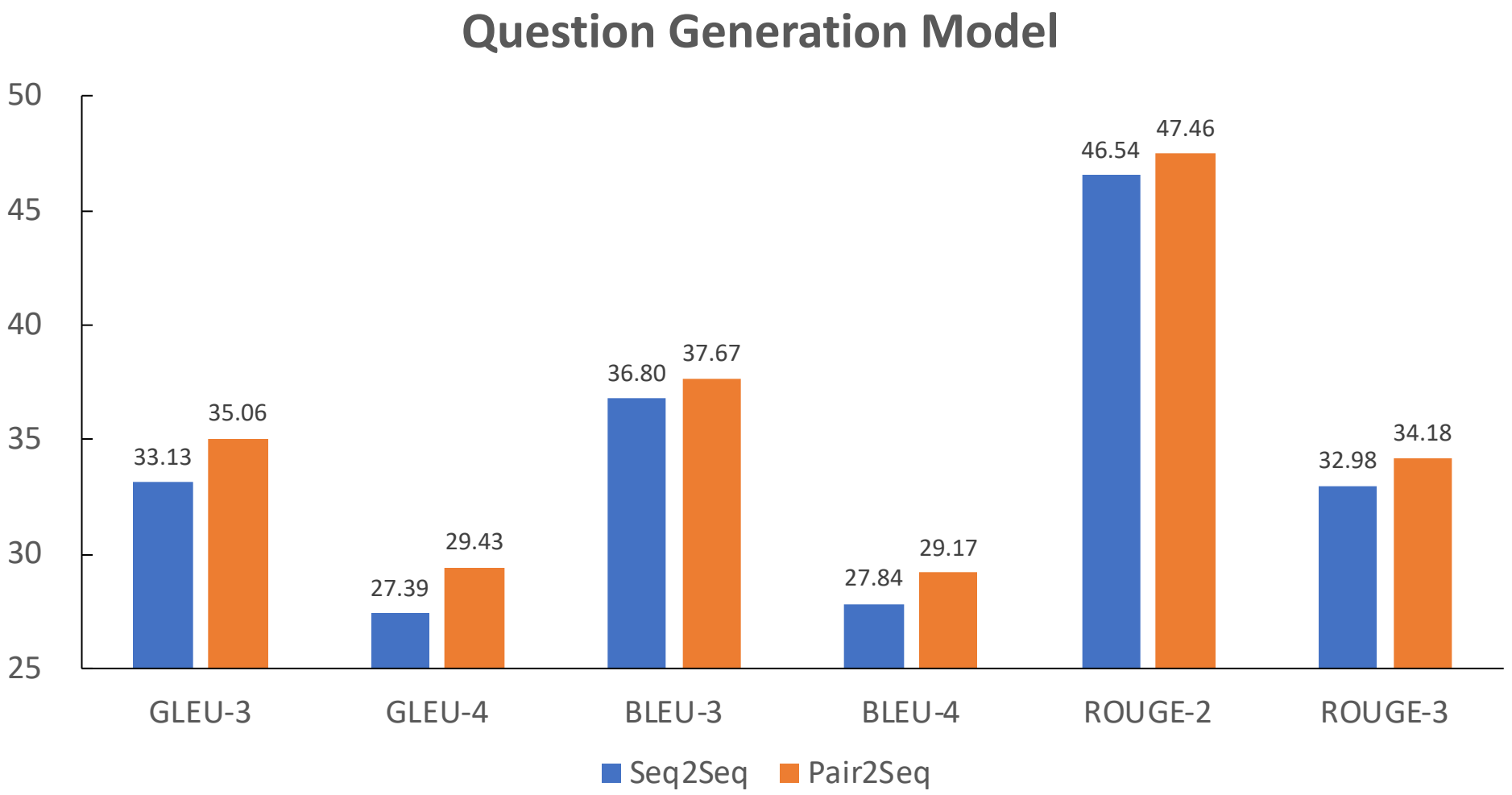
- Two-stage training scheme
  - First stage: train on answerable examples and generated unanswerable examples
  - **Second stage**: **fine-tune** model parameters on **original dataset**

Experiment Settings

- Dataset: SQuAD 2.0 (Rajpurkar et al., 2018)
  - Turker-generated questions about Wikipedia articles
  - 150k+ questions in total
  - **33.4%** questions in training set are unanswerable
- Question Answering Model

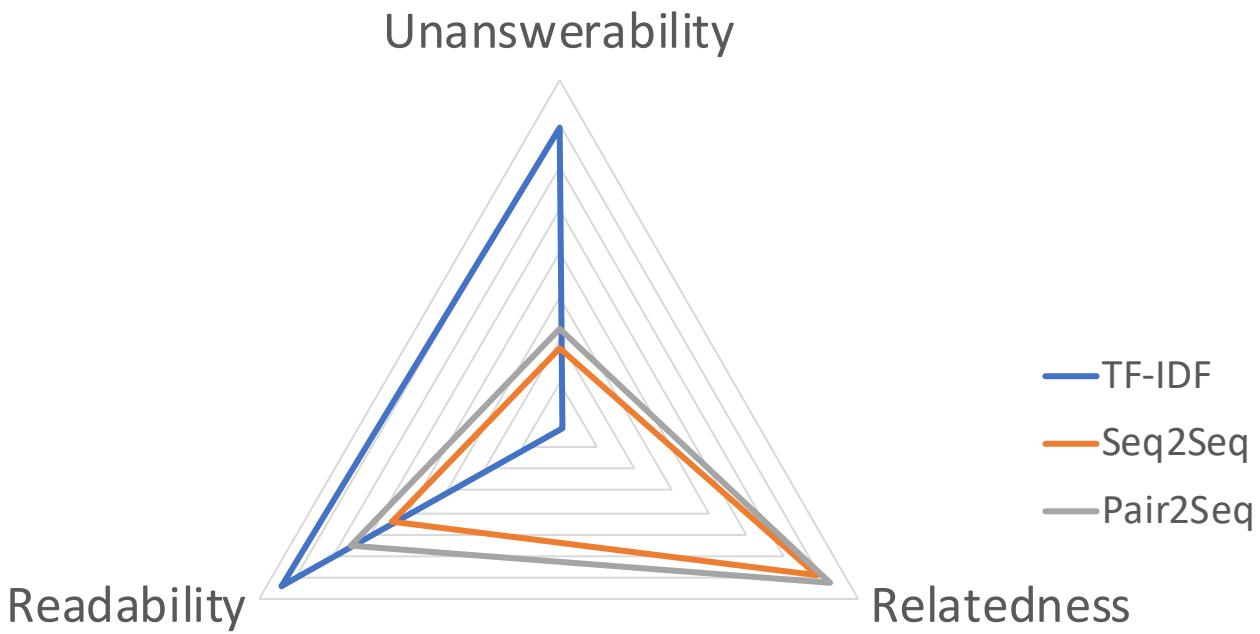
  BERT (Devlin et al., 2019)

Question Generation Results

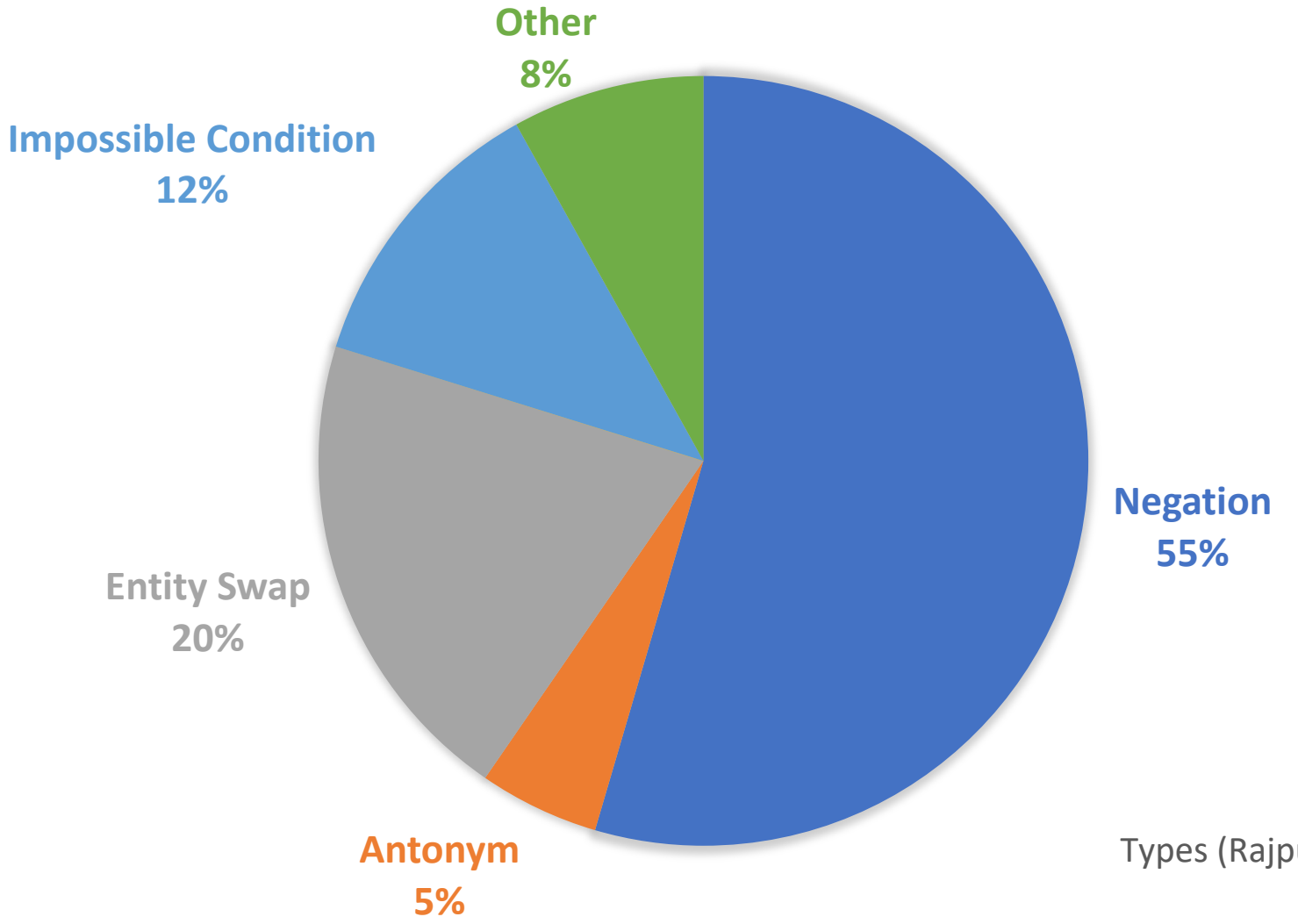


Human Evaluation

	Unanswerability	Relatedness	Readability
TF-IDF	**0.96**	1.52	**2.98**
Seq2Seq	0.62	2.88	2.39
Pair2Seq	0.65	**2.95**	2.61



Types of Generated Questions



Types (Rajpurkar et al., 2018)

Example #1 (Negation)

Paragraph: *"Victorian schools are either publicly or privately funded. Public schools, also known as state or government schools, are funded and run directly by the Victoria Department of Education . Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools run by the Roman Catholic Church and independent schools similar to British public schools. …"*

(Plausible) Answer: *"Roman Catholic Church "*

Ans. Question: *"What church runs some private schools in Victoria?"*

UnAns. Question: *"What church no longer runs some private schools in Victoria?"*

Example #2 (Entity Swap)

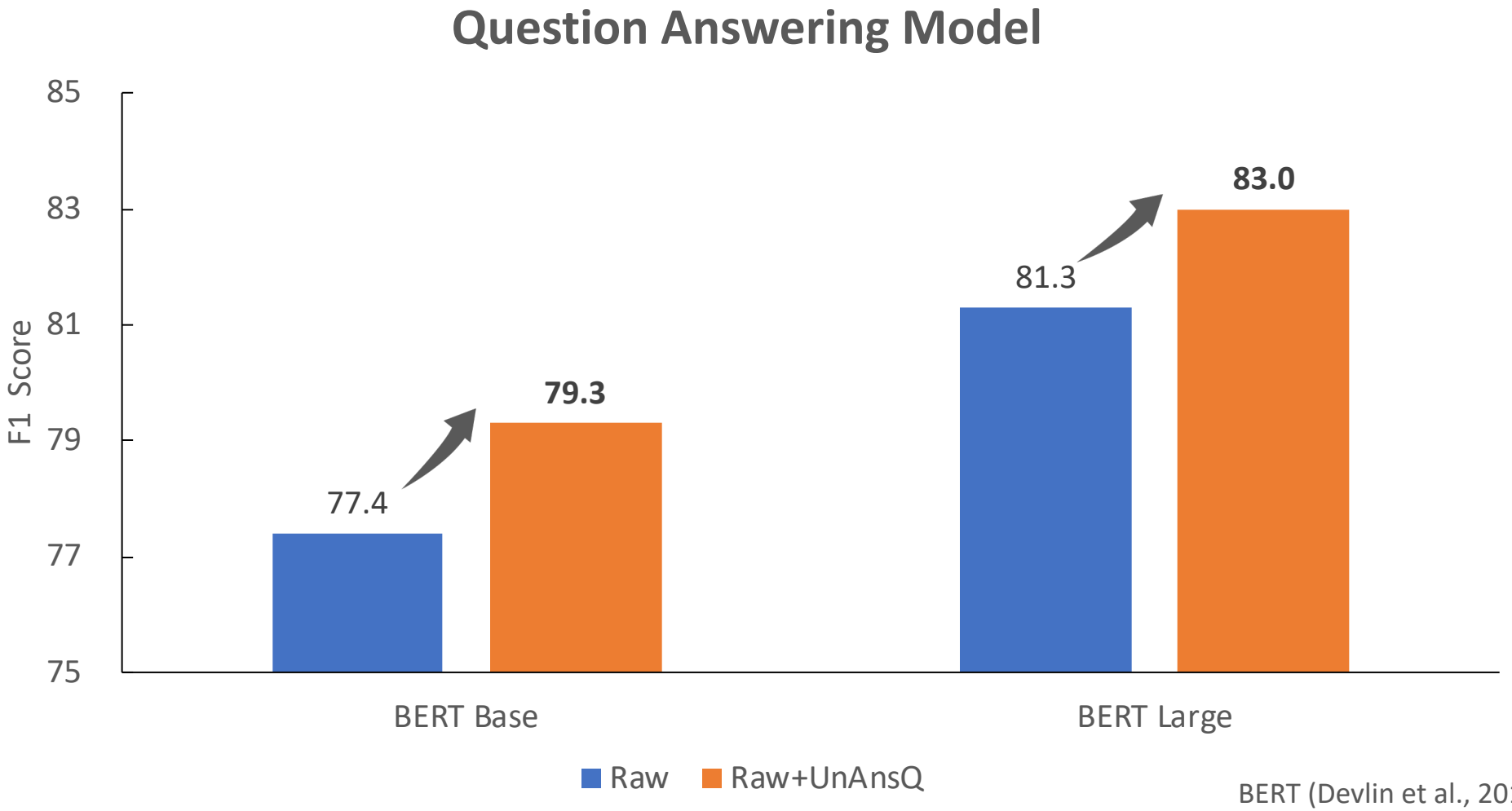
Paragraph: *"Victorian schools are either publicly or privately funded. Public schools, also known as state or government schools, are funded and run directly by the Victoria Department of Education . Students do not pay tuition fees, but some extra costs are levied. Private fee-paying schools include parish schools run by the Roman Catholic Church and independent schools similar to British public schools. …"*

(Plausible) Answer: *"Victoria Department of Education"*

Ans. Question: *"What organization runs the public schools in Victoria?"*

UnAns. Question: *"What organization runs the public schools in Texas?"*

Question Answering Results on SQuAD 2.0



BERT (Devlin et al., 2019)

Question Answering Results on SQuAD 2.0

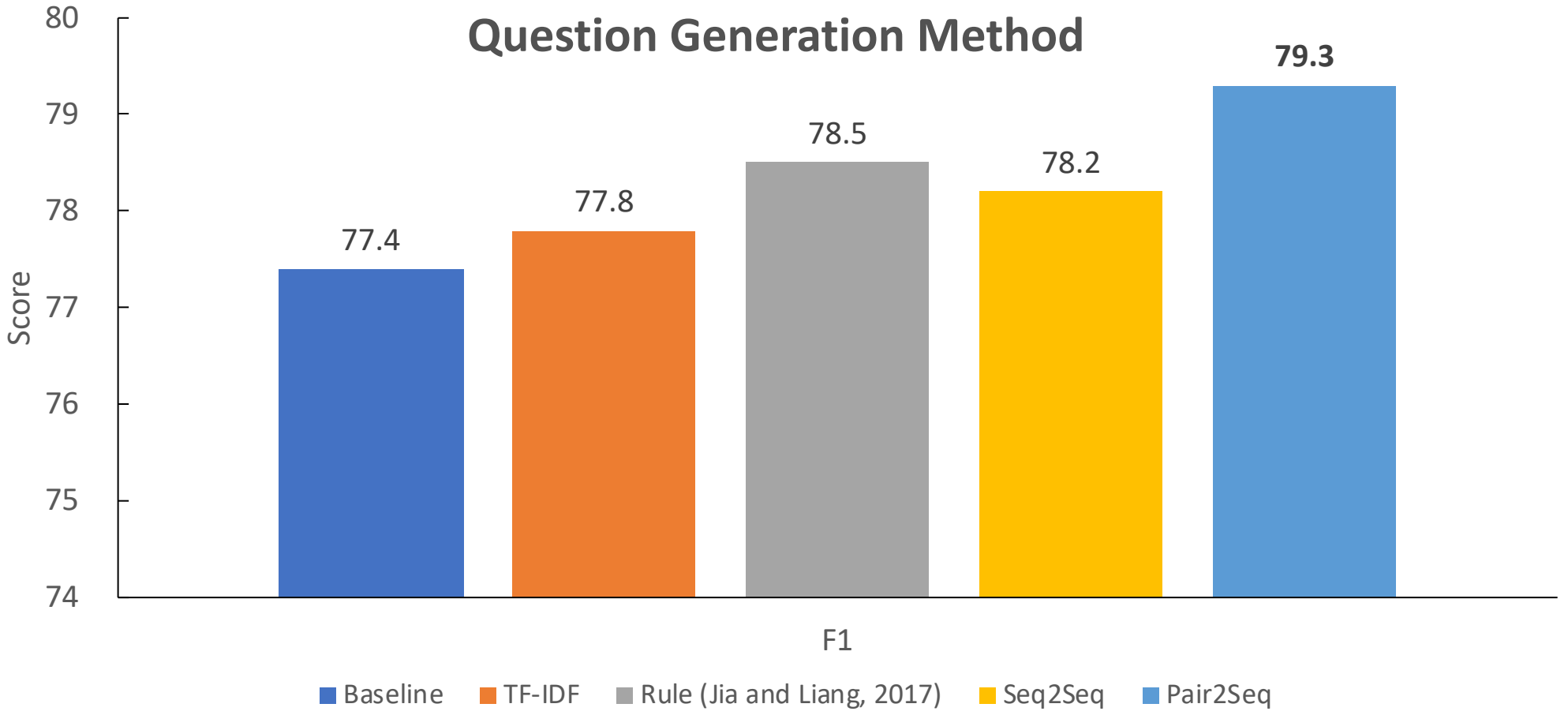
Effects of Augmentation Data Size

Generate multiple unanswerable questions via beam search

	UnAnsQ x1	UnAnsQ x2	UnAnsQ x3
BERT Base	79.3	79.4	79.6
BERT Large	83.0	82.9	83.1

Question Answering Results on SQuAD 2.0

TF-IDF: Retrieve questions from other articles
Rule: Swap entities and replaces words with antonyms



Conclusions & Future Work

- Conclusions
  - Propose to generate unanswerable questions as a means of **data augmentation** for machine reading comprehension
  - Introduce **pair-to-sequence** generation model to capture interactions between question and paragraph
  - Present a way to **construct training data** for unanswerable question generation models

- Future Work

  Leverage external resources (e.g., antonym dictionary) for unanswerable question generation

Thanks!
Q&A

Data available: https://aka.ms/AA5n4od