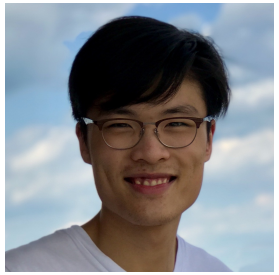
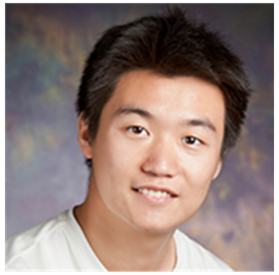
Temporal Common Sense Acquisition with Minimal Supervision


Ben Zhou


Qiang Ning*


Daniel Khashabi*


Dan Roth

Time and Common Sense

- Choose from "*will*" or "*will not*"

Dr. Porter is **taking a vacation** and ___ be able to see you soon.

Dr. Porter is **taking a walk** and ___ be able to see you soon.

Time and Common Sense

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Time and Common Sense

- Choose from “*will*” or “*will not*”

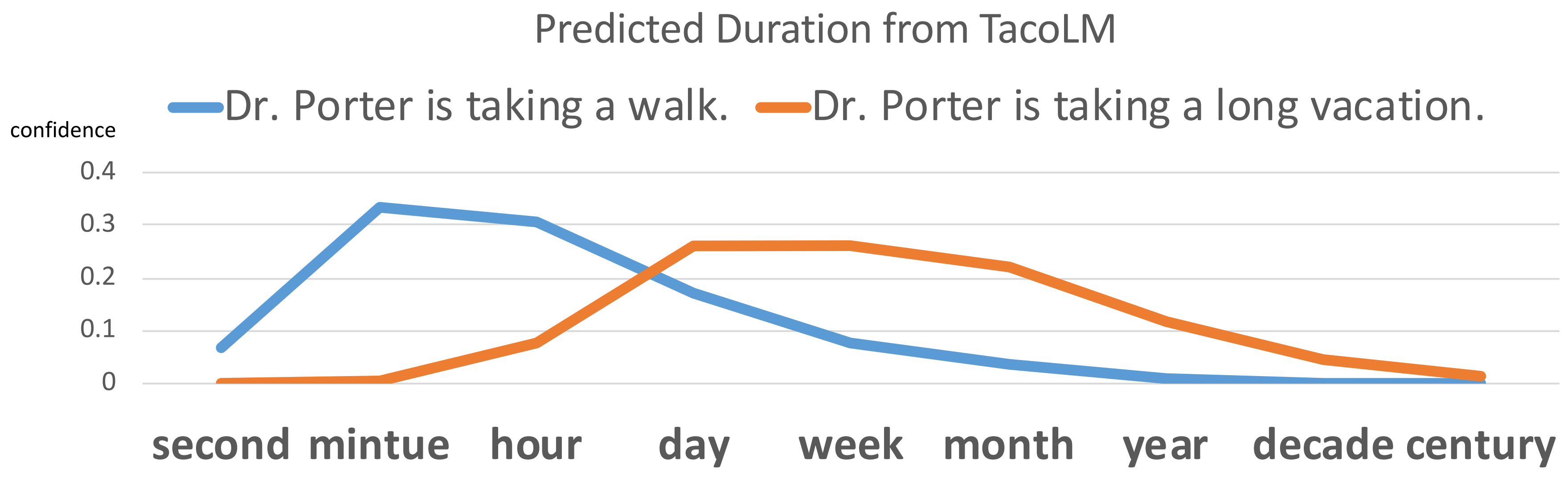
Time:
- An important component for reading comprehension
- Commonsense-level understanding is required

Dr. Porter is **taking a vacation** and will not be able to see you soon.

Dr. Porter is **taking a walk** and will be able to see you soon.

This work

- Time
  - An important component for reading comprehension
  - Commonsense-level understanding is required
- In this work
  - TacoLM – A general LM that is aware of time and temporal common sense
    - Minimal Supervision



Time and Common Sense

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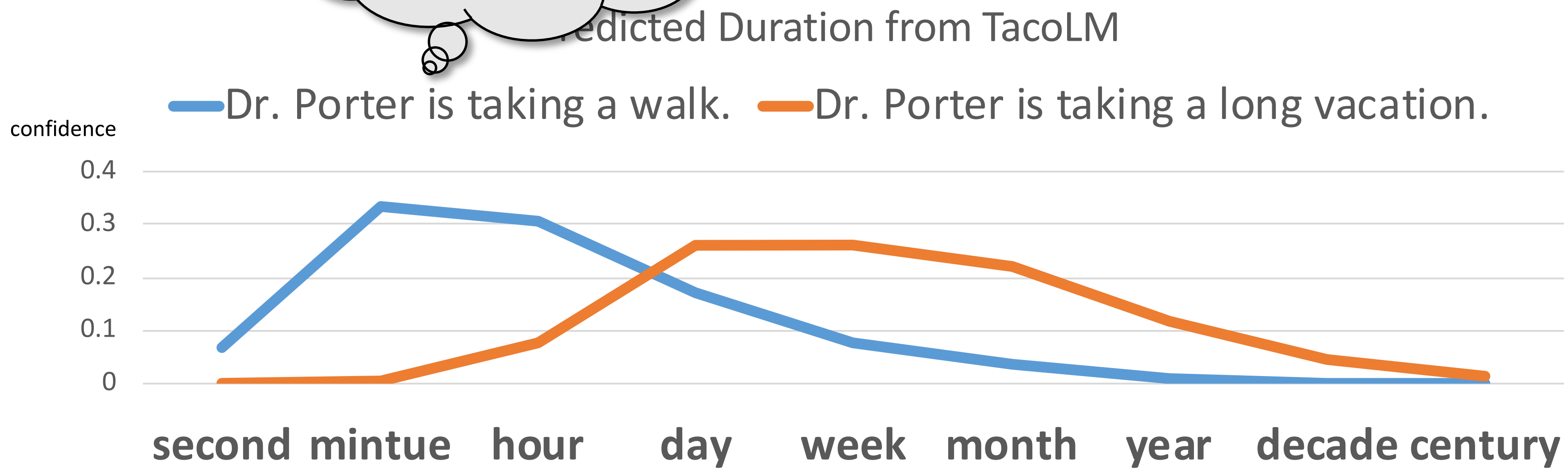
  - TacoLM – … vare of time and temporal common sense
    - Minim…

Dr. Porter is coming back shortly.



Time and Common Sense

- Time
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- In this work
  - ☐ TacoLM - vare of time a ense
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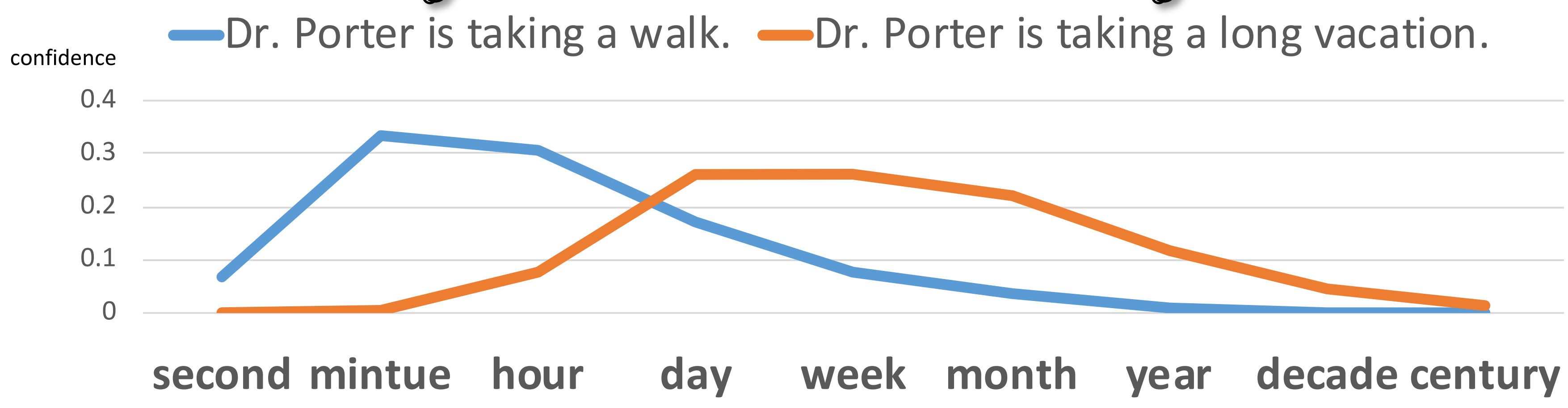
Dr. Porter is coming back shortly.

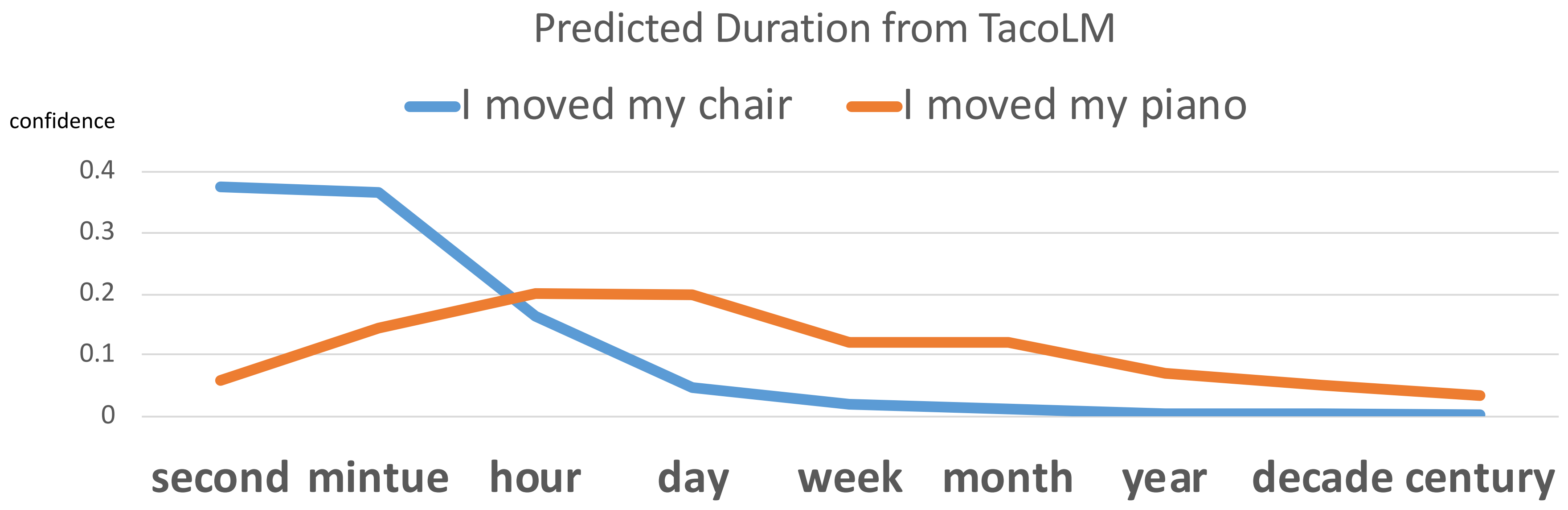
She may not be back for days.

edicted Duration from TacoLM



Acquiring Temporal Common Sense

- Challenging
  - Reporting Biases:
    - people rarely mention the common sense to be efficient "~~*It took me 2 seconds to move my chair*~~"
    - Sometimes highlight rarities "*It took me an hour to move my chair*"
  - Highly Contextual:
    - The duration of "Move" depends on the object's weight/size.



TacoLM – the Big Picture

Goal: build a general time-aware LM with minimal supervision

Step 1: Information Extraction

- ☐ Use high-precision patterns to acquire temporal information
  - ▪ Unsupervised automatic extraction
- ☐ Overcomes reporting biases with a large amount of natural text

Step 2: Joint Language Model Pre-training

- ☐ Multiple temporal dimensions
  - ▪ Duration ~ 1 / Frequency

“I brush my teeth every morning” → Duration of “brushing teeth” < morning

  - ▪ Further generalization to combat reporting biases

Output: TacoLM- a time-aware general BERT

Step 1: Information Extraction

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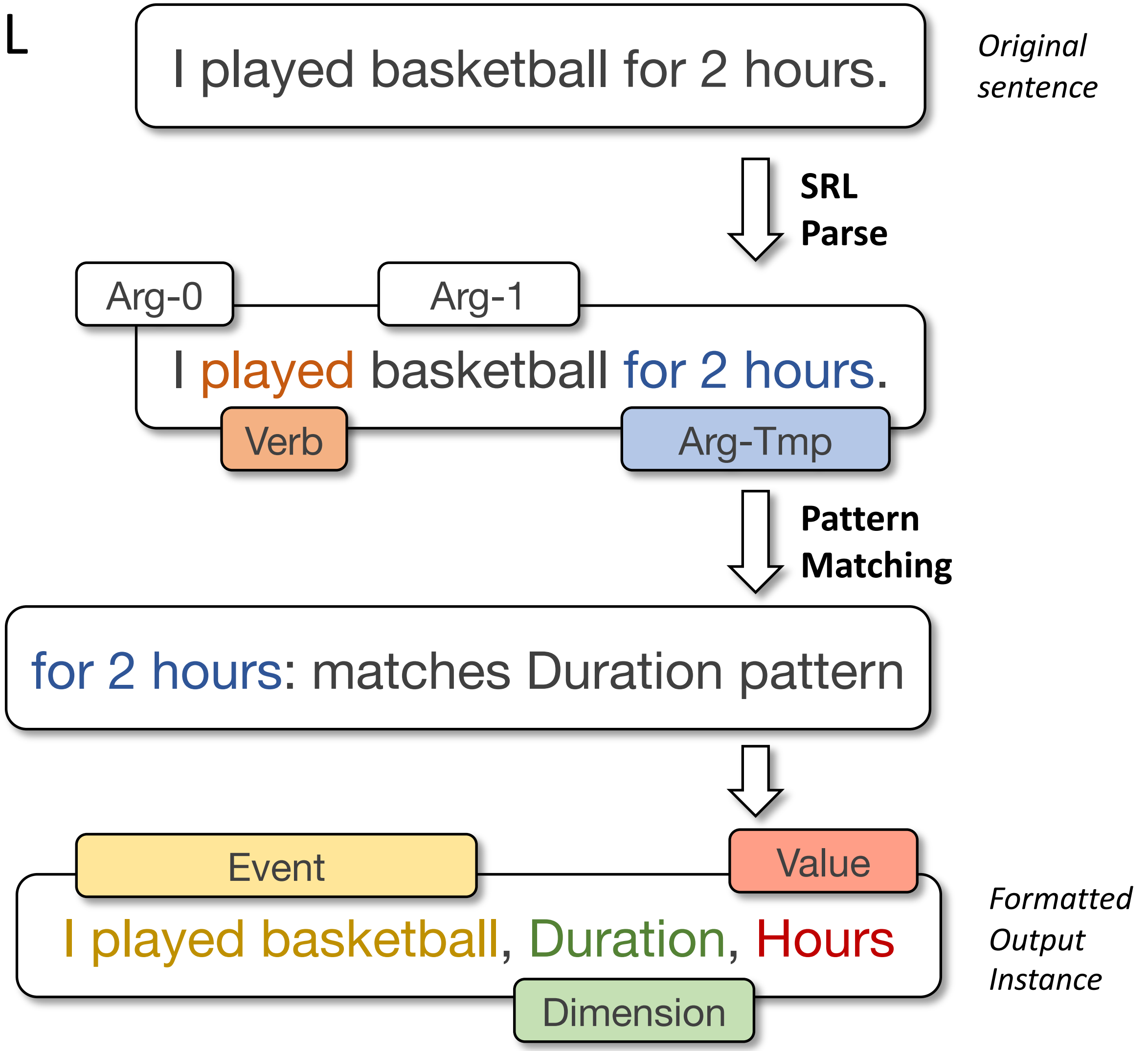
Step 2: Joint Language Model Pre-training

Output: TacoLM- a time-aware general BERT

Information Extraction

- Use high-precision patterns based on SRL
  - Duration
  - Frequency
  - Typical Time
  - Duration Upperbound
  - Hierarchy
- Labels
  - Units (seconds, … centuries)
  - Temporal keywords (Monday, January, …)
- Output
  - 4.3M instances of (event, dimension, value) tuple



Step 2: Language Model Pre-training

Step 1: Information Extraction

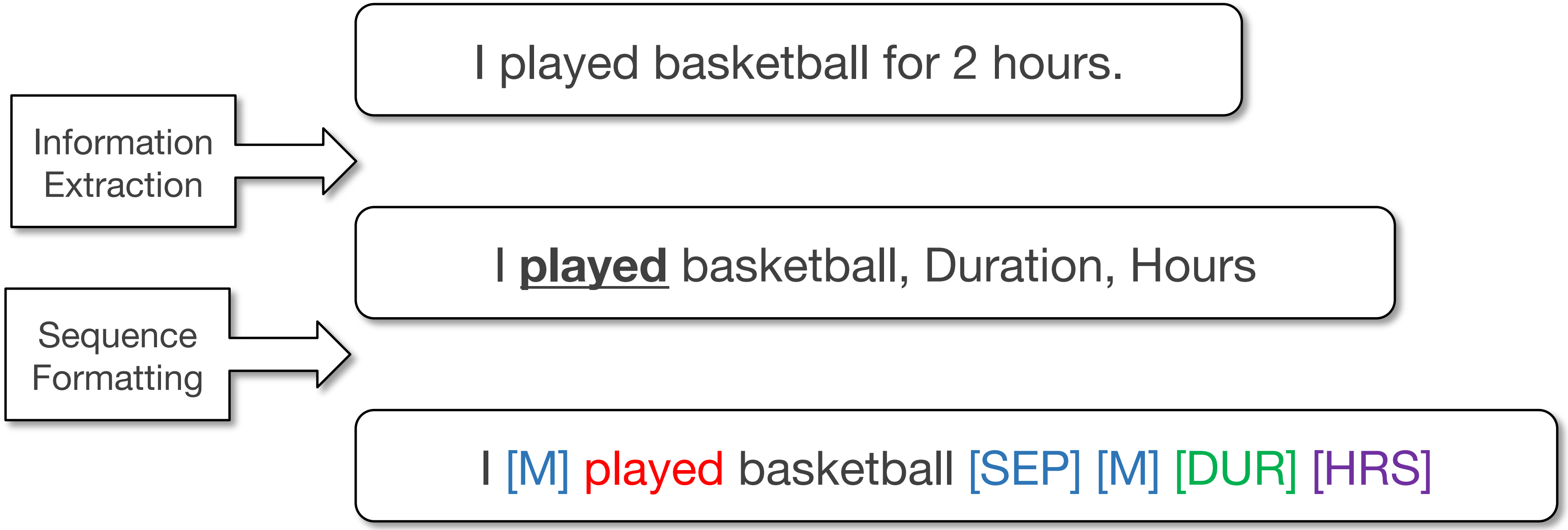
↓

Step 2: Joint Language Model Pre-training

Output: TacoLM- a time-aware general BERT

Sequence Classification

- Consider [Event] [Dimension] [Value] tuples in each instance
- [E1, E2, … M, ET … En, SEP, M, Dim, Val]
  - M is a special marker, same across all dimension/value
  - Dim is a marker for each dimension, Val is a marker for the value of the dimension
- With an example:



Joint Model with Masked LM

I [M] played basketball [SEP] [M] [DUR] [HRS]

- Baseline Model: Pre-trained BERT-base
- Main objective: mask some tokens and recover them
- How we mask:
  - With some probability, mask temporal value while keeping others

    I [M] played basketball [SEP] [M] [DUR] **[MASK]**

  - Otherwise, mask a certain portion of E1...En while keeping temporal value unchanged

    I [M] **[MASK] [MASK]** [SEP] [M] [DUR] **[HRS]**

  - Max (P(Event|Dim,Val) + P(Val|Event,Dim)); Preserving original LM capability
- Benefits:
  - Jointly learn **one** transformer towards **all** dimensions
  - Labels play a role in the transformer
  - One event may contain more than one (Dim + Val), so the model learns dimension relationships

Joint Model with Masked LM

I [M] played basketball [SEP] [M] [DUR] [HRS]

- 1: Soft cross entropy for recovering Val
  - If gold label is "hours", the label vector **y** for "minutes, hours, days" will be [0.16, 0.47, 0.25]

$$\hat{\mathbf{x}} = \log(\mathrm{softmax}(\mathbf{x}))$$

$$\mathrm{loss} = -\hat{\mathbf{x}}^{\top}\mathbf{y}$$

- 2: Label weight adjustment
  - Instances with "seconds" have higher loss than those with "years"
- 3: Full event masking
  - Instead of 15% used by BERT, we use 60% when masking E1, … En to reduce biases

I [M] had a cup of **[MASK]** [SEP] [M] [TYP] [Evening] -> MASK = coffee, because "cup of"

I [M] had **[MASK] [MASK]** of **[MASK]** [SEP] [M] [TYP] [Evening]

Evaluation

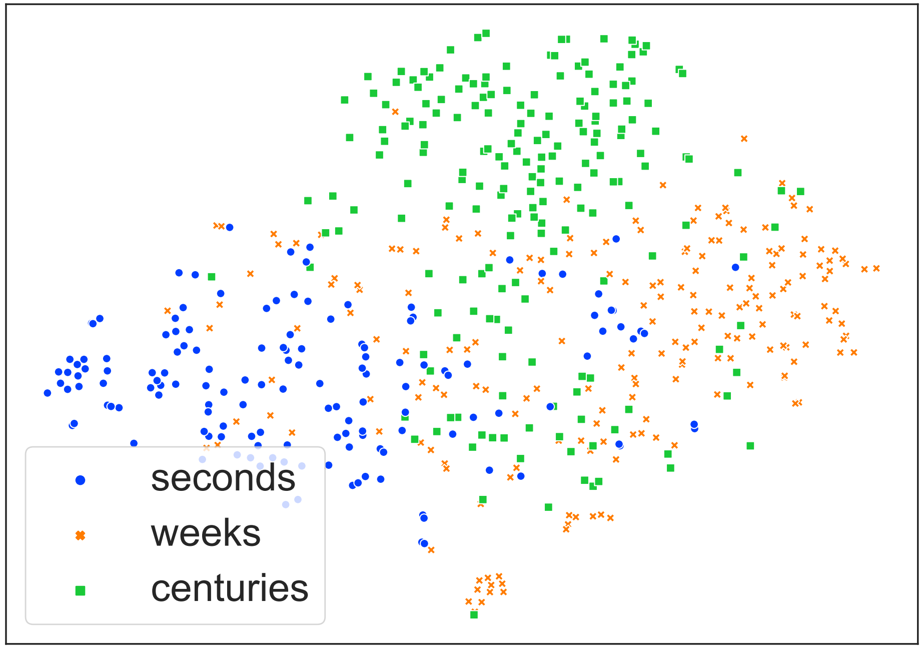
Step 1: Information Extraction

Step 2: Joint Language Model Pre-training

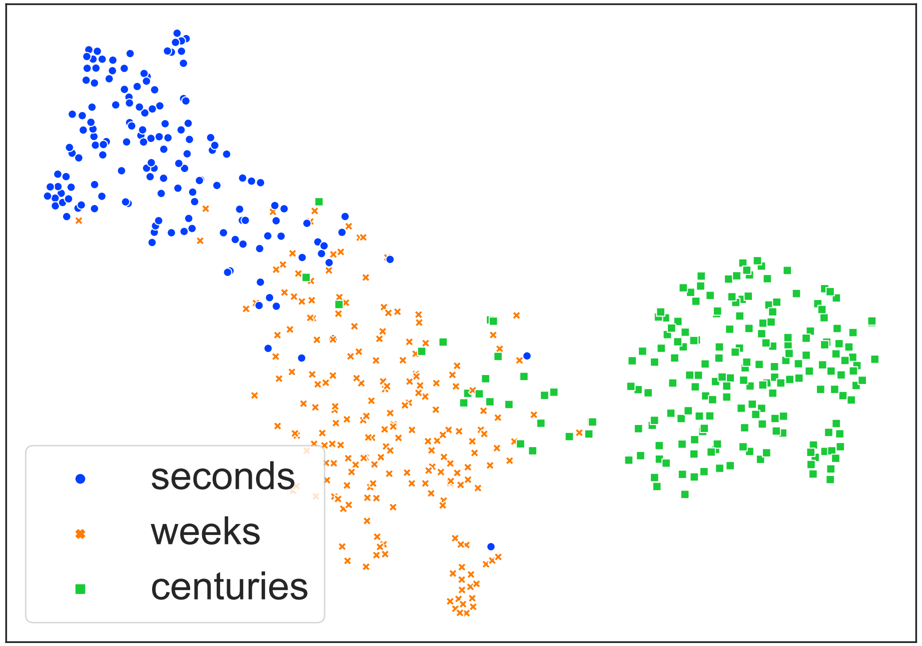
Output: TacoLM- a time-aware general BERT

Evaluation: Intrinsic (Embedding space)

- A collection of events with duration of "seconds," "weeks" or "centuries" (three extremes)
- BERT (left), Ours (right) representation on the event's trigger
  - PCA + t-SNE to 2D visualization
- Our model separates the events much better (➔ our model is aware of time)



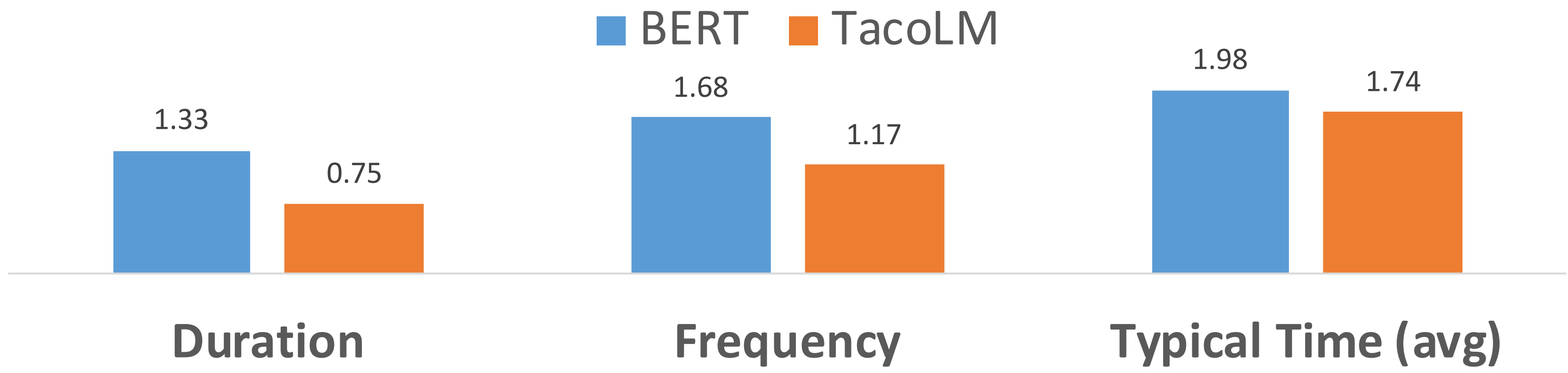
BERT



TacoLM

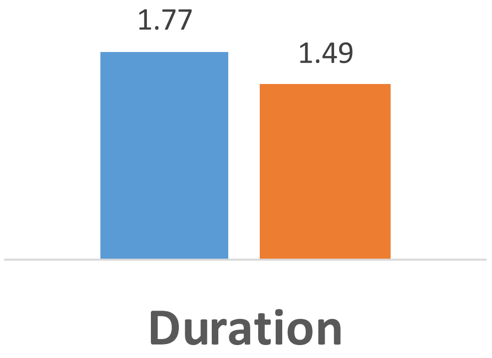
Evaluation: Intrinsic (Quantitatively)

- Metric: Distance to gold label
  - Dist (seconds, hours)=2, Dist (minutes, hours)=1
  - **Lower the better**
- RealNews [Zellers et al. 2019]: no document overlap
  - Raw corpus + MTurk annotation



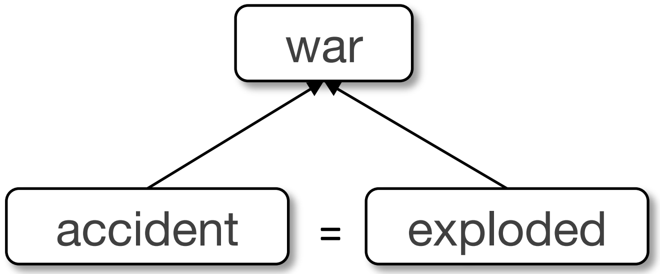
19% average improvement

- UDS-T [Vashishtha et al. 2019]: duration only

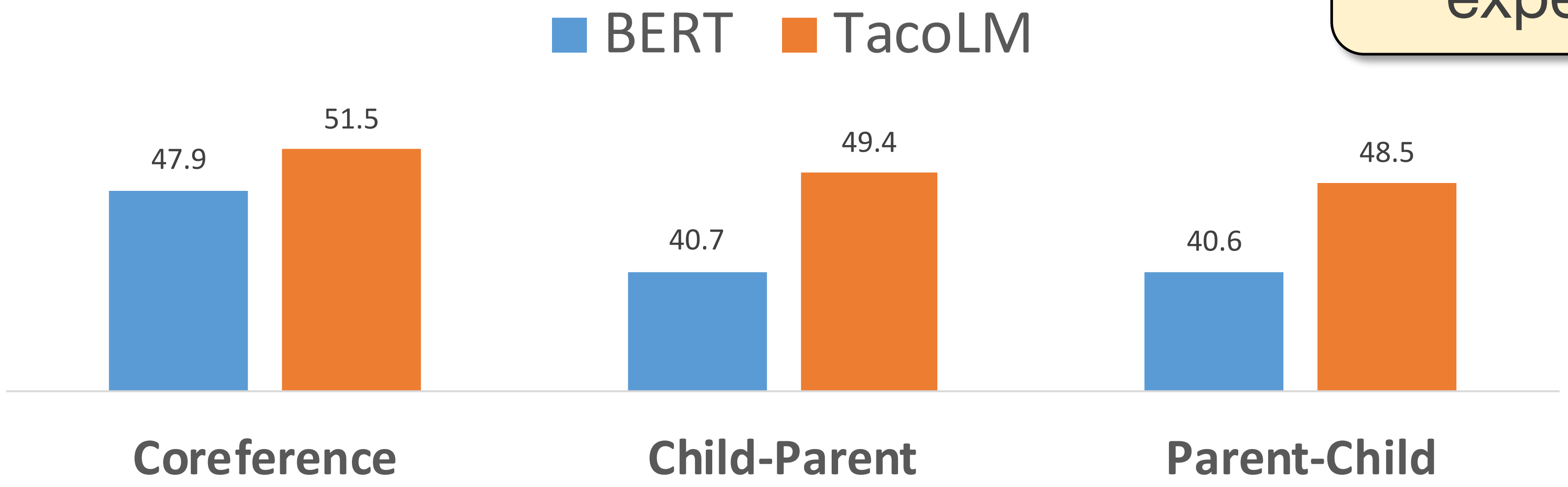


Evaluation: Extrinsic

- Use as a general language model with finetuning
- Task: Identify event-event hierarchical relations
  - HiEVE [Glavas et al. 2014]
  - Child-Parent / Parent-Child / Coreference
    - A bomb exploded. This is the sixth accident since the war started.
- Model (finetuned):
  - Sentence pair classification
- Results (F1, **higher the better**)



More Intrinsic/Extrinsic experiments in the paper!



Conclusion - TacoLM

Thank you!
Code & Data:
https://github.com/CogComp/TacoLM

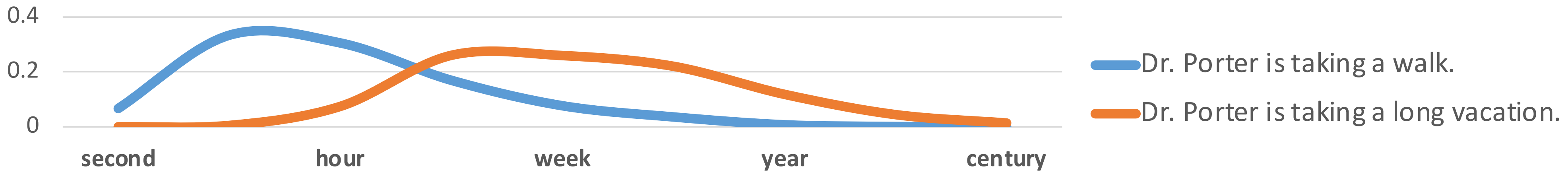
- Time-aware with minimal supervision

  I played basketball for 2 hours

- Joint pre-training over multiple temporal dimensions

  Frequency of “brushing teeth” = every morning” → Duration of “brushing teeth” < morning

- Able to directly predict events’ duration, frequency or typical time
  - 19% better on direct prediction tasks
  - Bell-shaped predictive distributions
  - Differentiates fine grained event contexts



- Works as a general language model
  - 8% improvement on child-parent event relation extraction