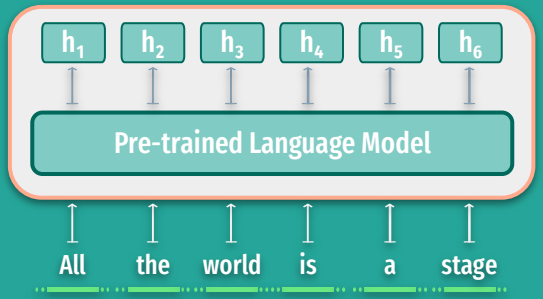


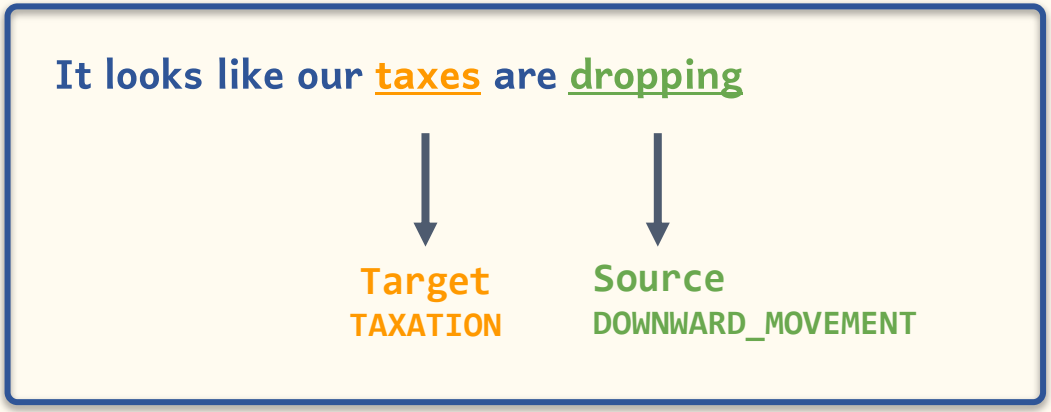
Metaphors in **Pre-Trained Language Models**: Probing and Generalization Across Datasets and Languages

Ehsan Aghazadeh*, Mohsen Fayyaz*, Yadollah Yaghoobzadeh

University of Tehran

Metaphor definition

- Conceptual Metaphor Theory [1]



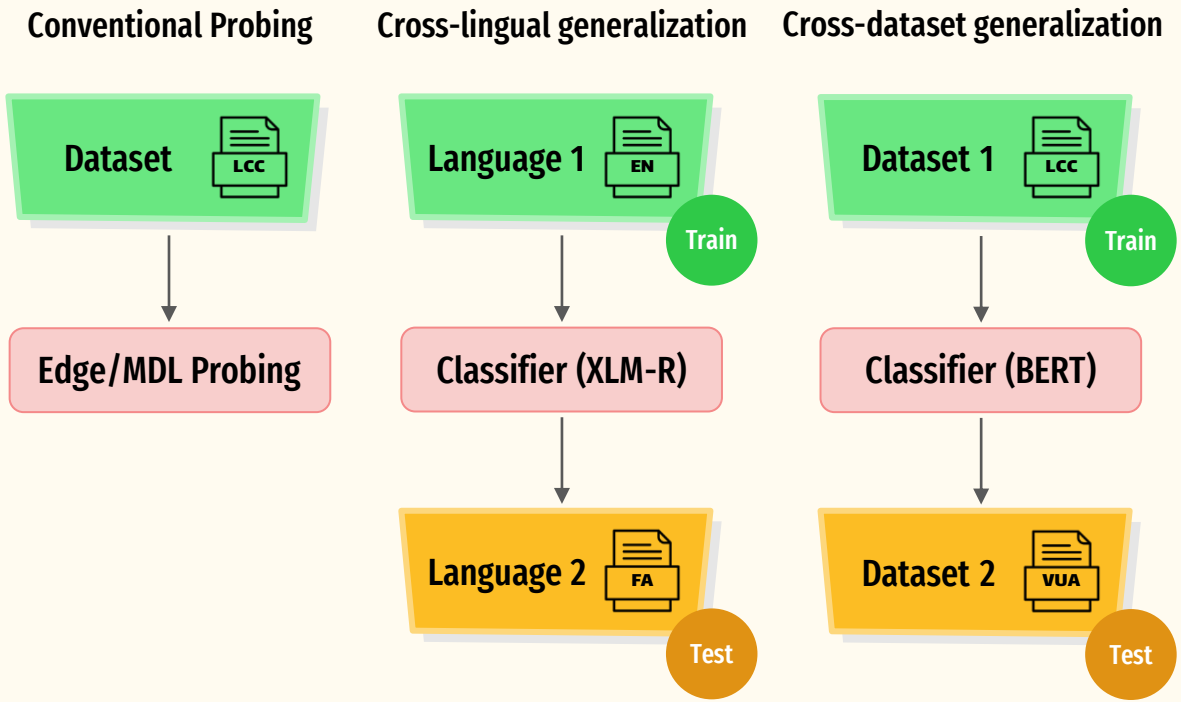
[1] George Lakoff and Mark Johnson. 2008. Metaphors we live by. University of Chicago press.

Motivation

- Metaphors are essential in human communication and constructing human-like computational systems.
- The creativity and generalization to new problems depend on the metaphors.

Do pre-trained language models represent metaphors?

Our methodology



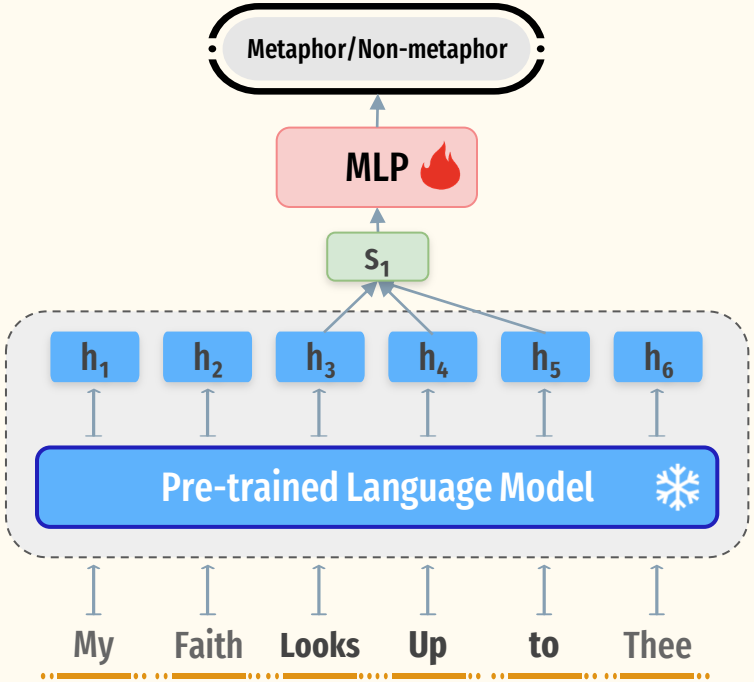
Datasets

VUA Verbs	He **[finds]**$_1$ it hard to communicate with people , not least his separated parents .$\rightarrow$ 1
	He finds it hard to **[communicate]**$_1$ with people , not least his separated parents . $\rightarrow$ 0
VUA POS	They picked up power from a **[spider]**$_1$'s web of unsightly overhead wires . $\rightarrow$ 1
	They picked up power from a spider 's web of unsightly overhead **[wires]**$_1$. $\rightarrow$ 0
TroFi	" Locals **[absorbed]**$_1$ a lot of losses , " said Mr. Sandor of Drexel $\rightarrow$ nonliteral
	Vitamins could be passed right out of the body without being **[absorbed]**$_1$ $\rightarrow$ literal
LCC	Lawful gun ownership is not a **[disease]**$_1$. $\rightarrow$ 3.0
	But the Supreme Court says it's not a way to **[hurt]**$_1$ the Second Amendment $\rightarrow$ 2.0
	Is he angry that gun rights **[progress]**$_1$ has been done without him? $\rightarrow$ 1.0
	I mean the 2nd amendment **[suggests]**$_1$ a level playing field for all of us. $\rightarrow$ 0.0

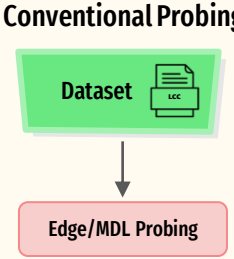
- ★ Positive and Negative examples are balanced
- ★ LCC dataset has four languages (English, Spanish, Russian, Farsi)
- ★ LCC scores less than 0.5 are considered literal and more than 1.5 non-literal

Probing

Evaluating linguistic knowledge in neural representations



[1] Ian Tenney, Patrick Xia, Berlin Chen, Alex Wang, Adam Poliak, R. Thomas McCoy, Najoung Kim, Benjamin Van Durme, Samuel R. Bowman, Dipanjan Das, and Ellie Pavlick. 2019b. What do you learn from context? Probing for sentence structure in contextualized word representations. In International Conference on Learning Representations.

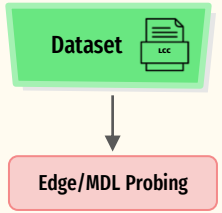


Conventional probing

- To answer:
  - Do PLMs represent metaphorical information within their representations?
  - If so, how is it distributed throughout their layers?

- Methods
  - Edge probing [1]
  - MDL probing [2]

[1] Ian Tenney, Patrick Xia, Berlin Chen, Alex Wang, Adam Poliak, R. Thomas McCoy, Najoung Kim, Benjamin Van Durme, Samuel R. Bowman, Dipanjan Das, and Ellie Pavlick. 2019b. What do you learn from context? Probing for sentence structure in contextualized word representations. In International Conference on Learning Representations.
[2] Elena Voita and Ivan Titov. 2020. Information-theoretic probing with minimum description length. In Proceedings of the 2020 Conference on Empirical Methods in Natural Language Processing (EMNLP), pages 183–196, Online. Association for Computational Linguistics.



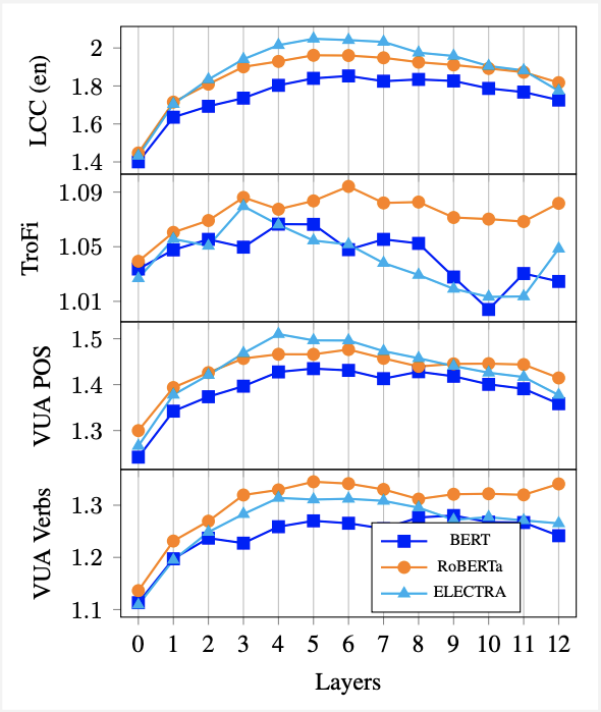
Conventional probing - results

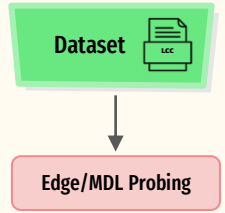
Dataset	Baseline		BERT		RoBERTa		ELECTRA	
	Acc.	Comp.	Acc.	Comp.	Acc.	Comp.	Acc.	Comp.
LCC (en)	74.86	1.05_{2}	88.25	1.85_{6}	88.06	1.96_{5}	**89.30**	$\mathbf{2.05_{5}}$
TroFi	67.34	1.01_{4}	**68.58**	1.07_{4}	68.46	$\mathbf{1.09_{6}}$	68.07	1.08_{3}
VUA POS	65.92	1.03_{0}	80.32	1.43_{5}	81.72	1.48_{6}	**83.03**	$\mathbf{1.51_{4}}$
VUA Verbs	65.97	1.04_{9}	78.29	1.28_{9}	78.88	$\mathbf{1.34_{5}}$	**79.96**	1.31_{4}

- Conclusions
  - PLMs do represent metaphors
  - RoBERTa and ELECTRA >>> BERT
    - Better pre-training objectives 👍
    - Extensive pre-training data 👍

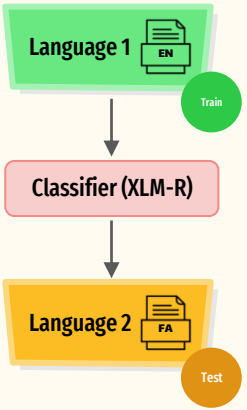
Layer-wise analysis

- Conclusions
  - Middle layers > Deeper layers
    - Not highly contextualized
    - Forecasting source domain ✕ target domain

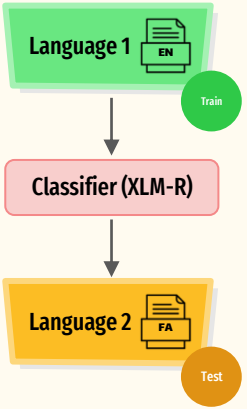




Cross-lingual generalization



- Are metaphors transferable across languages?
- Using edge probing
  - train a classifier on **language S**
    predict metaphoricity in **language T**.



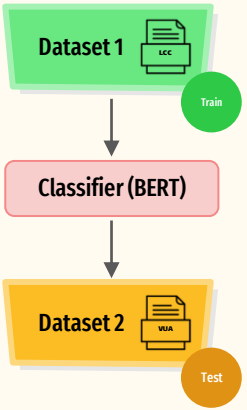
Cross-lingual generalization - results

		Train Language	
		English	Spanish
Test Language	English	85.14 (65.37)	79.31 (52.71)
	Spanish	79.40 (53.17)	84.59 (66.09)

⋆ XLM-R (randomly initialized XLM-R)

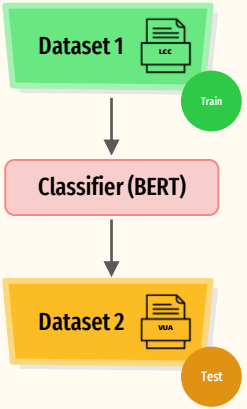
- **Conclusions**
  - XLM-R >>> Random
    - Transferability of metaphorical information between languages 👌
    - Capacity of XLM-R 👍

Cross-dataset generalization



- Are metaphors transferable across datasets?

- Using edge probing
  - train a classifier on **dataset S**
    to predict metaphoricity in **dataset T**.



Cross-dataset generalization - results

		Train Dataset	
		LCC(en)	VUA Verbs
Test Dataset	LCC(en)	84.26 (54.93)	70.37 (50.14)
	VUA POS	62.23 (51.47)	71.6 (53.47)
	VUA Verbs	60.20 (50.88)	75.21 (60.03)

⋆ BERT (randomly initialized BERT)

- **Conclusions**
  - PLM > Random
    - Generalizable metaphorical information ✅
  - Consistent data annotation → better results

Conclusion

- Contextual representations in PLMs do encode metaphorical knowledge
- Metaphorical knowledge is encoded better in the middle layers of PLMs
- Metaphorical knowledge is transferable between languages and datasets ~ Consistency of the annotation

THANK YOU!

eaghazade1998 @ut.ac.ir
mohsen.fayyaz77@ut.ac.ir
y.yaghoobzadeh @ut.ac.ir

Paper: https://arxiv.org/abs/2203.14139

Code: github.com/EhsanAghazadeh/Metaphors_in_PLMs

CREDITS: This presentation has partially included entities from templates created by SLidesgo, including icons by FLaticon, and infographics & images by Freepik