LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

SIEMENS

Analysis of the Attention in Tabular Language Models

Aneta Koleva, Martin Ringsquandl, Volker Tresp

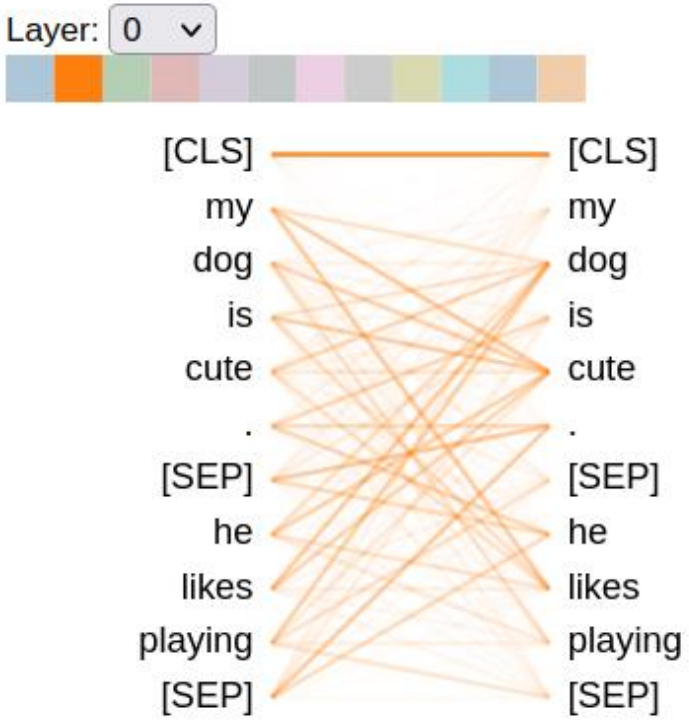
TRL@NeurIPS 2022

Motivation

BERT

- Pre-trained on large corpus of text
  - Masked Language Modeling (MLM)
  - Next Sentence Prediction (NSP)

"My dog is cute. He likes playing."



Transformer

- Encoder Block
  - Multi-layer with self-attention heads

$$\text{Attention}(Q, K, V) = \text{softmax}(\frac{QK^T}{\sqrt{d_k}})V$$

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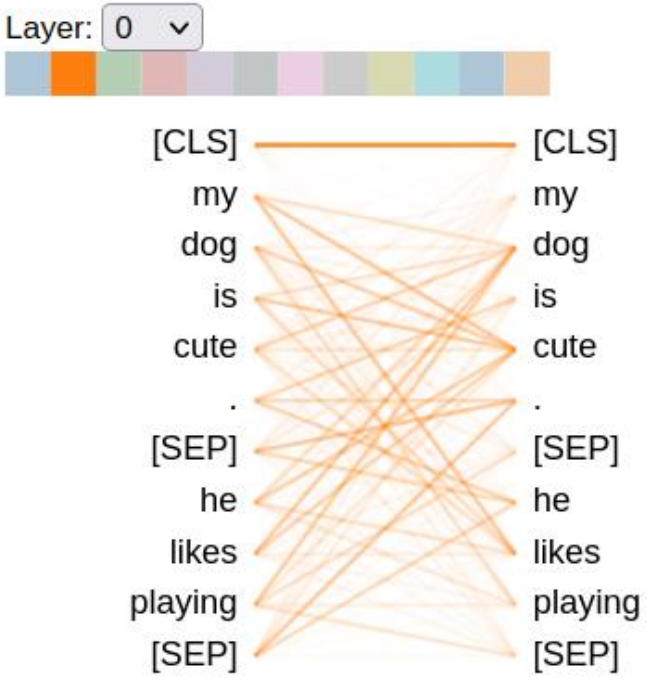

Tabular representation?

Name	Auto Racing Team	Formula 1 Race	Year
Michael Schumacher	Scuderia Ferrari	2005 United States Grand Prix	2005
Niki Lauda	McLaren	1985 Dutch Grand Prix	1985
Sebastian Vettel	Red Bull Racing	2011 European Grand Prix	2011

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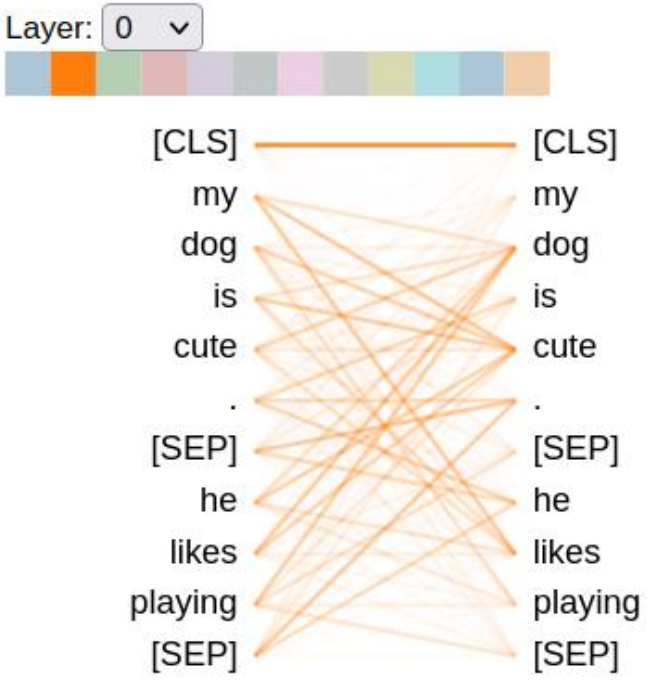

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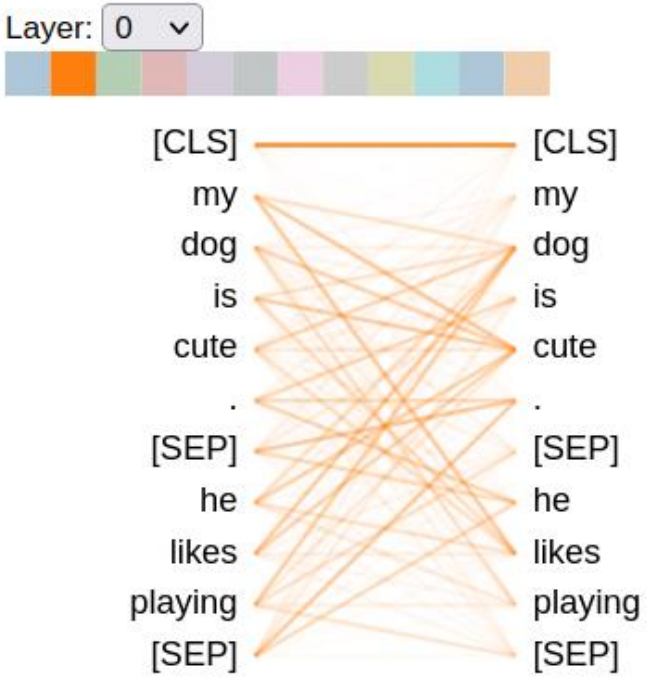

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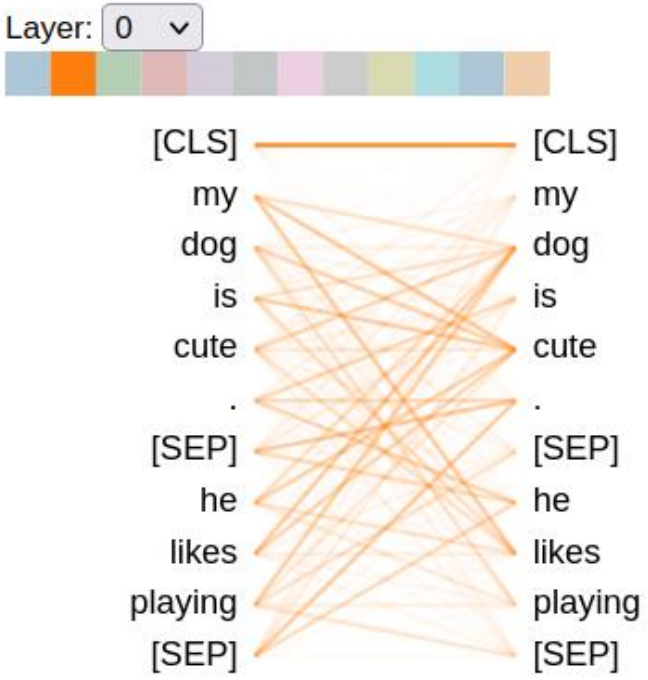

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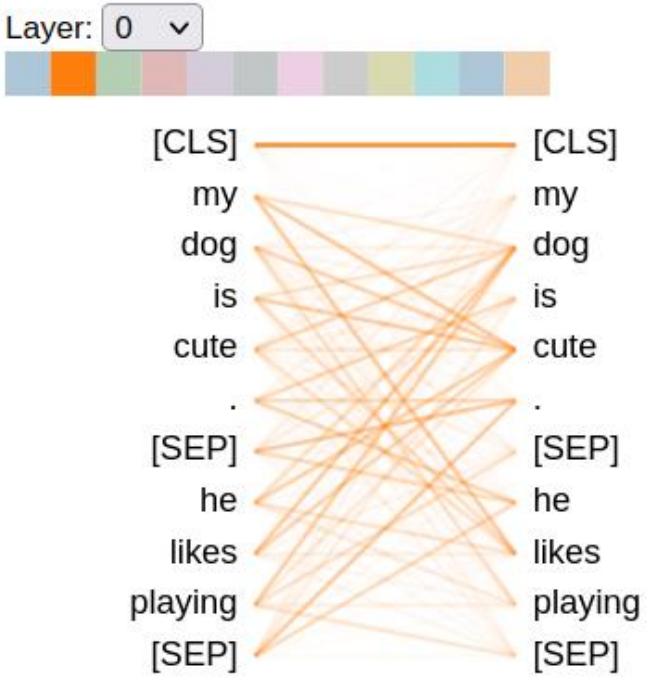

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- Best task-agnostic approach ?
- Architecture biased towards the table structure ?

Overview of attention in TaLMs

Table Language Models (TaLMs)

- Pre-trained on large corpus of tables
  - Masked Language Modeling (MLM)
  - Masked Column Prediction (MCP)
  - Masked Entity Recovery (MER)

Model	Attention	L	H
TAPAS	Transformer attention	12	12
TaBERT	Transformer attention + vertical on the columns	3	6
TURL	Restricted to entities in the same column/row + header	4	12
TUTA	Joint bi-tree based. Focused on spatial and hierarchical info	4	12
MATE	Column/row restricted attention heads	12	3
TableFormer	Added attention-bias to each attention head	12	12

TaBERT

Name	Auto Racing Team	Formula 1 Race	Year
Michael Schumacher	Scuderia Ferrari	2005 United States Grand Prix	2005
⋮	⋮	⋮	⋮

Row linearization

R_1 [CLS] [SEP] **Name** | *text* | Michael Schumacher [SEP] … [SEP] **Year** | *real* | 2005 [SEP]

Input

BERT

Cell level representations

$x_{r_{1,0}}$ $x_{r_{1,1}}$ … $x_{r_{1,3}}$

Michael Schumacher | Scuderia Ferrari | … | 2005

Column level representations

$x_{r_{*0}}$ $x_{r_{*1}}$ … $x_{r_{*3}}$

Vertical Attention

$x_{r_{1*}}$ ⋮ $x_{r_{n*}}$

Yin et al. TABERT: Pretraining for Joint Understanding of Textual and Tabular Data. ACL 2020

TaBERT

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Michael Schumacher	Scuderia Ferrari	2005 United States Grand Prix	2005

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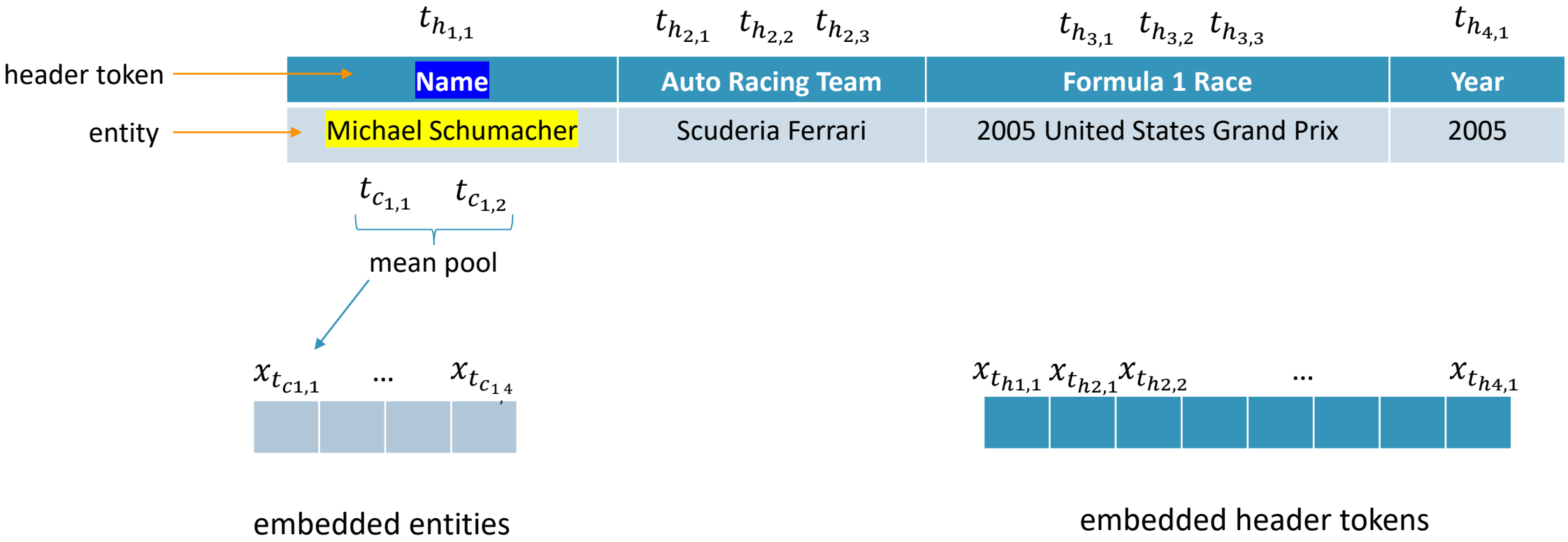
TURL



Deng et al. TURL: Table Understanding through Representation Learning. VLDB 2021

TURL

Name	Auto Racing Team	Formula 1 Race	Year
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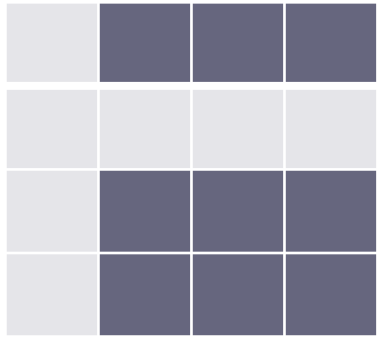
embedded tokens and entities

Visibility matrix



Input

Transformer Encoder

Deng et al. TURL: Table Understanding through Representation Learning. VLDB 2021

Visualization

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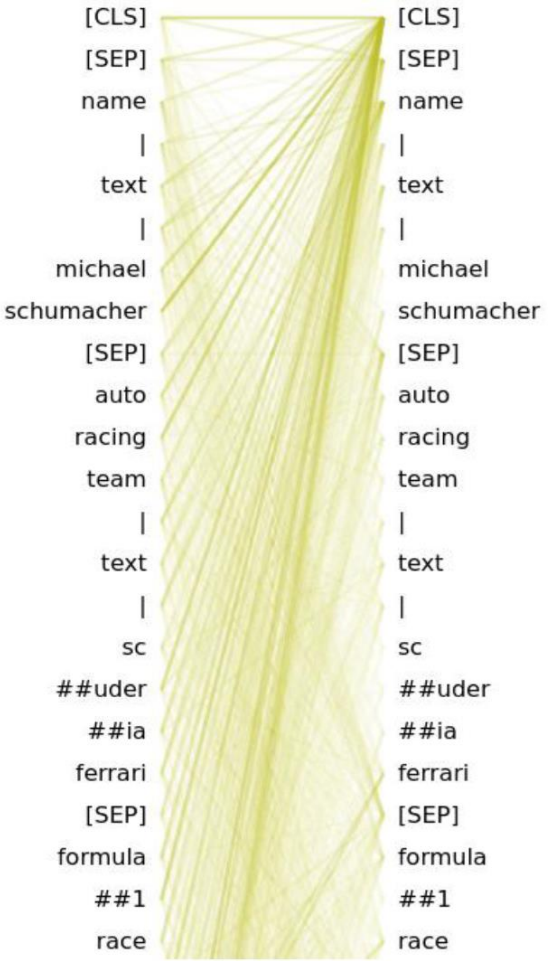
Michael Schumacher	Scuderia Ferrari	2005 United States Grand Prix	2005

TaBERT



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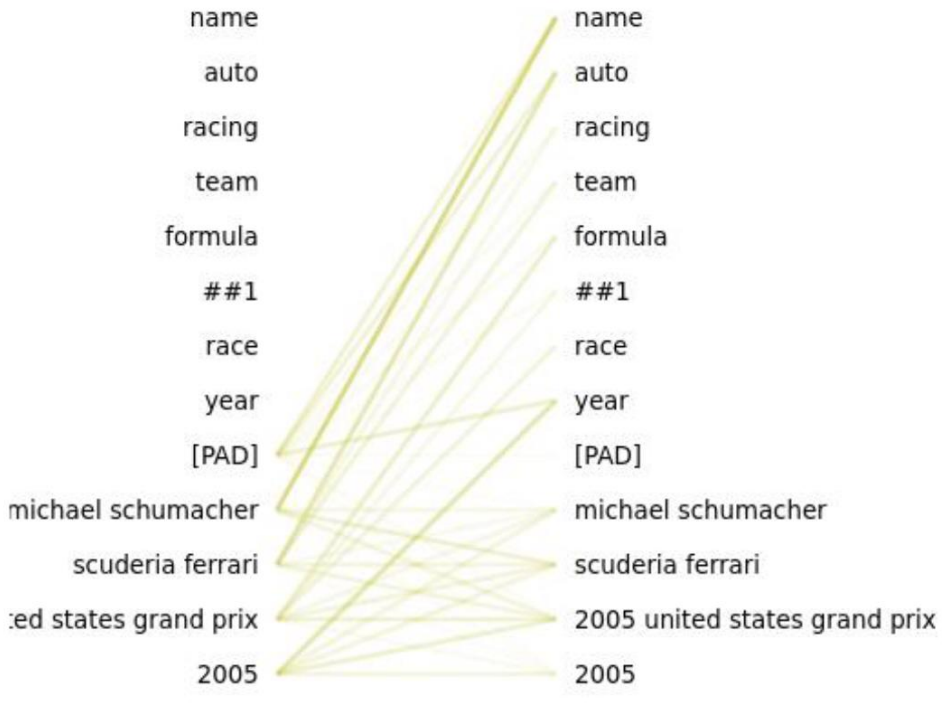
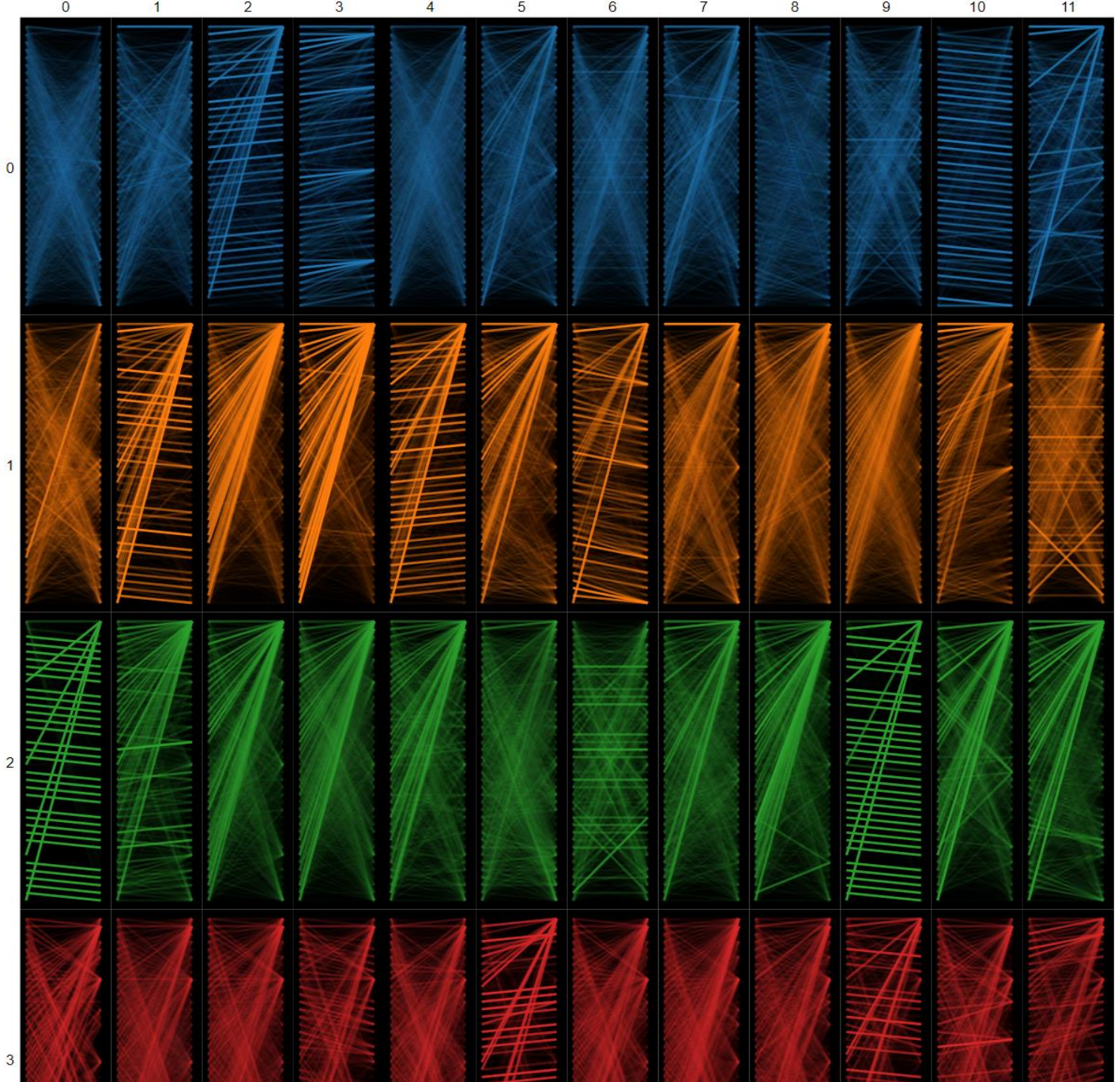


TaBERT – model view

- generated with BertViz



Vig and Belinkov. Analyzing the Structure of Attention in a Transformer Language Model. BlackboxNLP 2019

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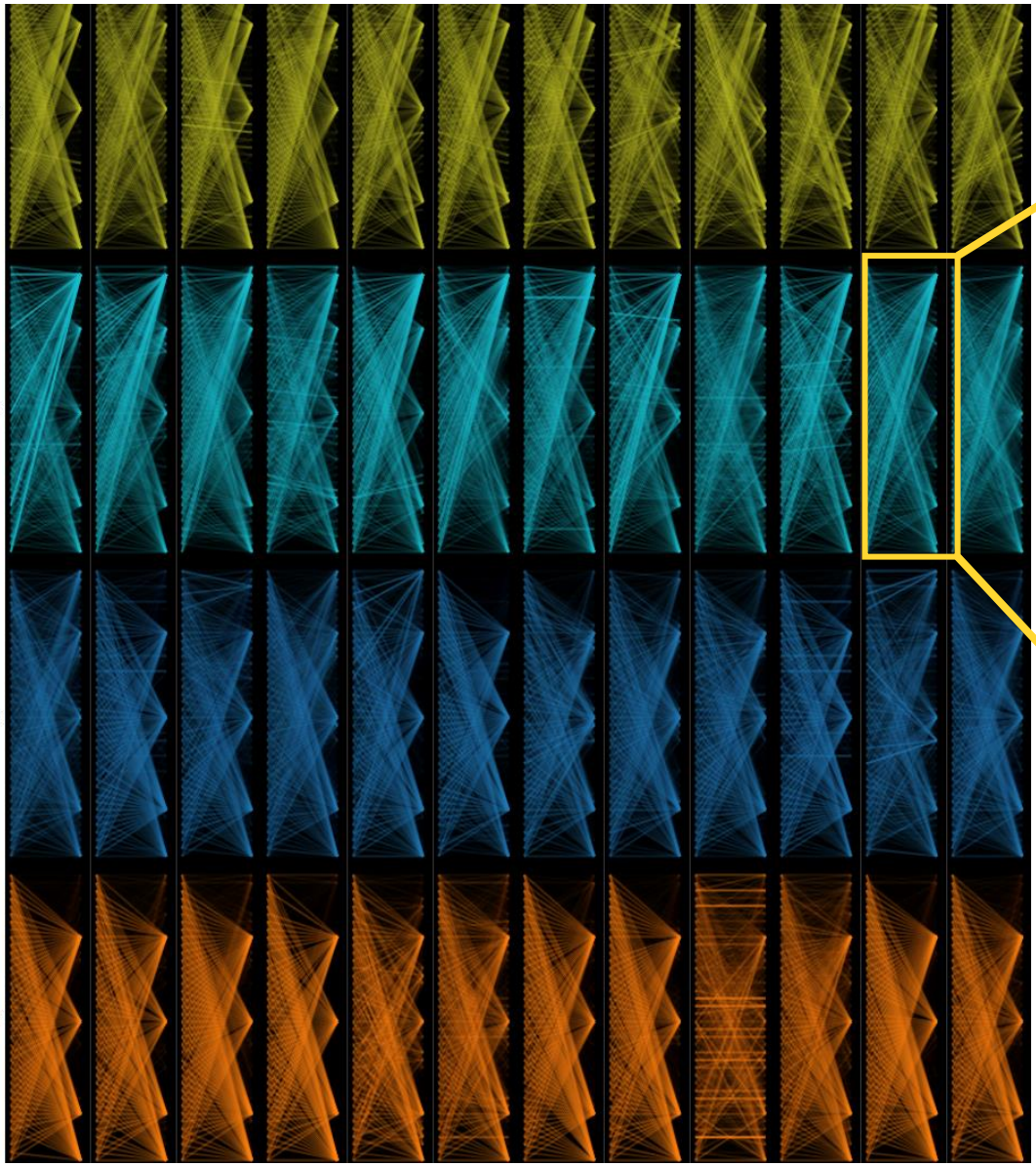

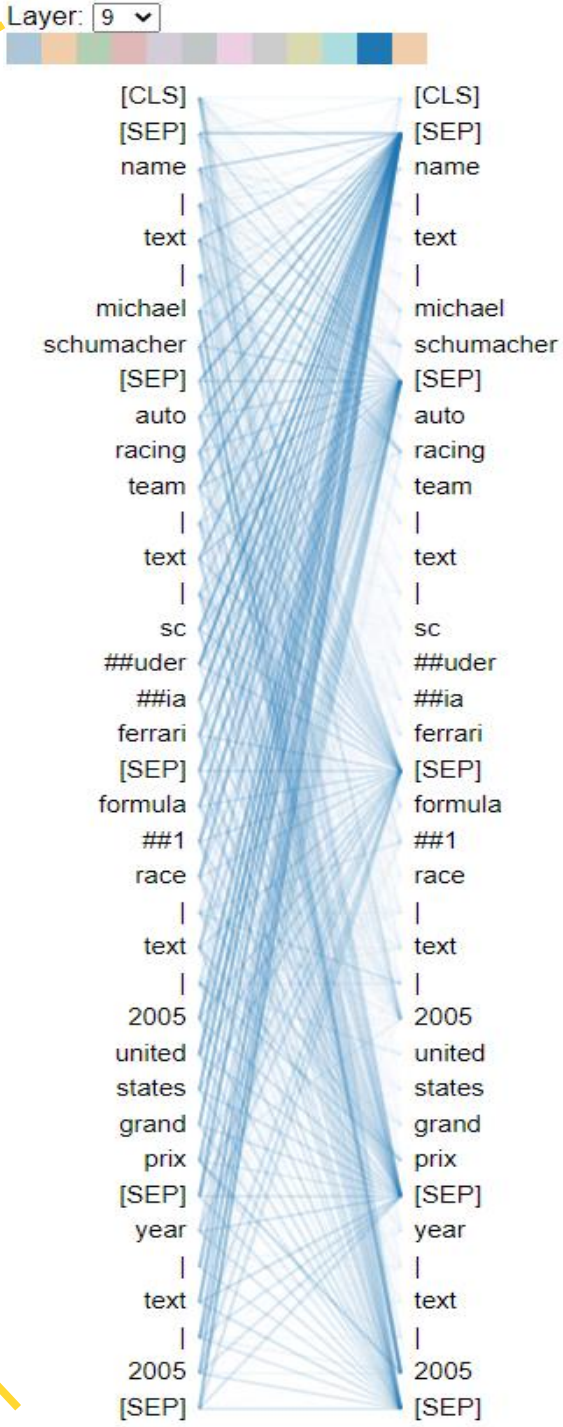

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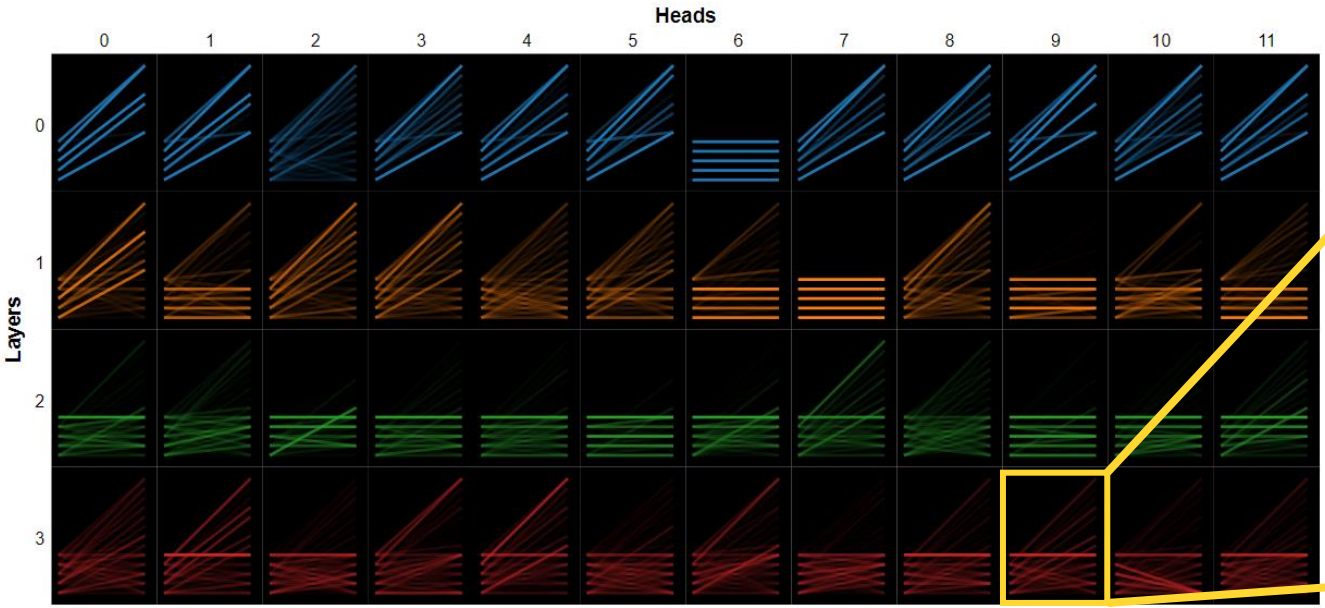

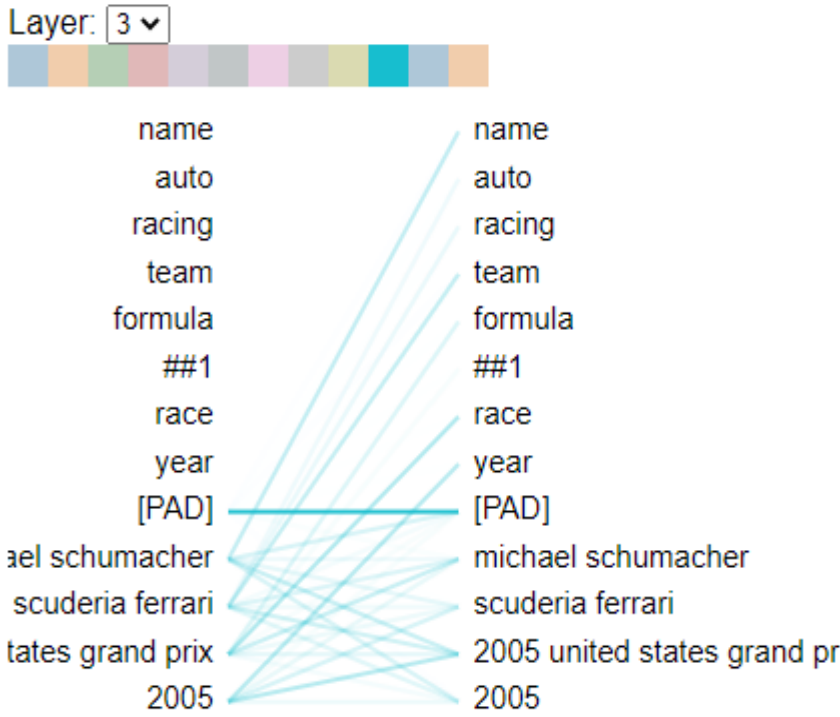

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Aggregate Attention Analysis

Datasets

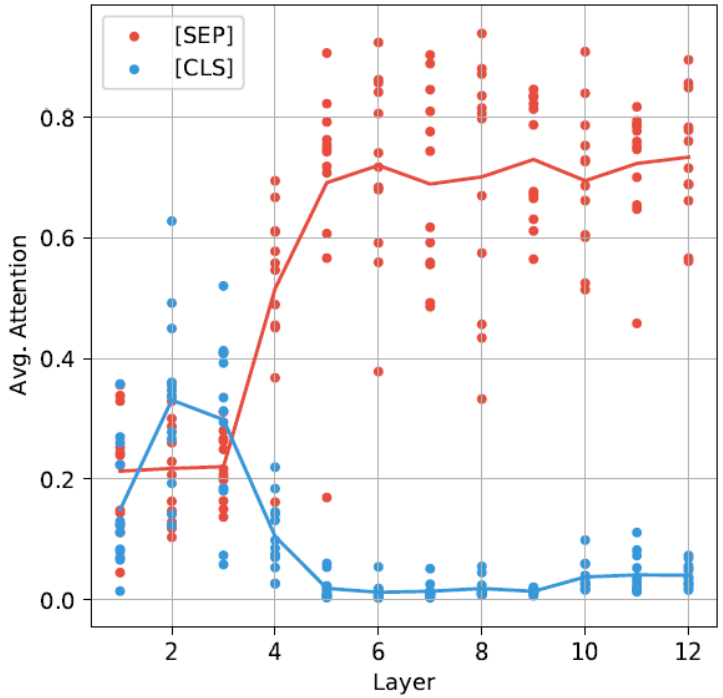
- T2D *[Ritze et al. Matching HTML Tables to Dbpedia. WIMS 2015]*
  - Textual
- GitTables *[Hulsebos et al. GitTables: A Large-Scale Corpus of Relational Tables. arXiv2021]*
  - Numeric

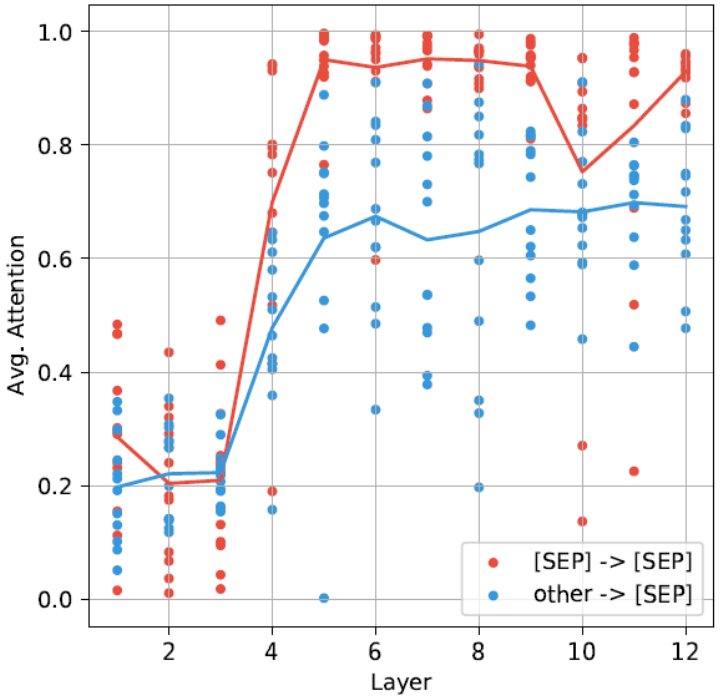
- Sampled rows
  - n = 1, 3, 5

- Analysis
  - Attention to special tokens
  - Attention to header-body tokens
  - Attention Entropy

Special tokens

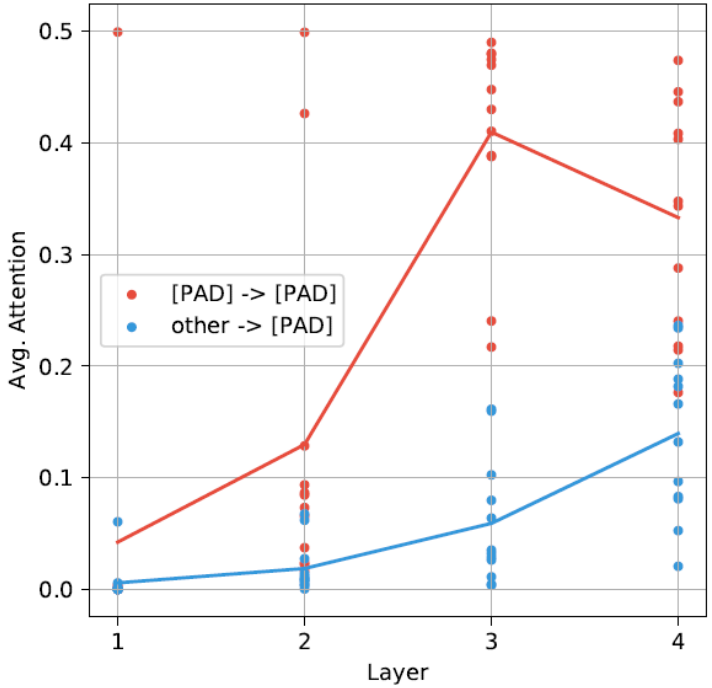
- TaBERT - Attention to [SEP] and [CLS]
  - GitTables
  - n = 1



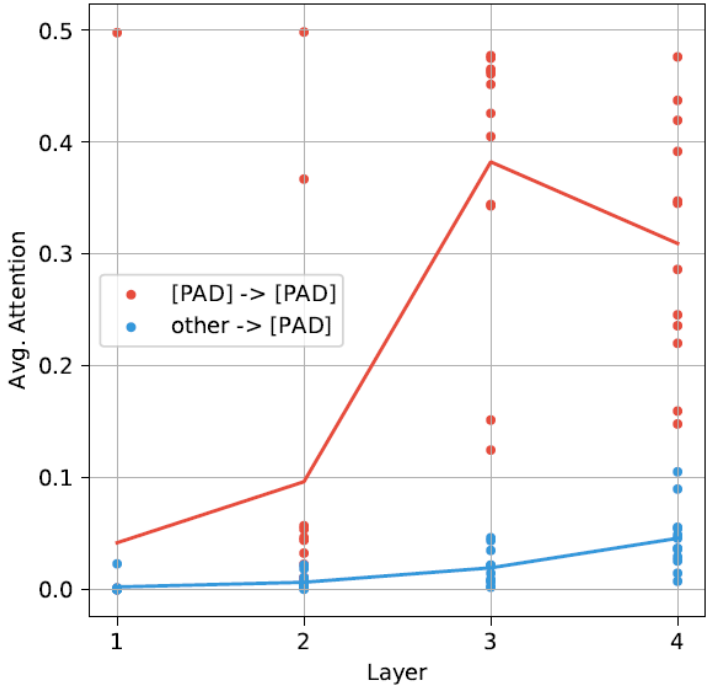


Special tokens

- TURL - Attention to [PAD]
  - n = 1



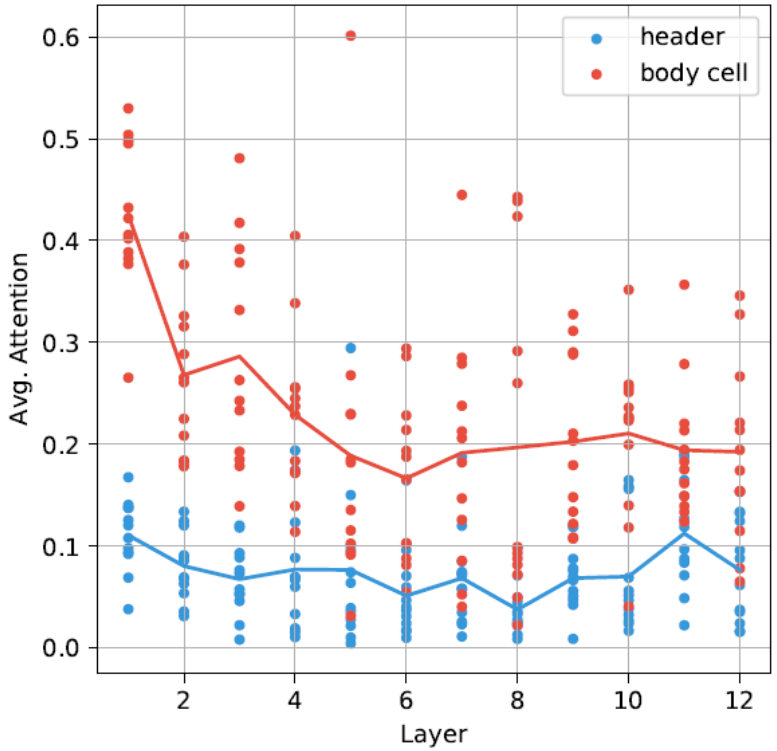
(a) GitTables



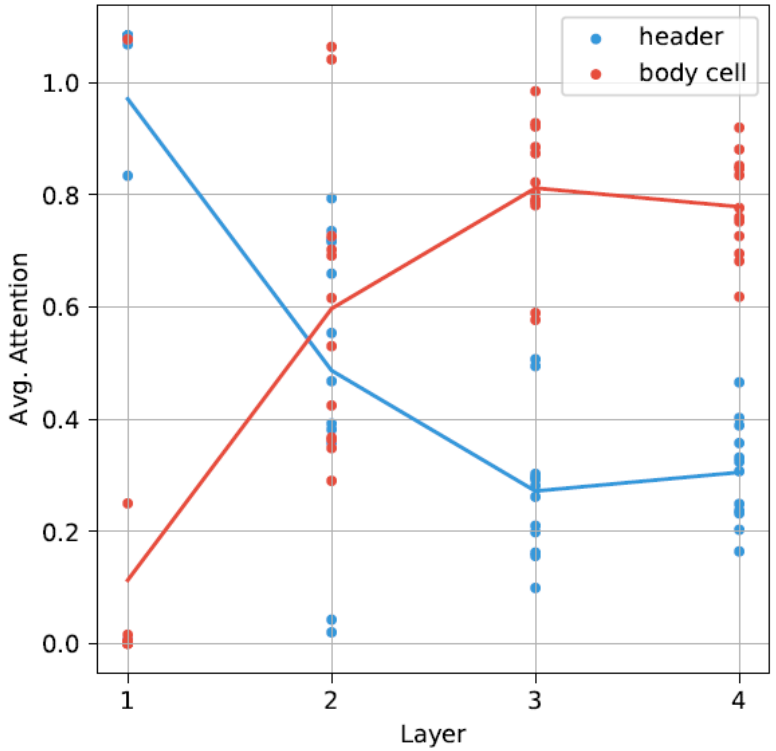
(b) T2D

Header-body attention

- GitTables
- n = 1



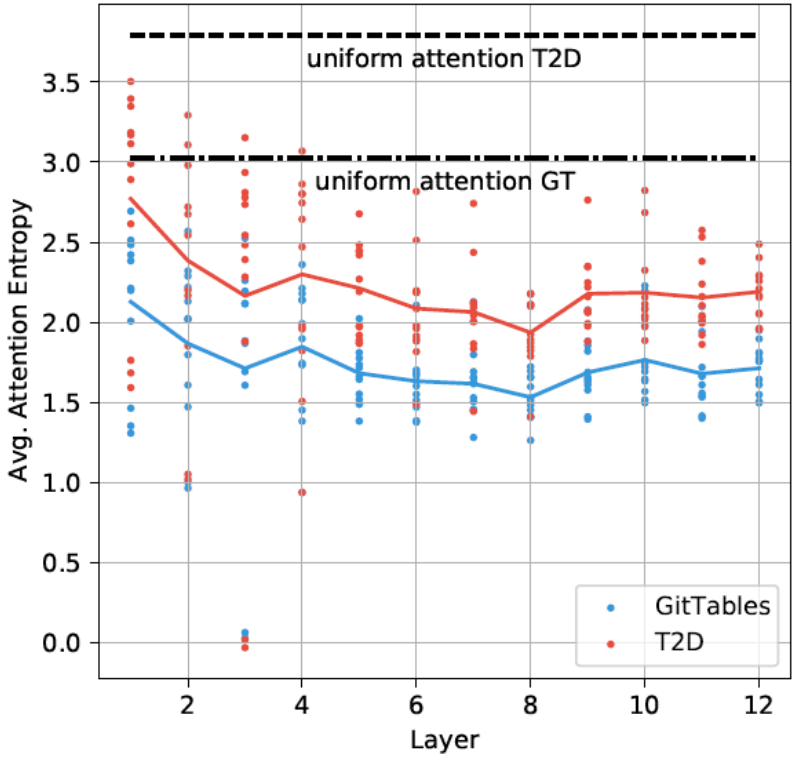
(a) TaBERT



(b) TURL

Attention entropy

- GitTables
- n = 1



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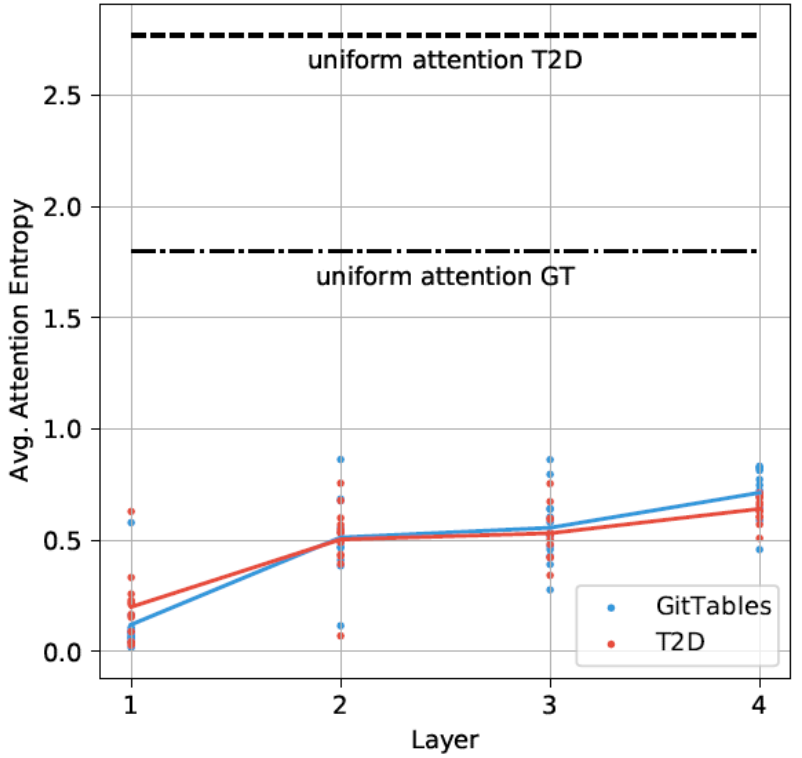

(b) TURL

Conclusion

- First work focused on analyzing the attention in TaLMs
- Heterogenous space of attention mechanisms in TaLMs
- Input matters
- TURL - more attention to the header, TaBERT - more attention to special tokens
- Do we need 12 layers with 12 attention heads in TaLMs?