Some linguistic correlates of gradients and attention weights in BERT

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Some findings

In the BERT transformer model:

- More info flows from noun to pronoun if they corefer;
- Open-class tokens more informative than closed-class;

With differences per layer and per measure used.

Measures of interest

I consider 3 notions of 'information flow' in BERT, from token t_1 to t_2:

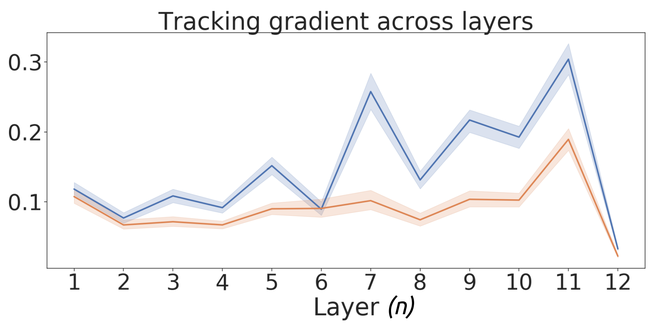
1. $G_n(t_1,t_2)$: magnitude (*2*-norm) of gradient of t_2 at layer n w.r.t. t_1 at layer $n-1$.
2. $G_n*(t_1,t_2)$: likewise, but w.r.t. t_1 at embedding layer.
3. $A_n(t_1,t_2)$: attention weight of t_2 at layer n w.r.t. t_1, averaged over all attention heads.

G_n and A_n are correlated of course: Spearman coef. = .41.

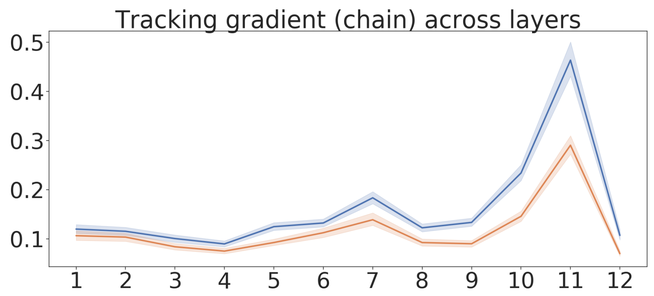
Coreference

t_1 = noun	coreference
t_2 = pronoun	no coreference

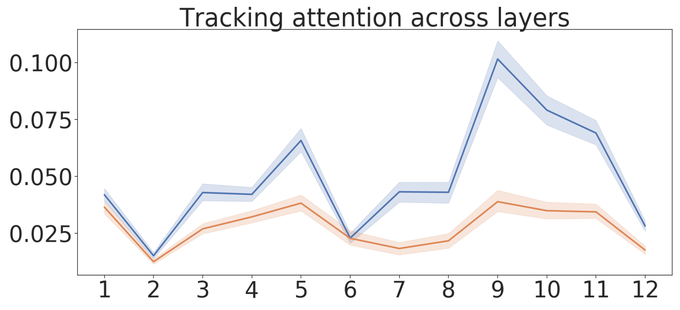
$G_n(t_1,t_2)$



$G_n*(t_1,t_2)$



$A_n(t_1,t_2)$



Some notes:

- Clear effect of coreference.
- Though in different layers for *G* vs. *A*.
- Effect persists if *distance* taken into account.

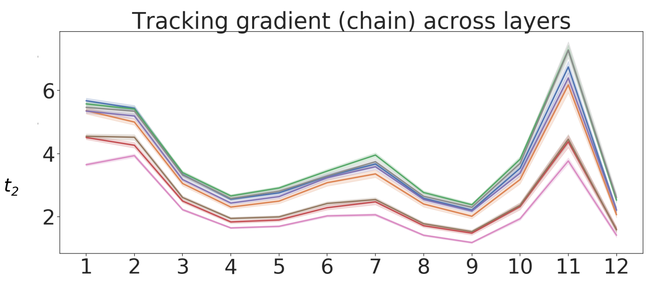
Data used

I apply BERT to random subsets of 500 sentences from:

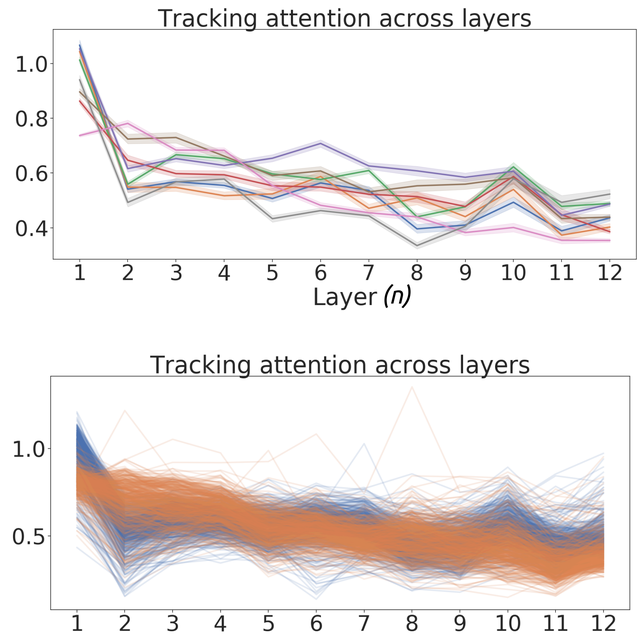
- OntoNotes, for coreference;
- Universal Dependencies (GUM portion) for dependency parses and POS tags.

Parts of speech / open vs. closed

$G_n*(t_1,t_2)$ *averaged over all* t_2



$A_n(t_1,t_2)$ *averaged over all* t_2



Some notes:

- *G** shows persistent effect, but this is almost wholly due to difference in *G* at layer 1.
- *A* is more messy.

Discussion

- Existing work often looks at what information is contained in hidden representations (diagn. classifiers).
- What might be the value of looking instead, or in addition, at how it got there?

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