

End-to-end systems in Natural Language Processing

   NSR from feature extraction to Sesame Street

Emanuele Lapponi

Language Technology Group

Institute for Informatics

University of Oslo

@emanlapponi

🤔 From-what-end-to-what-end NLP systems? And through what?

- Depends where you are starting from! Text? Speech? A picture, maybe?



Jason Brownlee June 6, 2018 at 6:37 am #

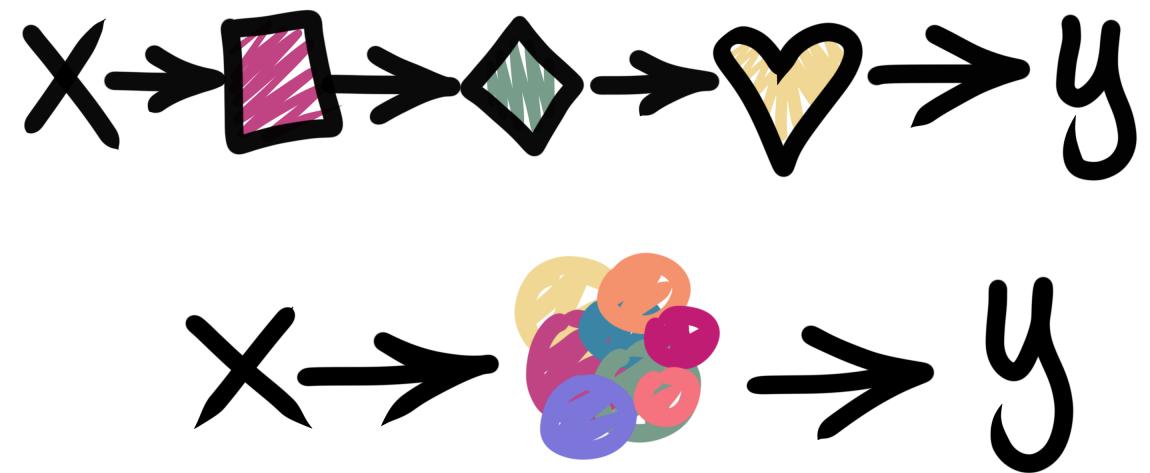
REPLY ↗

For me, end-to-end means from raw data to a model that can make predictions.
I don't know what a pipeline model is?

The image is a composite of three parts. The top right shows a close-up profile of a person's ear with a white circular Google I/O 2018 lanyard tag. The middle section is a screenshot of the Kahoot! for schools website, featuring a blue header with the text "Kahoot! for schools" and "Make learning fun, engaging and impactful for all students". Below the header is a text block about creating learning games and a "Sign up for free" button. To the right of the text is a photo of students in a classroom. The bottom section is a screenshot of a mobile messaging app. It shows a message bubble with the text "Would you like to grab some coffee with me in a" followed by a large blue upward arrow icon. Below this are keyboard keys for "a", "about", and "an". At the very bottom are full QWERTY keyboard keys.

Pipeline vs. end-to-end

- From separate modules (and feature "design")
- To separate neural models
- To one neural model





End-to-end NLP "experimental setups"

- Interesting case, as SOTA is moving *towards* end-to-end learning
- Today: NLP systems from 2012 to 2019, with Negation scope resolution



Negation Scope Resolution (NSR)

Given a sentence and a negation cue (**not**, **-less**, **without**), which tokens are negated?

- If { he was } in the hospital and yet **not** { on the staff } he could only have been a house-surgeon or a house-physician.
- ... and **no** { one could have escaped our notice }.



Negation Scope Resolution (NSR)

One way to think about it:

```
...
and      0
no       CUE
one      NEGATED
could    NEGATED
have     NEGATED
escaped   NEGATED
our      NEGATED
notice   NEGATED
-
```

* Arguably, deep semantic parsing is a better fit 😕: Packard et al. 2014. But it is detrimental to our story line, and time is of the essence 😅 ❤️

2012



UiO2: Sequence-Labeling Negation with Dependency Features

| Lapponi et al., 2012

- A Highly (over?) engineered system
- Uses the most fashionable tool of the time: CRFs
- But everyone has CRFs! What matters most here (and, arguably, in NLP in general) is representation.

What's a word?

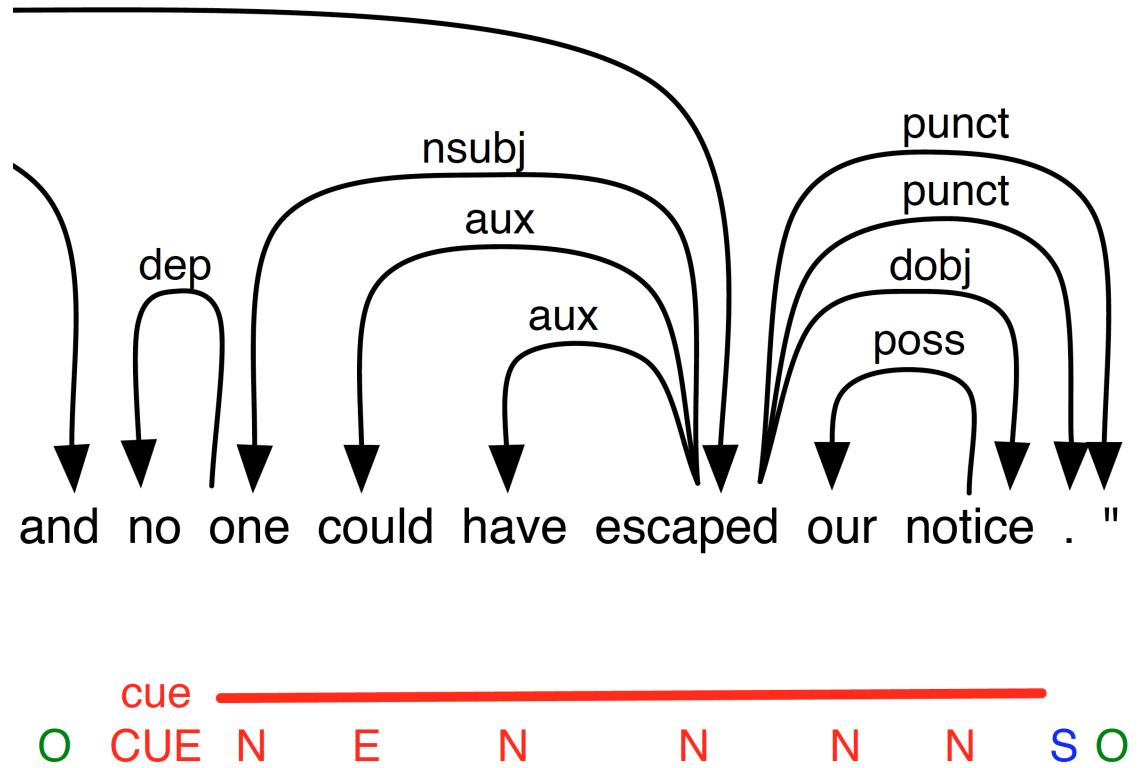
A bunch of symbols! we decide what those symbols are, for instance:

- token notice
- part-of-speech disambiguated: notice–NOUN
- the backward trigram: notice–our–escaped
- might help to know that it's a direct object: notice–dobj

What's the effect of a negation cue?

The same as a normal word, but also:

- a right/left distance from a negation cue: 5
- in a syntax (dependency) tree, a shortest path: 3
- and a very specific symbol to represent it: UP-dobj-DOWN-nsubj-DOWN-dep
- Very, very sparse matrix



Then, give the matrix to the model

Without diving into the specific, for intuition's sake:

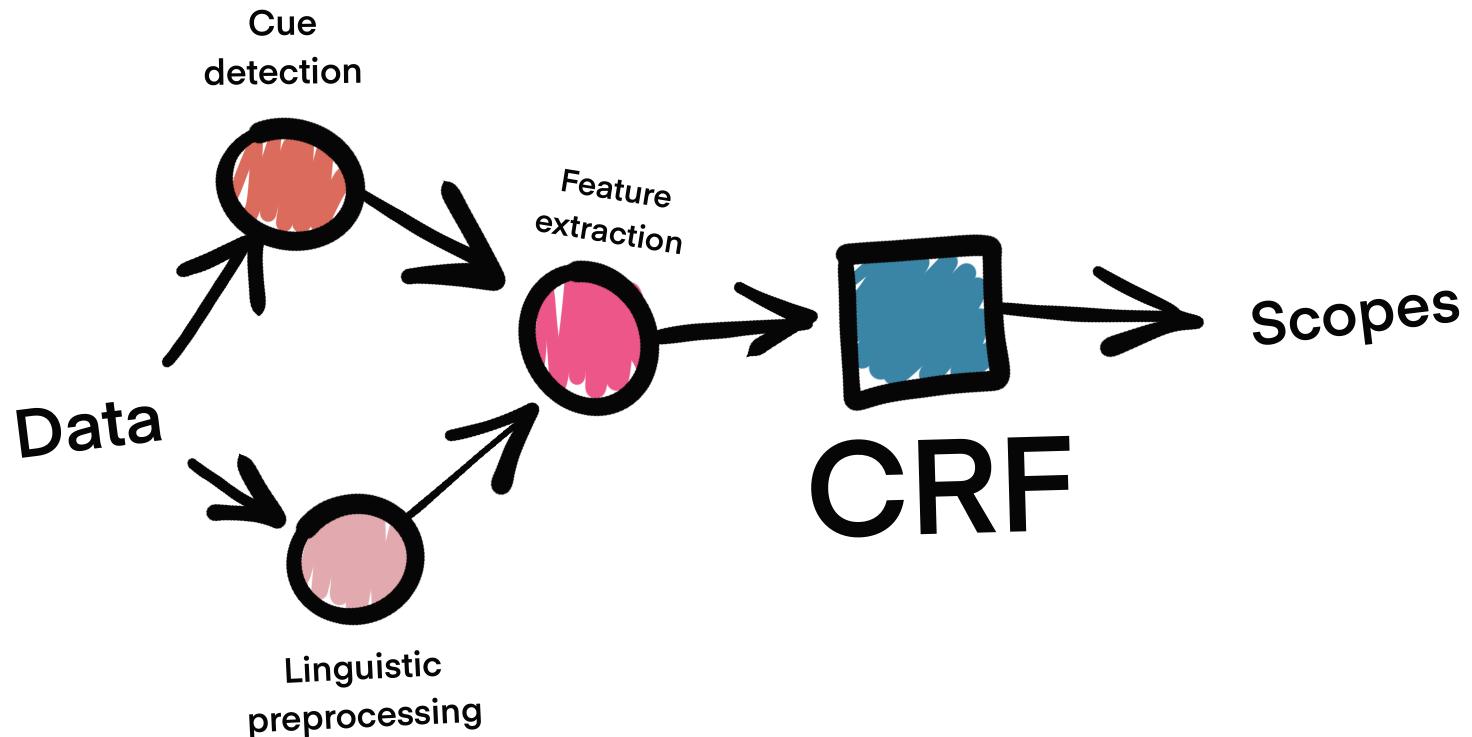
$$p(\mathbf{y}|\mathbf{x}) = \frac{1}{Z(\mathbf{x})} \prod_{t=1}^T \exp \left\{ \sum_{k=1}^K \theta_k f_k(y_t, y_{t-1}, \mathbf{x}_t) \right\}$$

Ah ha! One more thing

Since the transitions have an effect on the model, experiment with more labels:

[0, MCUE, CUE, N, S] - perhaps counterintuitive, but does the trick

Ye olde NLP pipeline



Where does it get us?

- The best CRF feature soup for negation in general, and the best system for exact scope match 

	Scope tokens F1	Exact scope F1
UiO2	83.73	72.39
UWashington	83.51	71.81

... by a quite small margin 

2013

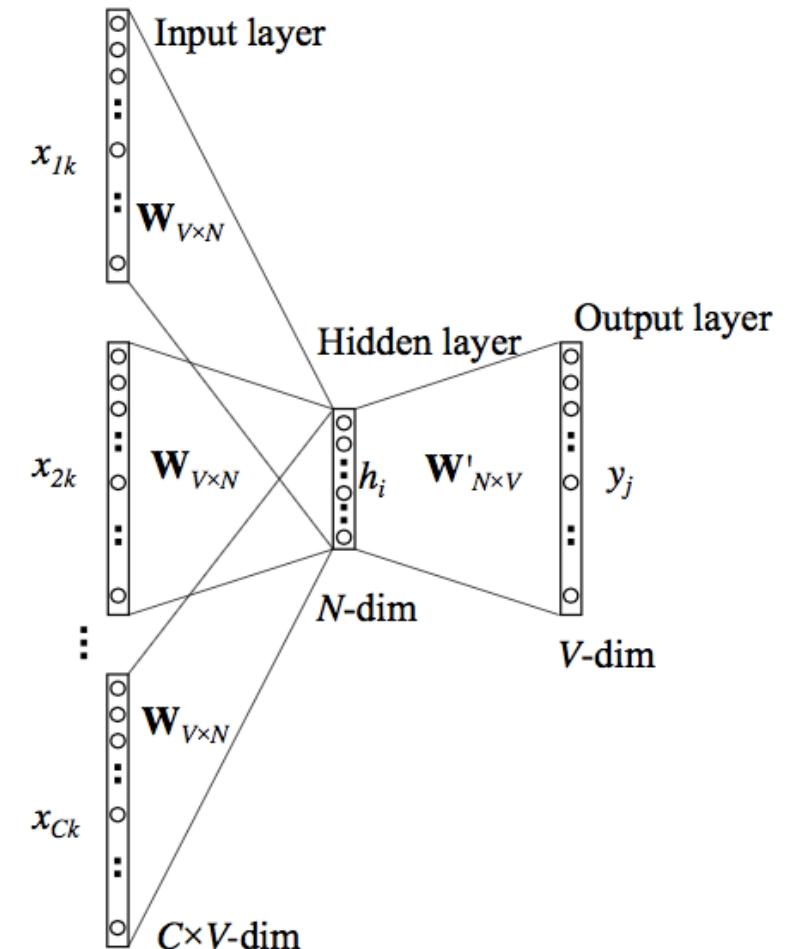
Representation revisited

- All the engineering in the 2012 system gets us little in the way of actual **meaning**
- Sherlock Holmes is a detective, and a fictional one at that
- How shall we know the meaning of a word, Prof. Firth?

You shall know the meaning of a word by the company it keeps

Word vectors

- Randomly initialize one vector per word
- Calculate a probability distribution of surrounding words (or the inverse)





Good at capturing similarities/concepts

```
e.most_similar('sherlock_holmes')[:3]  
# [('hercule_poirot', 0.808704137802124),  
# ('miss_marple', 0.7863813638687134),  
# ('fictional_detective', 0.7675886154174805)]
```

Semantic algebra! Linguistic properties!

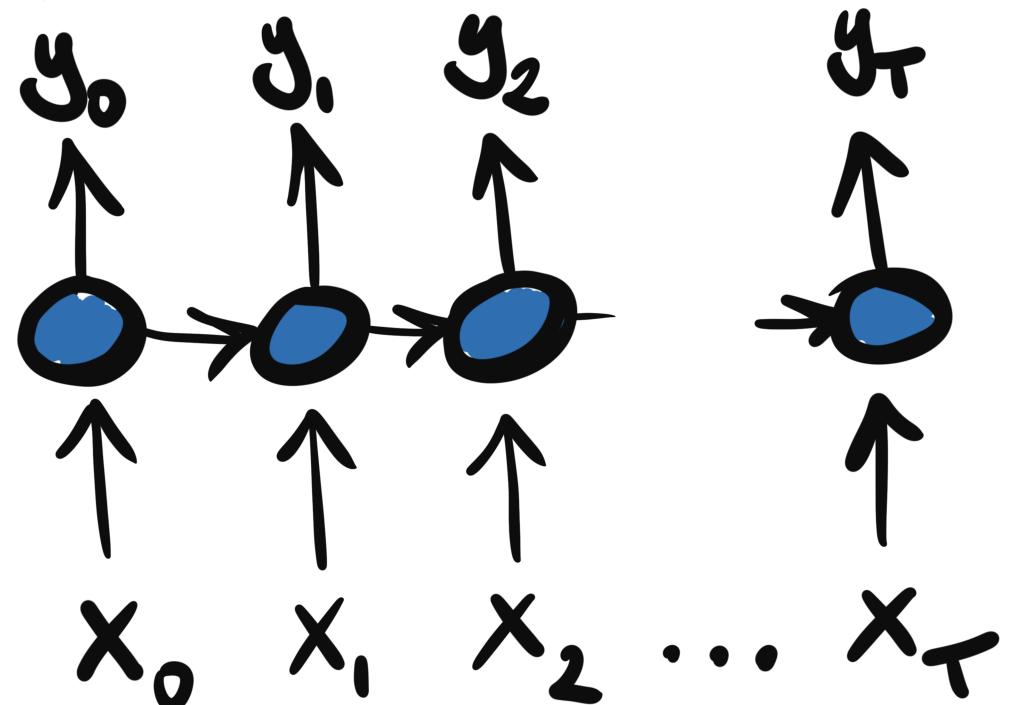
```
good = e['good']  
better = e['better']  
fast = e['fast']  
e.most_similar(  
    [better - good + fast])  
#[0]  
  
# ('faster', 0.7491286396980286)
```

LSTM RNNs

- Neural networks in time
- WV in context!
- Good at capturing long distance dependencies

For example

```
x = [e['no'], e['one'], e['cares'], e['.']]  
y = [[0,1], [1,0], [1,0], [0,1]]
```





2016



Neural Networks For Negation Scope Detection

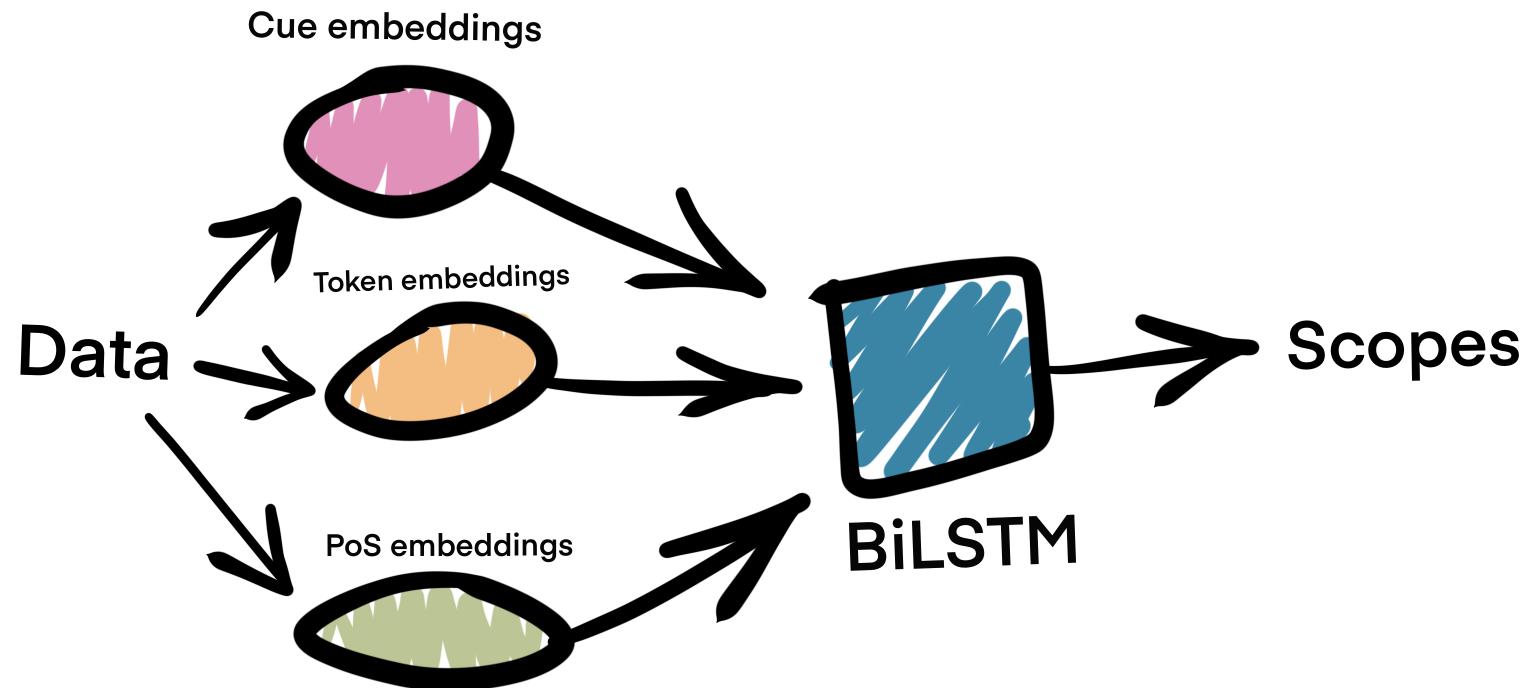
| Fancellu et al., 2016

- Bidirectional LSTMs seem to be a "natural" fit for negation
 - Scopes can be either to right or left of a cue, discontinuous scopes, etc.
- Unsupervised token modeling
- Semi-supervised pos modeling
- No explicit feature modeling of the relation between cues and tokens



Neural Networks For Negation Scope Detection

Fancellu et al., 2016



Less "intervention" and better performance 💰📈

	Scope tokens F1	Exact scope F1
BiLSTM	88.72	77.77
UiO2	83.73	72.39
UWashington	83.51	71.81

Less "intervention" ~~and better performance~~

	Scope tokens F1	Exact scope F1
BiLSTM	(?) 88.72	(?) 77.77
UiO2	83.73	72.39
UWashington	83.51	71.81

2018

The problem with word vectors



notice

/'nəʊtɪs/

noun

1. the fact of observing or paying attention to something.

"their silence did not escape my notice"

Lignende: attention

observation

awareness

consciousness

perception



2. notification or warning of something, especially to allow preparations to be made.

"interest rates are subject to fluctuation without notice"

Lignende: notification

(advance) warning

announcement

appraisal



verb

become aware of.

"he noticed the youths behaving suspiciously"

Lignende: observe

perceive

note

see

become aware of

discern





Deep contextualized word representations

Peters et al., 2018

- Instead of pre-training fixed dictionaries of WV, pre-train a deep biLSTM instead
- Run text through the pre-trained network, and out come the representations
- Different layers might help for different tasks
- lower layers: surface, higher layers: semantic
- The promise: swap your WVs with Elmo embeddings, and performance will improve



In practice

```
e = embed(  
    "interest rates are subject to fluctuation without notice".split(),  
    "we have yet to receive formal notification of the announcement".split(),  
    "notice the youth behaving suspiciously".split(),  
    "she observed that all the chairs were already occupied".split(),  
)  
  
notice_announcement = e[0][7]  
announcement = e[1][9]  
notice_observe = e[2][0]  
observe = e[3][1]  
  
print(all([  
    1-cosine(notice_announcement, announcement) > 1-cosine(notice_announcement, observe),  
    1-cosine(notice_observe, observe) > 1-cosine(notice_announcement, observe)  
]))  
  
# > True
```



BERT: Pre-training of Deep Bidirectional Transformers for Language Understanding

| Devlin et al. 2019

- The same general intuition as Elmo, but with a **transformer** architecture
- Ditches the recurrent part of Elmo, enables training massive models
- multi-head attention and transformer probing is a genre in itself
- Gets us closer to **end-to-end(-ness?)**: fine-tuning

Model fine-tuning

- More than just representation: add a layer for your task
- Gently (and cheaply!) retrain the whole network
- Text in, English SOTA out
- Made easily accessible by for example 😊



2019



NegBERT: A Transfer Learning Approach for Negation Detection and Scope Resolution

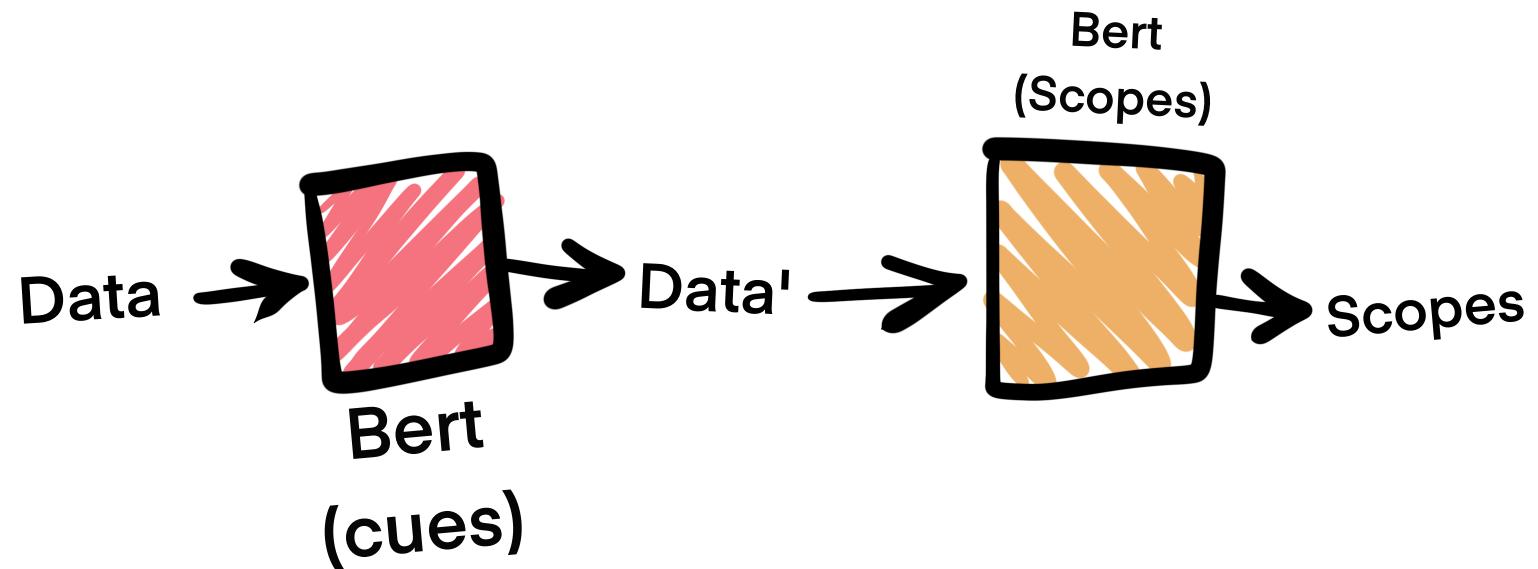
| Khandelwal and Sawant, 2019*

- Gets us even closer to end to end:
 - i. Fine-tune Bert for cue detection
 - ii. Fine-tune Bert for scope detection (w/ special cue tokens)
- Features-through-labels make a comeback!
['normal', 'affix', 'multiword', 'not-a-cue']



NegBERT: A Transfer Learning Approach for Negation Detection and Scope Resolution

| Khandelwal and Sawant, 2019*





	Scope tokens F1	Exact scope F1
NegBERT	92.36	---
BiLSTM	(?) 88.72	(?) 77.77
UiO2	83.73	72.39
UWashington	83.51	71.81



Conclusion

- End to end systems in NLP: from pipelines, through neural pipelines, to one neural model
- We took a historical, research-based look at this trend through architectural developments in a specific task: NSR
- Almost there but not quite!