

Weakly Supervised Attention Networks for Fine-Grained Opinion Mining and Public Health

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Training Segment Classifiers Without Ground Truth Segment Labels

1. Fine-Grained Analysis of Online User Reviews
2. Background: Multiple Instance Learning Networks
3. Hierarchical Sigmoid Attention Networks: The Importance of the Aggregation Function
4. Experimental Evaluation

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Application 1: Opinion Mining

SEGMENT-LEVEL SENTIMENT ANALYSIS

positive
neutral
negative



Tavc
\$

★★★★★ 7/24/2018
1 check-in

This is a review for Tavern on the Go, a convenient and could-be wonderful space to stop for a drink or snack while walking through Central Park.

So...right next to Tavern on the Green is a smaller building with a private garden and tables. There is a service window to order and pick up beverages and a few snacks. It is a beautiful and restful space, a great spot to unplug for a few minutes and enjoy the beauty around you. The prices are, as you might imagine, kind of nuts, BUT, your order gains you access to this sanctuary space, which makes the price point quite worth it.

Why two stars, you might be thinking?? The server working the window was cold, disinterested and gave off a VERY rude vibe! Not only to me, but to the group ordering before me which included a woman in a wheelchair! She gave the feeling that she was doing us all a BIG favor by taking our orders and the taking our money.

There seemed to be a secondary server behind her in the window who was trying very hard to be customer focused. Her efforts were noticed, but she was completely over shadowed by her colleague working the front.

C &
Squ
\$\$ - Italian, Ca

★ Write a Review

Kerrie D.
Portland, ME
281 friends
560 reviews
1108 photos
Elite '2019

★★★★★ 7/24/2018
1 check-in

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I would urge Tavern on the Green to check in with the servers working their "on the go" window, to make sure they are representing your brand of service in a way that you would expect!

Charisse J.
Newark, NJ
67 friends
7 reviews

★★★★★ 4/11/2017

Waited at the bar to be seated. Drink was very nice. Very strong delicious drink. People were all friendly. Our server Papa was amazing. Unfortunately I have been up half the night and suffering all day due to food poisoning. I'm assuming it was the shrimp. Its been a waterfall out of both ends and for the price I would expect better quality. Thus even making me late for school drop off and pick up today. My "medium rare" steak was too tough, more like medium well and the shrimp also was slightly over cooked. Both to the point I had to spit them out. Manager did take 50% off the steak. Great atmosphere. Just wish my bf and I weren't suffering.

Application 2: Public Health

FOODBORNE ILLNESS DISCOVERY

Not Sick
Sick

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Kerrie D. Portland, ME 281 friends 560 reviews 18 photos 7/24/2018 1 check-in This is a review for Tavern on the Go, a convenient and could-be wonderful space to stop for a drink or snack while walking through Central Park. So...right next to Tavern on the Green is a smaller building with a private garden and tables. There is a service window to order and pick up beverages and a few snacks. It is a beautiful and restful space, a great spot to unplug for a few minutes and enjoy the beauty around you. The prices are, as you might imagine, kind of nuts, BUT, you order gains you access to this sanctuary space, which makes the price point quite worth it. Why two stars, you might be thinking?? The server working the window was cold, disinterested and gave off a VERY rude vibe! Not only to me, but to the group ordering before me which included a woman in a wheelchair! She gave the feeling that she was doing us all a BIG favor by taking our orders and the taking our money. There seemed to be a secondary server behind her in the window who was trying very hard to be customer focused. Her efforts were noticed, but she was completely overshadowed by her colleague working the front. I would urge Tavern on the Green to check in with the servers working their "on the go" window, to make sure they are representing your brand of service in a way that you would expect!

Jasmine J. Newark, NJ 67 friends 7 reviews 4/11/2017 Waited at the bar to be seated. Drink was very nice. Very strong delicious drink. People were all friendly. Our server Papa was amazing. Unfortunately I have been up half the night and suffering all day due to food poisoning. I'm assuming it was the shrimp. Its been a waterfall out of both ends and for the price I would expect better quality. Thus even making me late for school drop off and pick up today. My "medium rare" steak was too tough, more like medium well and the shrimp also was slightly over cooked. Both to the point I had to spit them out. Manager did take 50% off the steak. Great atmosphere. Just wish my bf and I weren't suffering.

Tavern on the Go Manhattan, NY

Log In Sign Up

Write a Review Add Photo

\$\$ - Italian, Catering

Square logo with 3 stars

Application 2: Public Health

Detecting foodborne illness from Yelp restaurant reviews



NYC Restaurants

Tavern on the Green Claimed

★★★★½ 1377 reviews
\$\$\$ - American (New), Cocktail Bars [Edit](#)

Flat Top Claimed

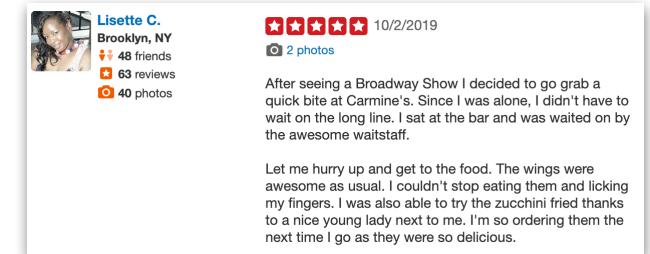
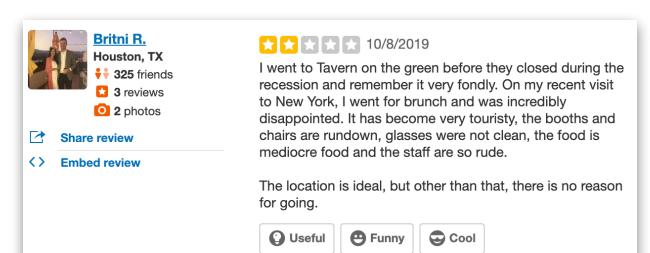
★★★★★ 448 reviews
\$\$ - American (New), Cafes, Breakfast & Brunch [Edit](#)

Carmine's Italian Restaurant - Times Square Claimed

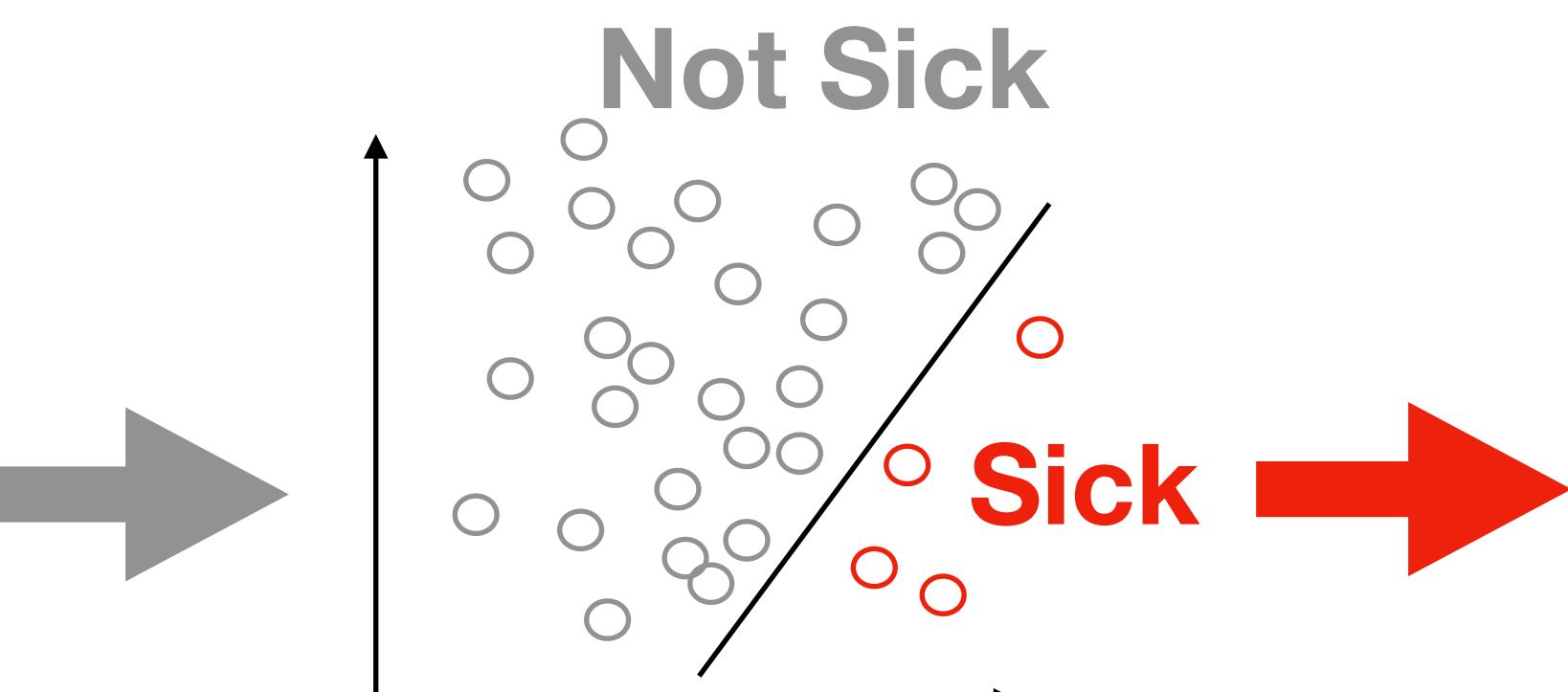
★★★★★ 3630 reviews
\$\$ - Italian, Caterers, Venues & Event Spaces [Edit](#)

Tom's Restaurant Claimed

★★★★★ 743 reviews
\$\$ - Breakfast & Brunch, Greek, American (Traditional) [Edit](#)



ML Classifier



Epidemiologists



I wish I could give it zero stars. I actually created a yelp account to write this review! At first I thought it was great that we got a table for 5 morning of on a Saturday. The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about. The service was good, it was overall fine. That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food poisoning in my life! That was the only place we ate or drank anything at that day, so I know it was from this restaurant. By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend! Whatever you do, do not eat here, it is not worth the risk of ending up so unwell. To clarify what I believe caused this- we both had carrot juice randomly. I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.

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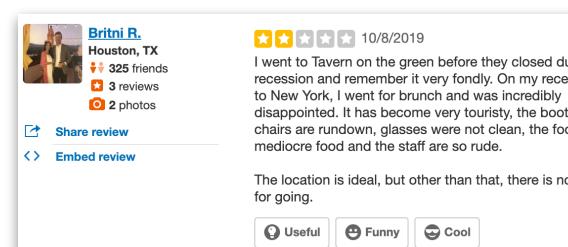
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[Write a Review](#) [Add Photo](#) [Share](#) [Save](#)

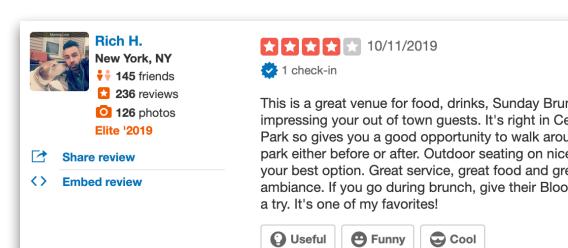


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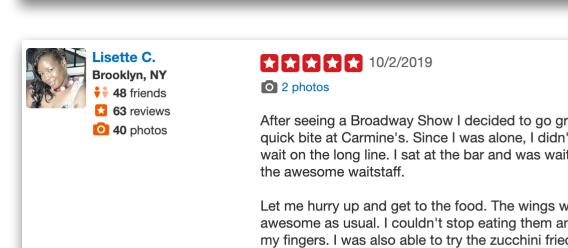


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[Write a Review](#) [Add Photo](#) [Share](#) [Save](#)

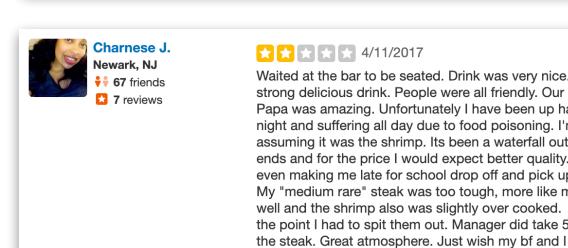


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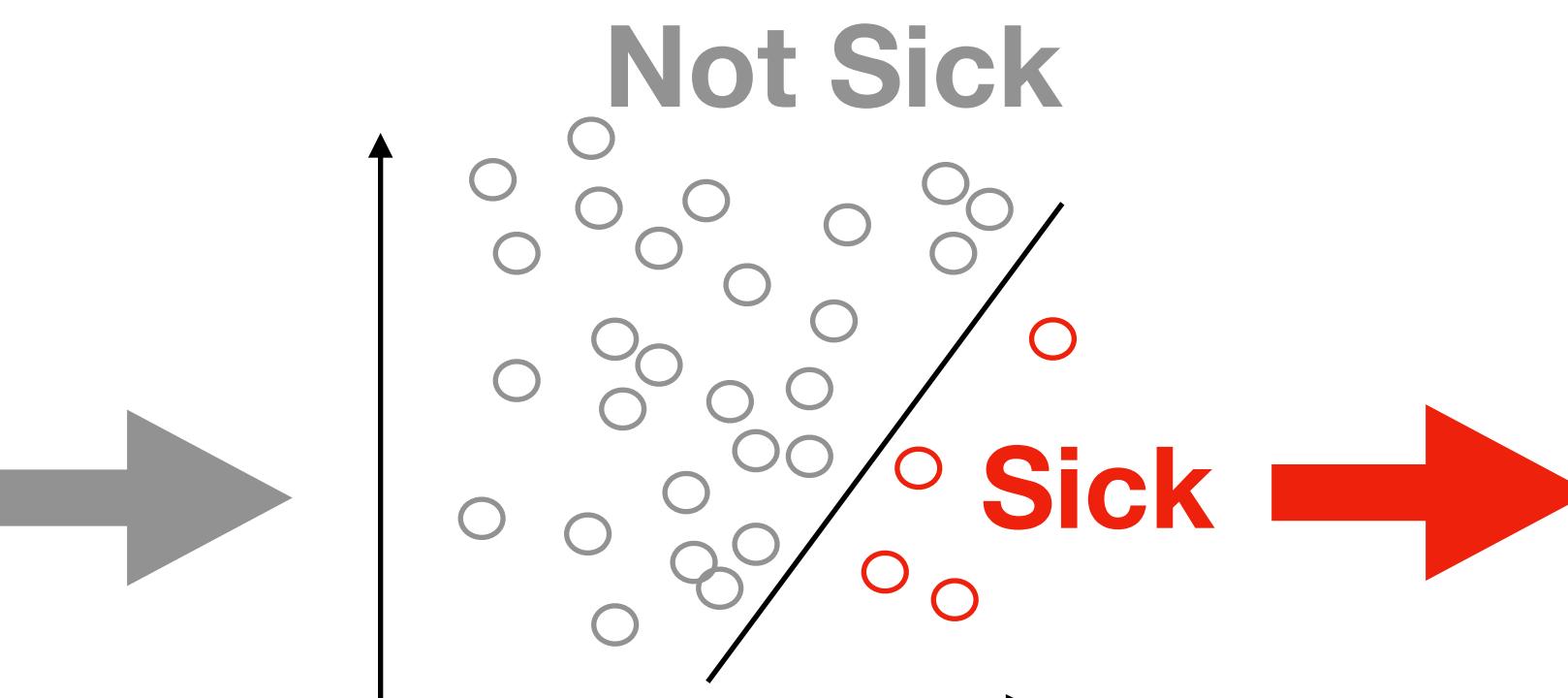
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[Write a Review](#) [Add Photo](#) [Share](#) [Save](#)



ML Classifier



Restaurant Inspectors



Epidemiologists



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Fine-Grained Text Classification

- Goal: provide **segment-level** predictions

SENTIMENT CLASSIFICATION

— positive
— neutral
— negative

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FOODBORNE CLASSIFICATION

— Not Sick
— Sick

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Fine-Grained Text Classification

- **Goal:** provide **segment-level** predictions
- **Issue:** segment labels are **expensive** to obtain
- **This work:** employ weakly supervised learning
 - Train **segment-level** classifiers using only **review** labels!

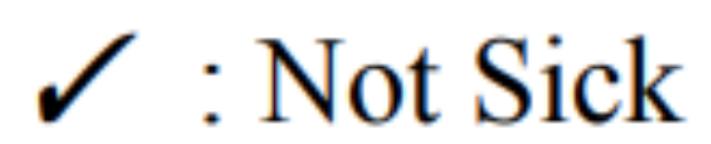
SENTIMENT CLASSIFICATION

User rating



FOODBORNE CLASSIFICATION

Epidemiologist diagnosis



Weakly Supervised Learning

- **Challenge:** How to train **segment**-level classifiers using **review** labels?

Weakly Supervised Learning

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- **Previous work:** Multiple Instance Learning (MIL)
 - Early approaches: simple MIL classifiers (e.g., LogReg) [Zhou et al., 2009; Kotzias et al., 2015]
 - State-of-the-art approaches: hierarchical MIL networks [Pappas and Popescu-belis, 2014;2017]
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Weakly Supervised Learning

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 - State-of-the-art approaches: hierarchical MIL networks [Pappas and Popescu-belis, 2014;2017]
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- **Question:** Where do performance gains stem from (in hierarchical MIL networks)?
 - Hierarchical MIL Structure?
 - Deep learning components?

Summary of Our Contributions

We identify a key improvement to hierarchical MIL networks:

changing the “aggregation” (AGG) function

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3. Demonstrate advantages of our approach in two applications:

- Segment-level sentiment classification
- Foodborne illness detection

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Leveraging Review Labels Through Multiple Instance Learning (MIL)

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- **Challenge:** How to train **segment**-level classifiers using **review** labels?
- **MIL Framework:** Bags of instances
 - **Bag:** review $r = (s_1, \dots, s_M)$ with observed label p
 - **Instances:** segments s_i with unobserved labels p_i

review label	p
segment labels	$p_1 \ p_2 \ \dots \ p_M$

Leveraging Review Labels Through Multiple Instance Learning (MIL)

- **Challenge:** How to train **segment**-level classifiers using **review** labels?

- **MIL Framework:**

- MIL assumption (“at least one”): $p = 1 \text{ iff } \exists i : p_i = 1$

review label p

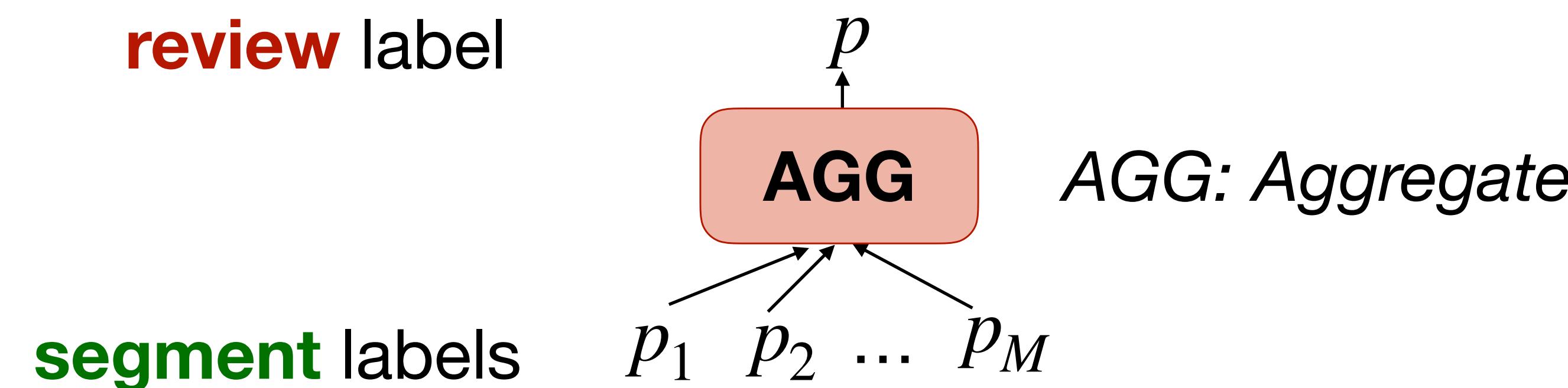
segment labels $p_1 \ p_2 \ \dots \ p_M$

Leveraging Review Labels Through Multiple Instance Learning (MIL)

- **Challenge:** How to train **segment**-level classifiers using **review** labels?

- **MIL Framework:**

- MIL assumption (“at least one”): $p = 1 \text{ iff } \exists i : p_i = 1$
- MIL assumption (relaxed): $p = \text{AGG}(p_1, \dots, p_M)$



Multiple Instance Learning Networks

Hierarchical MIL Network Architecture

[Pappas and Popescu-belis, 2017]

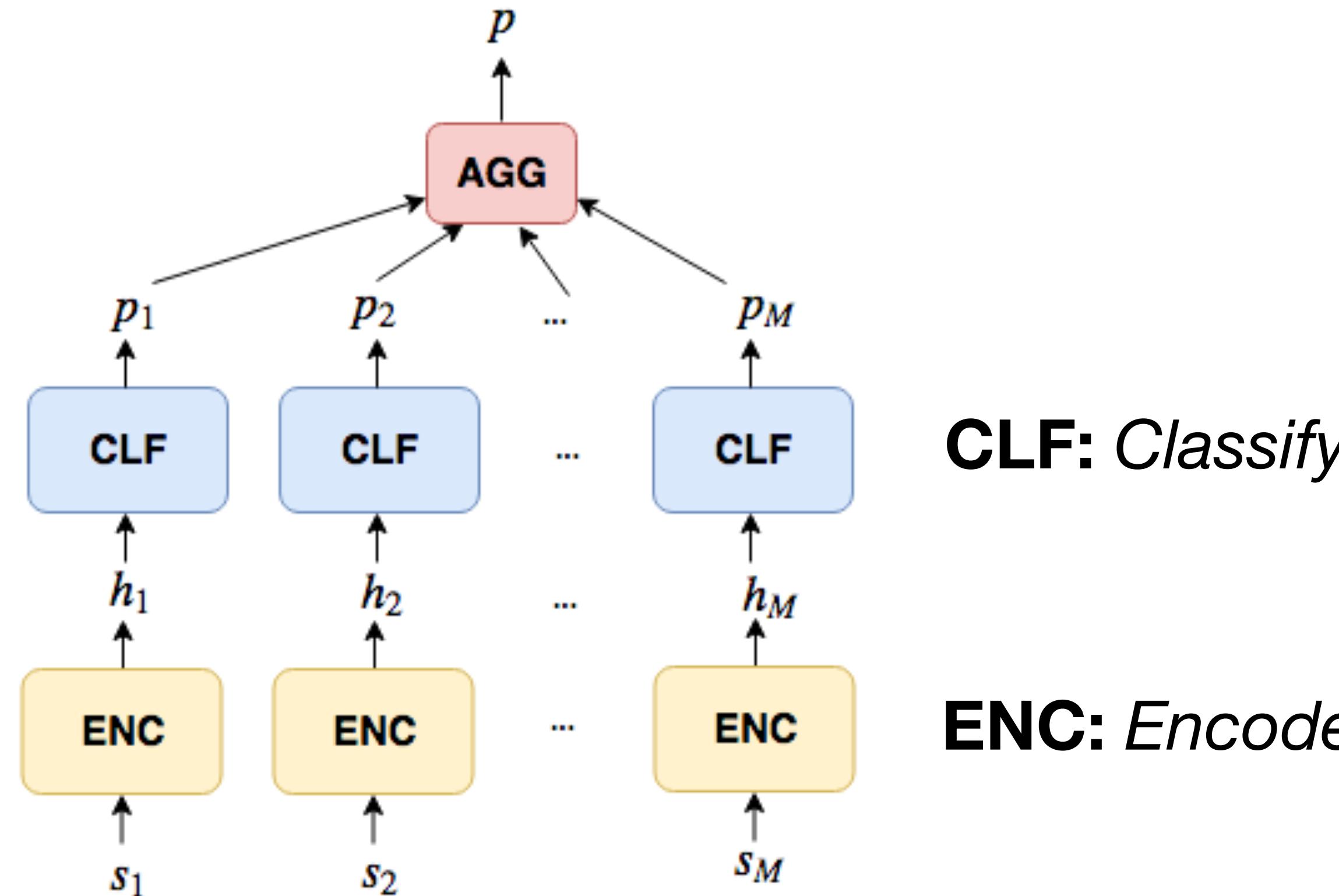
[Angelidis and Lapata, 2018]

review prediction

segment prediction

segment vectors

segments



CLF: *Classify*

ENC: *Encode*

MIL Networks may be outperformed by simpler networks

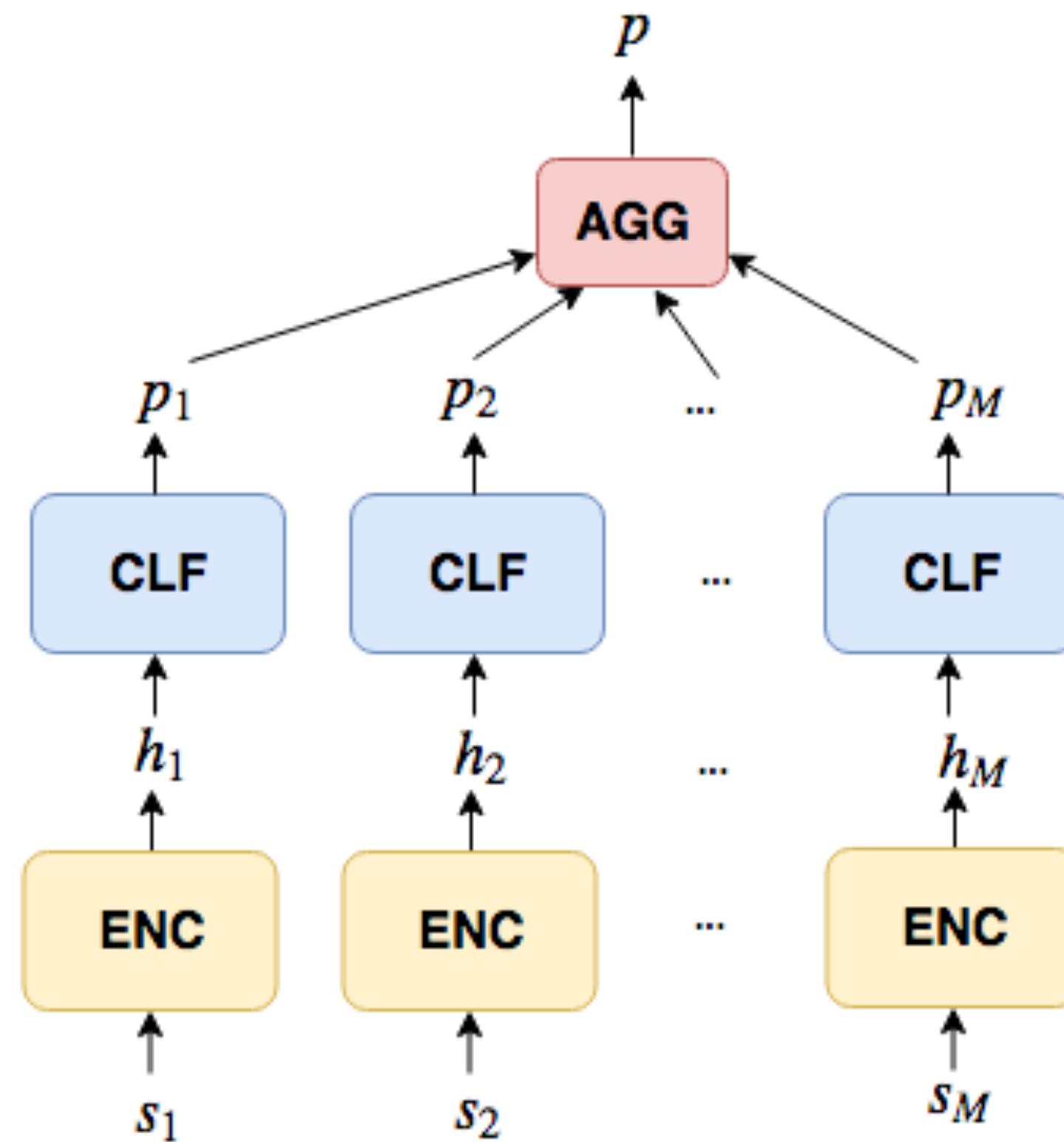
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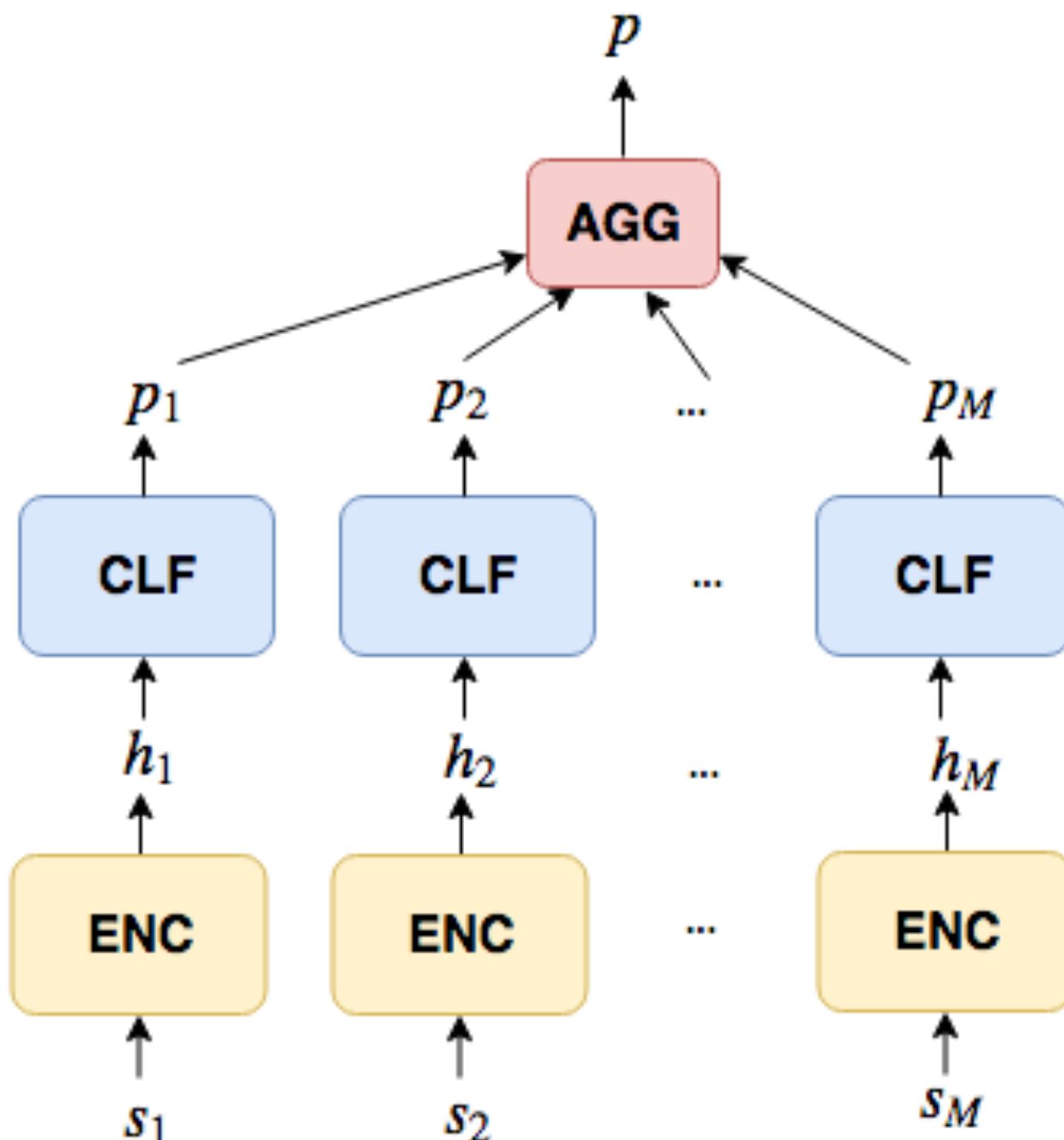
MIL Networks may be outperformed by simpler networks

Hierarchical MIL Networks

<

Non-Hierarchical Networks

review prediction



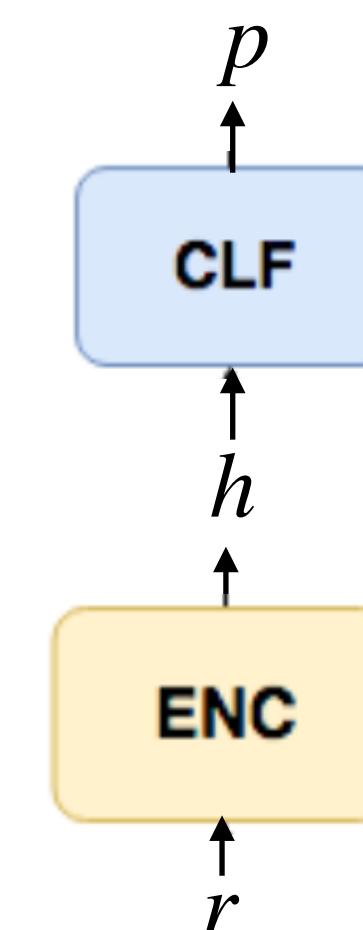
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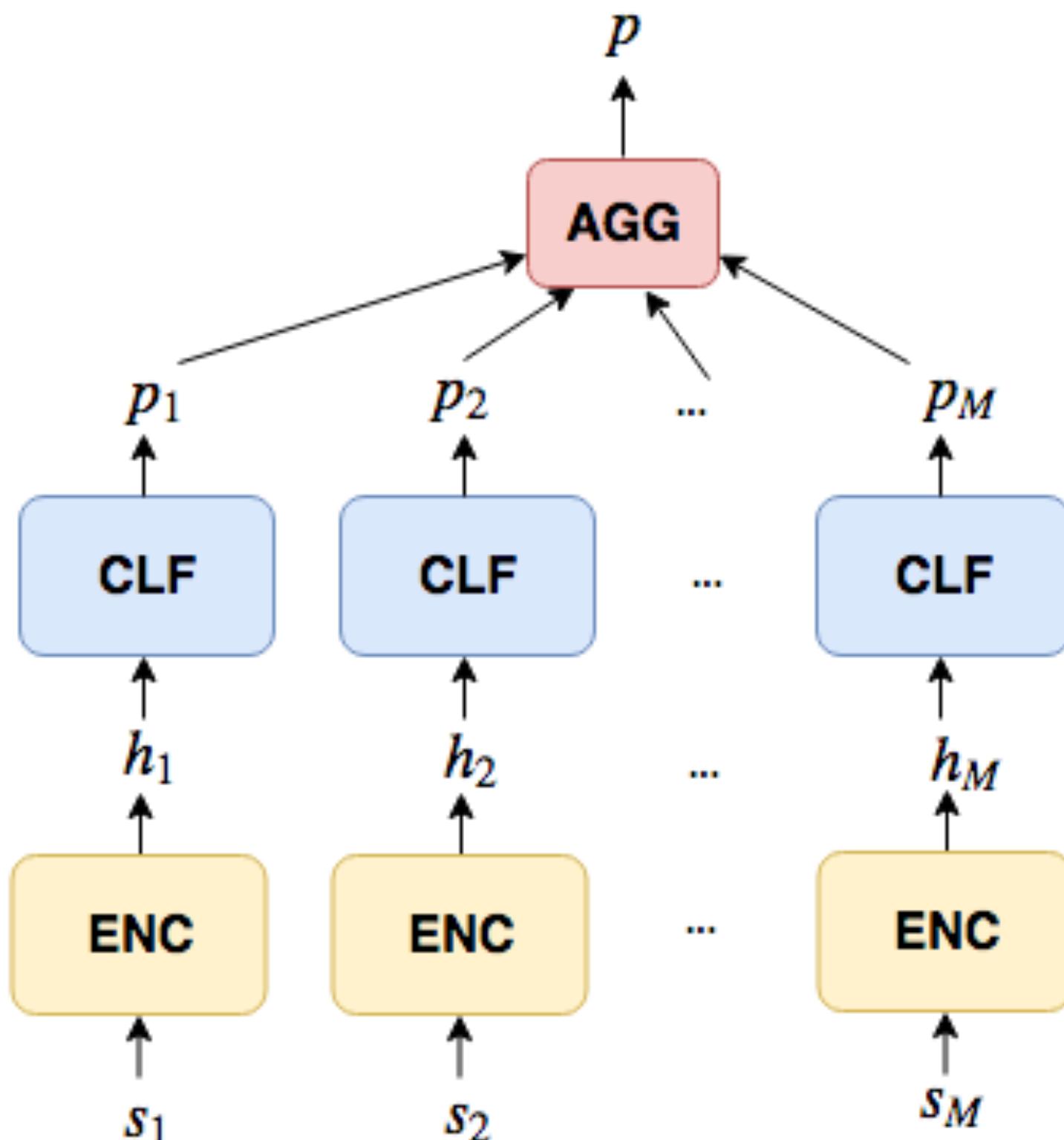
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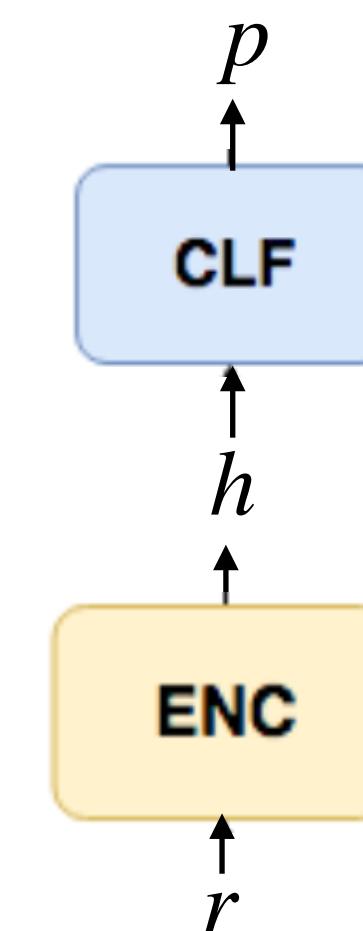
segment vectors

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review prediction

review vector

review



- **When?** When AGG functions in MIL networks are not suitable for the task at hand

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AGG in MIL \neq Standard AGG

$$p = \text{AGG}(p_1, \dots, p_M) \quad h = \text{AGG}(h_1, \dots, h_M)$$

AGG: Should Explicitly Capture the Label Hierarchy

- Desired Properties of AGG function in MIL:
 - Review label may be related to **multiple** segment labels
 - Segments may contribute to review label with **different** weights

★★★☆☆ 7/24/2018
1 check-in

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We change the AGG function in MIL Networks

- Desired Properties of AGG function in MIL:
 - Review label may be related to **multiple** segment labels
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- Previous AGG functions for MIL:
 - Uniform average [Kotzias et al., 2015]
 - Softmax attention [Angelidis and Lapata, 2018]

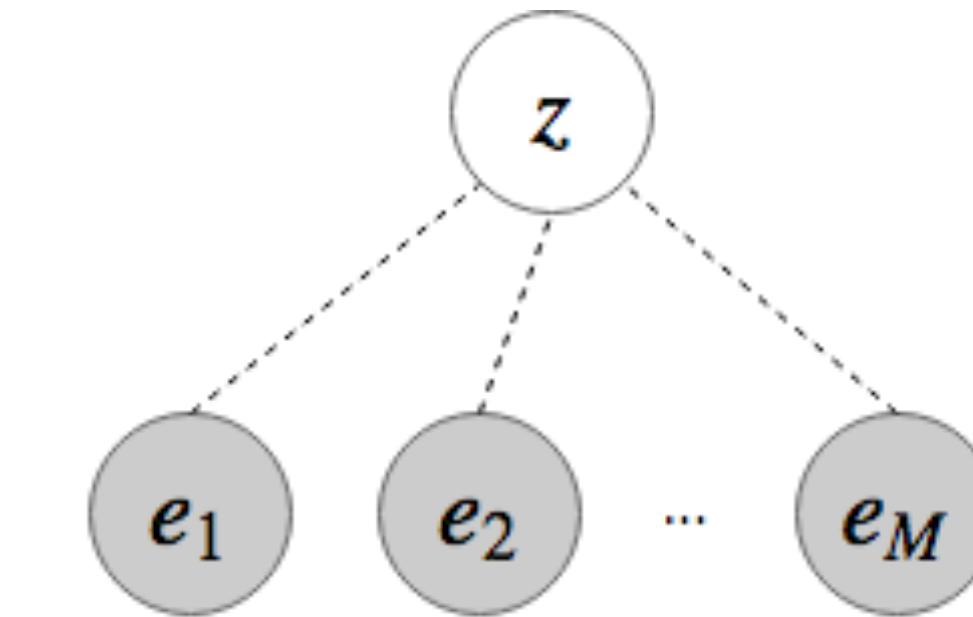
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- Previous AGG functions for MIL:
 - Uniform average [Kotzias et al., 2015]
 - Softmax attention [Angelidis and Lapata, 2018]
- Our AGG function: **Sigmoid attention**
 - Review label: **weighted** average of segment labels
 - Segment weights: estimated through **sigmoid attention**

Benefits of Sigmoid over Softmax for MIL

- **Softmax attention for MIL** (Angelidis and Lapata, 2018)

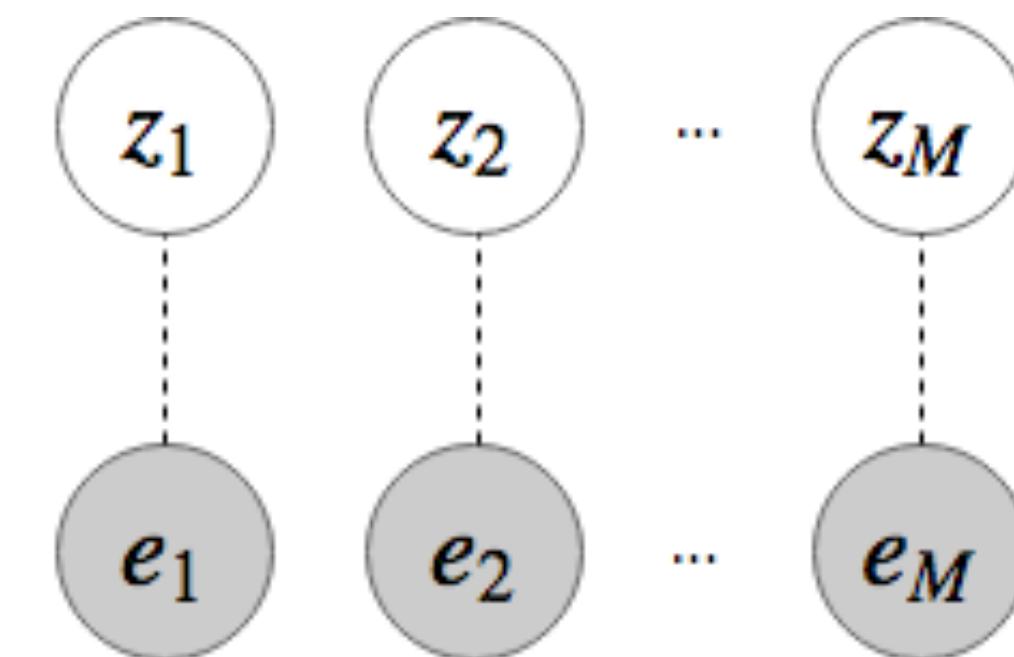
$$p(z = i \mid e_1, \dots, e_M) = \frac{\exp(e_i)}{\sum_{i=1}^M \exp(e_i)}$$



- prioritizes one segment

- **Sigmoid attention for MIL** (Our work)

$$p(z_i = 1 \mid e_1, \dots, e_M) = \frac{1}{1 + \exp(-e_i)}$$



- allows multiple segments to be selected

Hierarchical Sigmoid Attention Networks (HSANs)

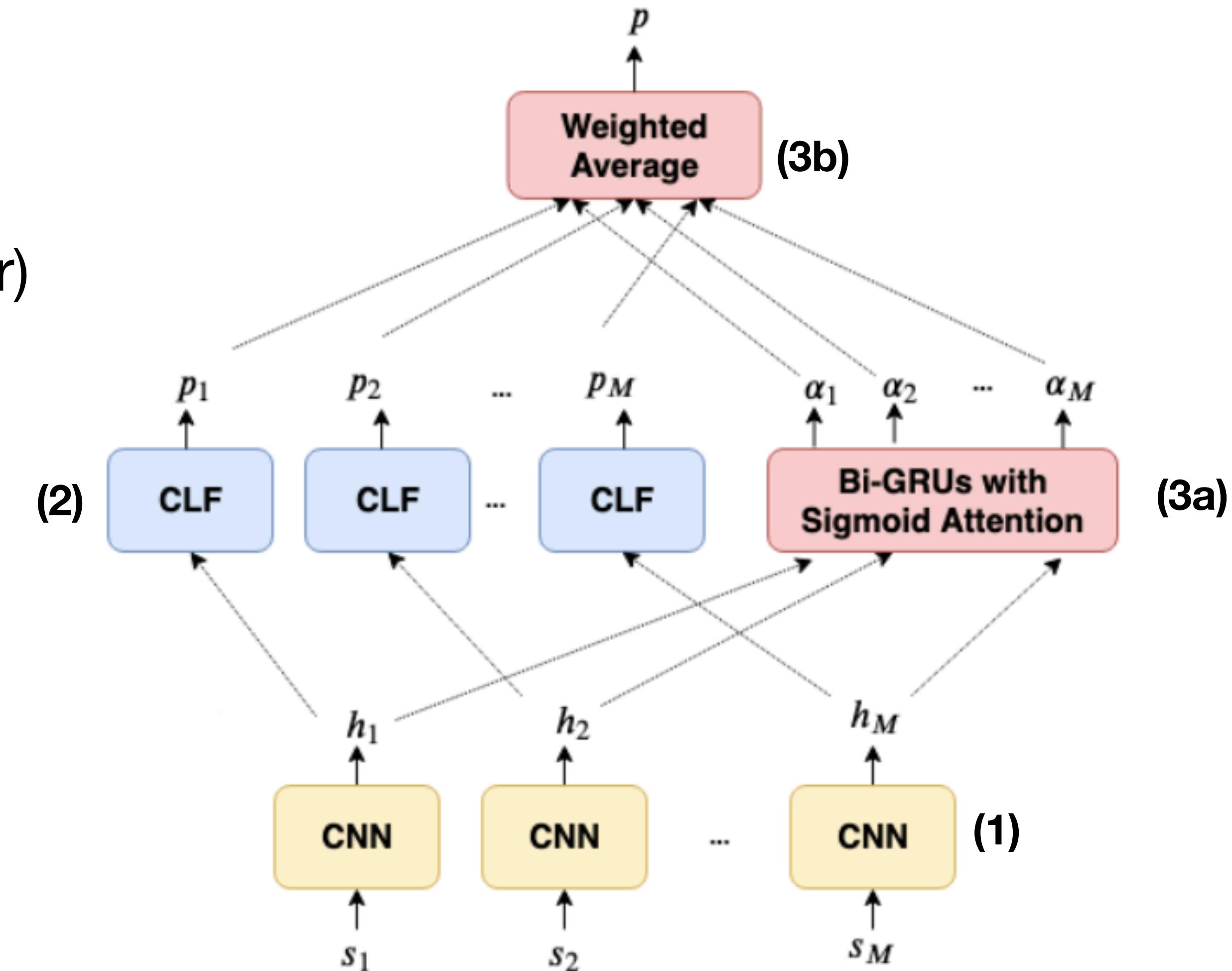
1. **ENC:** Encode segments (CNNs)

2. **CLF:** Classify segments (classification layer)

3. **AGG:**

a. Compute **Sigmoid Attention** weights

b. Classify review (Weighted Average)

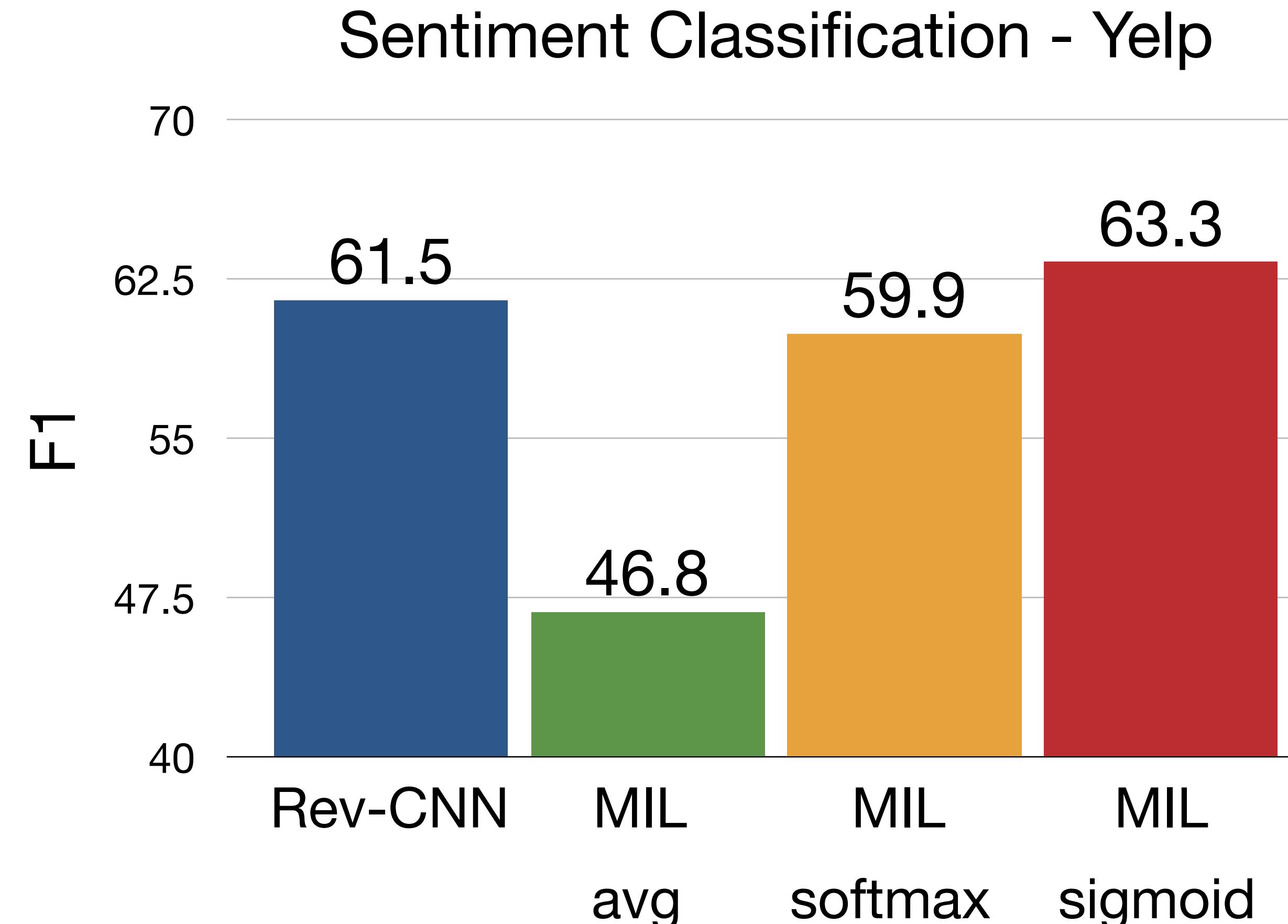


Training: Use only ground truth **review** labels

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 1. Segment-level sentiment classification
 2. Foodborne illness detection

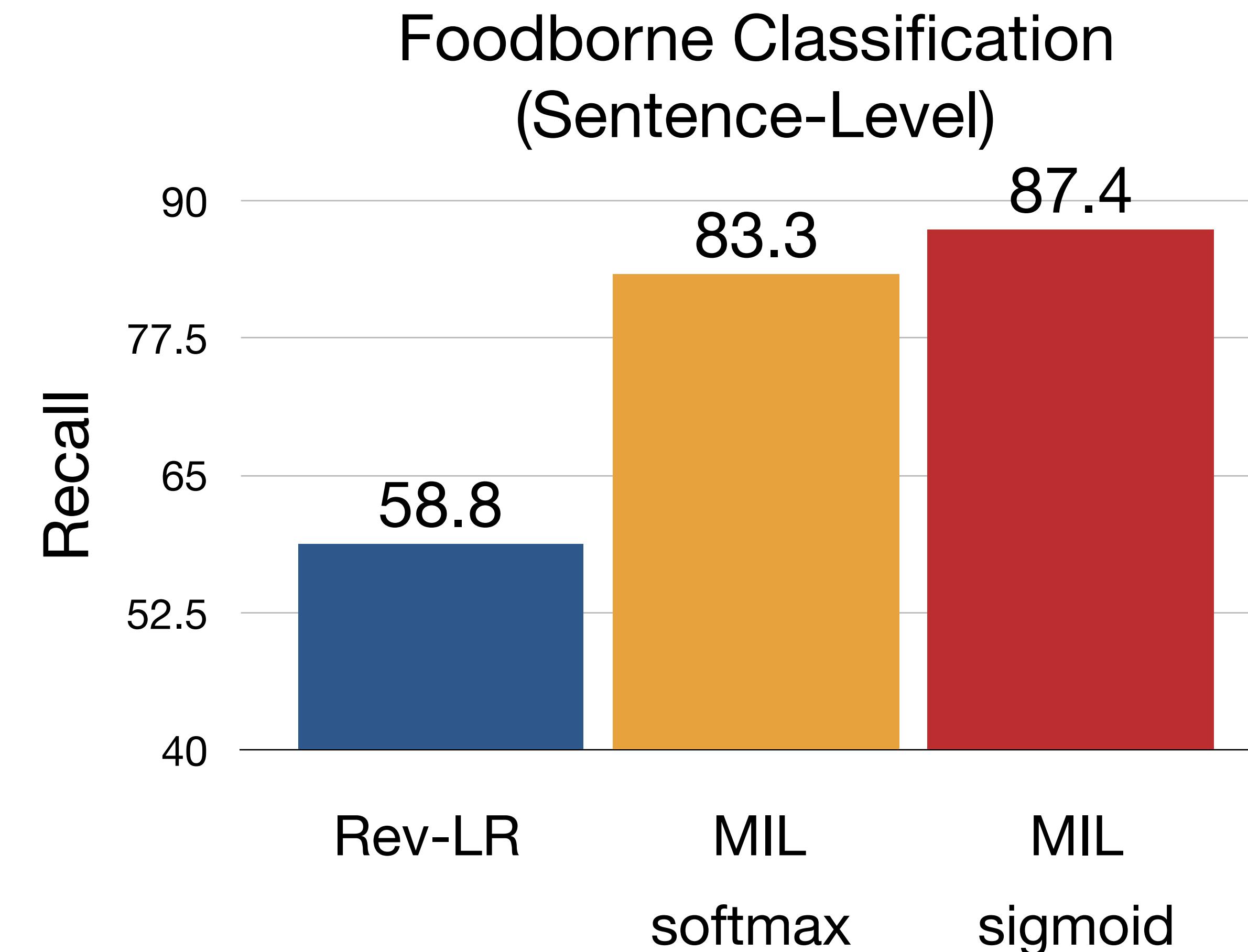
The choice of AGG function is crucial in MIL networks



- Non-hierarchical **Rev-CNN** outperforms hierarchical **MIL-avg** and **MIL-softmax**
- MIL-sigmoid** significantly outperforms all other models

Similar results for IMDB. See paper for details.

We Detect More Reviews Mentioning Foodborne Illness



- ▶ **MIL-sigmoid** has 48.6% higher recall than **Rev-LR** (best model in Effland et al. 2018)

More results in our paper.

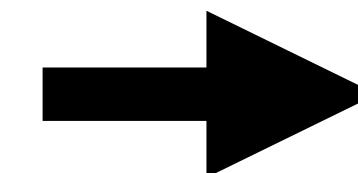
Highlighting Important Sentences

Previous Classifiers



: Pred = **Sick** (prob=0.9)

I wish I could give it zero stars. I actually created a yelp account to write this review! At first I thought it was great that we got a table for 5 morning of on a Saturday. The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about. The service was good, it was overall fine. That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food poisoning in my life! That was the only place we ate or drank anything at that day, so I know it was from this restaurant. By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend! Whatever you do, do not eat here, it is not worth the risk of ending up so unwell. To clarify what I believe caused this- we both had carrot juice randomly. I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.



MIL-sigmoid (HSAN)



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Pred	Att	Text	
✓	0.00	I wish I could give it zero stars.	:(Sick ✓ : Not Sick
✓	0.00	I actually created a yelp account to write this review!	
✓	0.00	At first I thought it was great that we got a table for 5 morning of on a Saturday.	
✓	0.00	The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about.	
✓	0.00	The service was good, it was overall fine.	
✓	0.00	That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet!	
:(0.18	I have never experienced such violent food poisoning in my life!	
✓	0.00	That was the only place we ate or drank anything at that day, so I know it was from this restaurant.	
:(0.82	By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend!	
:(0.00	Whatever you do, do not eat here, it is not worth the risk of ending up so unwell.	
✓	0.00	To clarify what I believe caused this- we both had carrot juice randomly.	
:(0.00	I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.	

Highlighting Important Sentences

Previous Classifiers

I have never experienced such violent food poisoning in my life

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Pred	Att	Text	
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✓	0.00	I actually created a yelp account to write this review!	
✓	0.00	At first I thought it was great that we got a table for 5 morning of on a Saturday.	
✓	0.00	The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about.	
✓	0.00	The service was good, it was overall fine.	
✓	0.00	That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet!	
	0.18	I have never experienced such violent food poisoning in my life!	
✓	0.00	That was the only place we ate or drank anything at that day, so I know it was from this restaurant.	
	0.82	By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend!	
	0.00	Whatever you do, do not eat here, it is not worth the risk of ending up so unwell.	
	0.00	To clarify what I believe caused this- we both had carrot juice randomly.	
	0.00	I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.	

Highlighting Important Sentences

Previous Classifiers

I have never experienced such violent food poisoning in my life

nothing to complain about. The service was good, it was overall fine. That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food

By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend

MIL-sigmoid (HSAN)



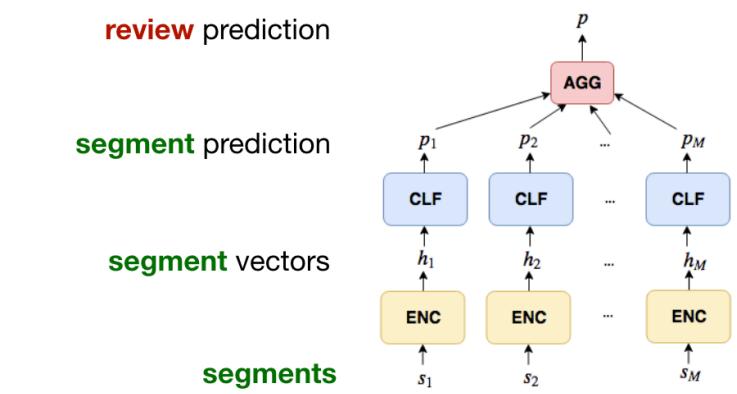
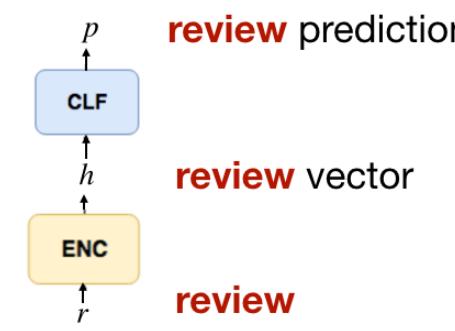
: Pred = **Sick** (prob=0.9)

Pred	Att	Text	
✓	0.00	I wish I could give it zero stars.	:(Sick ✓ : Not Sick
✓	0.00	I actually created a yelp account to write this review!	
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✓	0.00	That was the only place we ate or drank anything at that day, so I know it was from this restaurant.	
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/	0.00	Whatever you do, do not eat here, it is not worth the risk of ending up so unwell.	
	0.00	To clarify what I believe caused this- we both had carrot juice randomly.	
	0.00	I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.	

- Fine-grained predictions could help epidemiologists to quickly identify relevant sentences

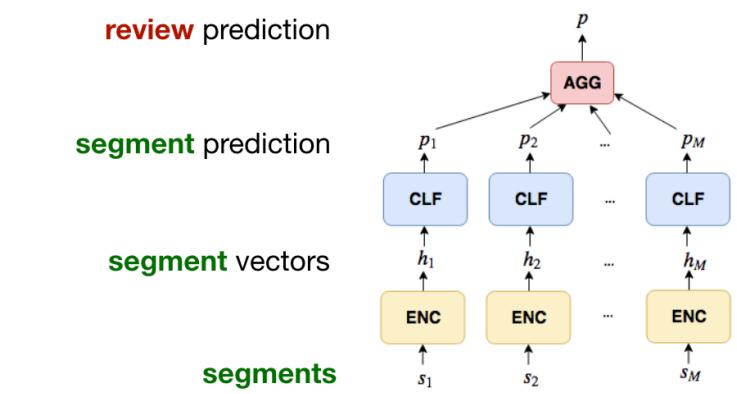
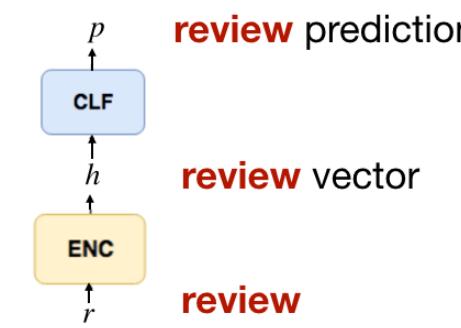
Summary of Our Contributions

1. Show that **non-hierarchical** baselines may outperform previous **MIL** networks.

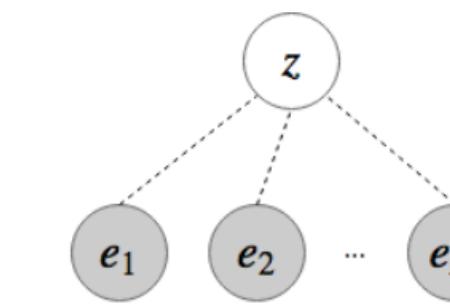
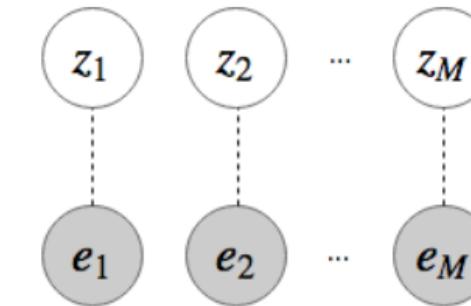


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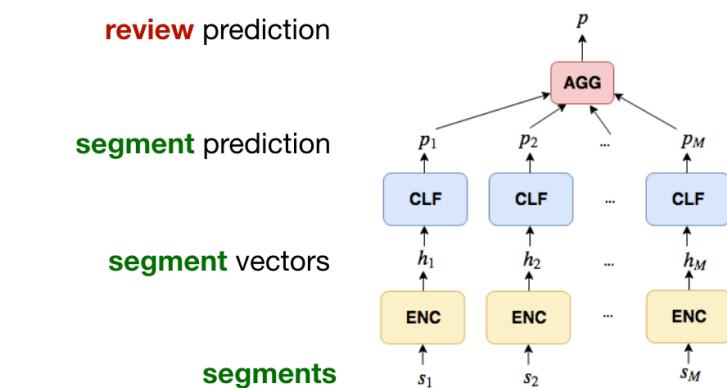
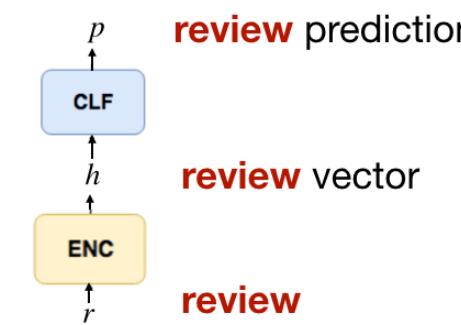


2. Identify that **sigmoid** attention is more appropriate than **softmax** attention for MIL.

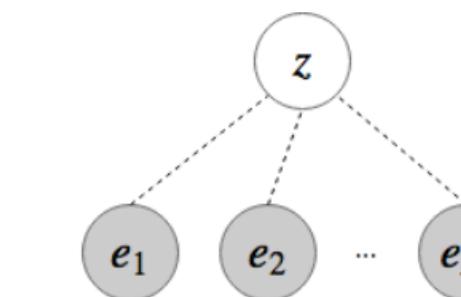
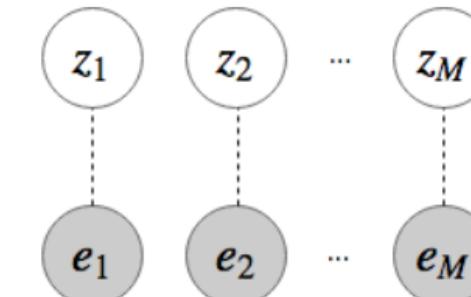


Summary of Our Contributions

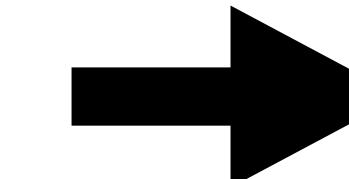
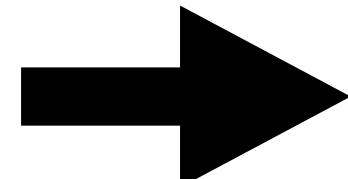
1. Show that **non-hierarchical** baselines may outperform previous **MIL** networks.



2. Identify that **sigmoid** attention is more appropriate than **softmax** attention for MIL.



3. Demonstrate that our model could have positive impact for **public health**.



Current and Future Work

1. Leverage “stronger” forms of weak supervision for neural networks

— **Session 9D: Sentiment Analysis and Argument Mining IV**

First steps:
(this Thursday)

[Leveraging Just a Few Keywords for Fine-Grained Aspect Detection](#)

[Through Weakly Supervised Co-Training \(# 3207\)](#)

Giannis Karamanolakis, Daniel Hsu and Luis Gravano

2. Evaluate how “explainable” are fine-grained predictions of MIL networks

3. Deploy our model to more health departments



Thank you!

Contact
gkaraman@cs.columbia.edu
<https://gkaramanolakis.github.io>



Please come to our poster and talk

— Session 9D: Sentiment Analysis and Argument Mining IV

Leveraging Just a Few Keywords for Fine-Grained Aspect Detection
Through Weakly Supervised Co-Training (# 3207)

Giannis Karamanolakis, Daniel Hsu and Luis Gravano

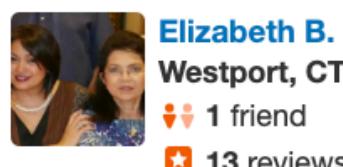
Contact

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<https://gkaramanolakis.github.io>



COLUMBIA
UNIVERSITY

Long Reviews...



Elizabeth B.
Westport, CT
1 friend
13 reviews

★★★★★ 9/12/2019

Although our experience ended up on a better note, the initial experience just left a poor taste in all of our mouths. And truthfully, we grow more appalled by the horrifying experience as the days go by. A group of us were having a small HS and birthday reunion and we met at the Tavern around 3:30 p.m. on 9/11. Someone came from Manila, Philippines and another from LA. We were all so excited but ended up having a very bad experience with one of their hostess. The hostess seemed to be hesitant to seat us in the main dining room from the start. I would like to point out that Tavern at that time and day was almost empty. Maybe because it was 9/11 and everyone was downtown instead of uptown NYC. I was waiting there for some time, at the lounge, and right in front of the hostess section. So, I observed the comings and goings of the hostesses and the customers coming in. When the group was complete and as we were being seated, the hostess tells us to just seat at the bar or the lounge and that we could not seat in the main dining room unless everyone in our party was going to order a main entrée and not just appetizers. That surprised me --- why would she single out our group? She didn't seem to be doing that with the other customers? Then when we got to the main dining room, she was insistent that we could not seat by the glass area nearest the park and that was where we wanted to sit. We wanted a view and also have some sun. She was putting us in the back area of the dining room, in the dark, and far away from the area we wanted. The place only had a few customers in the whole main dining room (around three tables with two diners each). And was very surprised that we still had to fight for a better table and only ended up midway. Then as we sat, in comes a pair of clients and the same hostess didn't seem to have any issues seating them in the area we wanted to sit in. The area we wanted to sit in was open since the few customers they had that day were seated in that section. So we told the wait staff when she asked how we were doing - "Not Great" and told her how we were made to feel. Truly, I felt like simply walking out of the Tavern at that time but I had guests visiting from out of town. The manager came to address the issue. She tried to explain that discrimination was not the restaurant's policy and that she assures us that her kitchen staff and wait staff had diversity. To which I quickly answered, "So do you mean, we should go into your kitchens as well?" I told her that we could agree to disagree but reminded her that we are customers, in a rather empty restaurant, and how we were made to feel was the most important when it came to judging their "customer service". The manager didn't charge us for our deserts for the grief we experienced, in an effort to make better our experience - but I have to admit, it was in my mind on the train back to CT, and even more so now that I am back in Westport CT - I am still appalled by the whole experience. I have dined in very top restaurants in NYC or in CT - and I never had such an experience. I did not expect this kind of mis-treatment in NYC and in a restaurant such as he Tavern on the Green. The new Tavern is not the same as the original Tavern that I used to frequent. It is not the same..

Food was not special and just okay. I did enjoy the chocolate dessert.



Jenny C.
New York, NY
1 friend
90 reviews
17 photos
Elite '2019

[Share review](#)
[Embed review](#)

★★★★★ 5/17/2019

2 photos 2 check-ins

Been here a few times on family dinners when I was younger, and also a very beautiful wedding before remodeling was done in the main dining area. I was here last summer and had a delicious salmon dish and their signature carrot cake. It was the best carrot cake I have ever tasted. I'm not a big fan of raisins in my dessert, so I'm glad I couldn't taste them if they were even in it.

More recently my aunt had her 80th birthday in the "glass box" along with close family. We coordinated with Audrey, who was very helpful in explaining the reservation process and choosing a menu. Even while she was out of town, she was helpful, as was Kerry, another reservations staff member. For the dinner, we had a prix fixe menu. I ordered the salmon which was pretty good (but I thought it could have been better for the price we were paying). I don't know what kind of dish we had the summer prior, it was better, and maybe because they were cooking for a group of people, the quality wasn't as good? Not sure. I could also say the same for the steak, from what I was told. But the appetizer salads were delicious, and moreover, the birthday cake (red velvet with dark chocolate ganache--instead of cream cheese--with a cream cheese icing, was amazing! Probably one of the best cakes I have ever tasted. The red velvet was so moist and dense and the dark chocolate ganache filling was perfect. Everyone wanted a piece to take home.

Tavern on the Green is a Central Park staple and a nice place to have a special occasion. That being said, I'm a little surprised that I did not find the main dishes as enjoyable as I did on prior occasions. Staff usually is pretty good, but I felt a little rushed with our specific waiter that evening because we wanted to use a special candle, but he kind of just came out with the birthday cake. Also, they could be a little more attentive with the water, we were running out and I had to ask another staff member for water, which actually never came out.

The dining room is nice with the panoramic view through the glass box, but I do miss the old dining room since it seemed so classic and was a little bigger. I'm not sure where you would hold a wedding or larger event in their space since it's more broken up and the room is smaller. But there is the outside space, which is nice with their lanterns.

I like the live band and the dancing in the room with the bar. I'm not sure if they hire professional ballroom dancers to get the crowd going, but they were entertaining to watch. All in all, I do recommend this place, even though our latest visit was not as satisfying as it was on previous visits.



Alex W.
Boise, ID
25 friends
287 reviews
601 photos
Elite '2019

★★★★★ 7/26/2018

I was excited to dine here as this seems to be one of the quintessential NYC brunch locations. However, we had just an okay experience here. I'm appalled at their lack care in presentation, as this is such a picturesque and historic place.

We came here for a Sunday brunch-- a reservation that we had to make at least a month in advance to get a prime spot at noon. When we arrived, we said we would like to be seated outside, and the hostess walked us past every other table (they were occupied) in the cute covered garden area, and sat us behind an ugly bush by the station where the waiters stop to refill drinks. We were completely separated from the rest of the dining area literally by a bush, and we felt less than cared for despite the fact that we had made the reservation so far in advance. After we complained to the waiters & asked for a more desirable location, they initially said they couldn't accommodate our request. After we saw a table clear up, we asked to move once more and after the many servers helping us out rolled their eyes & acted annoyed, they finally moved us to be a part of the regular dining area.

As for the food, we ordered the brown sugar bacon (\$16), the Tomato Gazpacho Soup (\$12), the Avocado Poached Eggs (\$20), and two orders of the Smoked Salmon Eggs Benedict Florentine (\$29 each). We also ordered coffee and lattes.

To start, my latte was absolutely horrible. It tasted like a latte that maybe came dispensed from a machine. It was a plain latte, but there was no foam on top, mostly just tasted like they mixed warm milk with some coffee.

Further, it came out all spilled all over the top, dripping down the side, and frankly looked like crap. I get that it can spill a bit while they walk it over to the table, but COME ON, this looked horrific.

As for the appetizers, the gazpacho was very good, but the bacon wasn't really anything special. The waiter raved that this was "the best bacon he'd ever had", but it was super thick, extremely fatty, and not crispy at all. Was more like slices of Christmas ham than bacon.

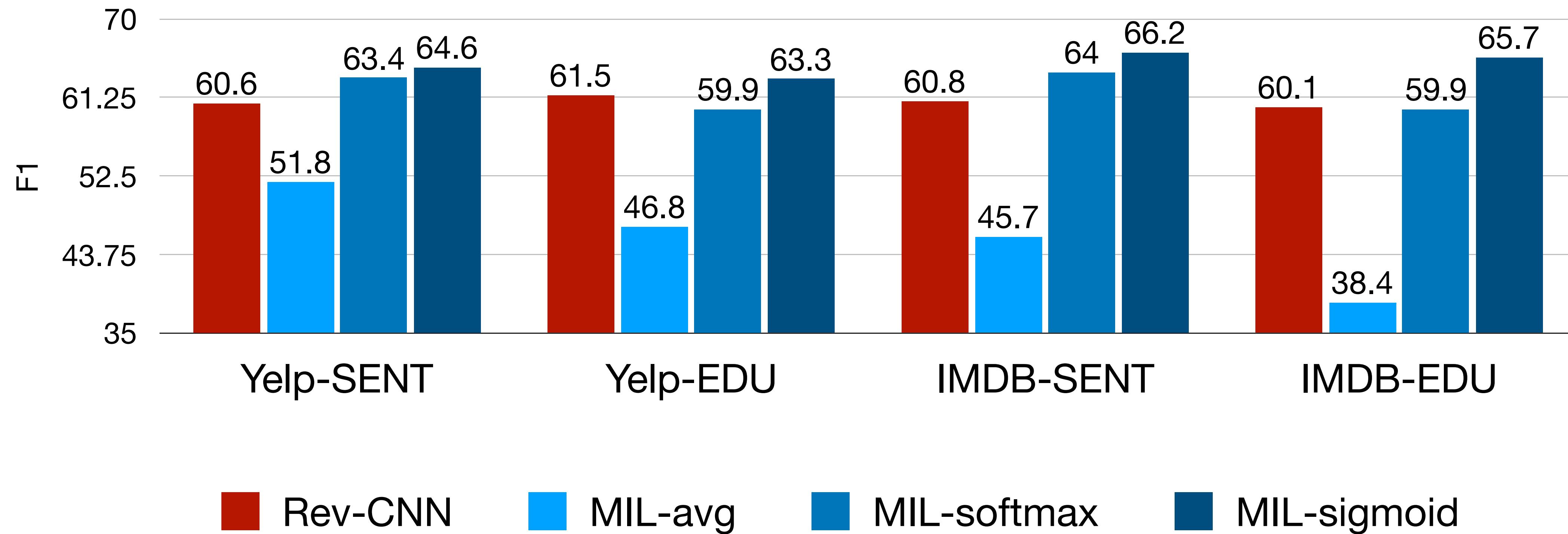
As for the entrees, the salmon benedict was well-liked by both of my friends who ordered it. It was filling and the eggs were perfectly poached. It came with very little smoked salmon though, which for a \$9 upcharge, I would've expected a bit more.

The real horror of the entire meal was the avocado toast. The menu clearly states "chunky FRESH avocado". Well take a look at the photo, folks, because that stuff ain't fresh. Further, it was clearly a guacamole-- seasoned with Mexican spices and filled with chunks of tomato and herbs. I HIGHLY doubt that they actually made this, as it tasted like the pre-packaged Sabra's guacamole. It's one thing to do that and lie about it on the menu, but hey at least make sure it's green. I eat a ton of avocado toast & I've NEVER seen it come out brown. Seriously?? This is unheard of. And I saw many plates of avocado toast go past our table with the same brown/ gray ugly mush slapped onto the English muffins. You'd think if they're churning out so many dishes, they could keep the guacamole fresh & not leave it sitting around to turn brown. This just looked atrocious. It tasted fine, but again, tasted like a Mexican meal as it was clearly GUACAMOLE NOT "FRESH AVOCADO" *eye roll*.

All the entrees came with potatoes, but you only got 4-5, so really stingy on that front. They could have definitely filled up the plate with a few more taters for the price you pay for the meal.

If it weren't for the somewhat decent food we experienced with some of the dishes, I would give this place 2 stars. The experience with the table, the ugliest latte I've ever been served, the small but expensive portions, and the most atrocious-looking avocado toast ever, this place really struck out on a lot of areas. That being said, it is an adorable atmosphere and really feels like a special occasion to dine here at this historic place. Just don't come here expecting to have a world-class meal.

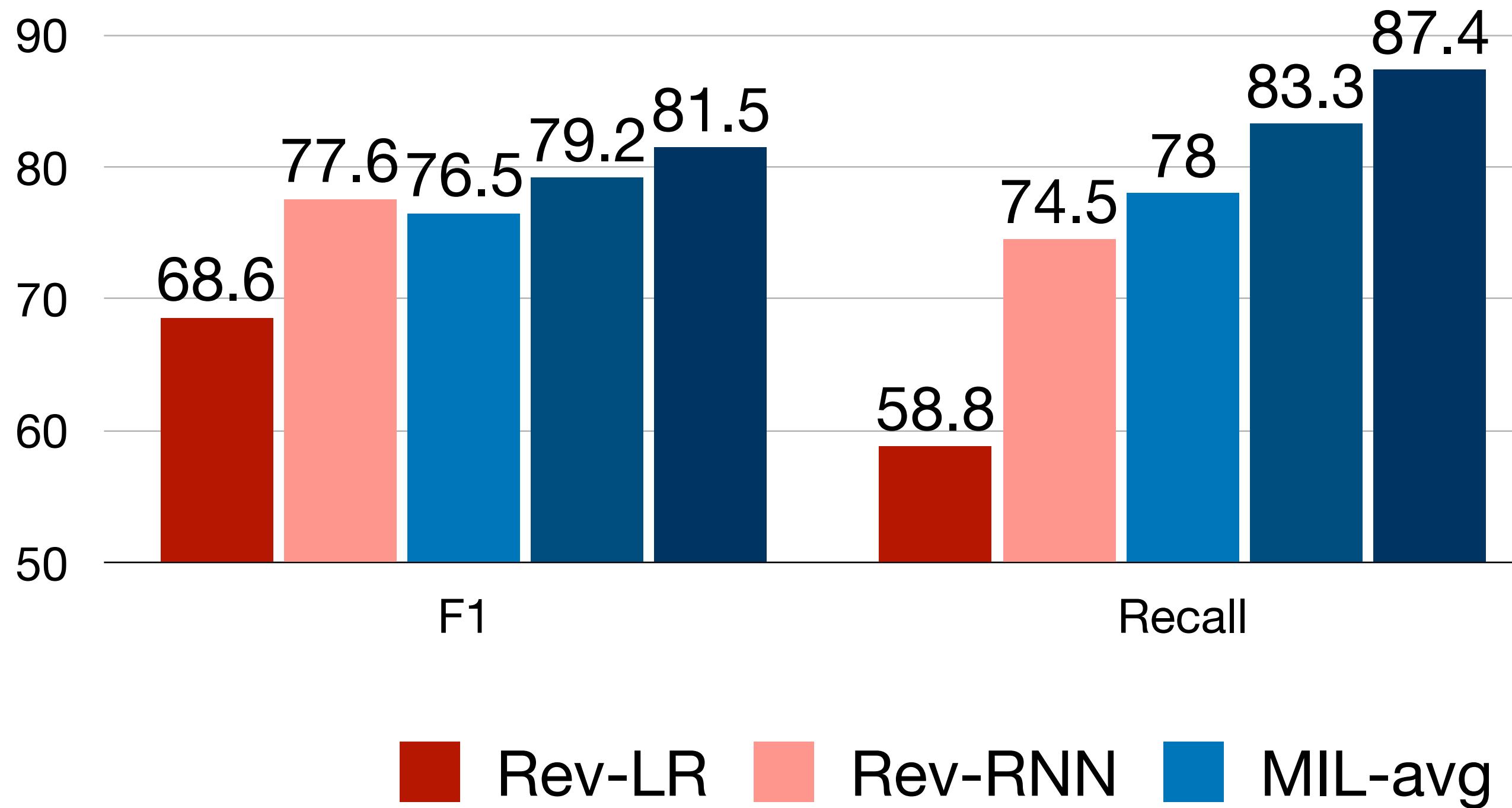
Results: Segment-Level Sentiment Classification



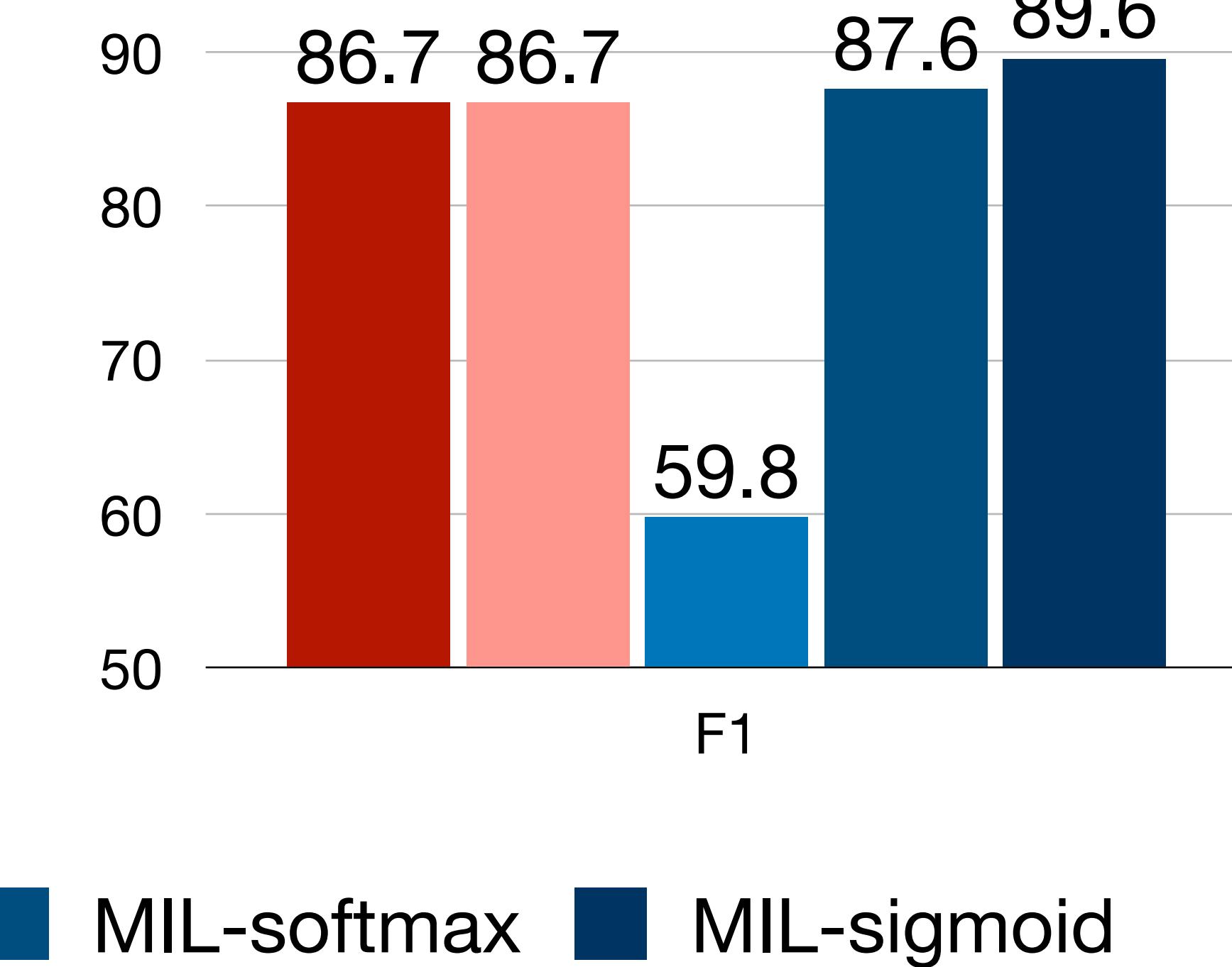
- Non-hierarchical **Rev-CNN** outperforms hierarchical **MIL-avg** and **MIL-softmax**
- MIL-sigmoid** significantly outperforms all other models

Results: Foodborne Classification

Sentence-level Classification

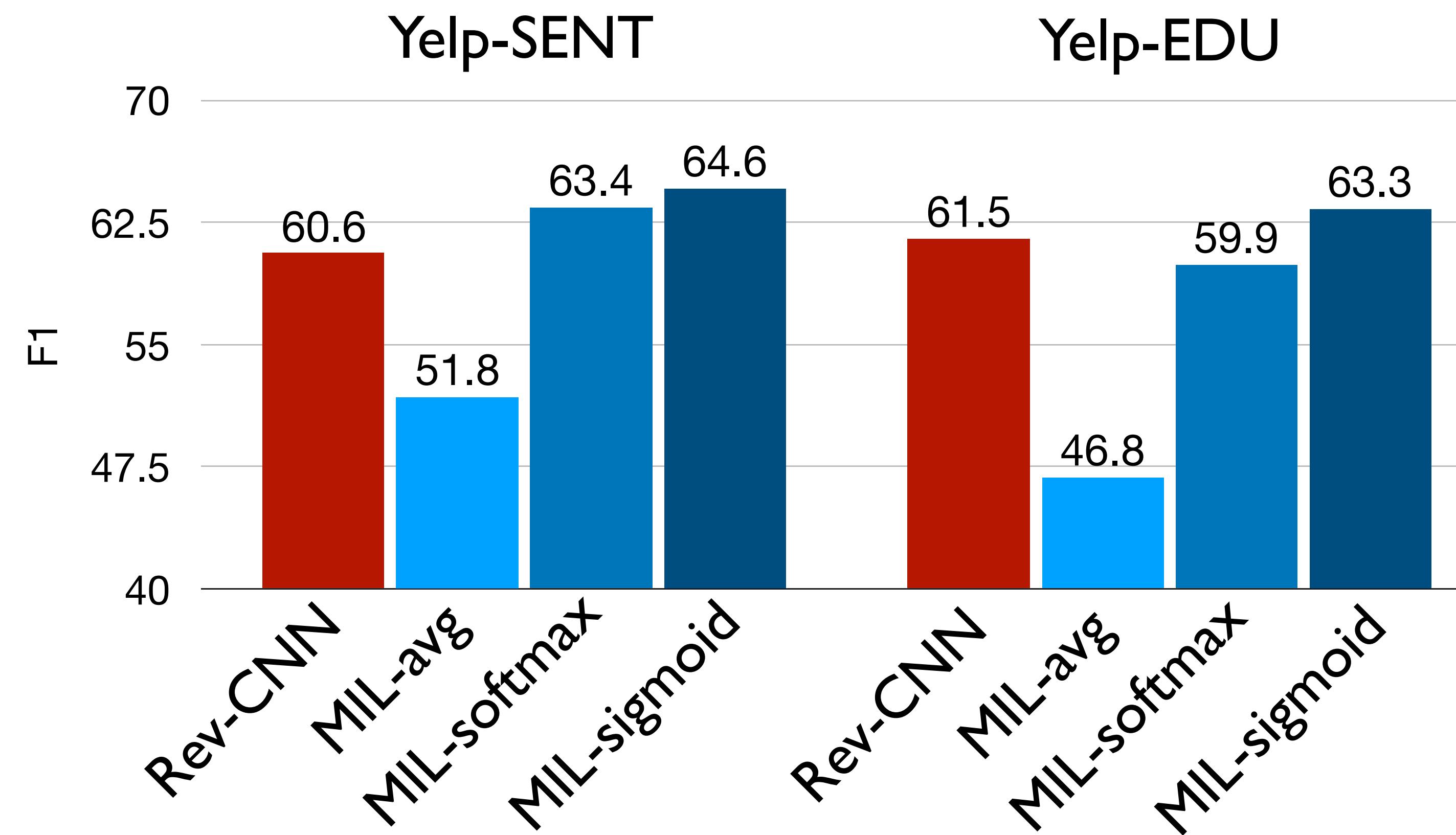


Review-level Classification



- ▶ **MIL-sigmoid** significantly outperforms all other models
- ▶ **MIL-sigmoid** has 48.6% higher recall than **Rev-LR** (best model in Effland et al. 2018)

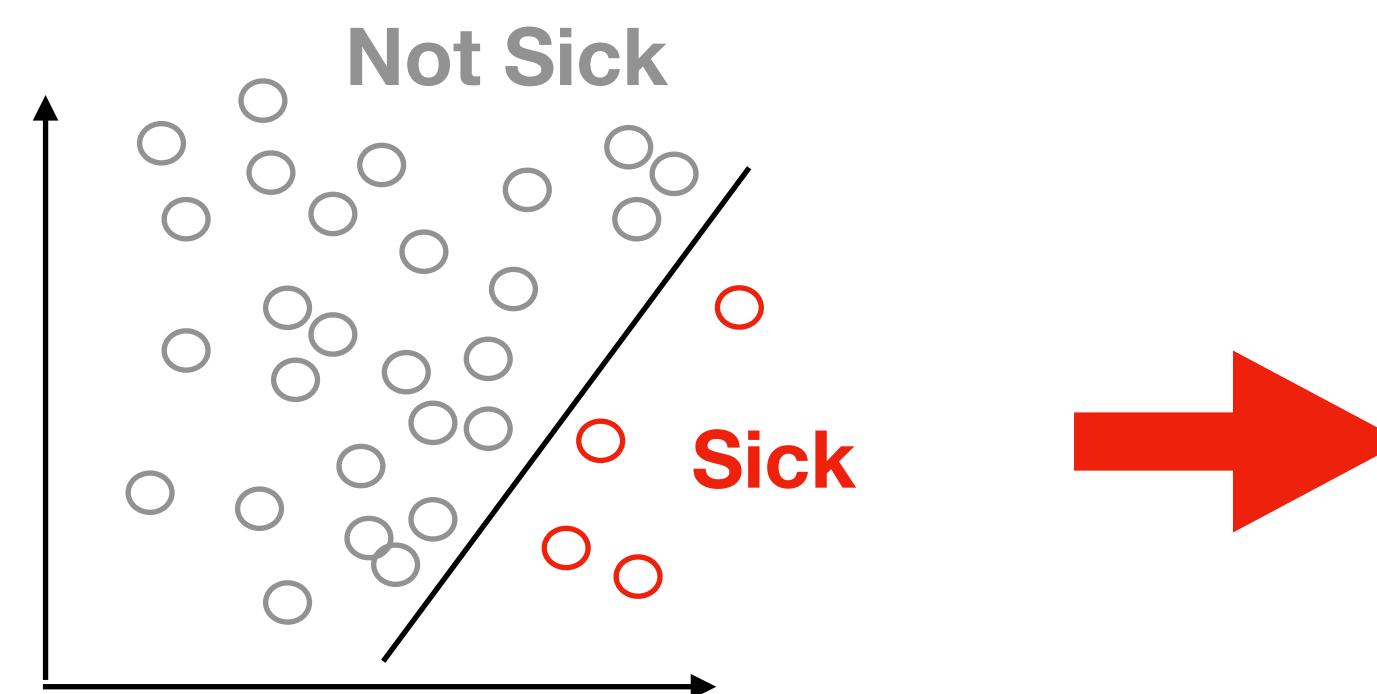
The choice of AGG function is crucial in MIL networks



*Similar results for IMDB datasets
Please see our paper for details*

- ▶ Non-hierarchical **Rev-CNN** outperforms hierarchical **MIL-avg** and **MIL-softmax**
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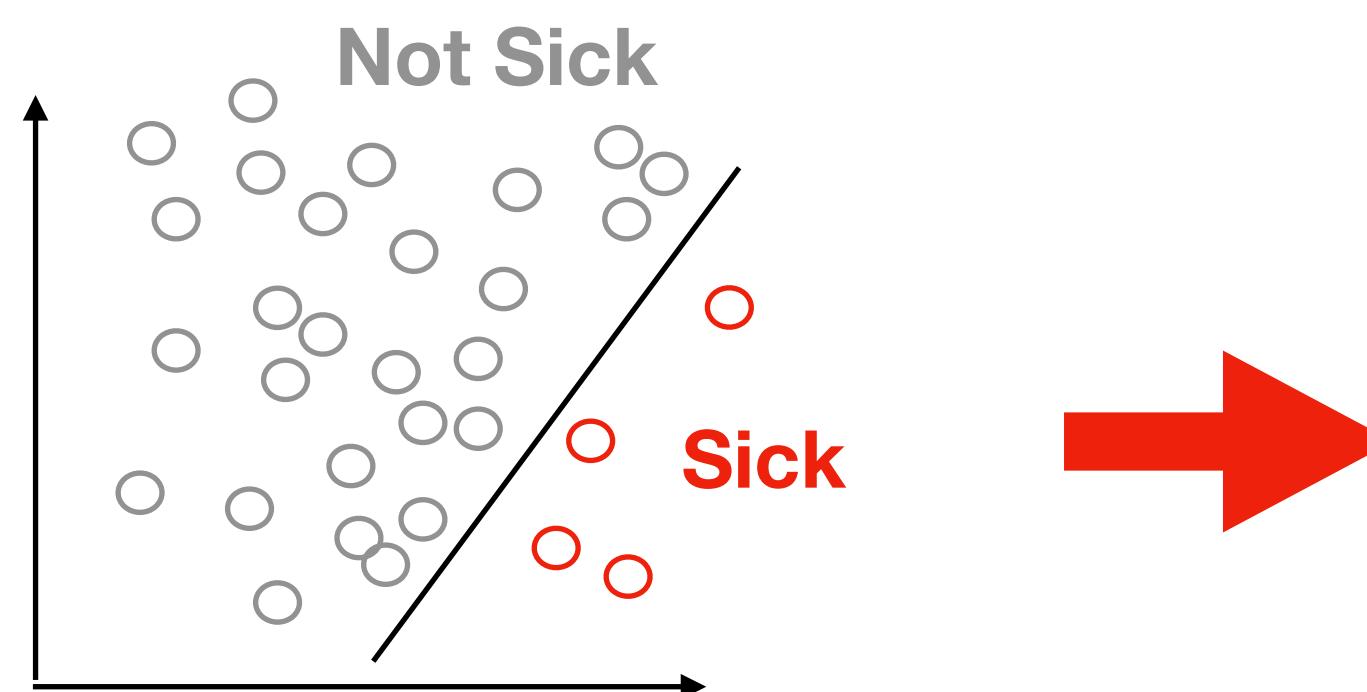
Fine-Grained Classification



😷 **Sick prob = 0.9**

I wish I could give it zero stars. I actually created a yelp account to write this review! At first I thought it was great that we got a table for 5 morning of on a Saturday. The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about. The service was good, it was overall fine. That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food poisoning in my life! That was the only place we ate or drank anything at that day, so I know it was from this restaurant. By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend! Whatever you do, do not eat here, it is not worth the risk of ending up so unwell. To clarify what I believe caused this- we both had carrot juice randomly. I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.

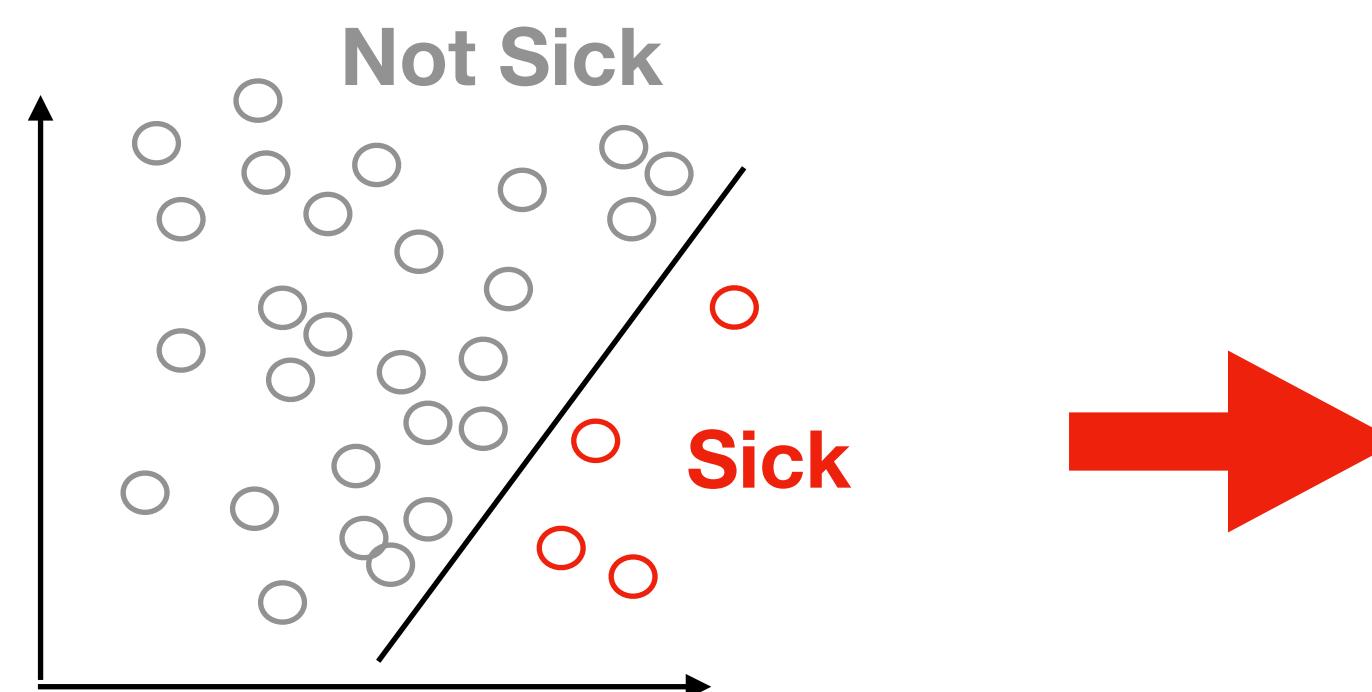
Fine-Grained Classification



恙 🤢 Sick prob = 0.9

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Fine-Grained Classification



恙 🤢 Sick prob = 0.9

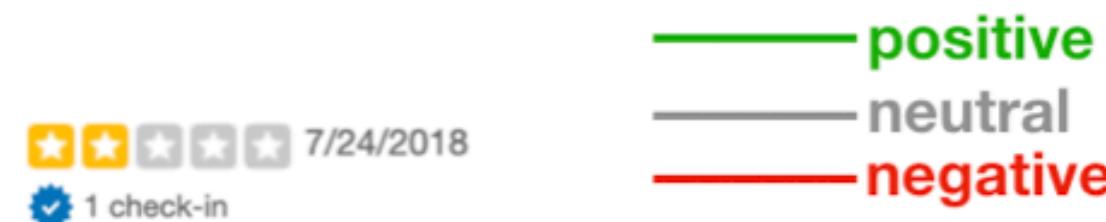
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Weakly Supervised Learning

- Goal: segment-level classification without segment labels
- Here: use available **review-level** labels for training **sentence-level** classifiers

Segment-level Sentiment Analysis

- target: sentence-level sentiment
- proxy label: review-level rating



This is a review for Tavern on the Go, a convenient and could-be wonderful space to stop for a drink or snack while walking through Central Park.

So...right next to Tavern on the Green is a smaller building with a private garden and tables. There is a service window to order and pick up beverages and a few snacks. It is a beautiful and restful space, a great spot to unplug for a few minutes and enjoy the beauty around you. The prices are, as you might imagine, kind of nuts, BUT, your order gains you access to this sanctuary space, which makes the price point quite worth it.

Why two stars, you might be thinking?? The server working the window was cold, disinterested and gave off a VERY rude vibe! Not only to me, but to the group ordering before me which included a woman in a wheelchair! She gave the feeling that she was doing us all a BIG favor by taking our orders and the taking our money.

There seemed to be a secondary server behind her in the window who was trying very hard to be customer focused. Her efforts were noticed, but she was completely overshadowed by her colleague working the front.

Foodborne Illness Detection

- target: sentence-level “Sick” label
- proxy label: review-level “Sick” label

Sick?

I wish I could give it zero stars. I actually created a yelp account to write this review! At first I thought it was great that we got a table for 5 morning of on a Saturday. The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about. The service was good, it was overall fine. That is- until I got home and my boyfriend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food poisoning in my life! That was the only place we ate or drank anything at that day, so I know it was from this restaurant. By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend! Whatever you do, do not eat here, it is not worth the risk of ending up so unwell. To clarify what I believe caused this- we both had carrot juice randomly. I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.

Highly Rated Reviews With Negative Sentences

Low Rated Reviews With Positive Sentences



S.T.

Brooklyn, NY

0 friends

12 reviews

2 photos

Share review

Embed review



8/20/2019

I've been here several times and the only reason to go to Tavern on the Green is for the music. Specifically the woman who sings there on Fridays/Saturdays. There's a guy who sings there a lot as well during the weekend afternoons who's good too. Both of their jazz bands are great. I've been seeing them there less so I've stopped going. The actual restaurant though is insanely over priced for the quality.

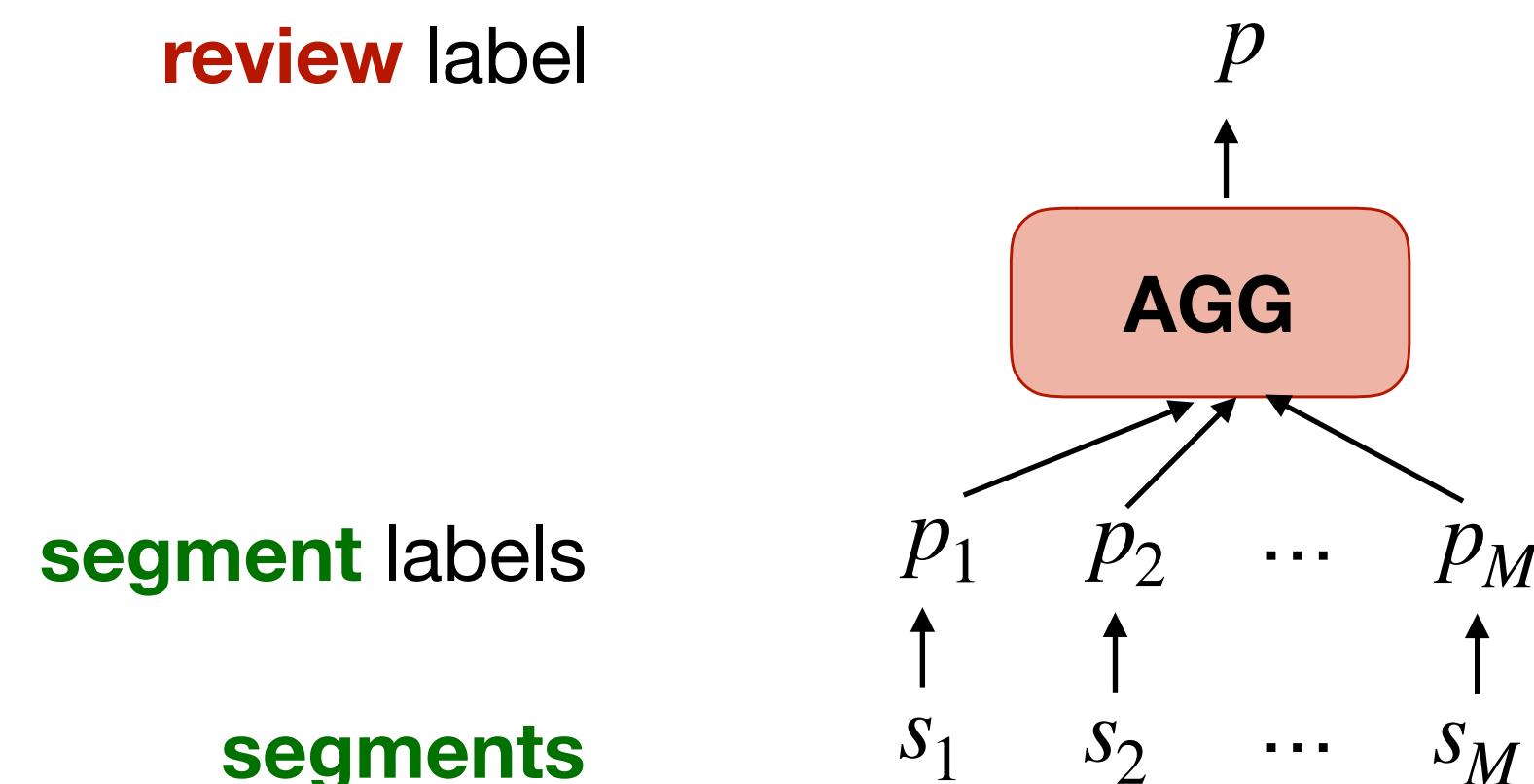
Useful

Funny

Cool

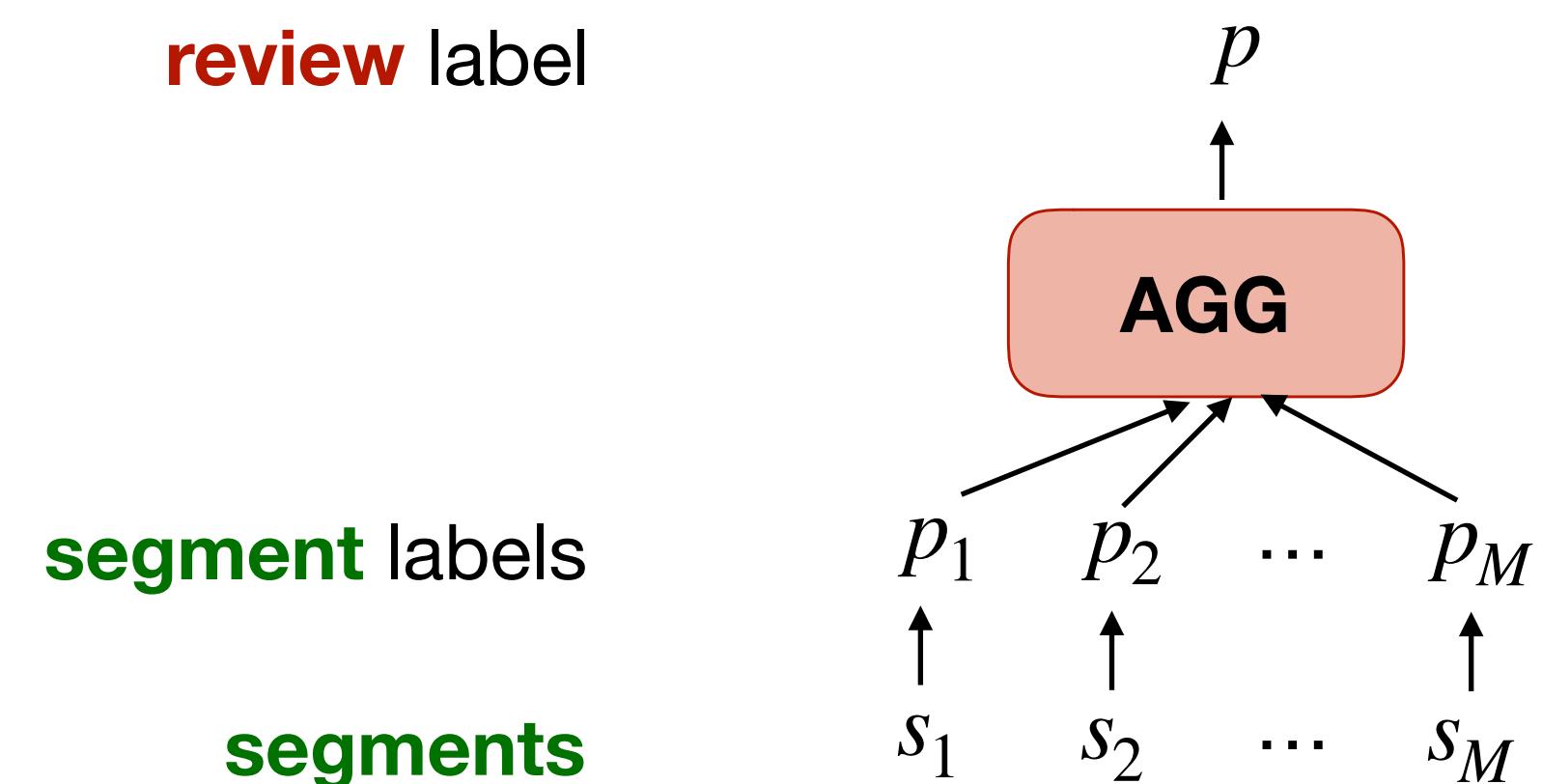
Weakly Supervised Learning

- How to train **segment**-level classifiers using **review** labels?
 - **Approach 1:** train **review-level** classifiers and apply on individual **segments**
 - Test distribution different than train distribution
 - **Approach 2:** assume all **segments** have the same **review** label
 - Diverse segments
 - **Multiple Instance Learning (MIL):** assume **review** label is aggregation function (AGG) of **segment** labels



AGG functions for MIL

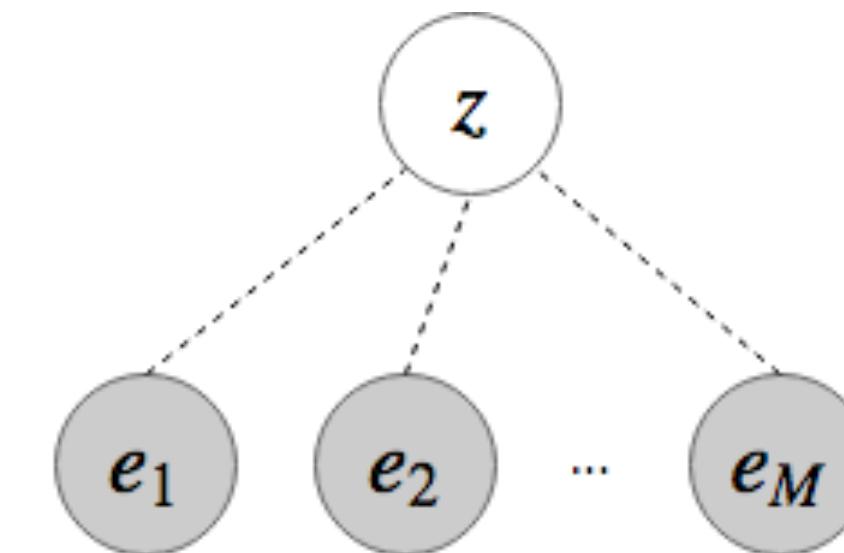
- **Unweighted average:** $p = \frac{1}{M} \sum_{i=1}^M p_i$ (Kotzias et al., 2015)
- **Weighted average:** $p = \frac{\sum_{i=1}^M \alpha_i p_i}{\sum_{i=1}^M \alpha_i}$ (Pappas and Popescu-Belis, 2017; Angelidis and Lapata, 2018)
 $\alpha_1, \dots, \alpha_M \in [0,1]$



Attention-Based MIL

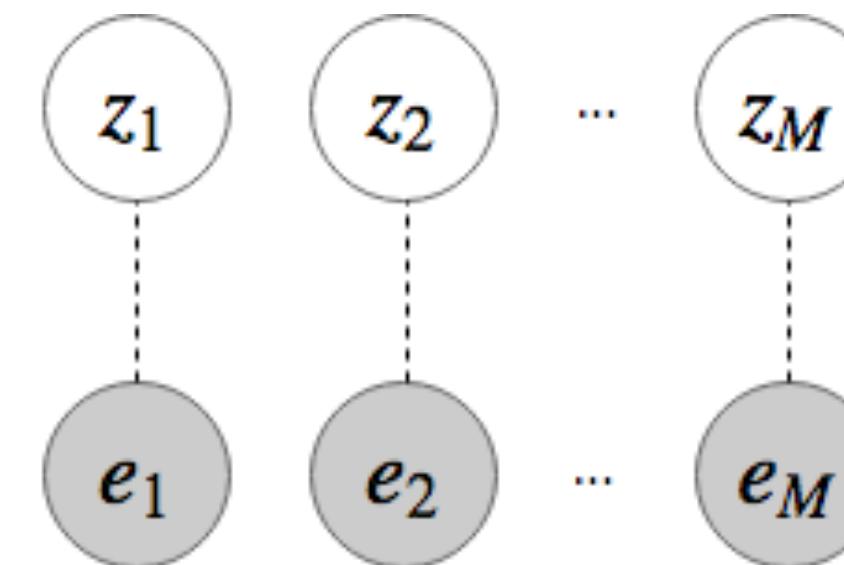
- How to estimate weights $\alpha_1, \dots, \alpha_M$?
 - **Softmax attention for MIL** (Angelidis and Lapata, 2018)

$$p(z = i \mid e_1, \dots, e_M) = \frac{\exp(e_i)}{\sum_{i=1}^M \exp(e_i)}$$



- **Sigmoid attention for MIL** (Our work)

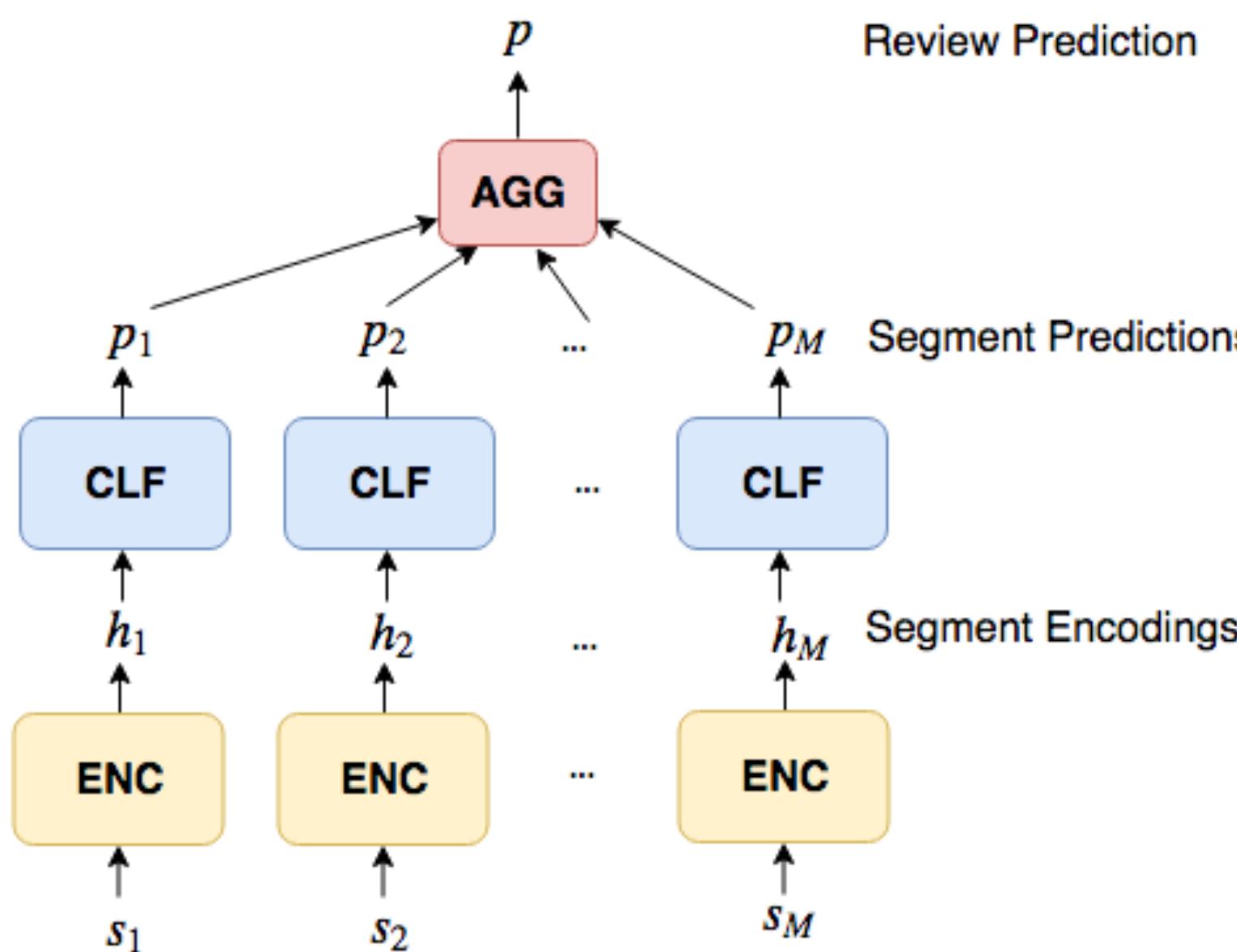
$$p(z_i = 1 \mid e_1, \dots, e_M) = \frac{1}{1 + \exp(-e_i)}$$



MIL Attention vs Standard Attention

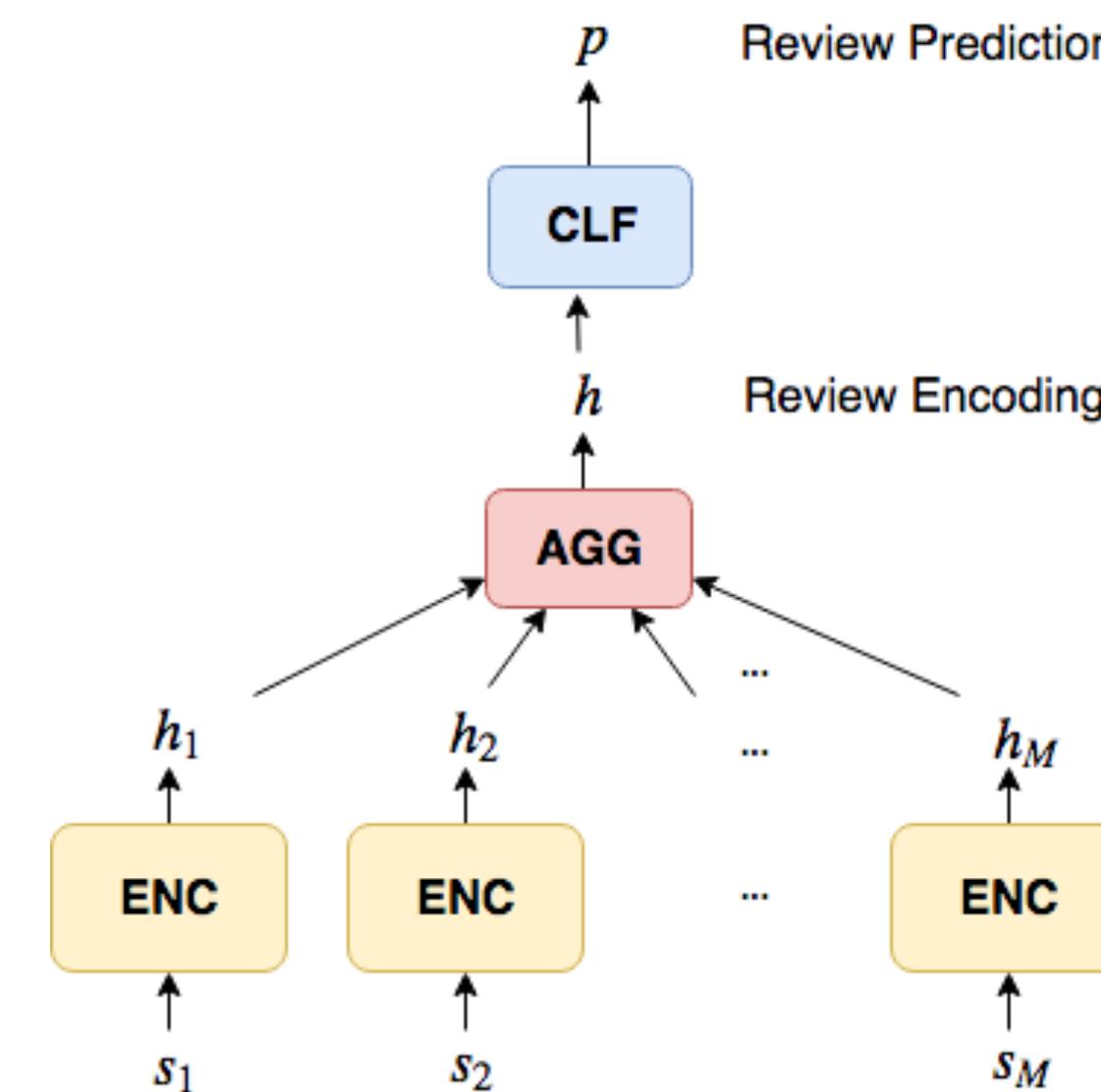
MIL Attention

$$p = \text{AGG}(p_1, \dots, p_M)$$



Standard Attention

$$h = \text{AGG}(h_1, \dots, h_M)$$



Results

Model	Yelp-SENT	Yelp-EDU	IMDB-SENT	IMDB-EDU
Rev-CNN	60.6	61.5	60.8	60.1
MIL-avg	51.8	46.8	45.7	38.4
MIL-sigmoid	63.4	59.9	64.0	59.9

- Non-hierarchical Rev-CNN beats hierarchical MIL networks with inappropriate AGG functions

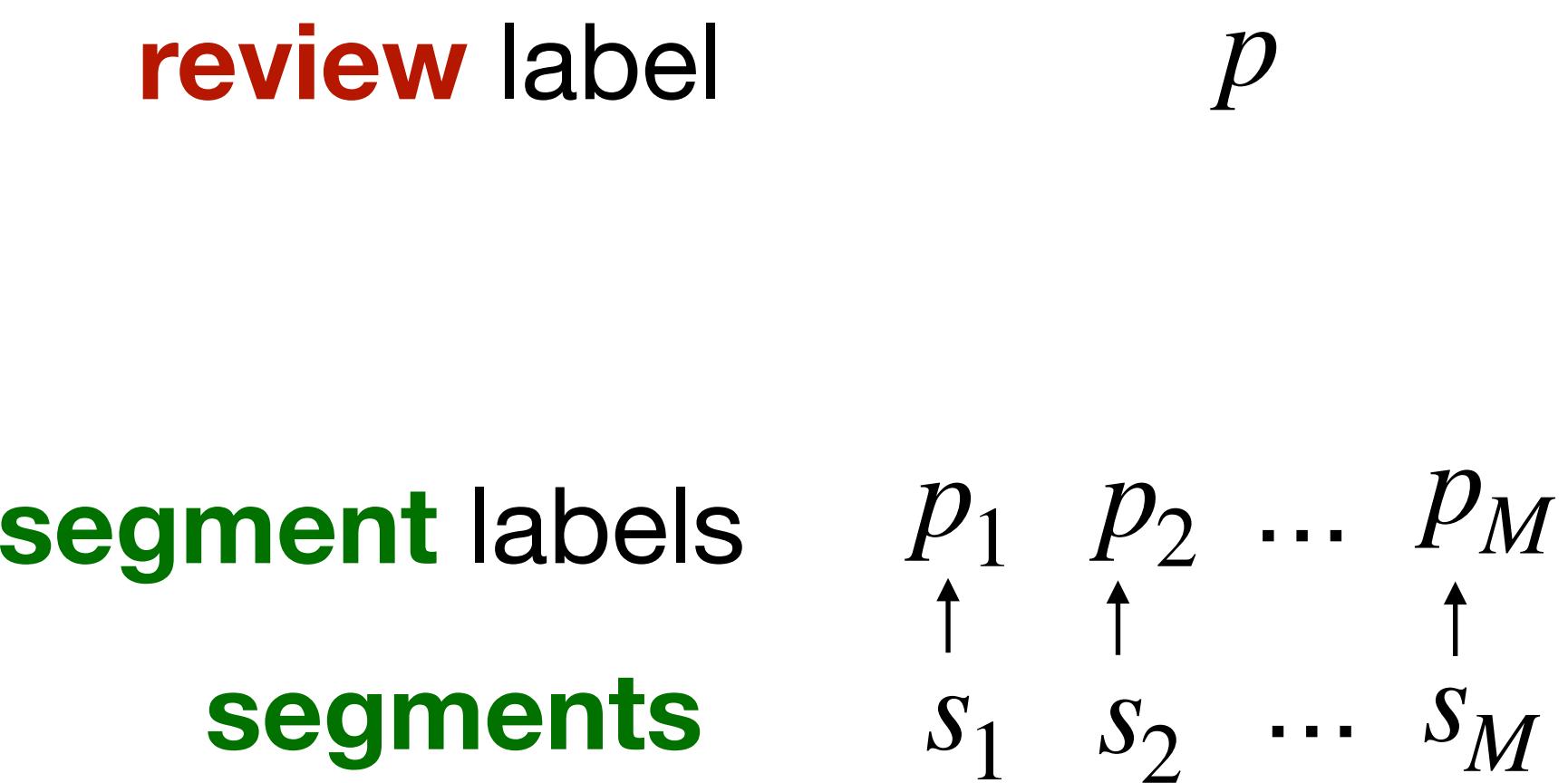
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Rev-CNN	60.6	61.5	60.8	60.1
MIL-avg	51.8	46.8	45.7	38.4
MIL-sigmoid	63.4	59.9	64.0	59.9
MIL-sigmoid	64.6	63.3	66.2	65.7

- ▶ MIL-sigmoid significantly outperforms all other models

Weakly Supervised Learning

- How to train **segment**-level classifiers using **review** labels?



Weakly Supervised Learning

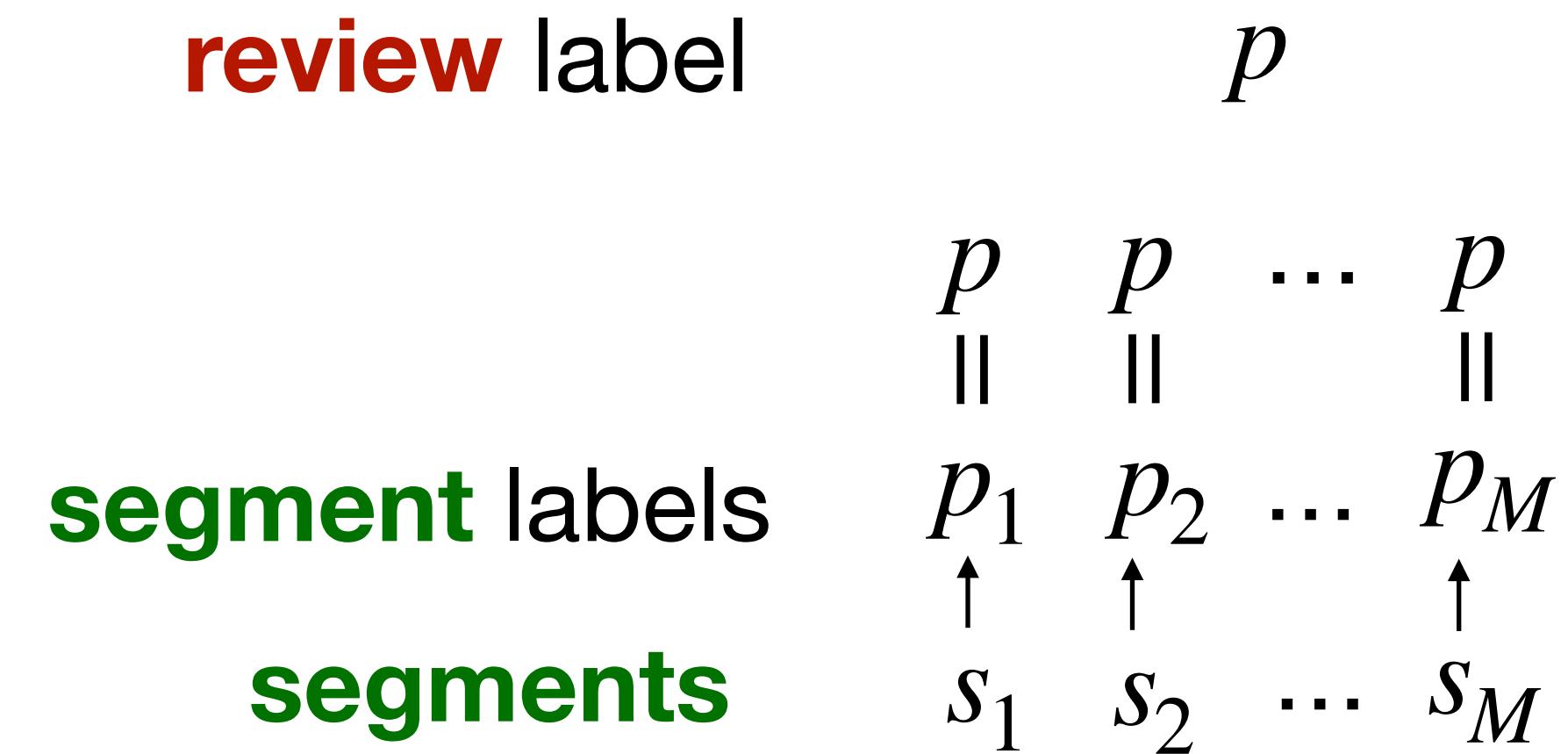
- How to train **segment**-level classifiers using **review** labels?
 - Approach 1: train **review-level** classifiers and apply on individual **segments**

1) Train **review** label p

2) Test **segment** labels $p_1 \ p_2 \ \dots \ p_M$
 ↑ ↑ ↑
 segments $s_1 \ s_2 \ \dots \ s_M$

Weakly Supervised Learning

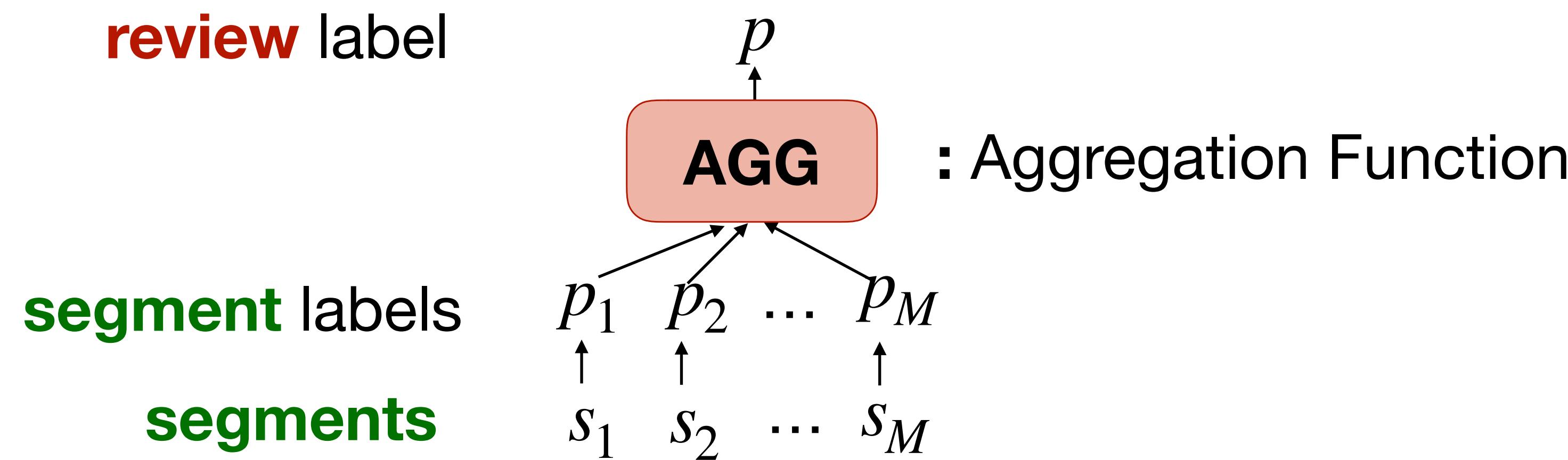
- How to train **segment**-level classifiers using **review** labels?
 - Approach 1: train **review-level** classifiers and apply on individual **segments**
 - Approach 2: assume all **segments** have the same **review** label



Weakly Supervised Learning

- How to train **segment**-level classifiers using **review** labels?
 - Approach 1: train **review-level** classifiers and apply on individual **segments**
 - Approach 2: assume all **segments** have the same **review** label
 - Approach 3: assume **review** label is a function of **segment** labels

Multiple Instance Learning (MIL)



Multiple Instance Learning (MIL) Networks

- This work:

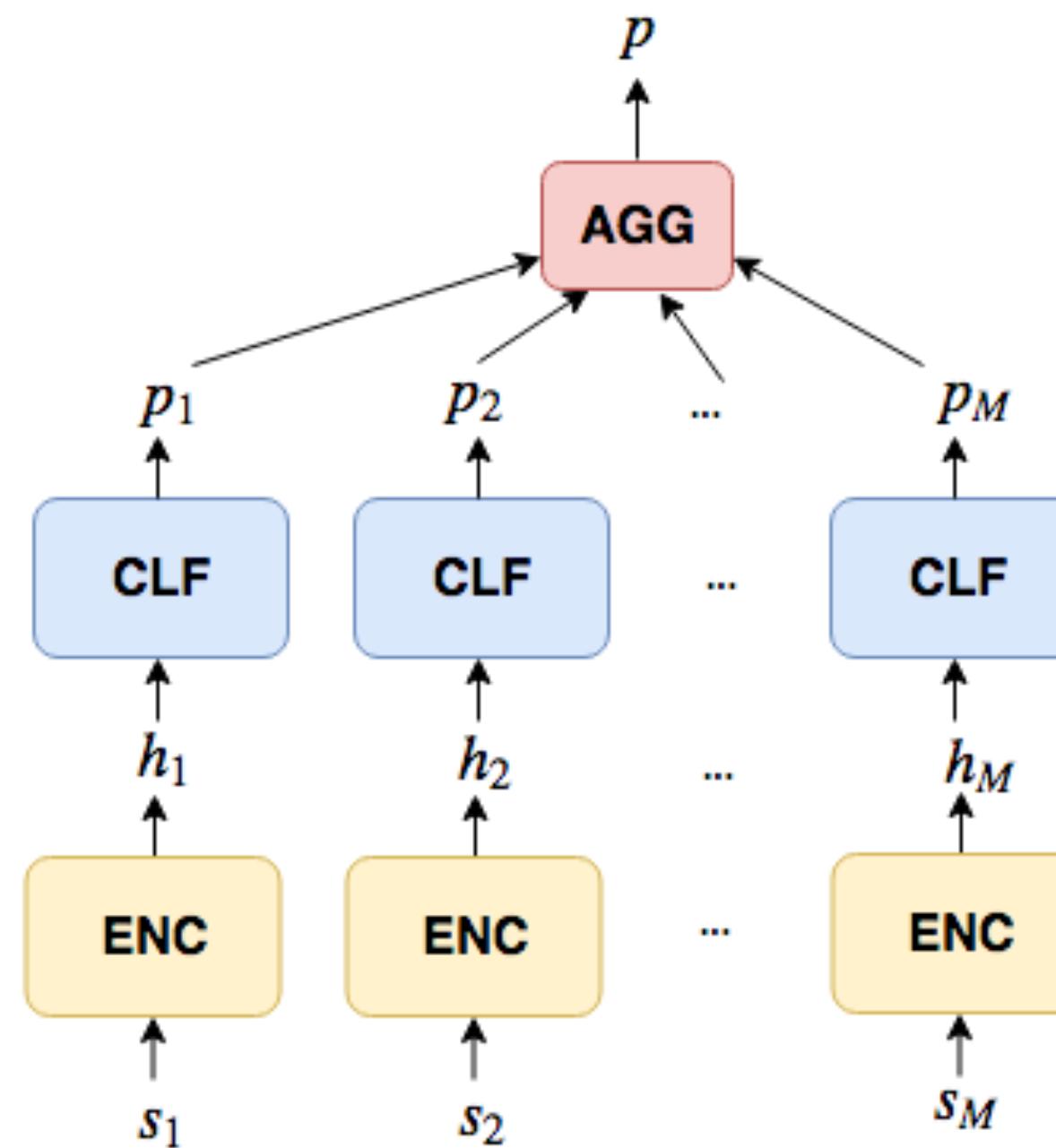
1. Train hierarchical **MIL** networks for segment-level text classification
2. Emphasize **importance of AGG function** for MIL
3. Propose **sigmoid attention** as AGG function for MIL

review prediction

segment prediction

segment embeddings

segments



AGG = Sigmoid Attention

$$p = \frac{\sum_{i=1}^M \alpha_i \cdot p_i}{\sum_{i=1}^M \alpha_i}$$

$$\alpha_1, \dots, \alpha_M \in [0, 1]$$

$$\alpha_i = p(z_i = 1 \mid e_1, \dots, e_M)$$

Application 1: Segment-Level Sentiment Classification

- **Dataset:** OPOSUM (Yelp/IMDB reviews) [Angelidis and Lapata, 2018]
- **Methodology:**
 - Train model using 5-star/10-star review ratings
 - Predict segment-level sentiment (positive, neutral, negative)
- **Model Comparison:**
 - Non-hierarchical Rev-CNN: trained at review level, applied at segment-level
 - Hierarchical MIL Networks with various AGG functions:
 - (1) average; (2) softmax attention; (3) sigmoid attention

Application 2: Foodborne Classification

- **Dataset:** 21,551 Yelp reviews [Effland et al., 2018]
- **Methodology:**
 - Train model using review labels (provided by epidemiologists)
 - Predict sentence-level “Sick”/“Not Sick” label
- **Model Comparison:**
 - Rev-LR: best model in Effland et al. (2018)
 - MIL networks with various AGG functions
 - More models in our paper

Highlighting Important Sentences

- We highlight “**Sick**” sentences with high attention scores

Previous Classifiers



: Pred = **Sick** (prob=0.9)

I wish I could give it zero stars. I actually created a yelp account to write this review! At first I thought it was great that we got a table for 5 morning of on a Saturday. The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about. The service was good, it was overall fine. That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet! I have never experienced such violent food poisoning in my life! That was the only place we ate or drank anything at that day, so I know it was from this restaurant. By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend! Whatever you do, do not eat here, it is not worth the risk of ending up so unwell. To clarify what I believe caused this- we both had carrot juice randomly. I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.

HSAN



: Pred = **Sick** (prob=0.9)

Pred	Att	Text	
✓	0.00	I wish I could give it zero stars.	:(Sick ✓ : Not Sick
✓	0.00	I actually created a yelp account to write this review!	
✓	0.00	At first I thought it was great that we got a table for 5 morning of on a Saturday.	
✓	0.00	The food was okay- the poached eggs on the Benedict were a little over cooked, but nothing to complain about.	
✓	0.00	The service was good, it was overall fine.	
✓	0.00	That is- until I got home and me and boy friend spent the rest of the day/night and into the morning hunched over or sitting on the toilet!	
:(0.18	I have never experienced such violent food poisoning in my life!	
✓	0.00	That was the only place we ate or drank anything at that day, so I know it was from this restaurant.	
:(0.82	By far the most miserable I've been- chills and crippling abdominal pain along with uncontrollable vomiting and something worse out the other end for my boyfriend!	
:(0.00	Whatever you do, do not eat here, it is not worth the risk of ending up so unwell.	
✓	0.00	To clarify what I believe caused this- we both had carrot juice randomly.	
:(0.00	I know more than one person who has gotten food poisoning recently from carrot juice- especially if its raw or cold pressed.	

- Fine-grained predictions could help epidemiologists to quickly identify relevant sentences

AGG in MIL \neq Standard AGG

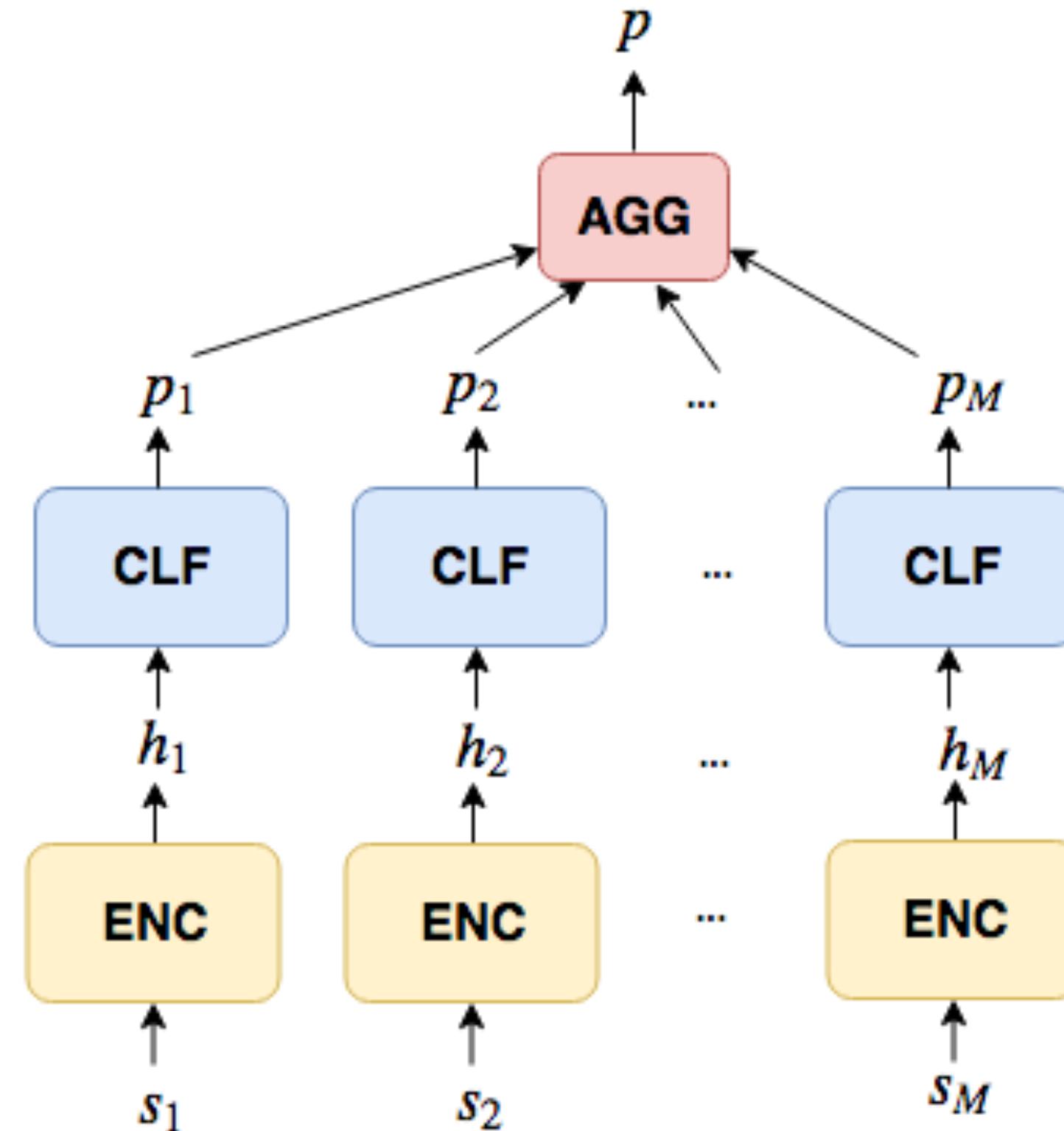
Hierarchical MIL Networks

review prediction

segment prediction

segment vectors

segments



$$p = \text{AGG}(p_1, \dots, p_M)$$

AGG in MIL \neq Standard AGG

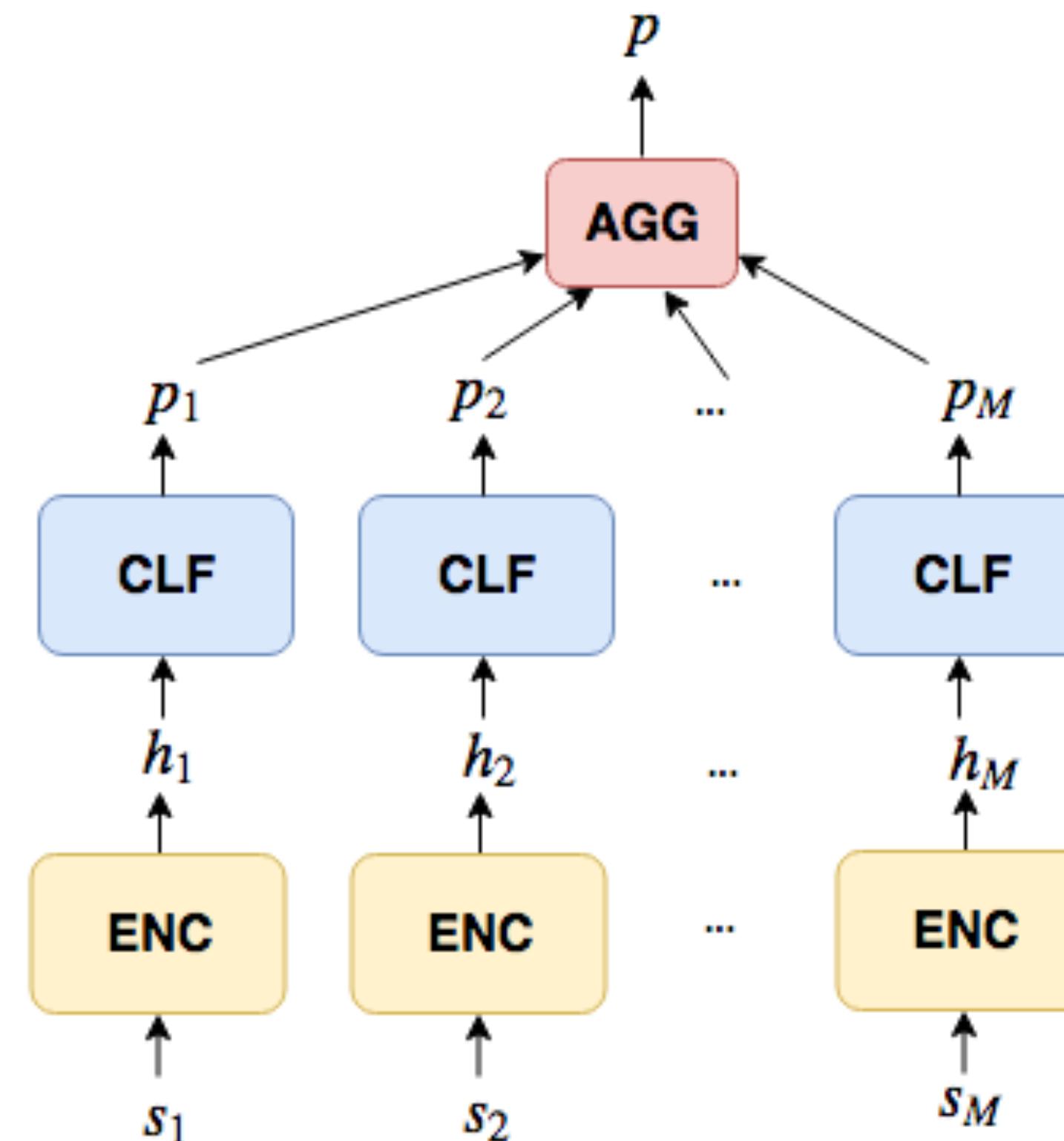
Hierarchical MIL Networks

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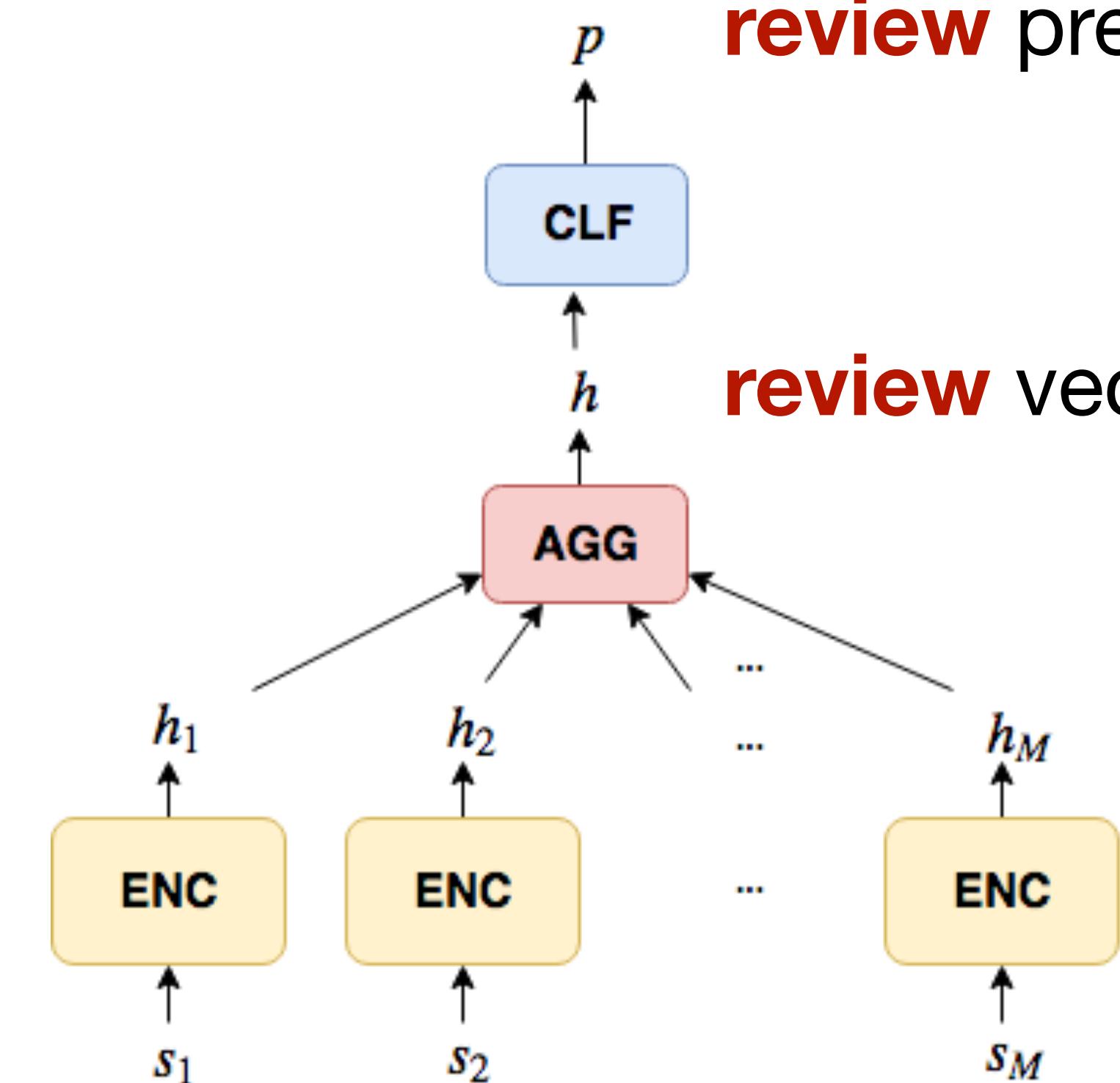


$$p = \text{AGG}(p_1, \dots, p_M)$$

Standard Hierarchical Networks

review prediction

review vector



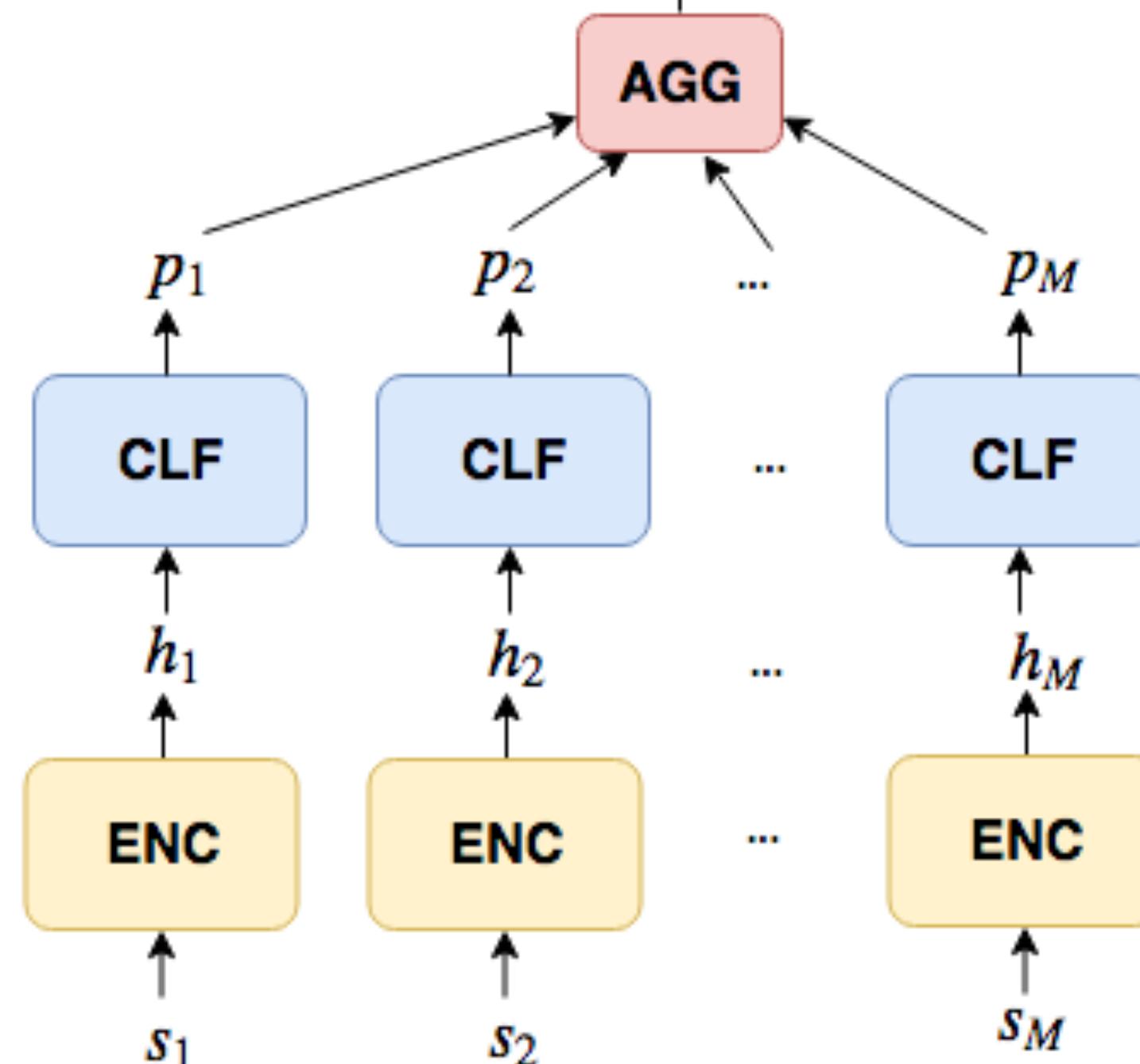
$$h = \text{AGG}(h_1, \dots, h_M)$$

AGG in MIL \neq Standard AGG

review prediction
segment prediction
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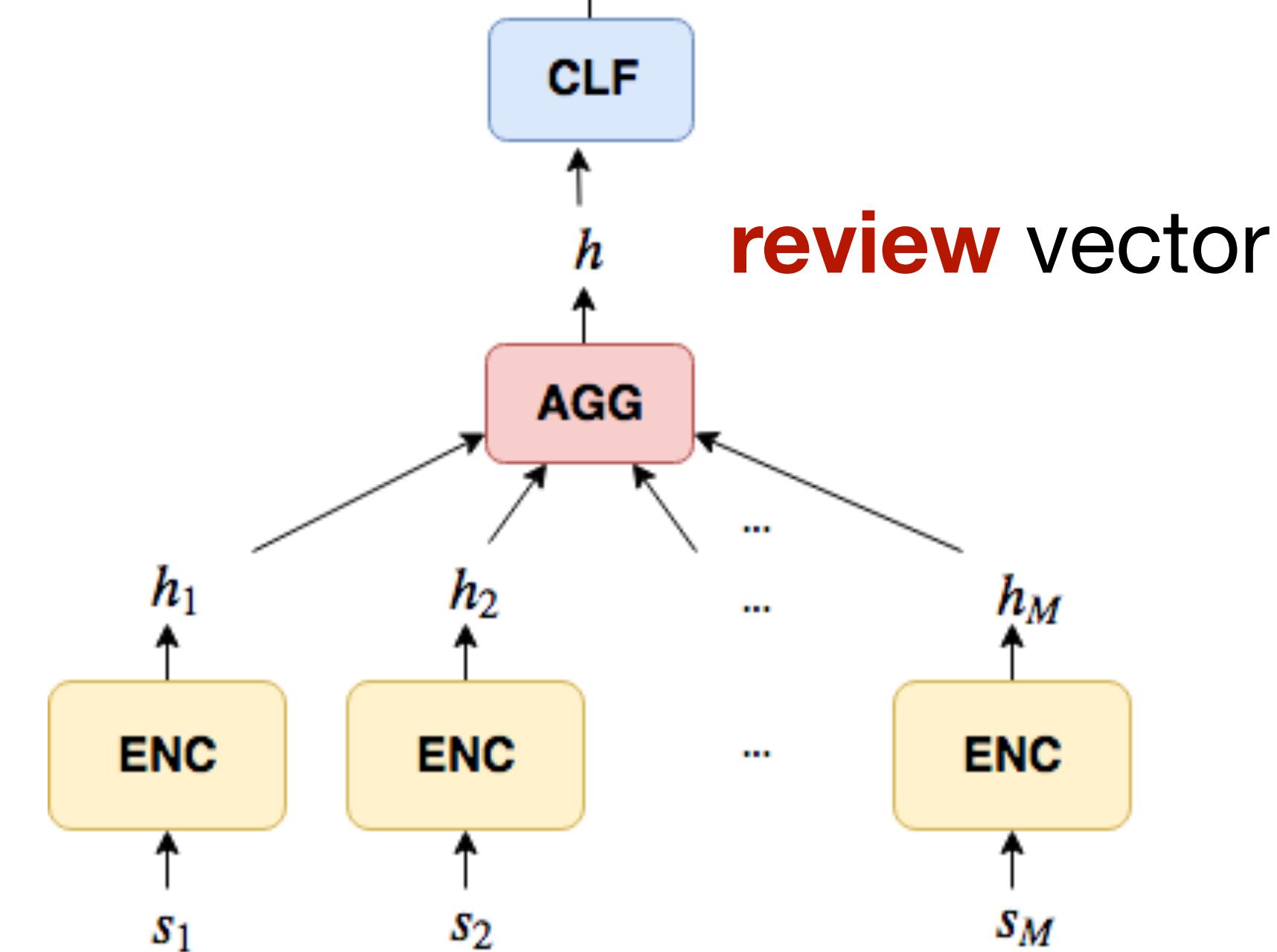
Hierarchical MIL Networks

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Standard Hierarchical Networks

$$h = \text{AGG}(h_1, \dots, h_M)$$



Multiple Instance Learning Networks

Hierarchical MIL Network Architecture

[Pappas and Popescu-belis, 2017]

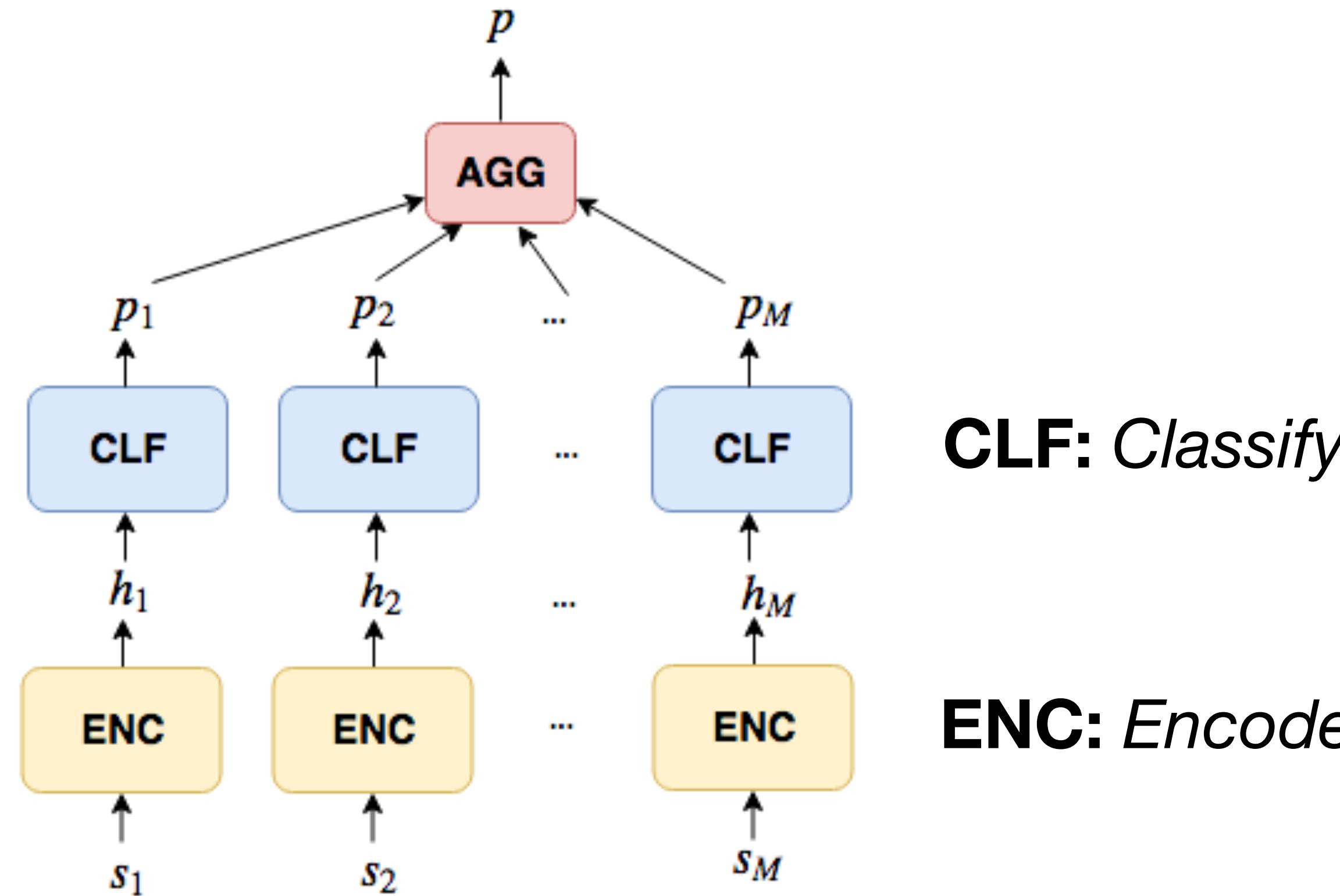
[Angelidis and Lapata, 2018]

review prediction

segment prediction

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segments



CLF: *Classify*

ENC: *Encode*

- **Training:** Use only review labels