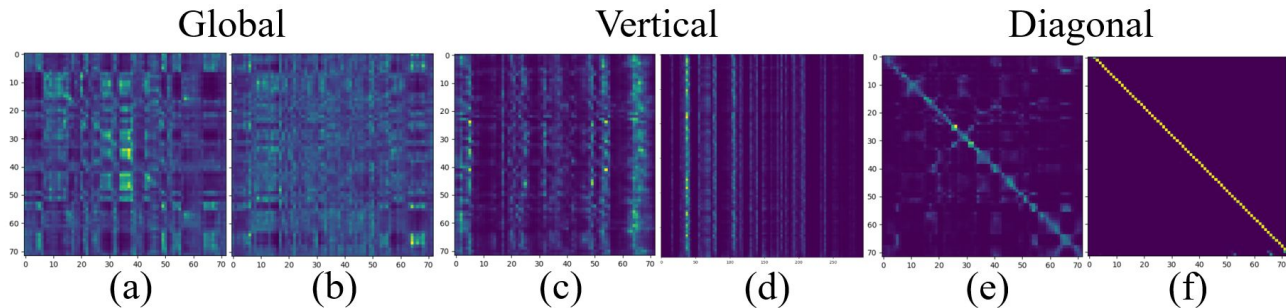


What do **self-attentions** learn
from **reconstruction** loss?

Attention categories

- Attention maps



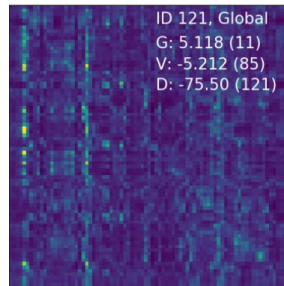
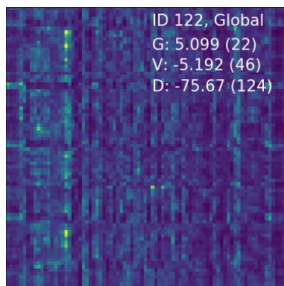
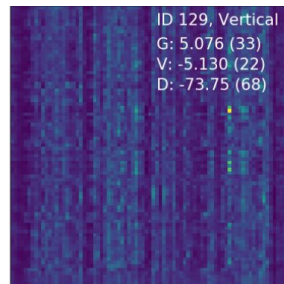
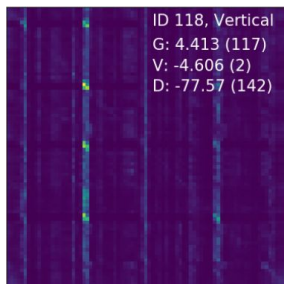
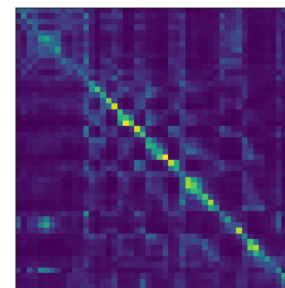
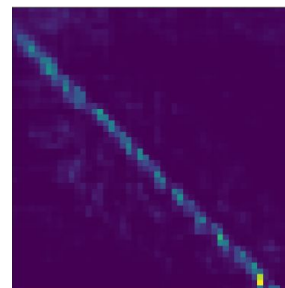
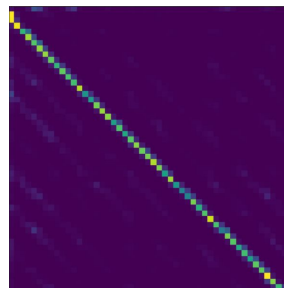
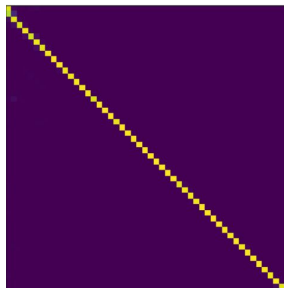
$$G(h) = \mathbb{E}_{u \sim U} \left[\frac{1}{T} \sum_{q=1}^T \mathbb{H}(A_u^h[q]) \right] \quad (1)$$

$$V(h) = \mathbb{E}_{u \sim U} \left[-\mathbb{H}\left(\frac{1}{T} \sum_{q=1}^T A_u^h[q]\right) \right] \quad (2)$$

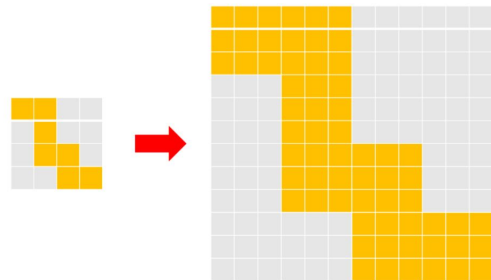
$$D(h) = \mathbb{E}_{u \sim U} \left[-\frac{1}{T^2} \sum_{q=1}^T \sum_{k=1}^T |q - k| \cdot A_u^h[q, k] \right] \quad (3)$$

Outline

- Diagonal
 - Focus
 - Block diagonal
- Vertical
- Global
 - Still working on

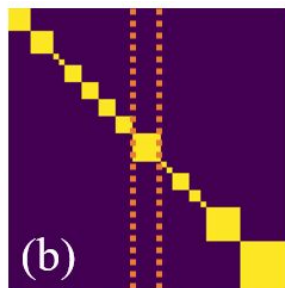
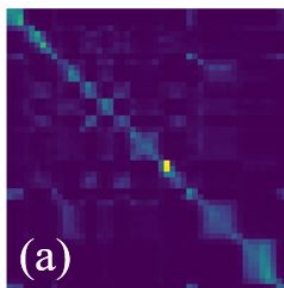


Phoneme segmentation

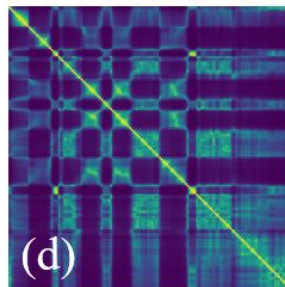
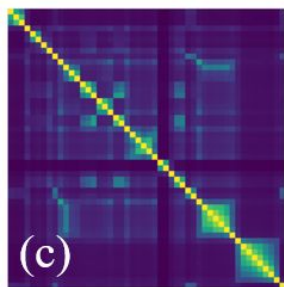


True boundaries

Attention map

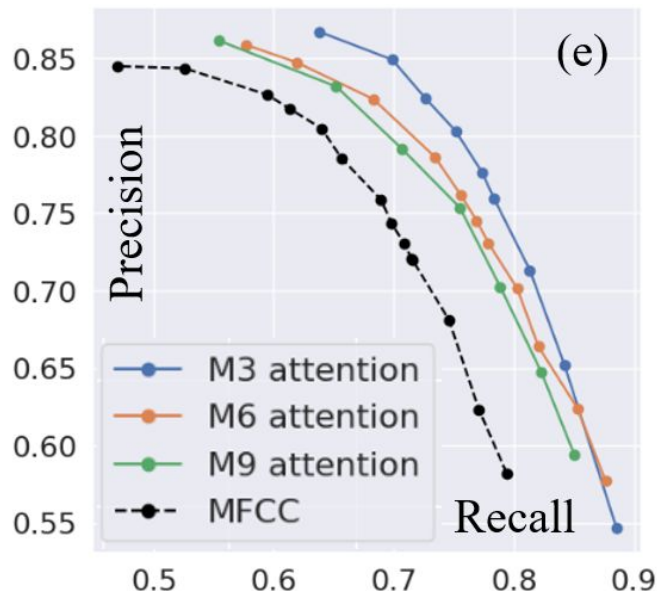


Similarity matrix on
(a)



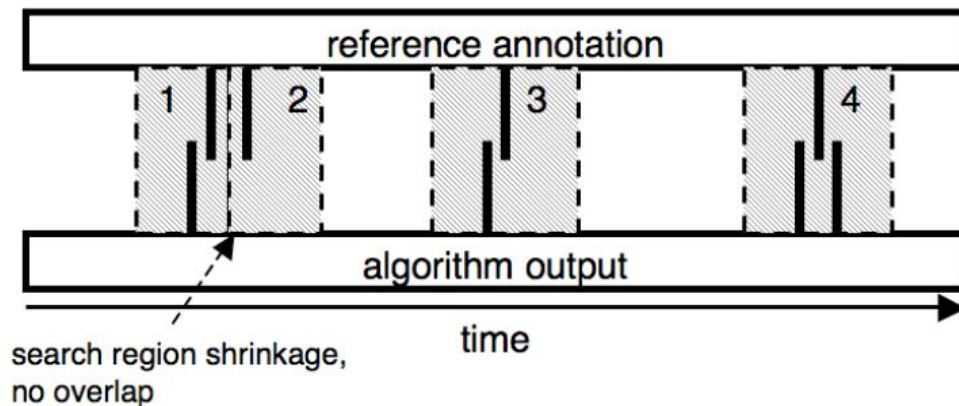
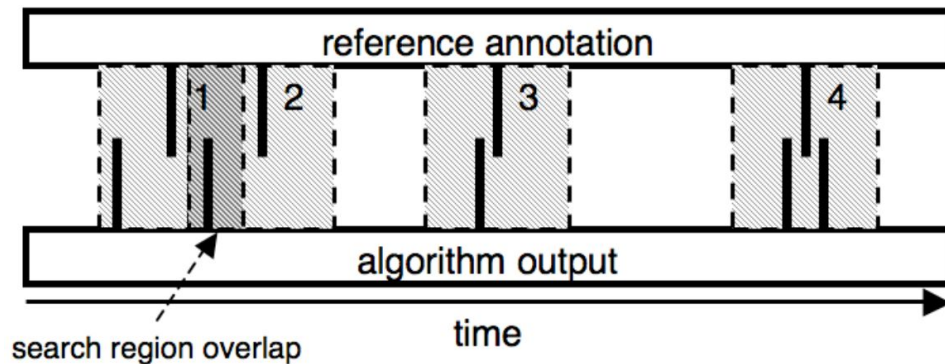
Similarity matrix on MFCC

$$K[i, j] = \exp\left(-\frac{\|v_i - v_j\|}{\alpha}\right)$$



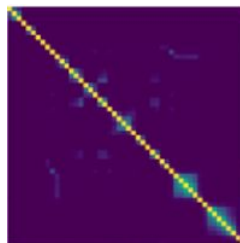
Evaluation: Precision-recall

- How to count a hit?

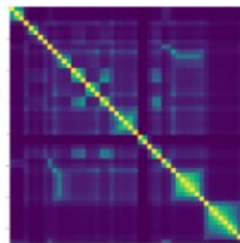


Block diagonal learned to neglect

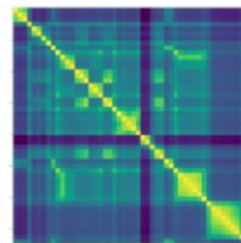
- Further frames \rightarrow more different? **NO**



(d)

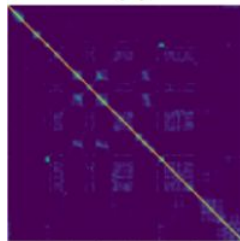


(e)

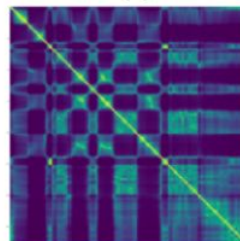


(f)

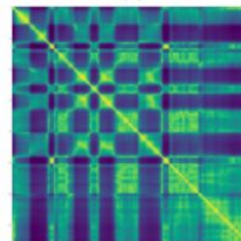
Attention map



(g)

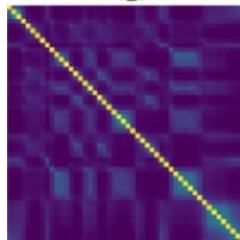


(h)

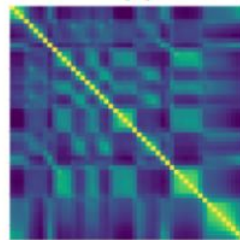


(i)

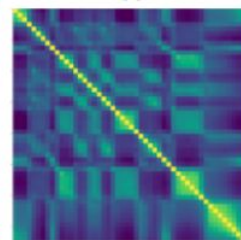
MFCC



(j)



(k)



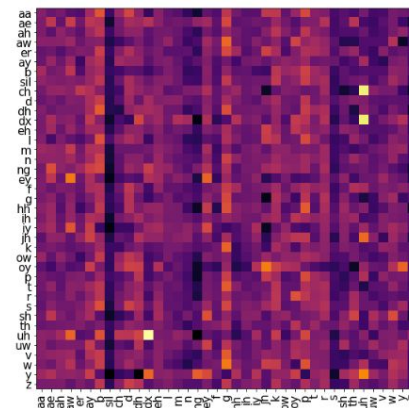
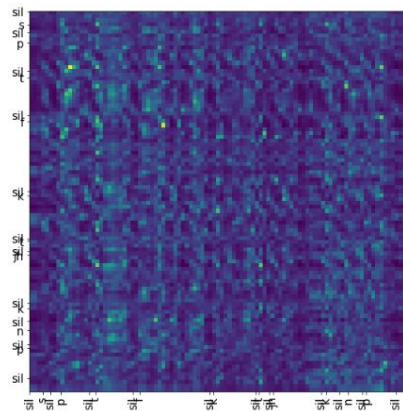
(l)

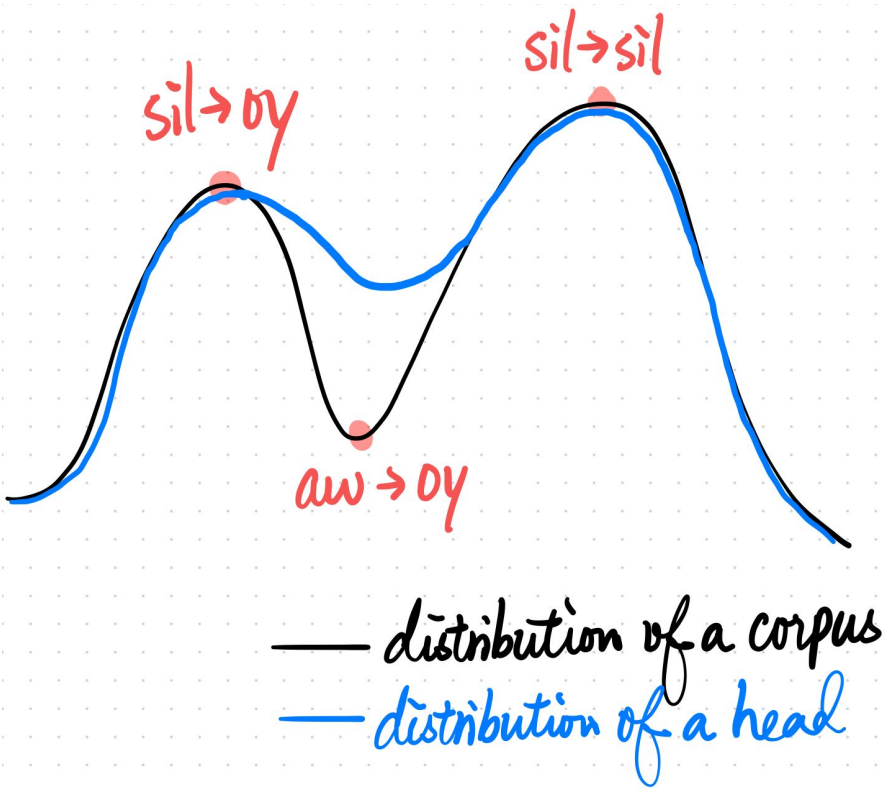
Representation

Phoneme relation map

- Different input utterance \rightarrow different attention map
- How to summarize the operation of a head (if exists)
 - Propose to align to phonemes

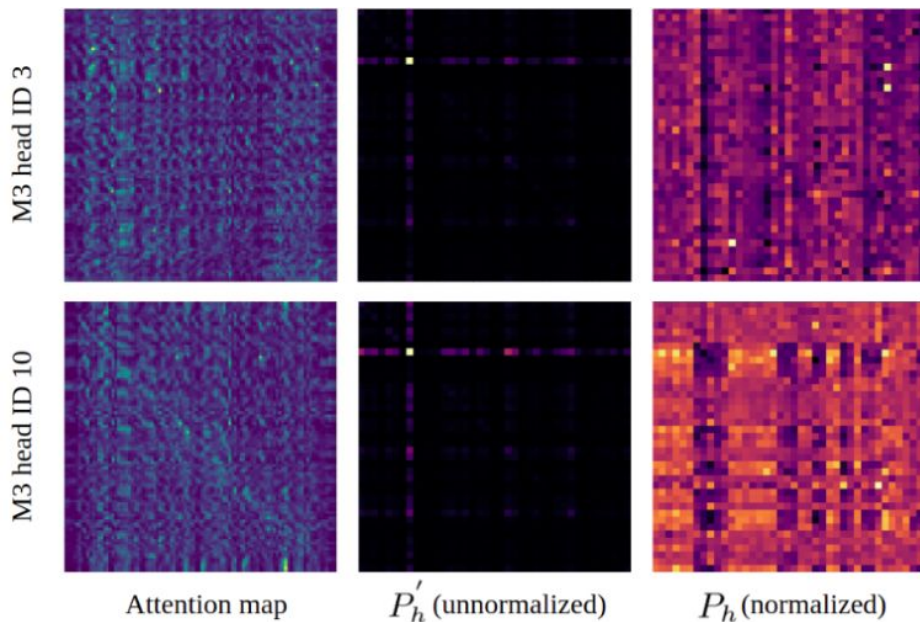
$$P'_h[m, n] = \mathbb{E}_{u \sim U} \left[\frac{1}{T} \sum_{q=1}^T \sum_{k=1}^T \mathbb{I}_{y_q=Y_m} \cdot \mathbb{I}_{y_k=Y_n} \cdot A_u^h[q, k] \right]$$



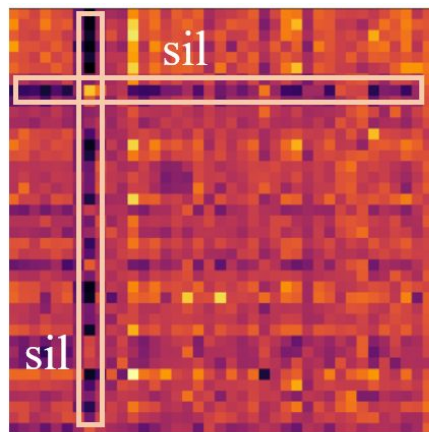


$$P_h[m, n] = \frac{P'_h[m, n] - P_U[m, n]}{P_U[m, n]}$$

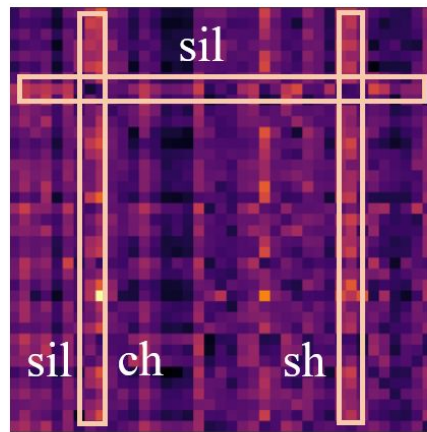
- The positive represent preference



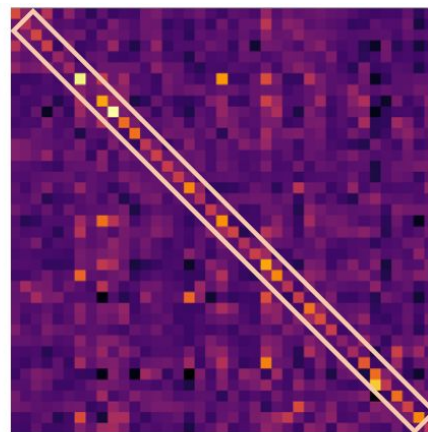
Global



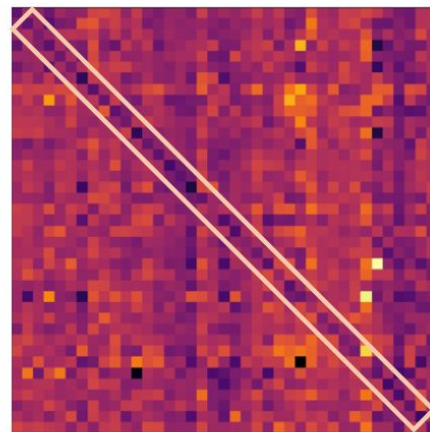
(a)



(b)

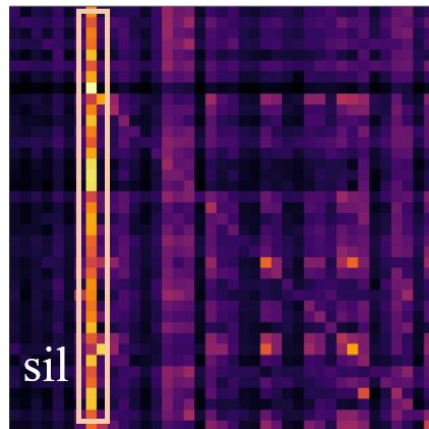


(c)

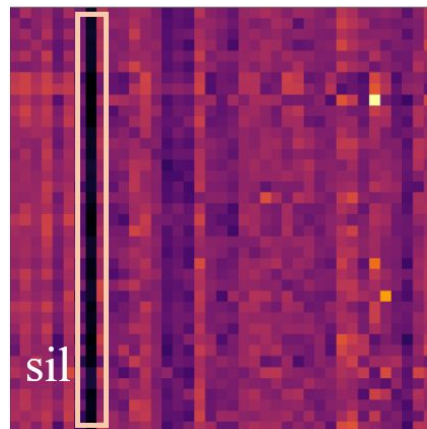


(d)

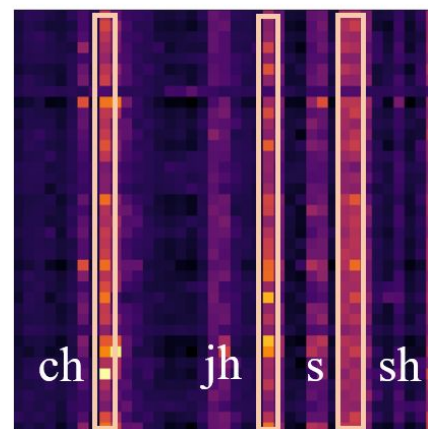
Vertical



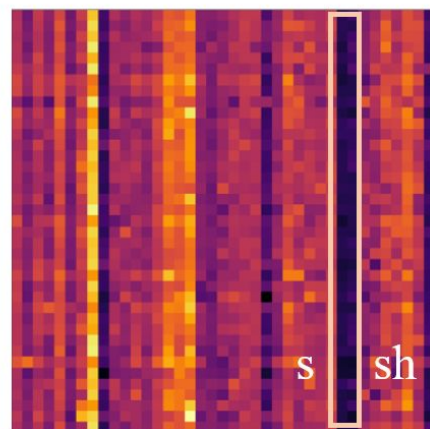
(e)



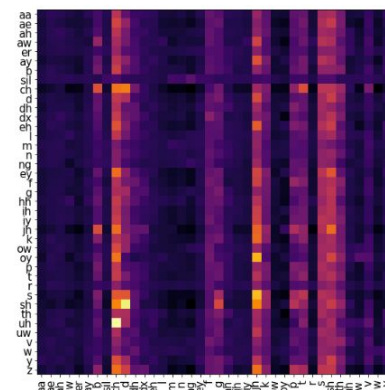
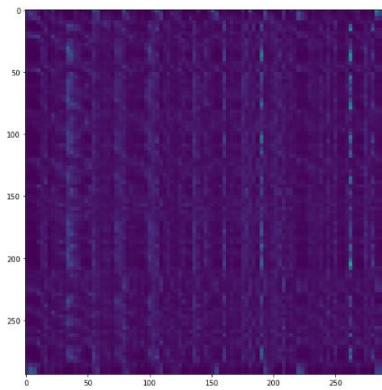
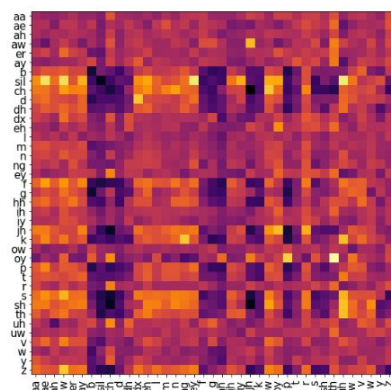
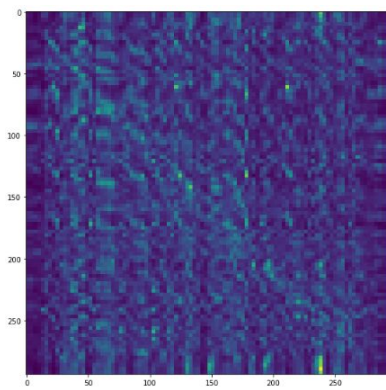
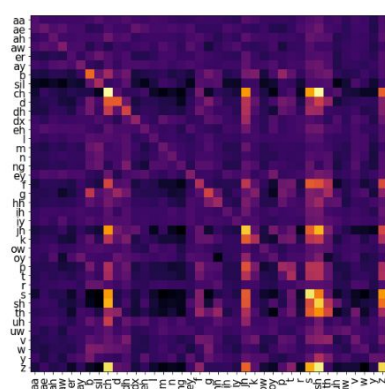
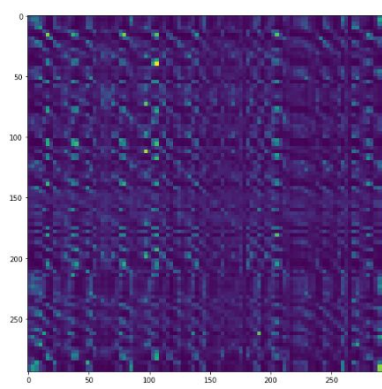
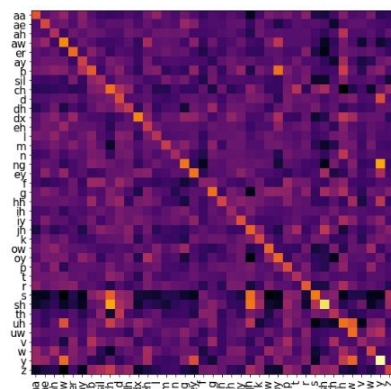
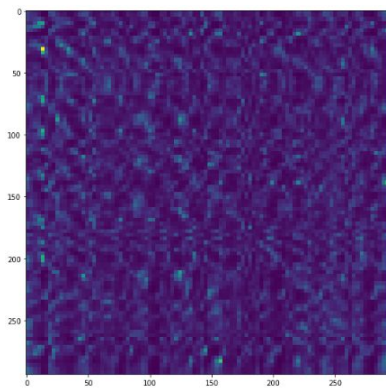
(f)



(g)

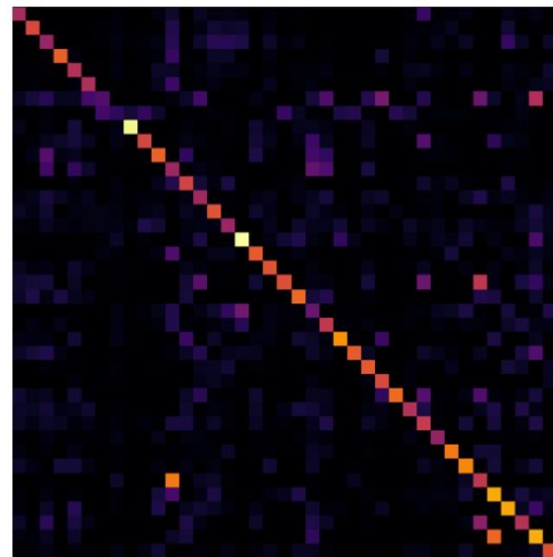
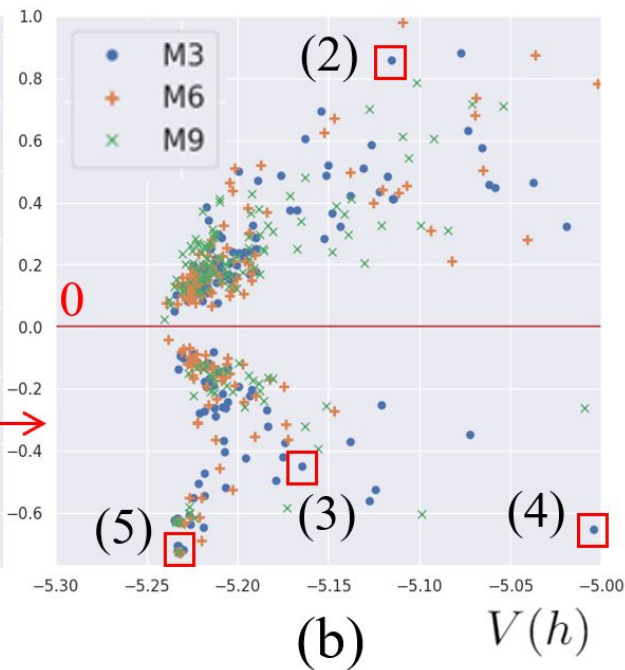
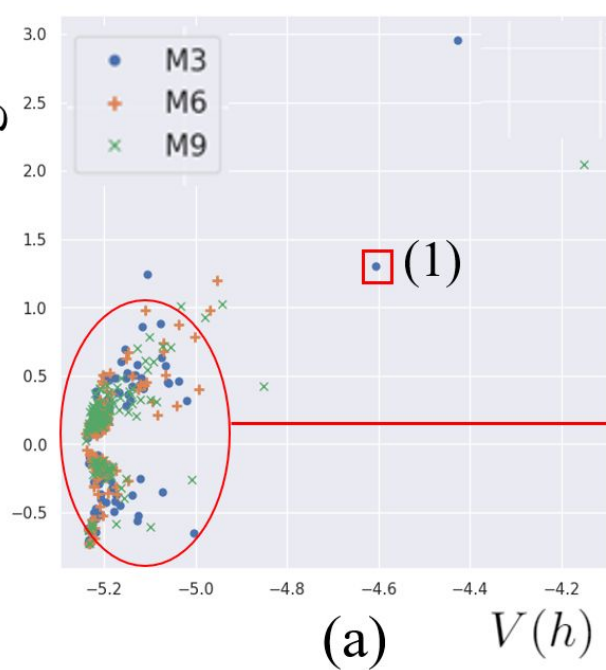


(h)



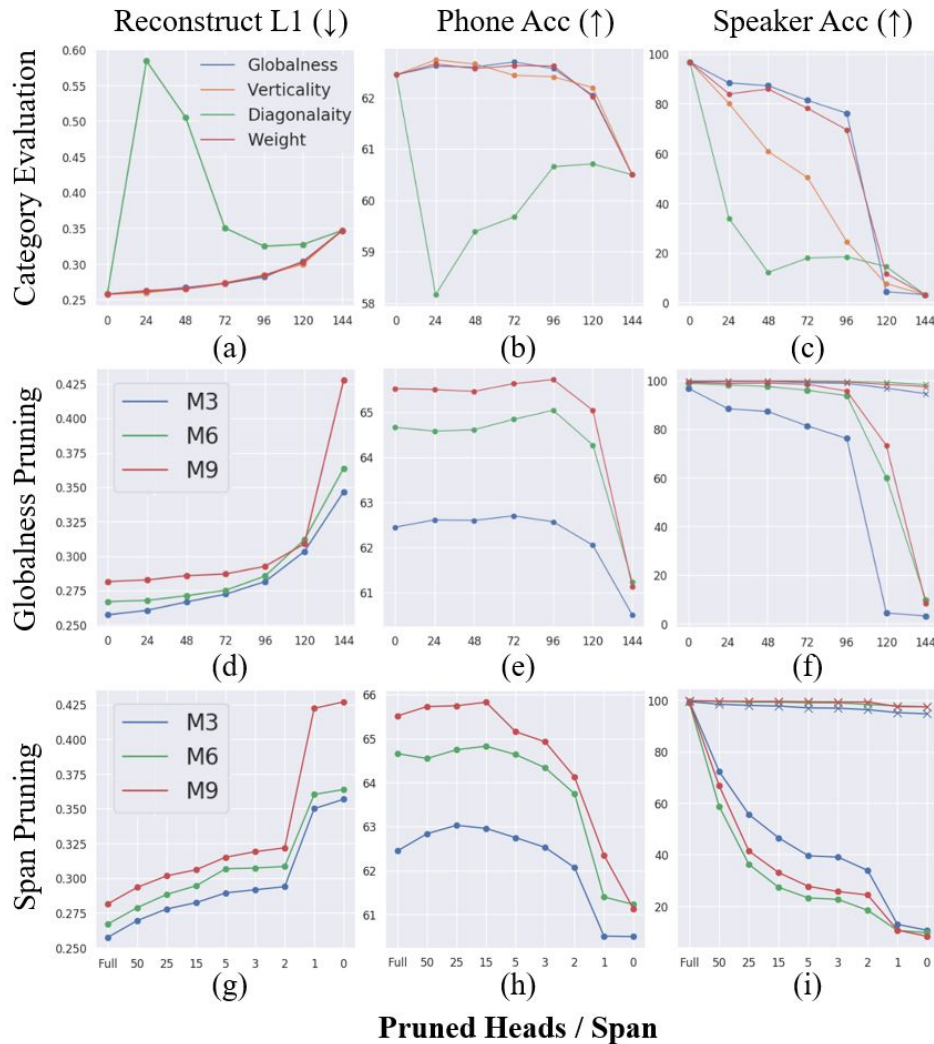
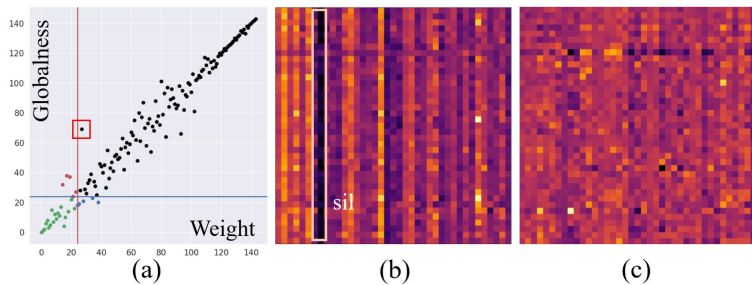
$$C_h[n] = \frac{1}{|Y|} \sum_{m=1}^{|Y|} P_h[m, n]$$

Maximum Focus or Neglect



Importance ranking

- Diagonal > Vertical > Global
- Compare with **weight**



Take-away

- Reconstruction:
 - Phonetic information → Diagonal attentions
 - Aware of pretraining mask length
 - Phoneme interval
 - Speaker identity → Vertical attentions
 - Focus
 - Neglect