Discovering Hidden Visual Concepts Beyond Linguistic Input in Infant Learning

Xueyi Ke[1], Satoshi Tsutsui[1], Yayun Zhang[2], Bihan Wen[1]

[1]Nanyang Technological University [2]The Max Planck Institute for Psycholinguistics

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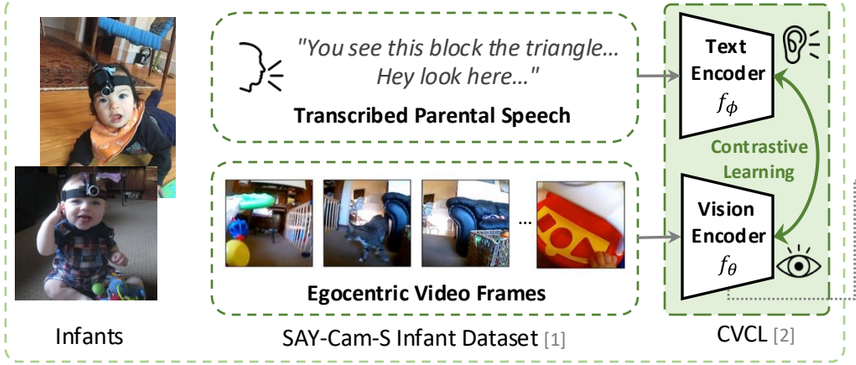
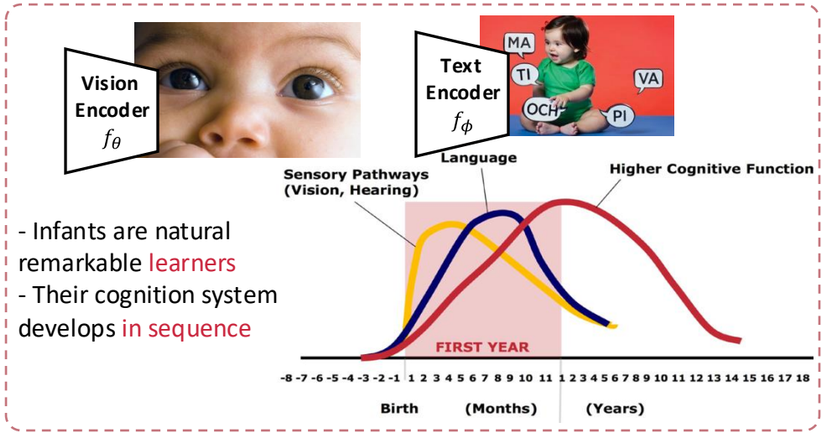
Prior Work: Training Models from Infant Data



Computational Model

Our Research Question:

Does the vision encoder of a model trained on infant egocentric data develop visual representations beyond its linguistic training data, like human infants?

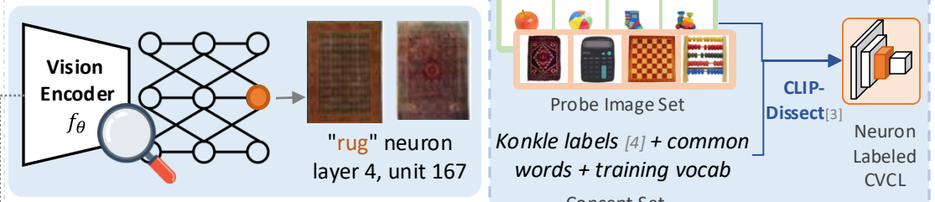


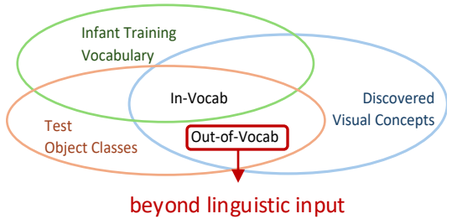
- Infants are natural remarkable learners
- Their cognition system develops in sequence

Does Vision Develop Earlier?

Vision encoder may recognize patterns beyond text in representation space:

To verify, we apply "neuron labeling"[3] : assign an object label to each neuron.

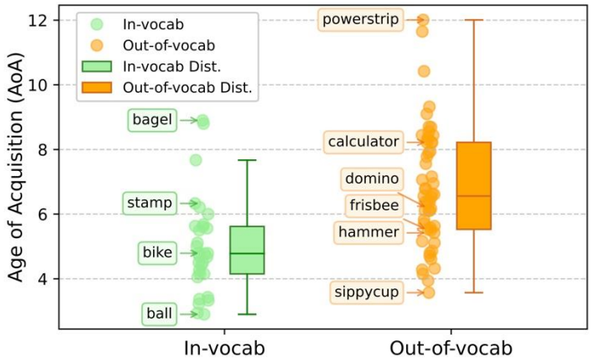




Discovered visual concepts from visual representation are categorized as in- or out-of-vocabulary.

Many out-of-vocabulary visual concepts emerge in specific neurons.

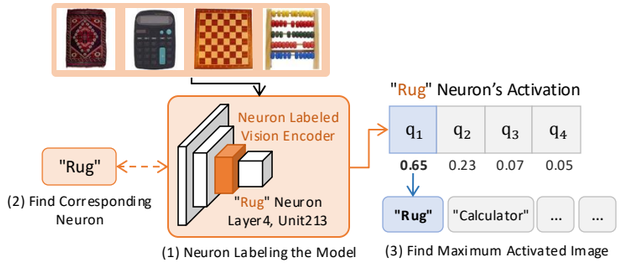
We rate visual concept from cognitive perspective: Age of Acquisition (AoA) [5]



Complex patterns in out-of-vocabulary concepts suggest visual learning **beyond text supervision**.

Neuron-based Classification

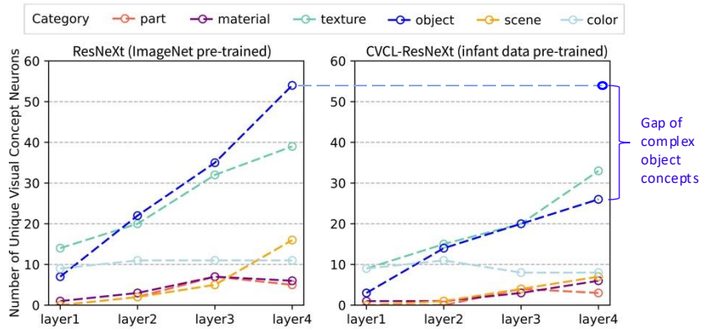
Model can classify images using only a single visual concept neuron, **without any additional training**.



Method	Model	In-vocab	Out-of-vocab	All
Vanilla	CLIP-ResNet50	$98.81_{\pm 0.16}$	$96.93_{\pm 0.06}$	$97.42_{\pm 0.05}$
	ResNeXt50	✗	✗	✗
	CVCL-ResNeXt50 (*Baseline*)	$\mathbf{36.18}_{\pm 0.91}$	✗	✗
Neuron Classifier	CLIP-ResNet50	$91.59_{\pm 0.52}$	$88.66_{\pm 0.35}$	$89.79_{\pm 0.38}$
	ResNeXt50	$88.17_{\pm 0.45}$	$93.28_{\pm 0.36}$	$91.88_{\pm 0.15}$
	CVCL-ResNeXt50	$\mathbf{79.50}_{\pm 0.78}$	$\mathbf{76.81}_{\pm 0.35}$	$\mathbf{77.79}_{\pm 0.40}$

ImageNet vs Infant Pretrained Representations

A significant gap in representation richness exists across final layers.



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Acknowledgements: This work was partially supported by the National Research Foundation Singapore Competitive Research Program (award number CRP29-2022-0003). We thank Wai Keen Vong for invaluable discussion and CVCL's pretrained weights. We thank Jingyi Lin for figure discussions.