Learning Semantic Representations for Novel Words: Leveraging Both Form and Context

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Motivation

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... but standard learning algorithms learn **no or poor embeddings** for them.

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- Two recent approaches to address this problem:
  - learning based on the **surface-form** of novel words
  - learning based on the **context** of novel words
- We present the first model to combine form and context
- Our combined model outperforms previous models

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Surface-Form:

$S_{\mathbf{w}} = \{\langle s\rangle\text{p}, \text{po}, \text{om}, \text{me}, \text{el}, \text{lo}, \text{o}\langle e\rangle, \langle s\rangle\text{po}, \text{pom}, \text{ome}, \text{mel}, \text{elo}, \text{lo}\langle e\rangle\}$

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Context:

$\mathcal{C} = \{\text{unlike}, \text{the}, \text{grapefruit}, \text{the}, \text{has}, \text{very}, \text{little}, \ldots, \text{marketplace}\}$

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$$\mathcal{C} = \{c_1, \ldots, c_m\}$$

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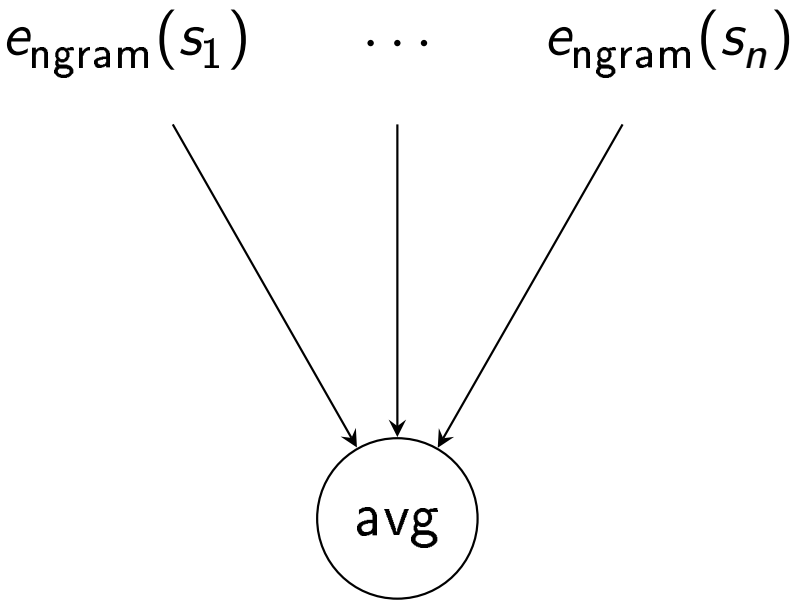

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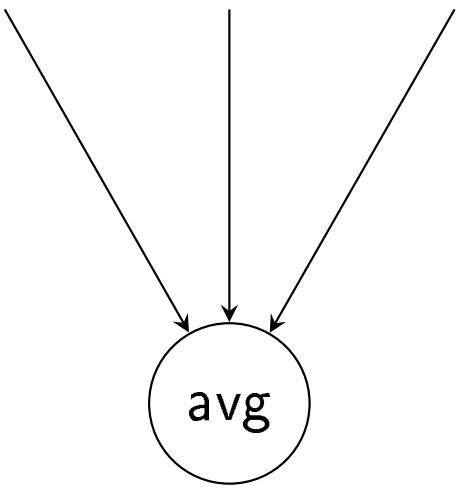

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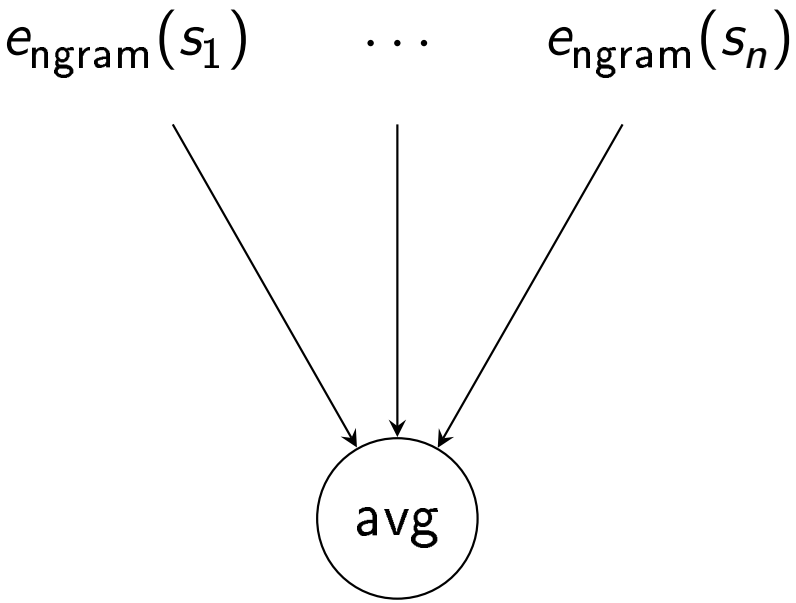

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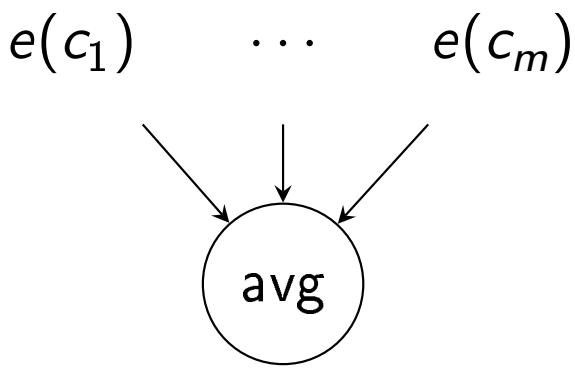

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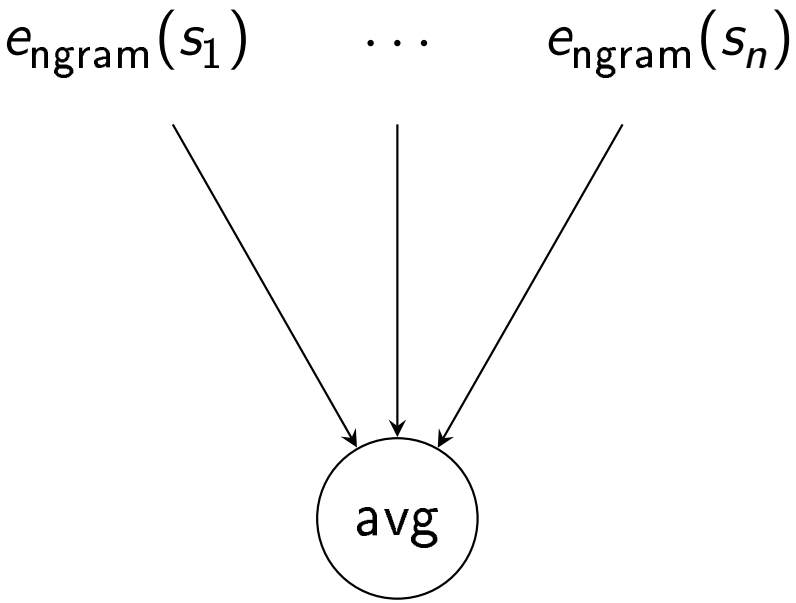

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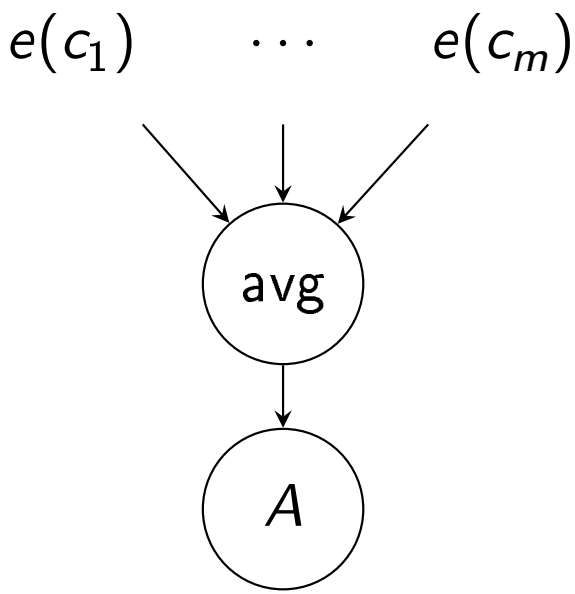

$$\hat{v}^{\text{context}}_{(\mathbf{w},\mathcal{C})}$$

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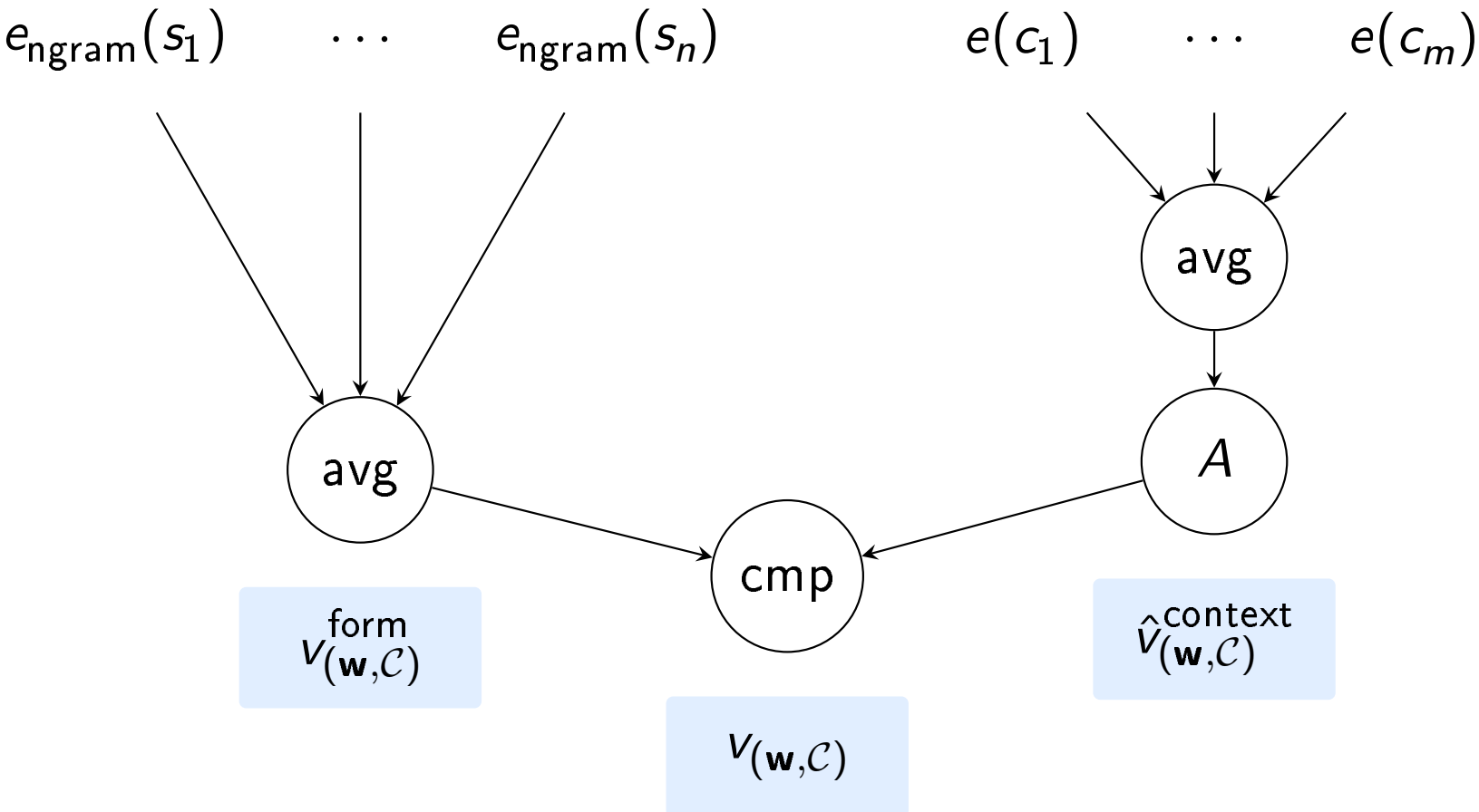

Composition Functions

(i) single-parameter

$$v_{(\mathbf{w},\mathcal{C})} = \alpha \cdot \hat{v}^{\text{context}}_{(\mathbf{w},\mathcal{C})} + (1-\alpha) \cdot v^{\text{form}}_{(\mathbf{w},\mathcal{C})}.$$

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(ii) gated

As above, except:

$$\alpha = \sigma(w^\top [v^{\text{context}}_{(\mathbf{w},\mathcal{C})} \circ v^{\text{form}}_{(\mathbf{w},\mathcal{C})}] + b)$$

Training

$$\begin{aligned}\mathcal{B} &= \{(\mathbf{w}_1, \mathcal{C}_1), (\mathbf{w}_2, \mathcal{C}_2), \ldots, (\mathbf{w}_k, \mathcal{C}_k)\} \\ &= \{(\text{pomelo}, \{\text{unlike}, \text{the}, \text{grapefruit}, \ldots\}), (\mathbf{w}_2, \mathcal{C}_2), \ldots, (\mathbf{w}_k, \mathcal{C}_k)\}\end{aligned}$$

$$L_{\mathcal{B}} = \frac{1}{|\mathcal{B}|} \sum_{(\mathbf{w},\mathcal{C}) \in \mathcal{B}} \left\| v_{(\mathbf{w},\mathcal{C})} - e(\mathbf{w}) \right\|^2$$

Evaluation

- We train the form-context model using skipgram embeddings trained on Wikipedia
- For each word **w**, we create $\mathcal{C}$ by randomly sampling sentences in which **w** occurs
- We evaluate the model on two tasks:
  - the **Definitional Nonce Task**
  - the **Contextual Rare Words Task**

The Definitional Nonce Task

spies most commonly refers to people who engage in spying, espionage or clandestine operations

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	form	**context**	**frm-ctx**
neighbours	pies, cakes, spied, sandwiches	espionage, clandestine, covert, spying	espionage, spying, clandestine, covert
rank	668	8	6

The Definitional Nonce Task

hygiene which comes from the name of the greek goddess of health hygieia is a set of practices performed for the preservation of health

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	form	**context**	**frm-ctx**
neighbours	hygienic, hygiene, cleansers, hypoallergenic	hygieia, goddess, eileithyia, asklepios	hygienic, hygieia, health, hygiene
rank	2	465	4

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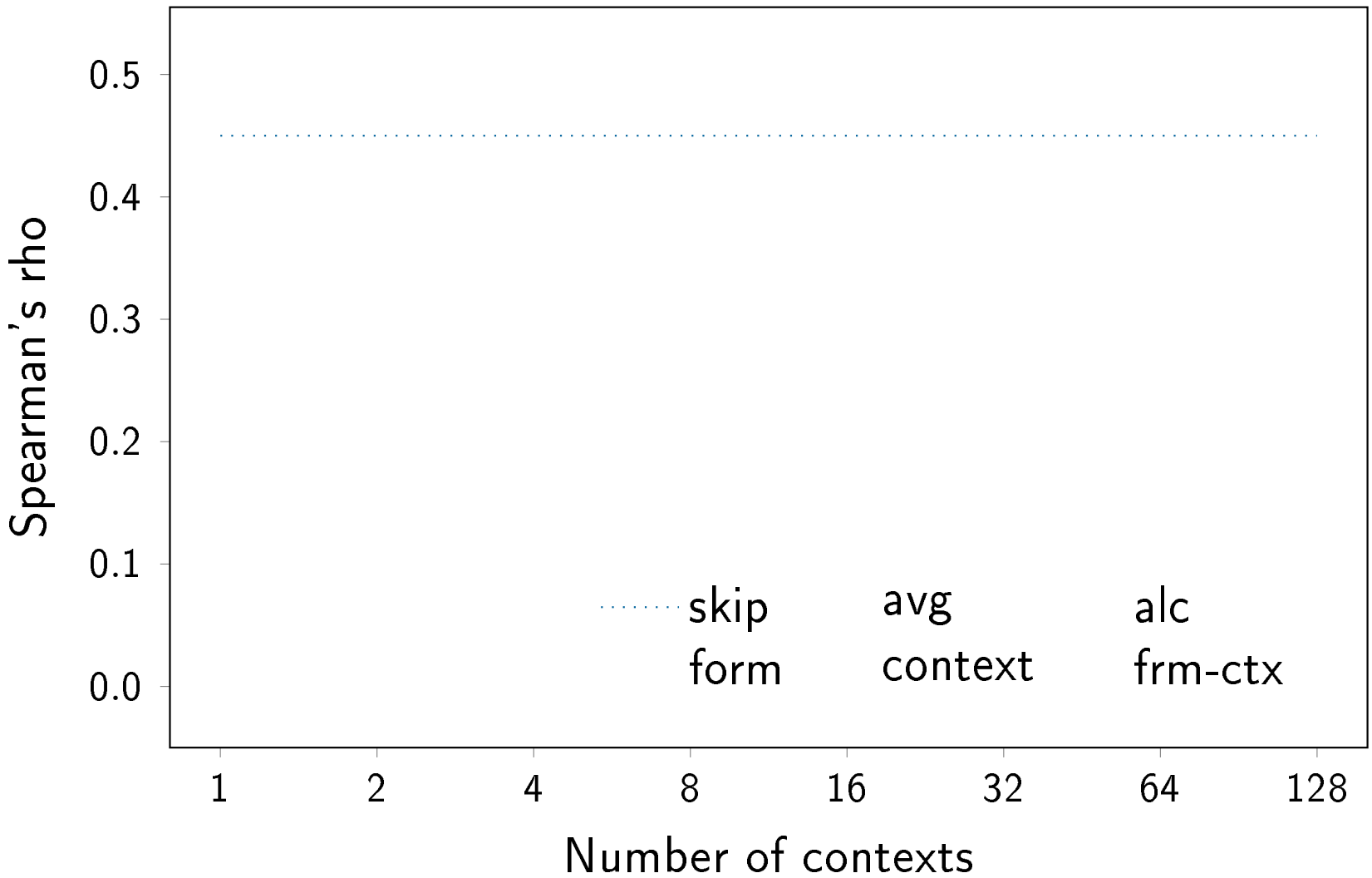
	form	**context**	**frm-ctx**
neighbours	interception, interceptions, fumble, touchdowns	sensory, perceptual, auditory, contextual	sensory, perceptual, perception, auditory
rank	115	51	3

The Definitional Nonce Task

Model	Type	Median Rank	MRR
Mimick	form	85573	0.00006
Skipgram	context	111012	0.00007
Additive	context	3381	0.00945
Nonce2Vec	context	623	0.04907
A La Carte	context	165.5	0.07058
surface-form	form	404.5	0.12982
context	context	184	0.06560
single-parameter	both	55	0.16200
gated	both	**49**	**0.17537**

The Contextual Rare Words Task



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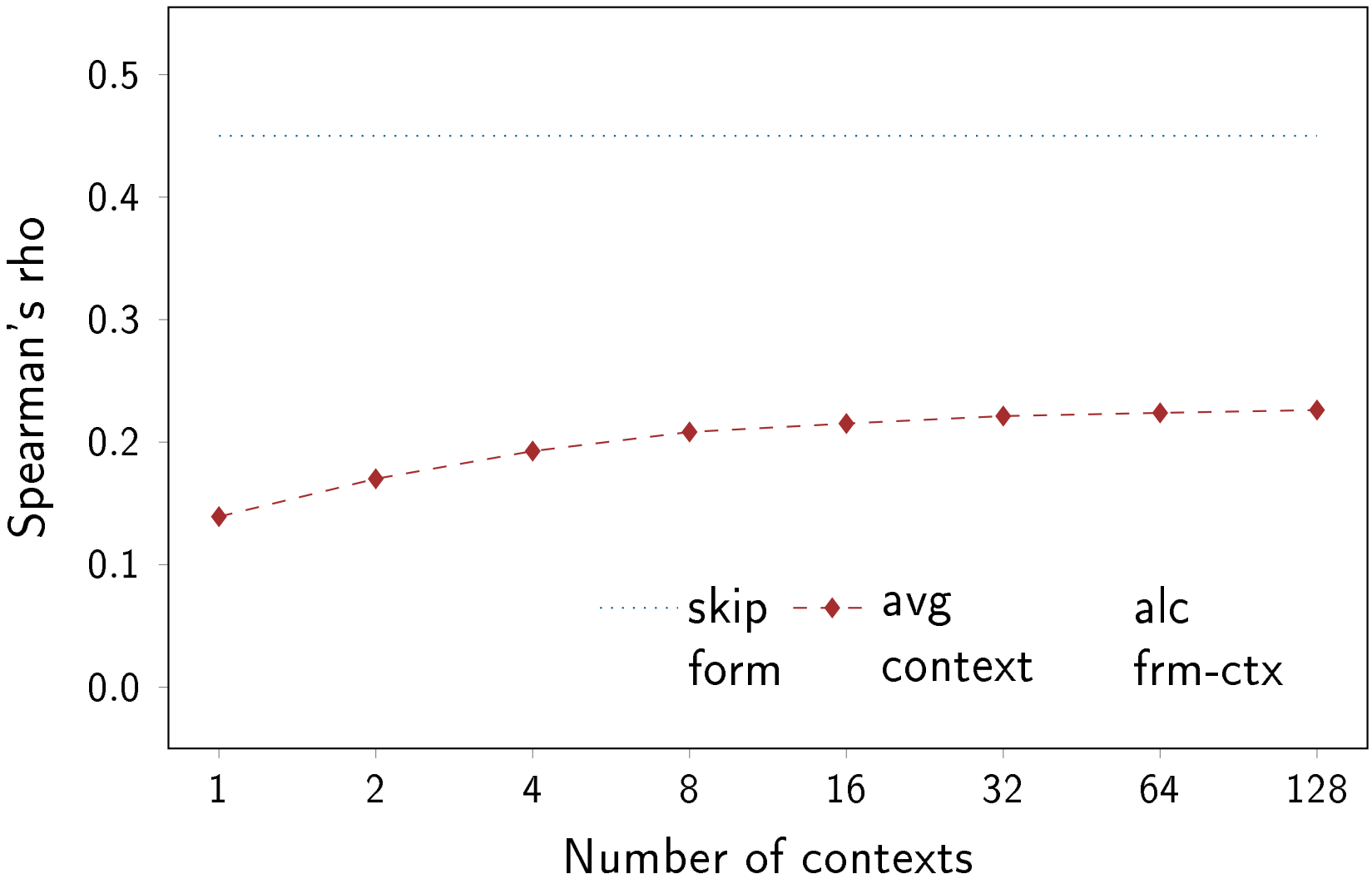

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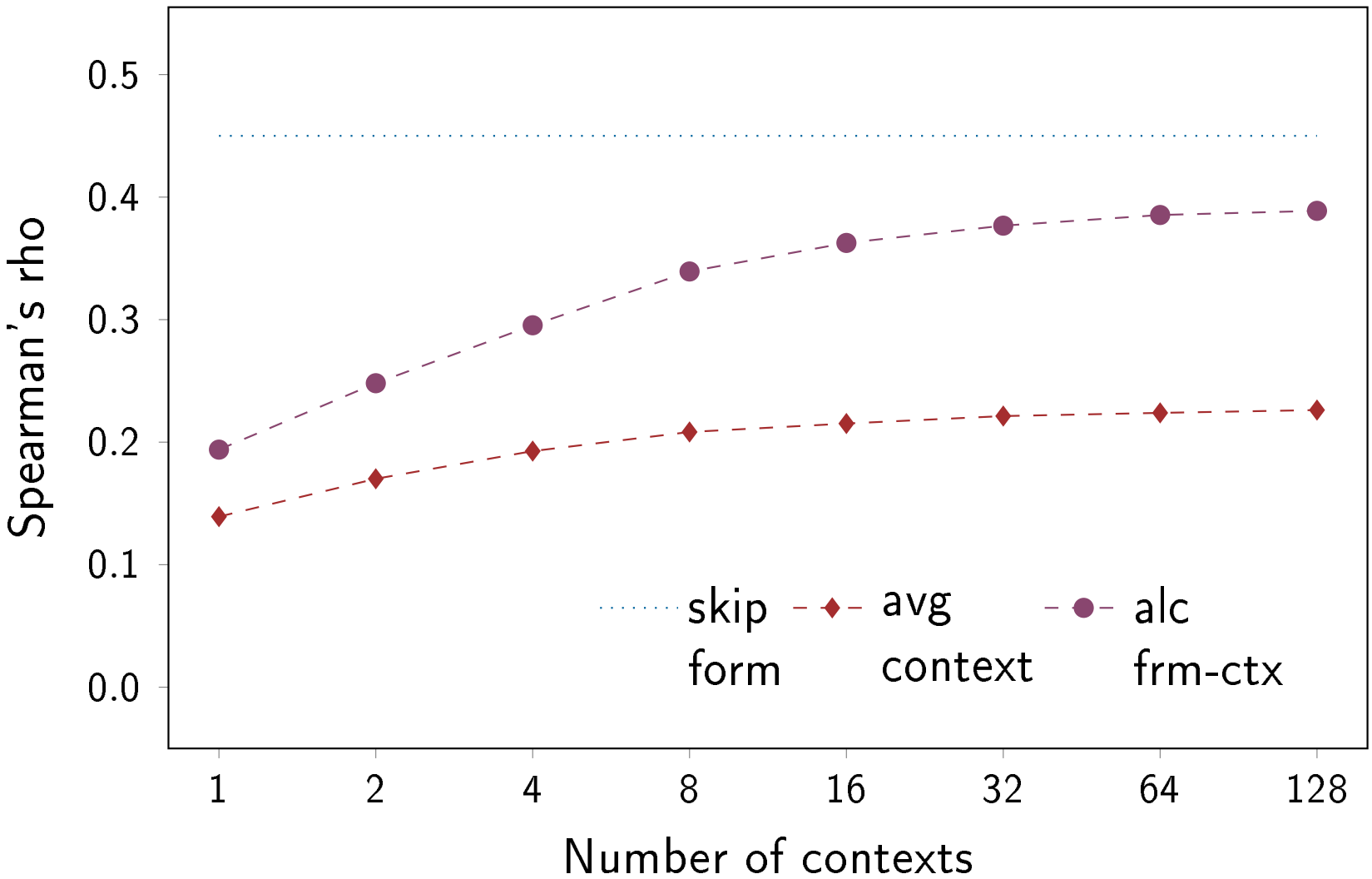

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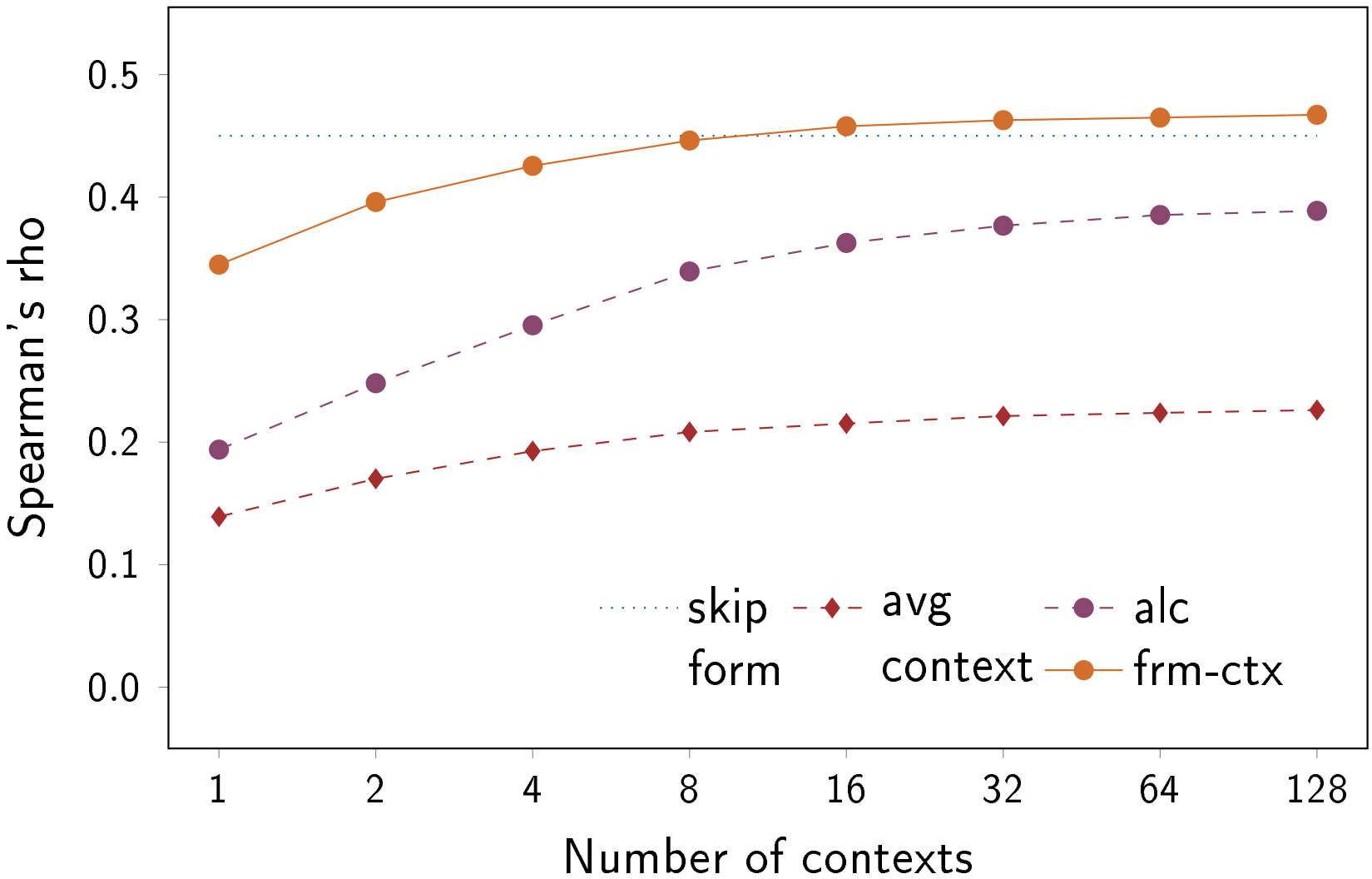

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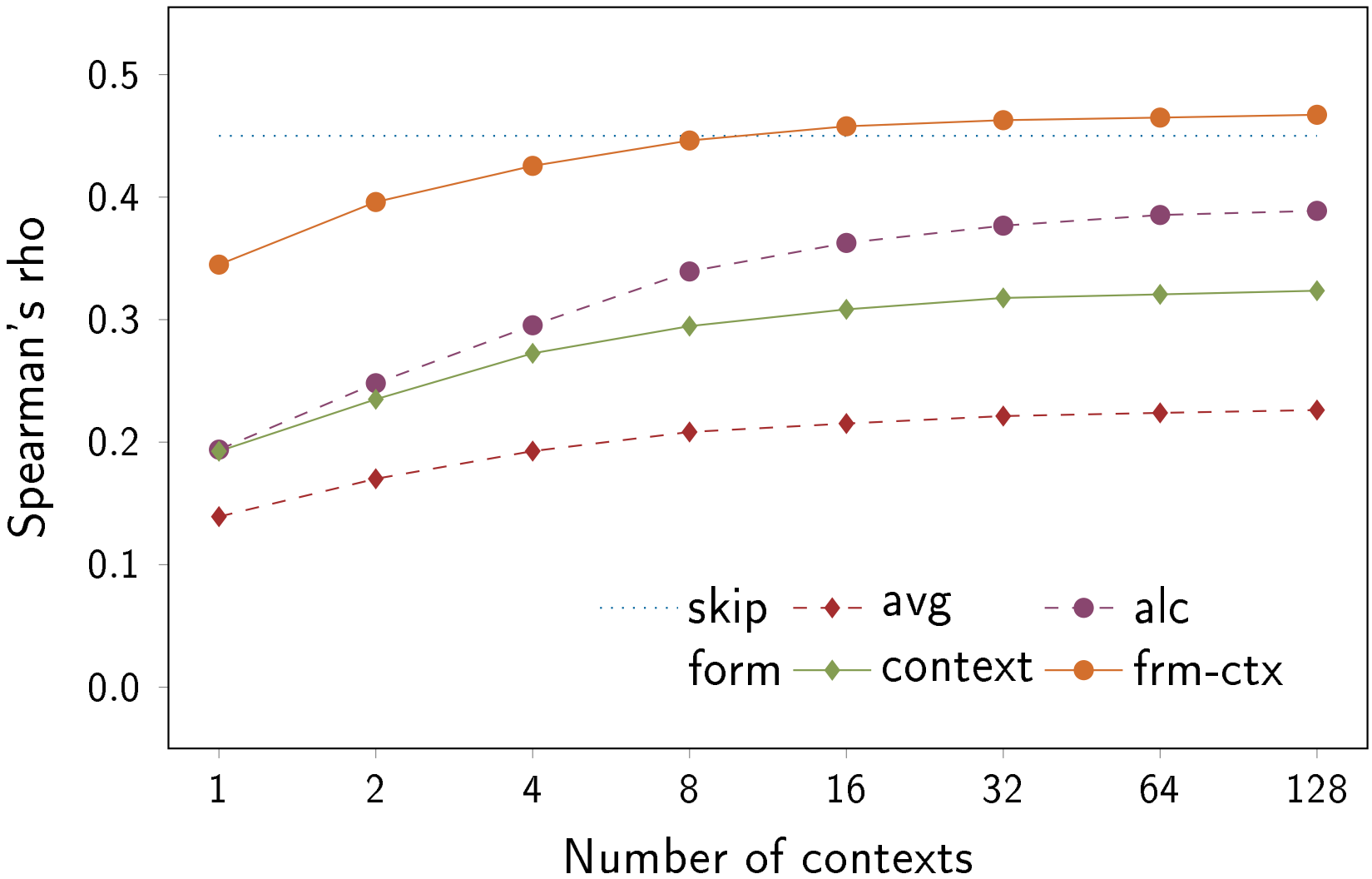

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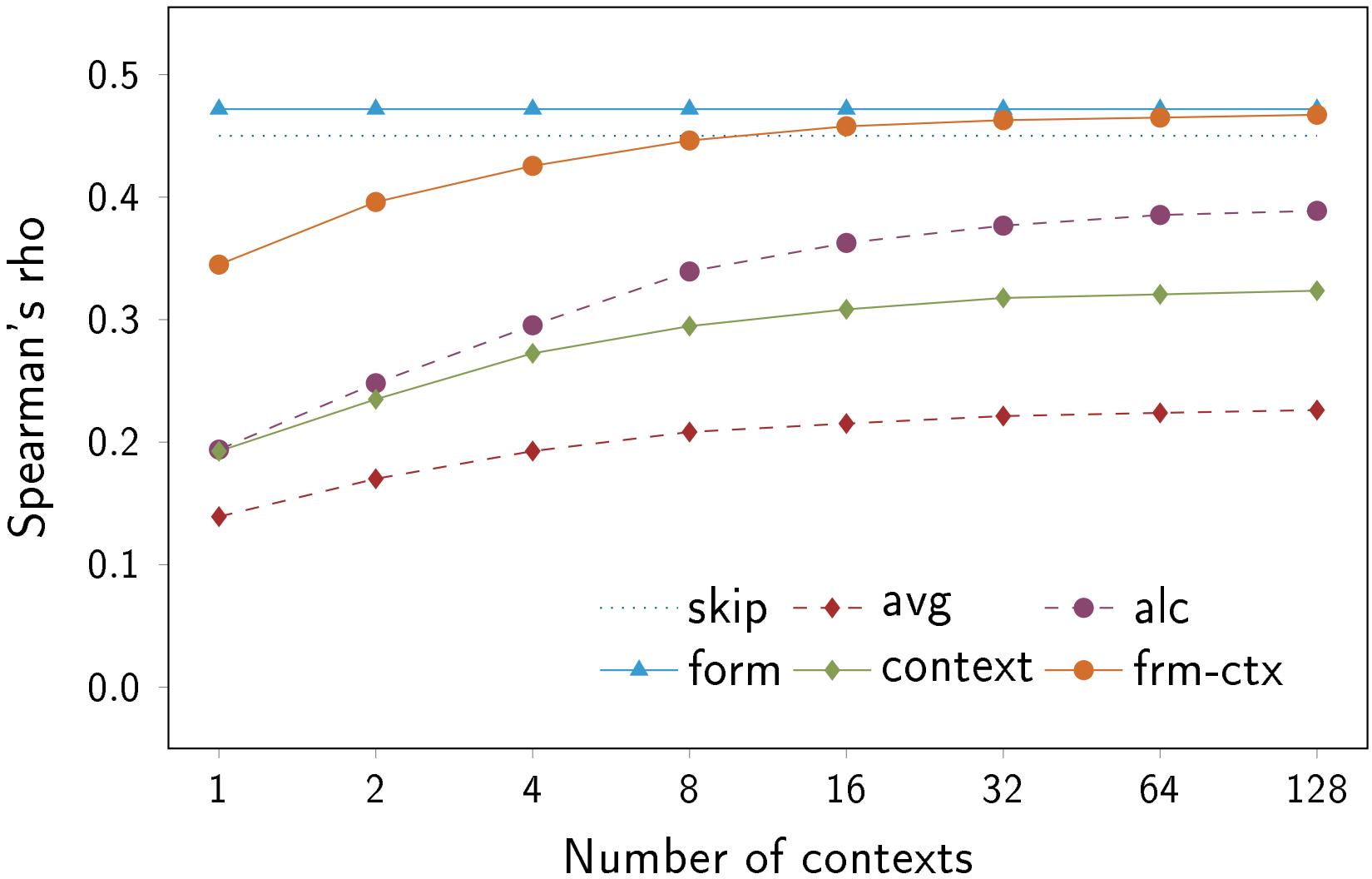


The Gated Model

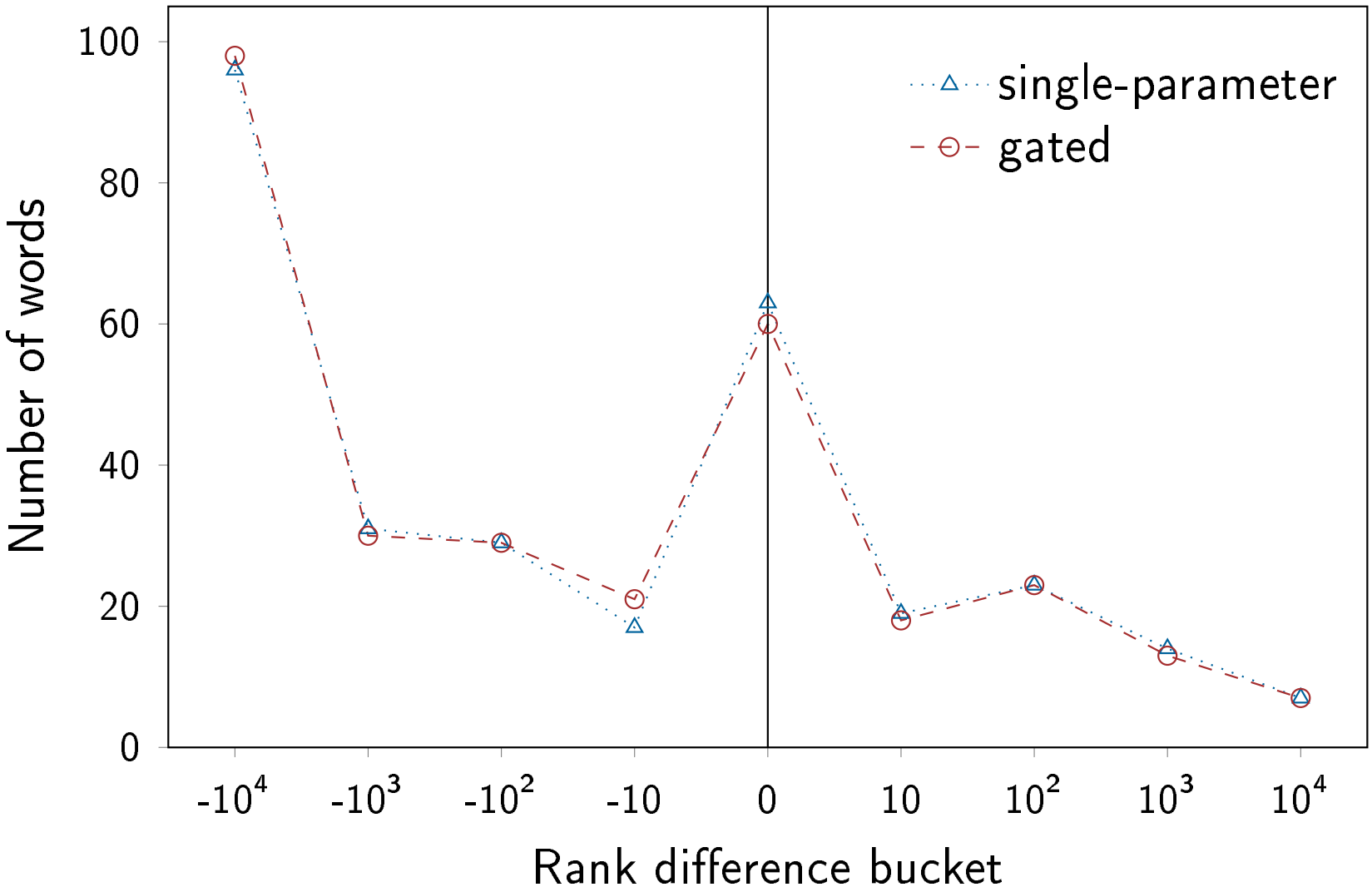
Words with high form weights:

cookstown, feltham, sydenham, wymondham, cleveland, banbury, highbury, shaftesbury

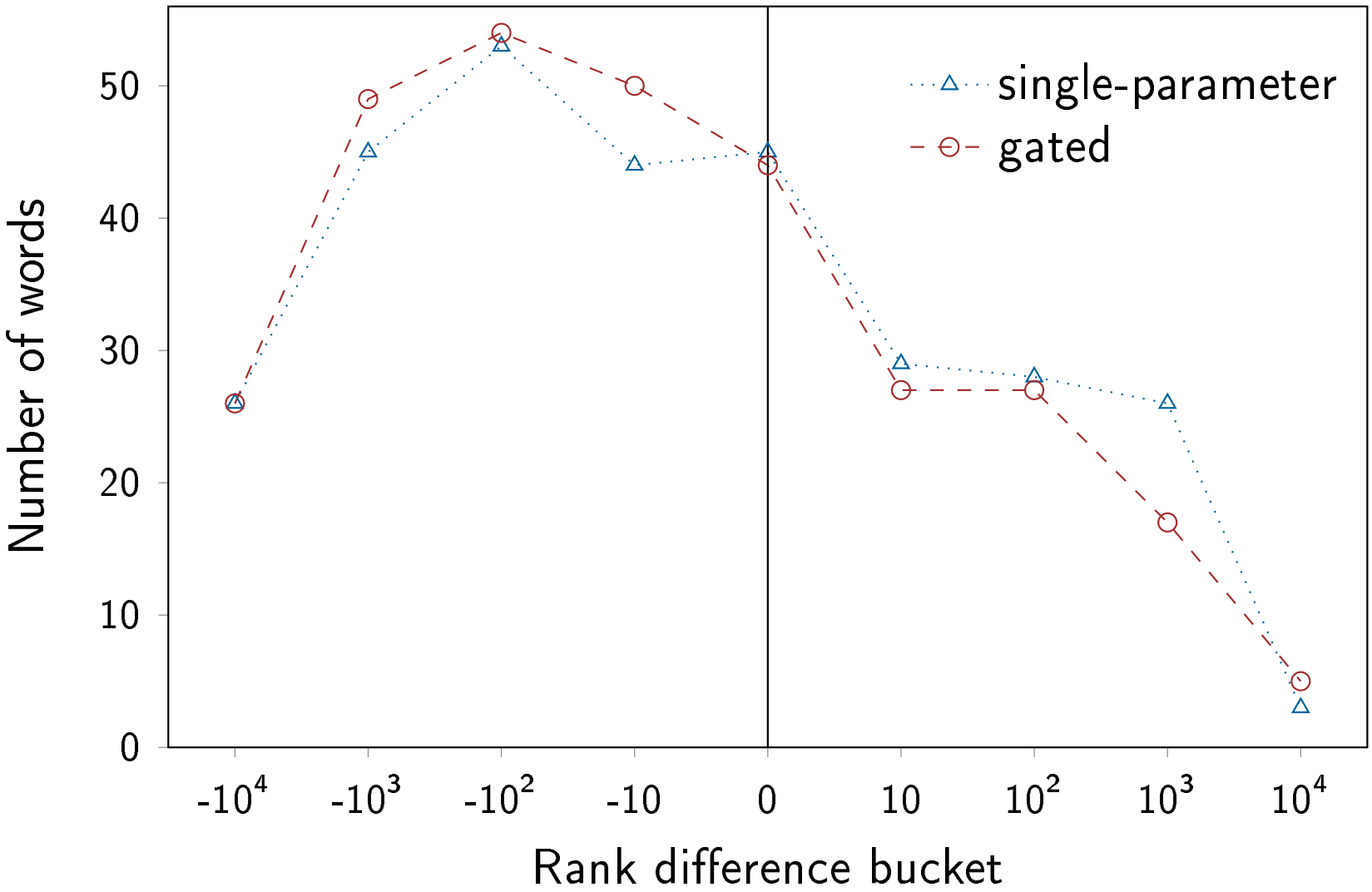
Words with high context weights:

poverty, hue, slang, flax, rca, bahia, atari, snooker, icq, bronze, esso

Adding Context Information



Adding Subword Information



Related Work

Bojanowski, P.; Grave, E.; Joulin, A.; and Mikolov, T. 2017. **Enriching word vectors with subword information**. *Transactions of the ACL*

Herbelot, A., and Braoni, M. 2017. **High-risk learning: acquiring new word vectors from tiny data**. In *Proceedings of the 2017 Conference on EMNLP*

Khodak, M.; Saunshi, N.; Liang, Y.; Ma, T.; Steward, B.; and Arora, S. 2018. **A la carte embedding: Cheap but effective induction of semantic feature vectors**. In *Proceedings of the 56th Annual Meeting of the ACL*

Pinter, Y.; Guthrie, R.; and Eisenstein, J. 2017. **Mimicking word embeddings using subword RNNs**. In *Proceedings of the 2017 Conference on EMNLP*

Conclusion and Future Work

The **form-context model** generates high-quality representations for novel words by using both subword-form and context.

Possible directions for future work include:

- investigating the model's performance for other languages;
- using more complex composition functions or ways to obtain surface-form and context embeddings.