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Kiki or Bouba? Sound Symbolism in Vision-and-Language Models

Morris Alper and Hadar Averbuch-Elor

NeurIPS 2023 ✨SPOTLIGHT✨

VAILab

TEL AVIV UNIVERSITY אוניברסיטת תל אביב

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Next you will be shown two images that were generated by Stable Diffusion using the prompt:

"A 3D rendering of a _____-shaped object"

For one the missing word is *bouba* and for the other *kiki*.

Which is which?

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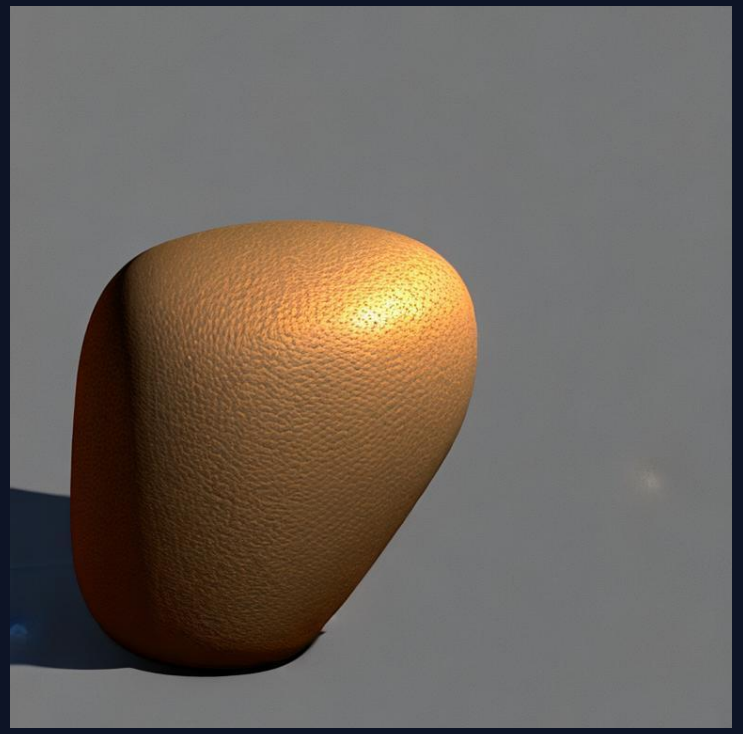

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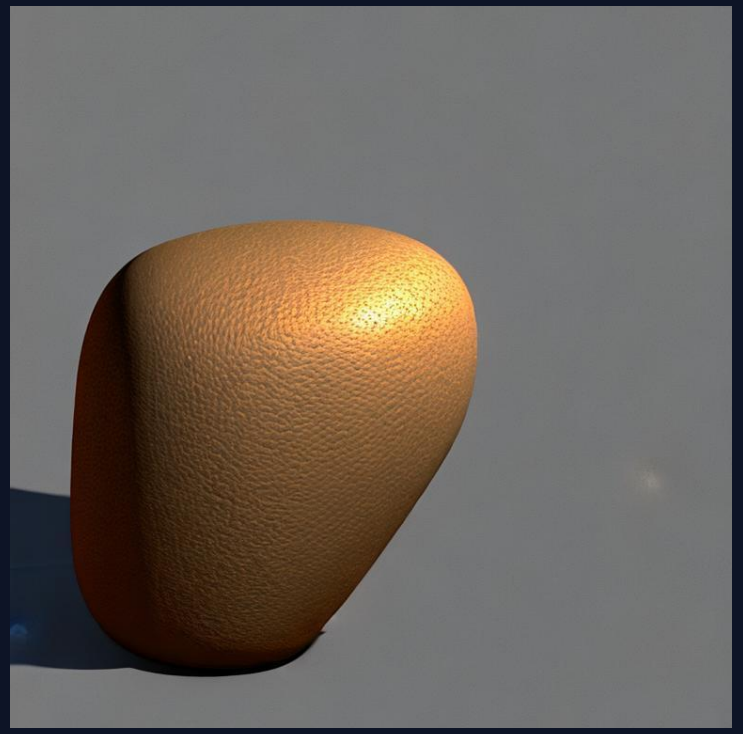

bouba

kiki

The Kiki-Bouba Effect

A well-known study in psycholinguistics

Holds across cultures, languages, and even among infants.

[Blasi et al. 2016, Ćwiek et al. 2022, Maurer et al. 2006, Ozturk et al. 2013]

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Sound Symbolism

Connections between sound and meaning in language

kapow, glub-glub, boom

crunch/crush/crash/crinkle/crack

mama　　אמא (ima)　　妈妈 (māma)

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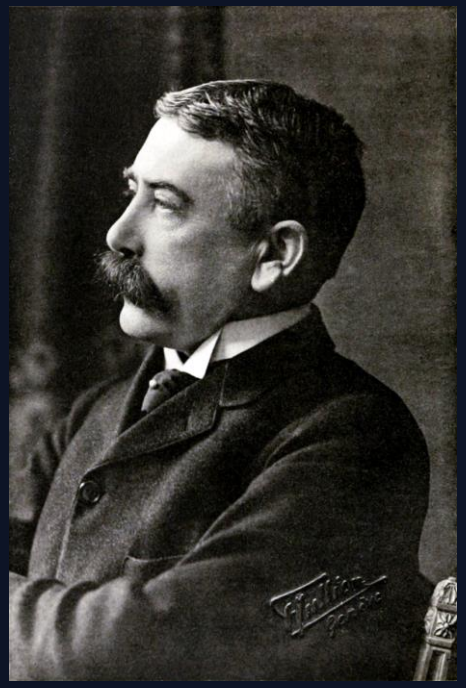
Sound Symbolism

Connections between sound and meaning in language

“Le signe est arbitraire” !
(the sign is arbitrary)

Ferdinand de Saussure
(1857–1913)



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Sound Symbolism

Connections between sound and meaning in language

Have VLMs learned sound symbolism?

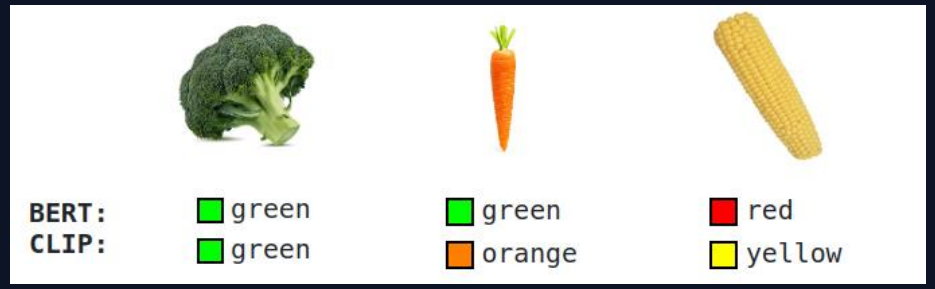
Why is this important?

Interpreting the **black box of foundation VLMs**

Why is this important?

Interpreting the **black box of foundation VLMs**

Tewel et al. (CVPR 2022)

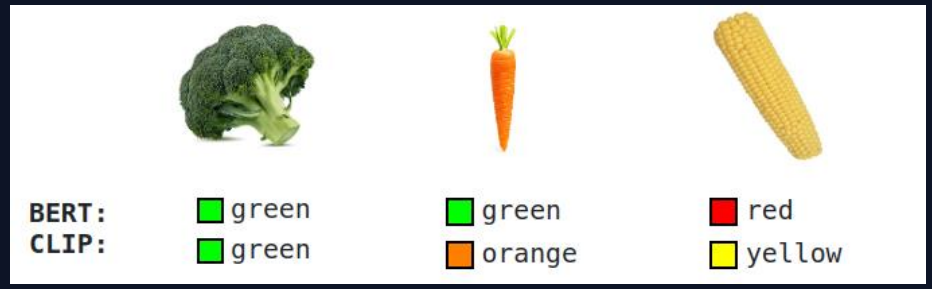


Alper et al. (CVPR 2023)

Why is this important?

Interpreting the **black box of foundation VLMs**

Tewel et al. (CVPR 2022)



Alper et al. (CVPR 2023)

New tool for studying language

Insight into how sound symbolism could be learned

Probing VLMs for Sound Symbolism

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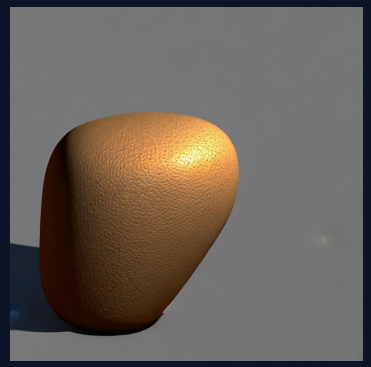
Probing VLMs for Sound Symbolism

Measuring geometric attributes of pseudowords

rounder

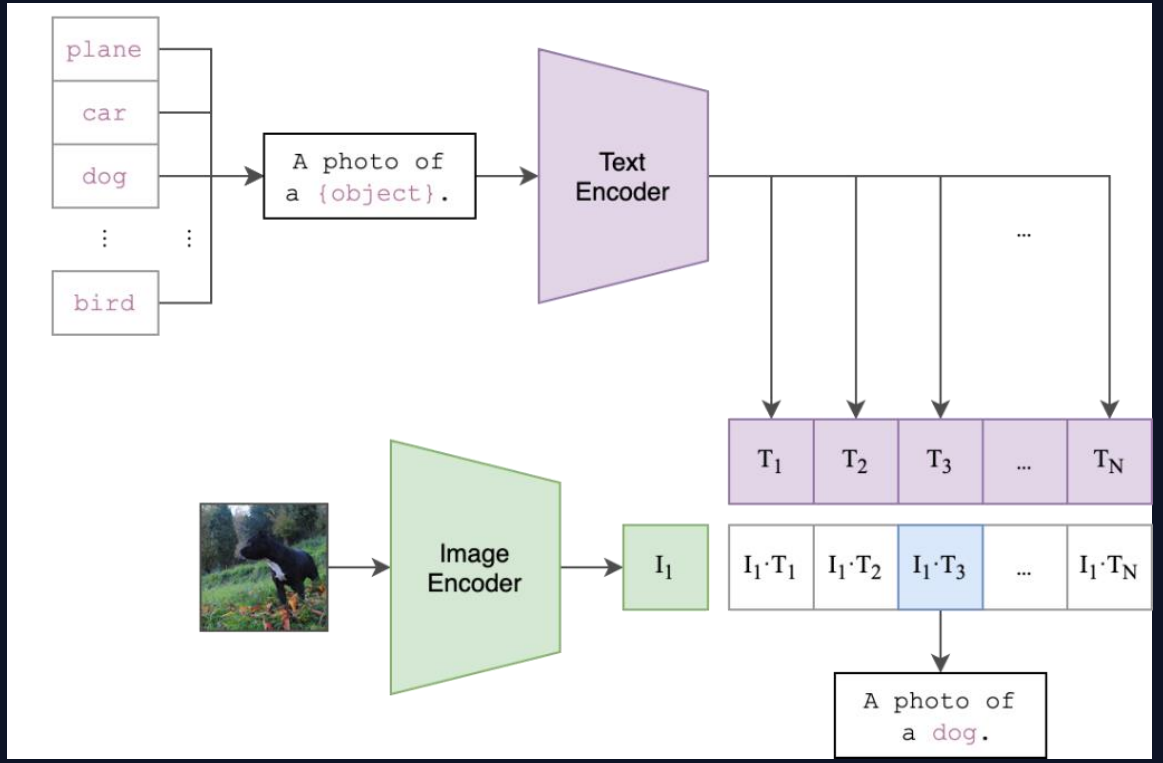


bouba

sharper

kiki

CLIP: Embeds images and text in a shared semantic space



Radford et al. (ICML 2021)

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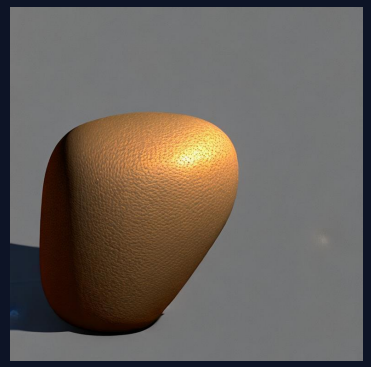
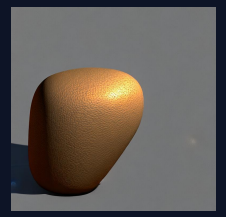
Probing VLMs for Sound Symbolism

Measuring geometric attributes of pseudowords with CLIP

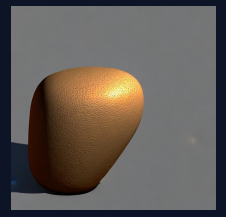
rounder



bouba

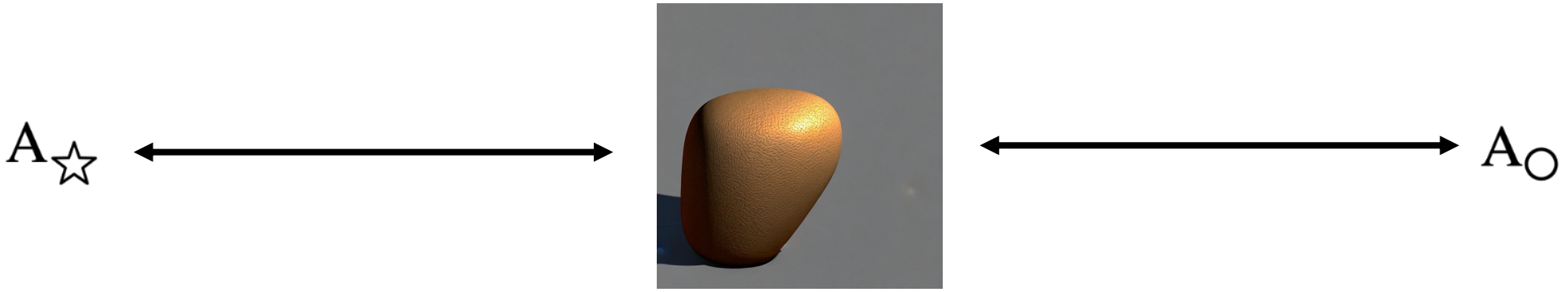


"round"



"sharp"

. . .



$A_{☆}$ = {*sharp, spiky, angular, jagged, hard, edgy, pointed, prickly, rugged, uneven*}

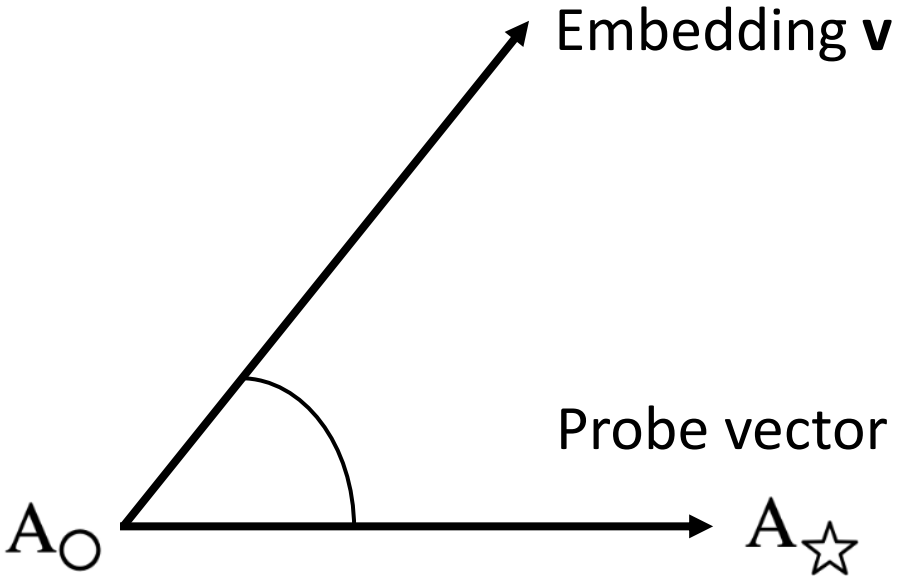
$A_{○}$ = {*round, circular, soft, fat, chubby, curved, smooth, plush, plump, rotund*}

Probe vector

$\mathrm{A}_{\bigcirc} \longrightarrow \mathrm{A}_{\star}$ $\quad w_{adj} := \sum_{\langle a \rangle \in \mathrm{A}_{\star}} \hat{w}_{\langle a \rangle} - \sum_{\langle a \rangle \in \mathrm{A}_{\bigcirc}} \hat{w}_{\langle a \rangle}$

$\mathrm{A}_{\star}$ = {*sharp, spiky, angular, jagged, hard, edgy, pointed, prickly, rugged, uneven*}

$\mathrm{A}_{\bigcirc}$ = {*round, circular, soft, fat, chubby, curved, smooth, plush, plump, rotund*}



$$w_{adj} := \sum_{\langle a \rangle \in A_{\star}} \hat{w}_{\langle a \rangle} - \sum_{\langle a \rangle \in A_{\bigcirc}} \hat{w}_{\langle a \rangle}$$

$A_{\star}$ = {*sharp, spiky, angular, jagged, hard, edgy, pointed, prickly, rugged, uneven*}

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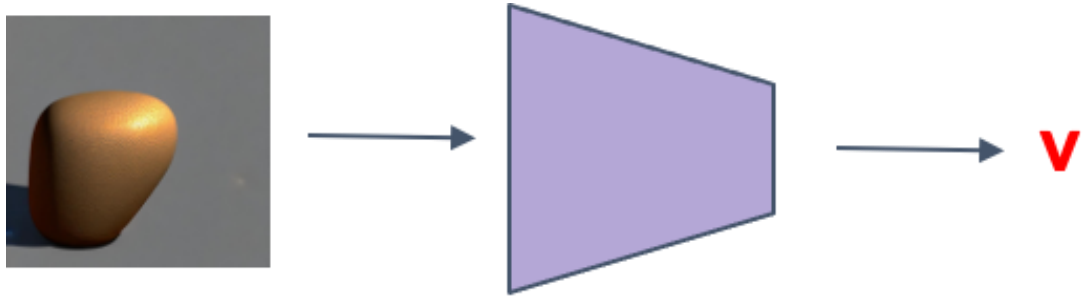

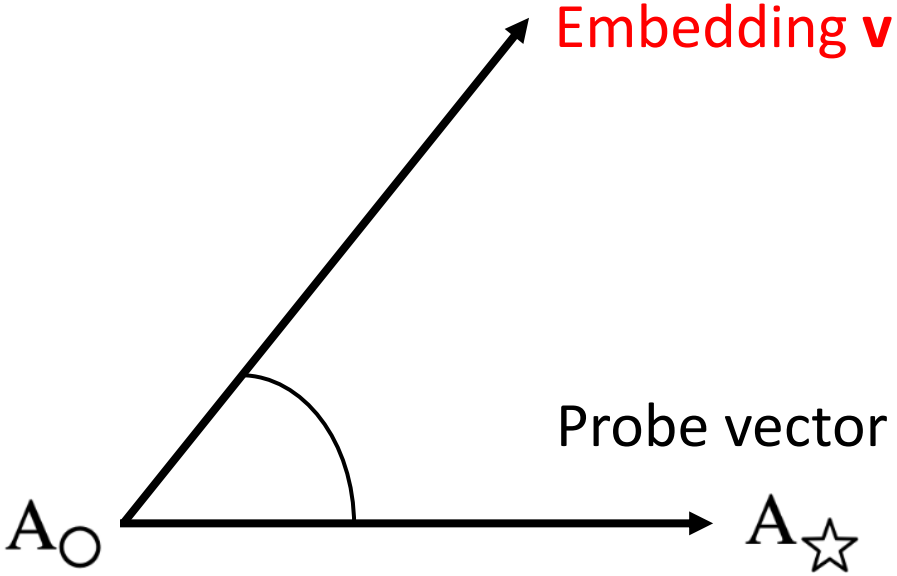

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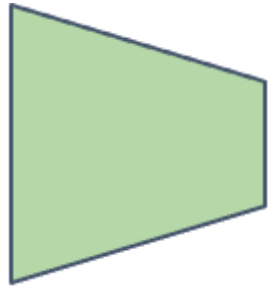
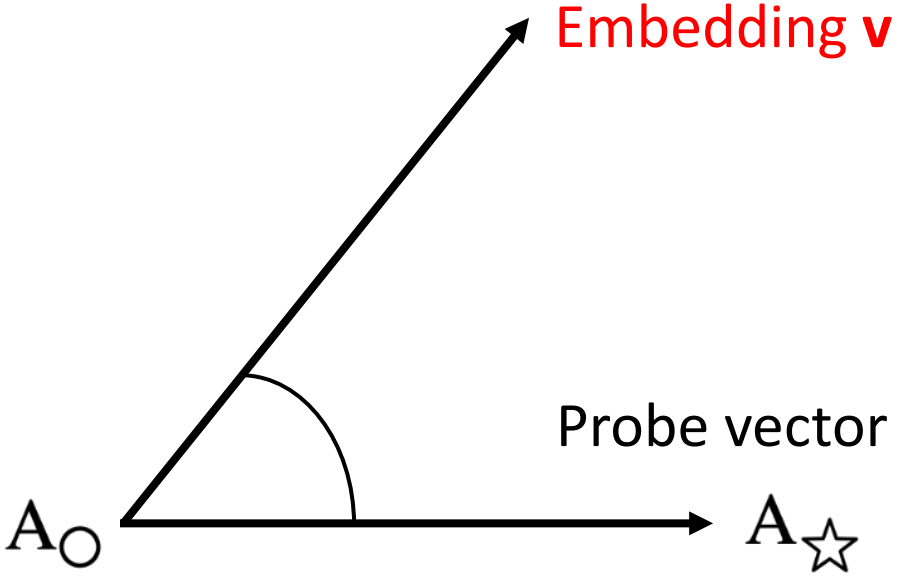
"A 3D rendering of a bouba-shaped object" →  → **v**



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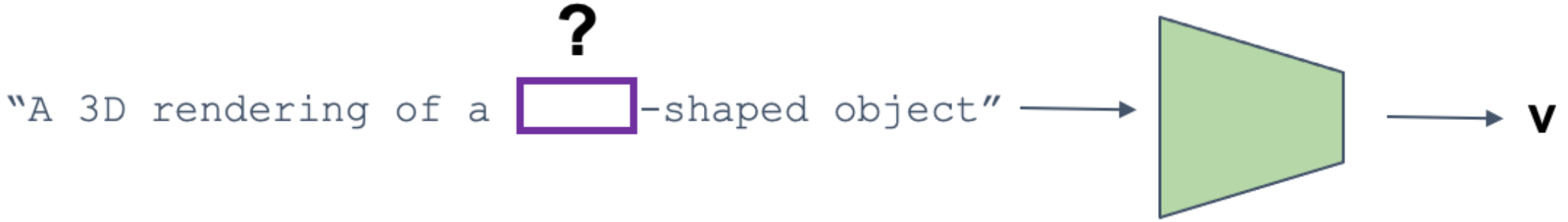
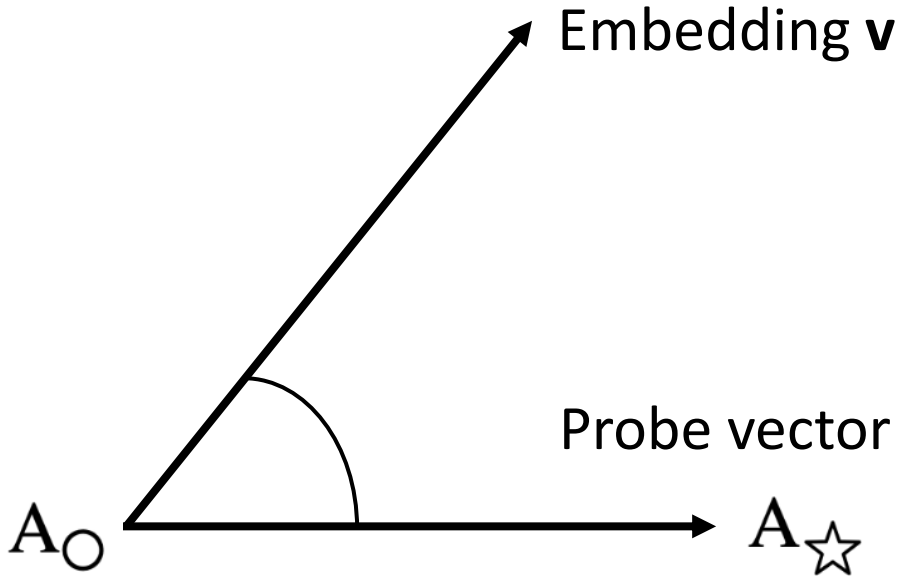
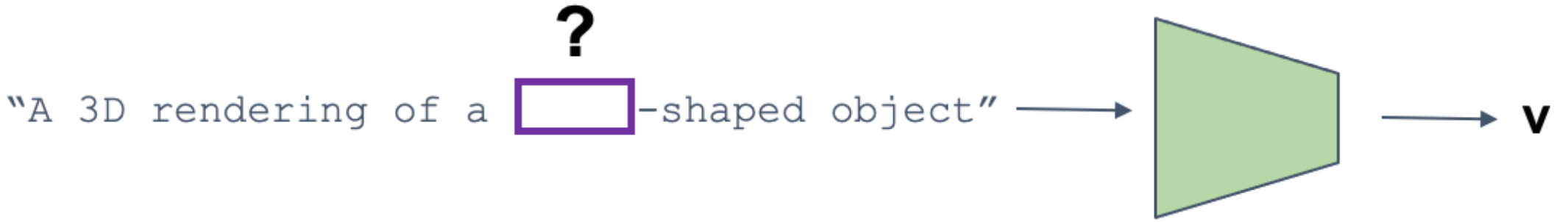
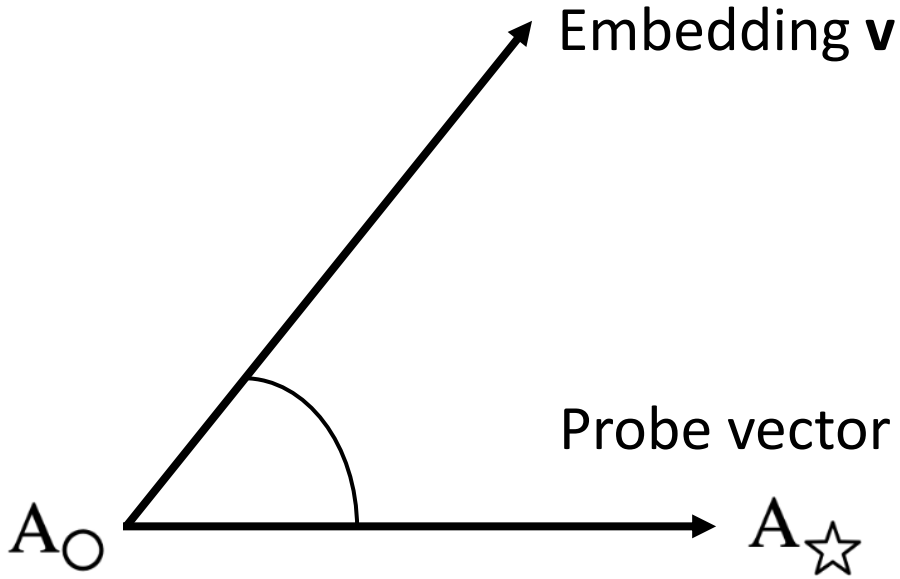

?
"A 3D rendering of a -shaped object"
v


Embedding v
Probe vector
A○
A☆



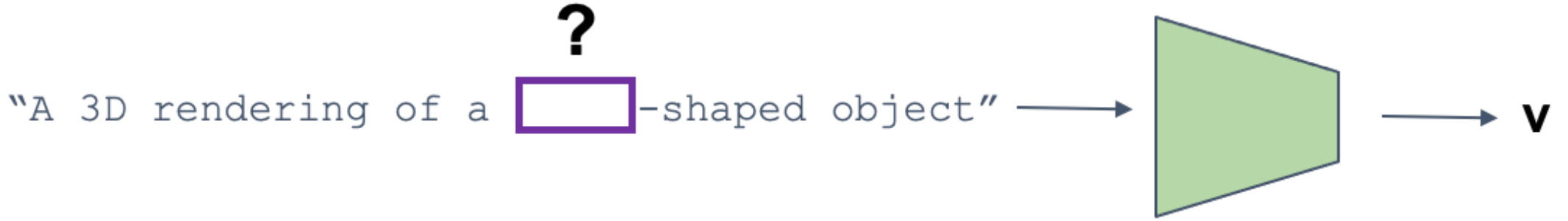


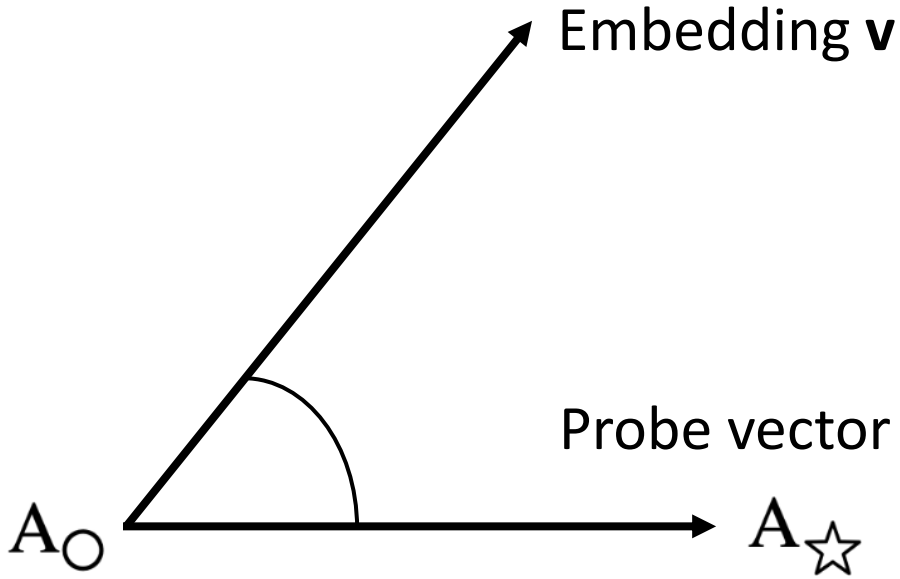
$C_{☆}$: ⟨p t k s h x⟩
$V_{☆}$: ⟨e i⟩

$C_{○}$: ⟨b d g m n l⟩
$V_{○}$: ⟨o u⟩

$V_{\_}$: ⟨a⟩

McCormick et al. (2015)





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$V_{☆}$: ⟨e i⟩

$C_{○}$: ⟨b d g m n l⟩
$V_{○}$: ⟨o u⟩

$V_{\_}$: ⟨a⟩

McCormick et al. (2015)

$\Psi_{☆}$:	*kitaki*	*hatiha*	*pepape*	*xisixi*	*hipehi*	*xaxaxa*	*texete*	...
$\Psi_{○}$:	*gugagu*	*bodubo*	*gunogu*	*daluda*	*momomo*	*lunulu*	*gadaga*	...

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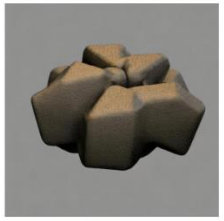
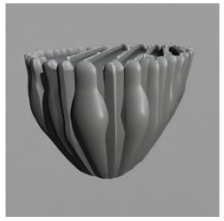
Pseudowords sorted by geometric score

High (☆)


tepite ☆


kataka ☆

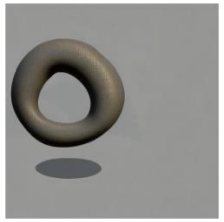

gugugu ○

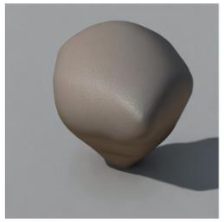

pitapi ☆

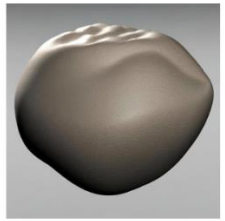

daguda ○


setese ☆

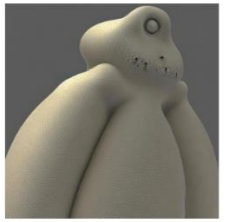
Low (◯)


nubanu ○


gomago ○


magama ○


bomabo ○


mamoma ○


lobalo ○

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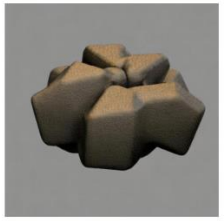
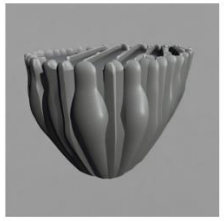
Pseudowords sorted by geometric score

High (☆)



tepite☆

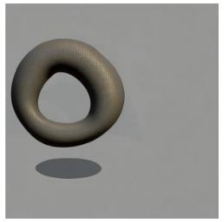
kataka☆



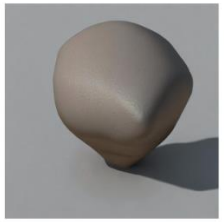
gugugu○

pitapi☆

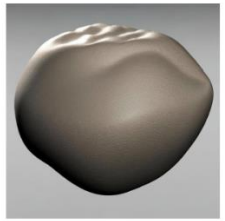
Low (◯)



nubanu○



gomago○



magama○

bomabo○

Model	AUC	τ
Stable Diffusion	0.74	0.34
CLIP	0.77	0.39
(random)	0.50	0.00

Geometric scoring

kitaki

daluda

xaxaxa

$\Psi_{☆}$:	*kitaki*	*hatiha*	*pepape*	*xisixi*	*hipehi*	*xaxaxa*	*texete*	...
$\Psi_{○}$:	*gugagu*	*bodubo*	*gunogu*	*daluda*	*momomo*	*lunulu*	*gadaga*	...

$A_{☆}$ = {*sharp, spiky, angular, jagged, hard, edgy, pointed, prickly, rugged, uneven*}

$A_{○}$ = {*round, circular, soft, fat, chubby, curved, smooth, plush, plump, rotund*}

Geometric scoring

kitaki

daluda

xaxaxa

Phonetic scoring

potato

spike

circular

$\Psi_{\star}$:	*kitaki*	*hatiha*	*pepape*	*xisixi*	*hipehi*	*xaxaxa*	*texete*	...
$\Psi_{\bigcirc}$:	*gugagu*	*bodubo*	*gunogu*	*daluda*	*momomo*	*lunulu*	*gadaga*	...

$A_{\star}$ = {*sharp, spiky, angular, jagged, hard, edgy, pointed, prickly, rugged, uneven*}

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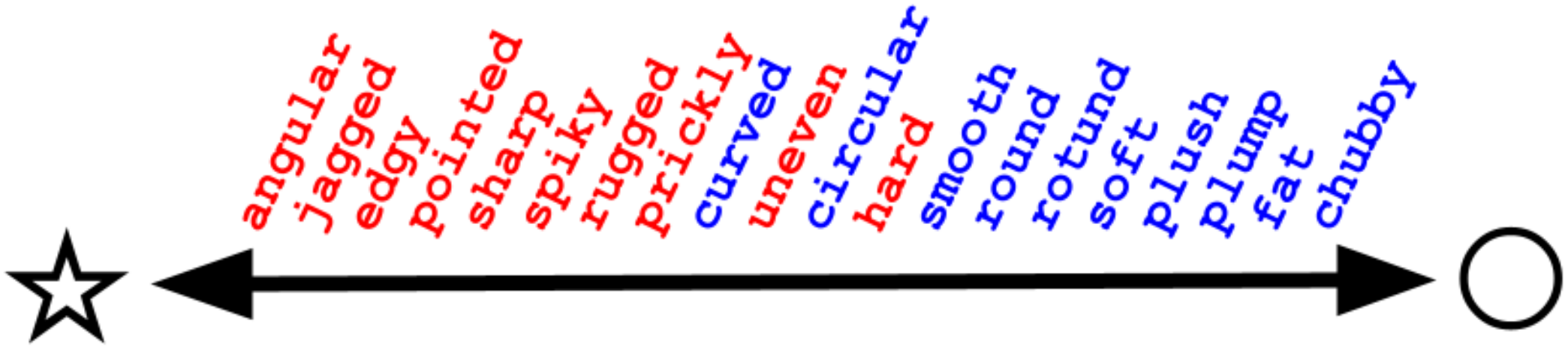
Real English words sorted by phonetic score

	Low (◯)	High (☆)
Stable Diffusion		
Noun	*butterball, yolk, pregnancy, booger, eggnog, turnip, bellyful, crybaby, doughboy*	*shard, kite, origami, hexagon, diamond, flake, octagon, triangle, protractor, lozenge, foldout*
Adj.	*obese, chubby, stinky, pudgy, overweight, fat, pregnant, plump, drowsy, soggy, squishy*	*triangular, diagonal, angular, shattering, jagged, rectangular, edgy, housebroken, geometrical*
CLIP		
Noun	*doughboy, loudmouth, gumdrop, boogeyman, madwoman, lord, butterball, goddaughter*	*prefix, talkativeness, asker, flexibility, shears, shift, peek, slope, task, exit, hemline, tightness*
Adj.	*muggy, soggy, gloomy, grouchy, lumpy humongous, hungry, cloudless, unsmiling*	*apelike, flexible, diagonal, static, triangular, external, shipshape, interlocking, angular*

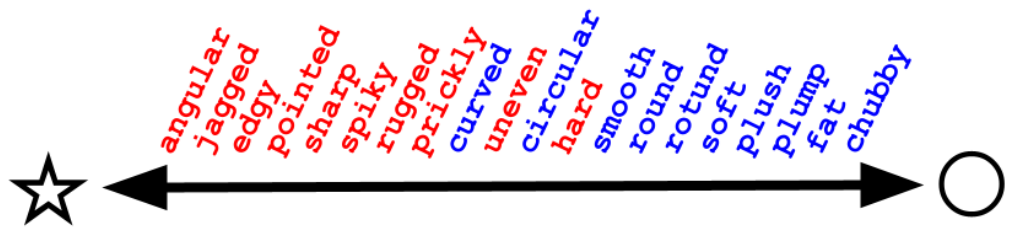
GT adjectives sorted by phonetic score

Stable Diffusion

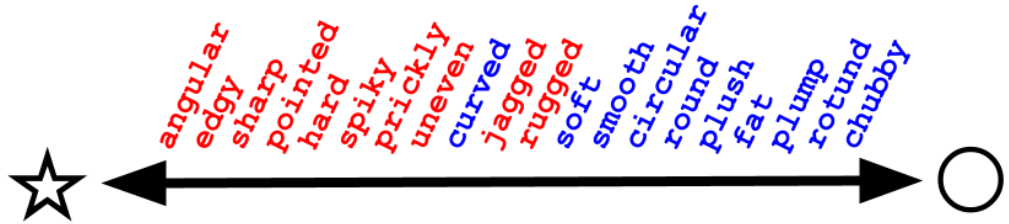


GT adjectives sorted by phonetic score

Stable Diffusion

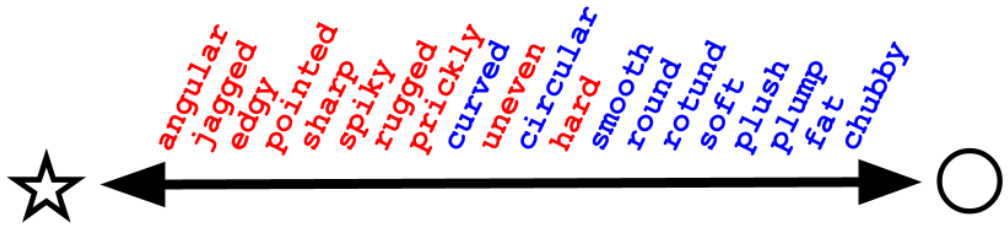


CLIP



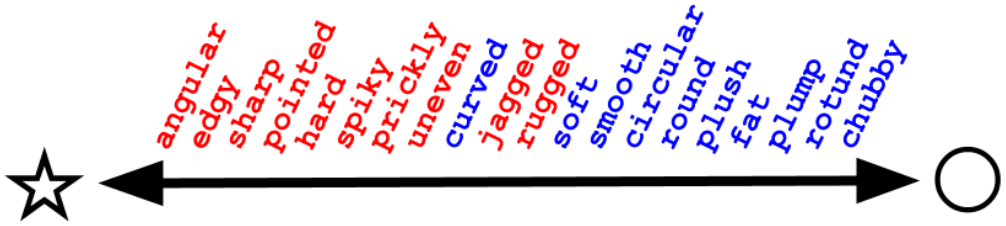
GT adjectives sorted by phonetic score

Stable Diffusion



Model	AUC	τ
Stable Diffusion	0.97	0.68
CLIP	0.98	0.70
(random)	0.50	0.00

CLIP



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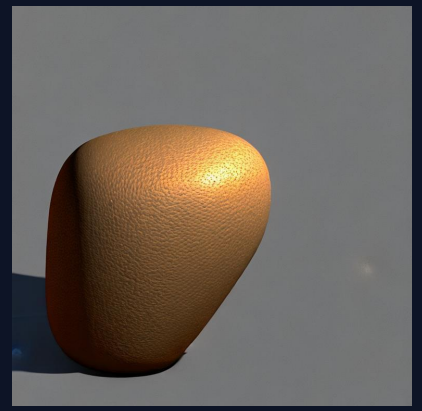
Conclusion

We show that VLMs have learned sound symbolism, providing:

- **Insight and interpretability** for black-box models
- **A new computational tool** for studying sound symbolism in language



Questions?