'LIGHTER' CAN STILL BE DARK: MODELING COMPARATIVE COLOR TERMS

OLIVIA WINN, SMARANDA MURESAN
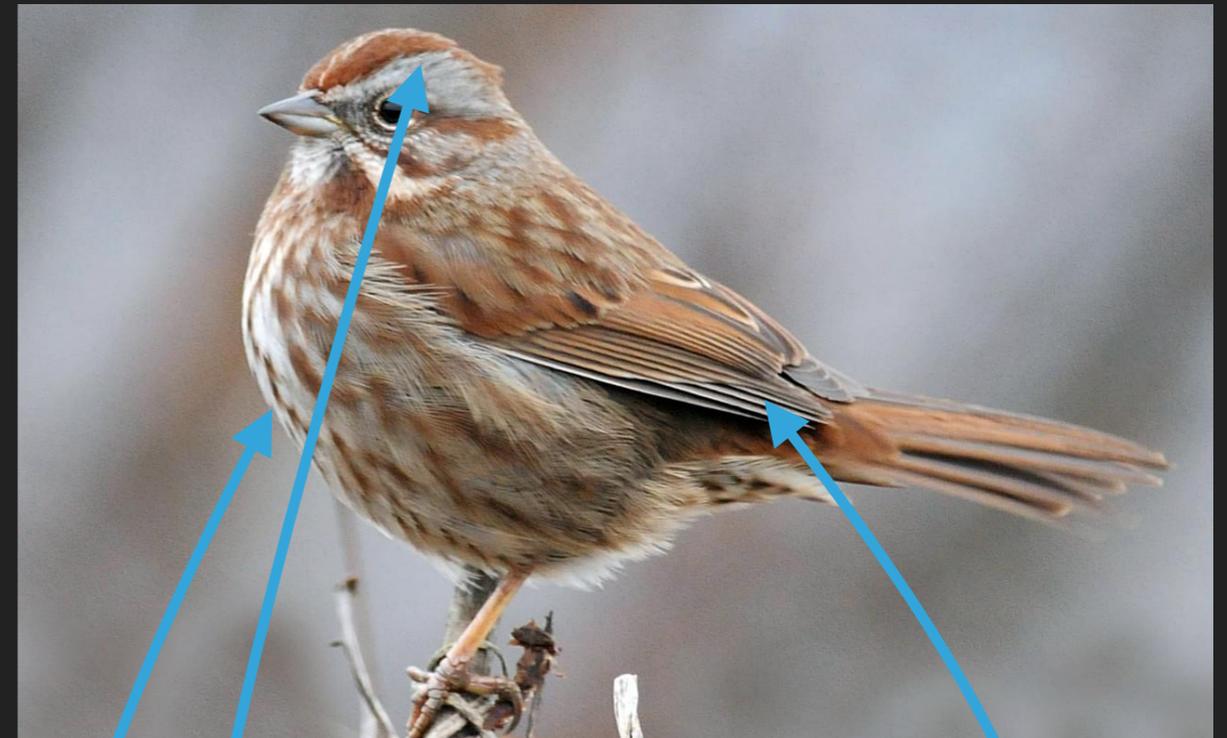
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ATTRIBUTE–BASED OBJECT RECOGNITION

WHITE STRIPES ON WINGS

BLACK CROWN

PALE TAN BELLY

WHITE STRIPES ON WINGS

BROWN CROWN

STRIPED BELLY

Image Credit: allaboutbirds.org, txtbba.tamu.edu

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ATTRIBUTE–BASED OBJECT RECOGNITION

Chickadee   **Sparrow**

WHITE STRIPES ON WINGS	=	WHITE STRIPES ON WINGS
BLACK CROWN	≠	BROWN CROWN
PALE TAN BELLY	≠	STRIPED BELLY

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FINE-GRAINED OBJECT RECOGNITION

Black-Capped Chickadee

Carolina Chickadee

WHITE STRIPES ON WINGS	=	WHITE STRIPES ON WINGS
BLACK CROWN	=	BLACK CROWN
PALE TAN BELLY	=	PALE TAN BELLY
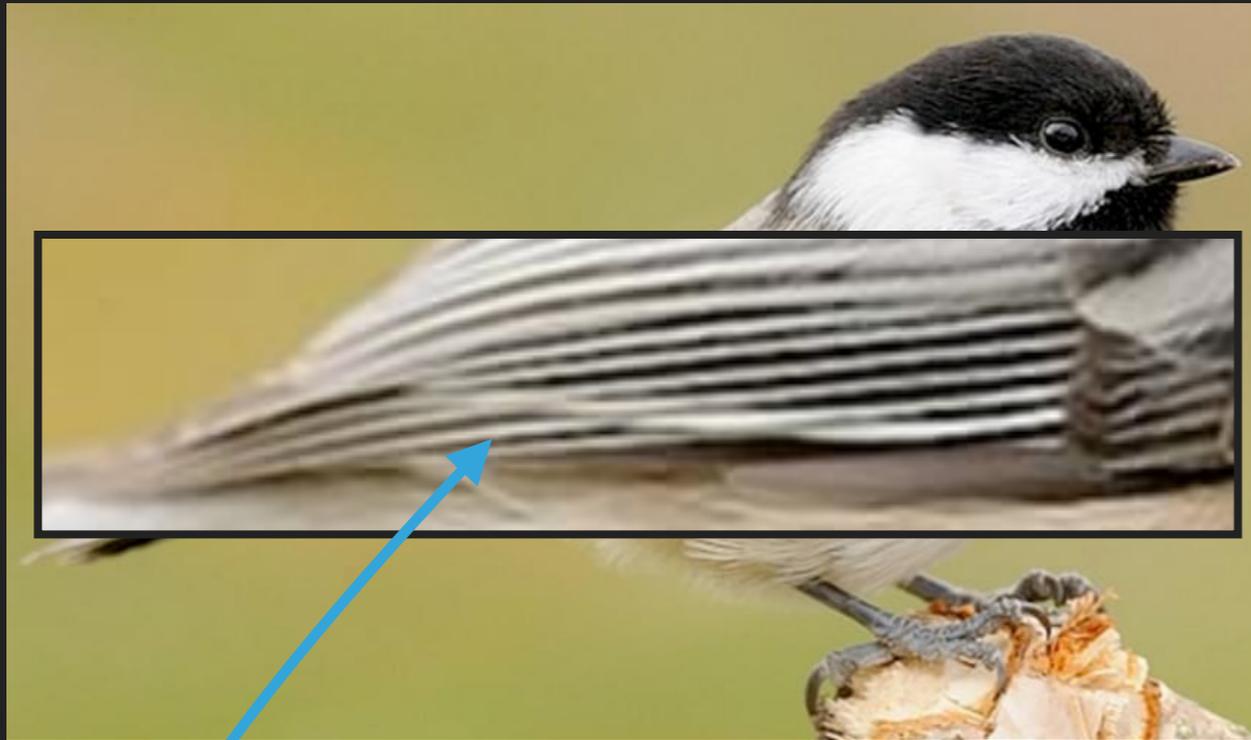
Image Credit: allaboutbirds.org, txtbba.tamu.edu

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FINE-GRAINED OBJECT RECOGNITION

Black-Capped Chickadee

Carolina Chickadee

"MORE WHITE EDGING ON WINGS"

Image Credit: allaboutbirds.org, txtbba.tamu.edu

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FINE-GRAINED OBJECT RECOGNITION

Black-Capped Chickadee

Carolina Chickadee

"MORE WHITE EDGING ON WINGS"

"LESS ORANGISH ON SIDES"

Image Credit: allaboutbirds.org, txtbba.tamu.edu

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FINE-GRAINED OBJECT RECOGNITION
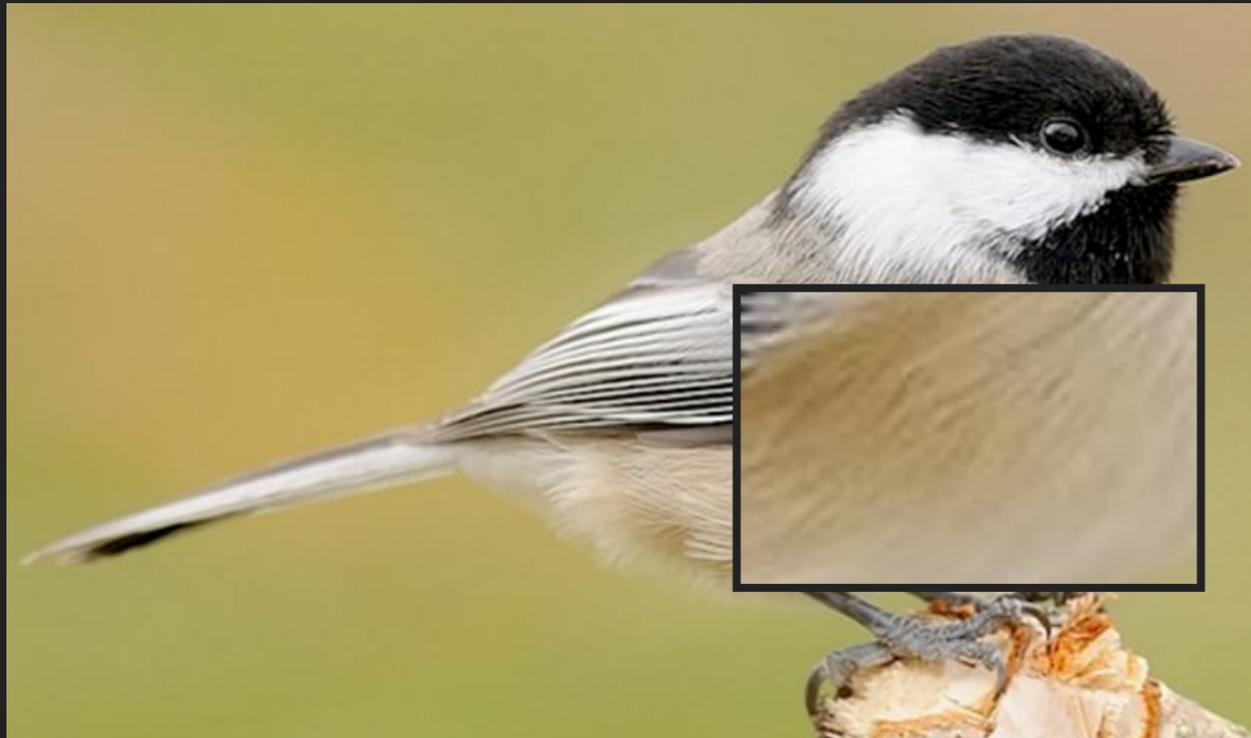
Black-Capped Chickadee

"**MORE WHITE** EDGING ON WINGS"

WHITE STRIPES ON WINGS
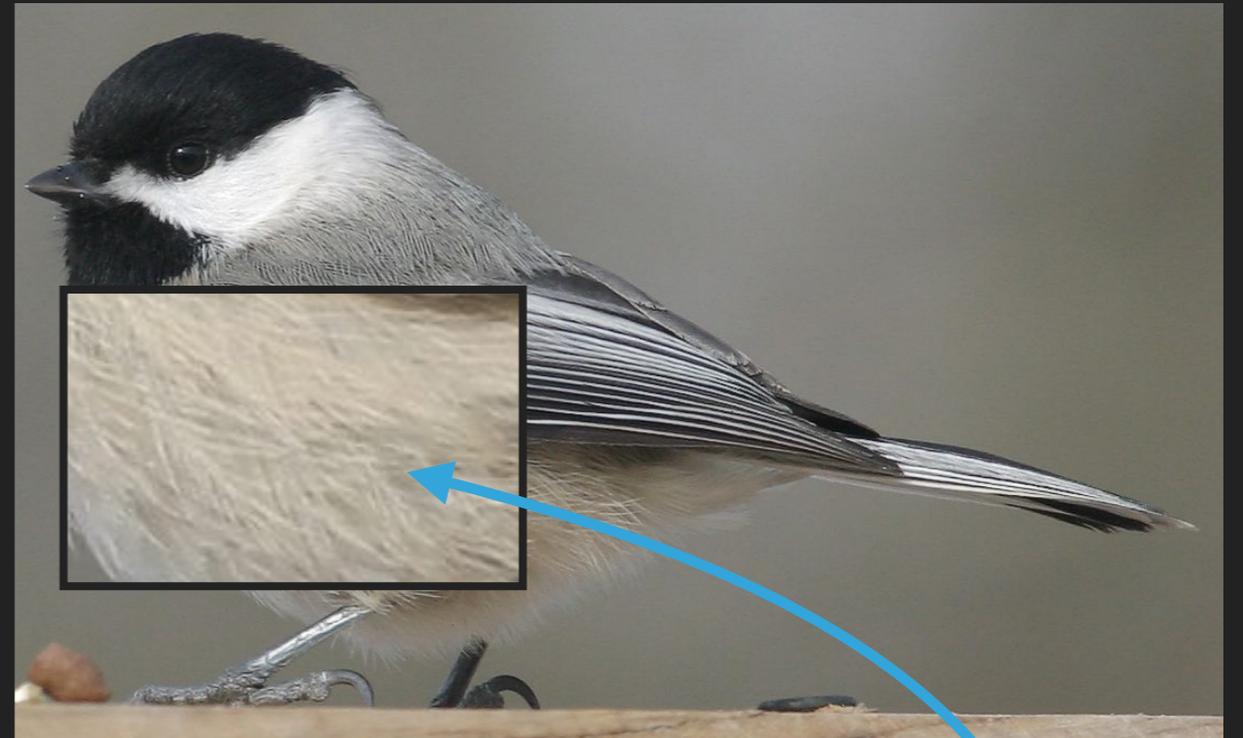
Carolina Chickadee

"**LESS ORANGISH** ON SIDES"

PALE TAN BELLY

Image Credit: allaboutbirds.org, txtbba.tamu.edu

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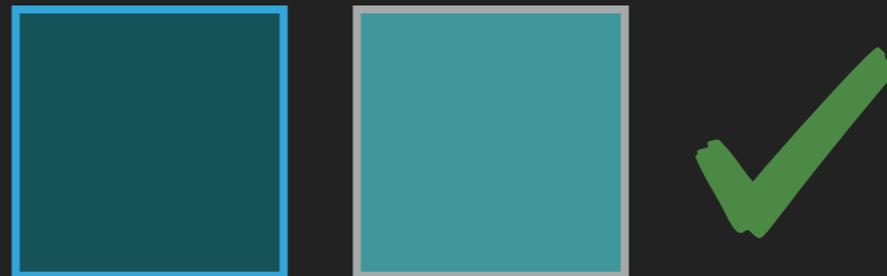IN THE CITY OF NEW YORK

ATTRIBUTES VS. COMPARATIVES

▸ Attribute: **set** of feature values in isolation

"**Dark teal**"

▸ Comparative: **strength** of feature *with respect to* a reference

"**Darker teal**"

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ATTRIBUTES VS. COMPARATIVES

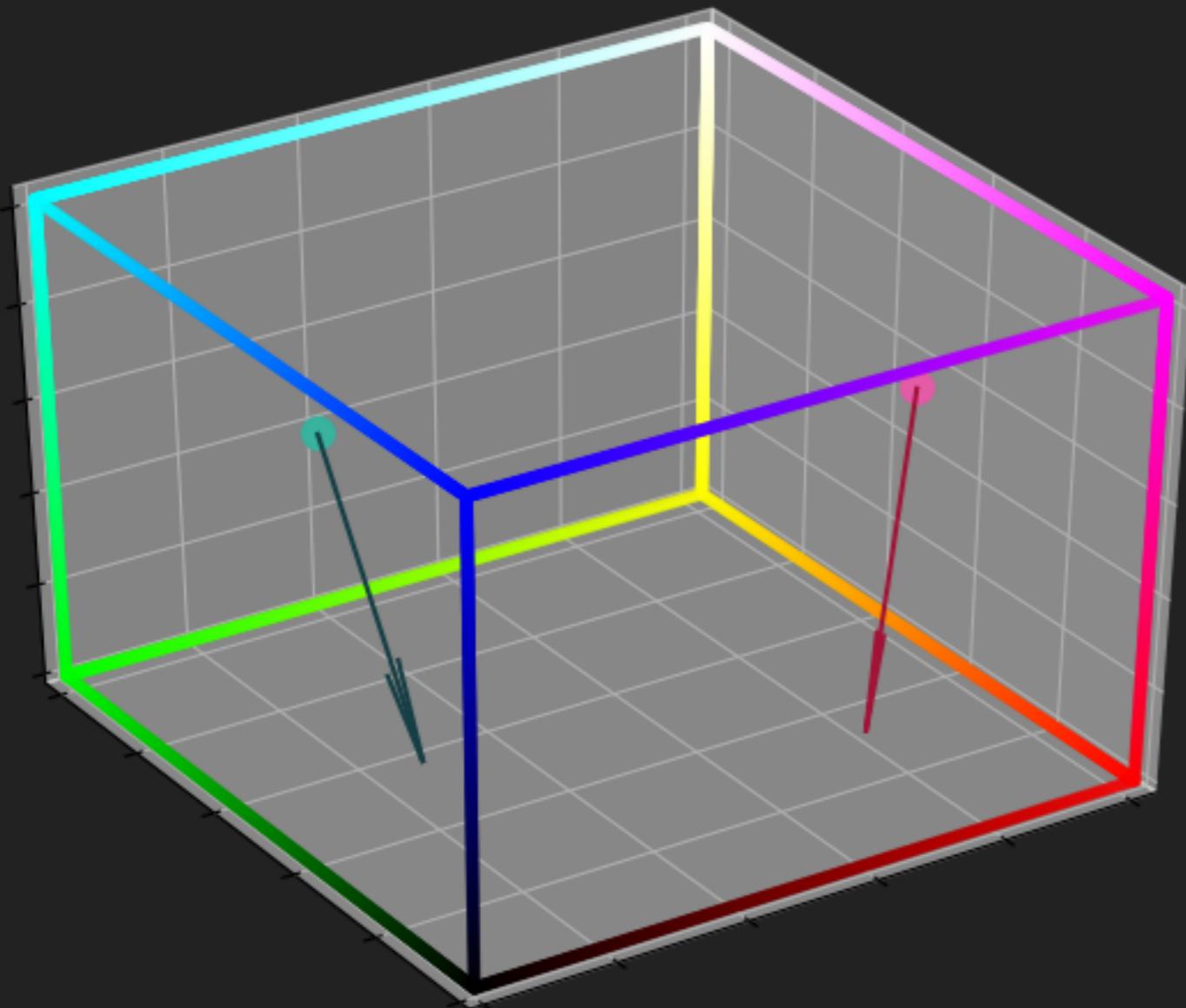▸ Attribute: **set** of feature values in isolation

"**Dark teal**"

▸ Comparative: **strength** of feature *with respect to* a reference
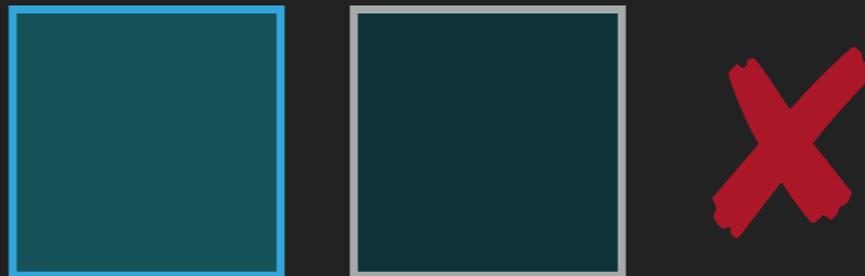
"**Darker teal**"

▸ Comparatives frequently used to distinguish similar colors
[Monroe et al 2017]
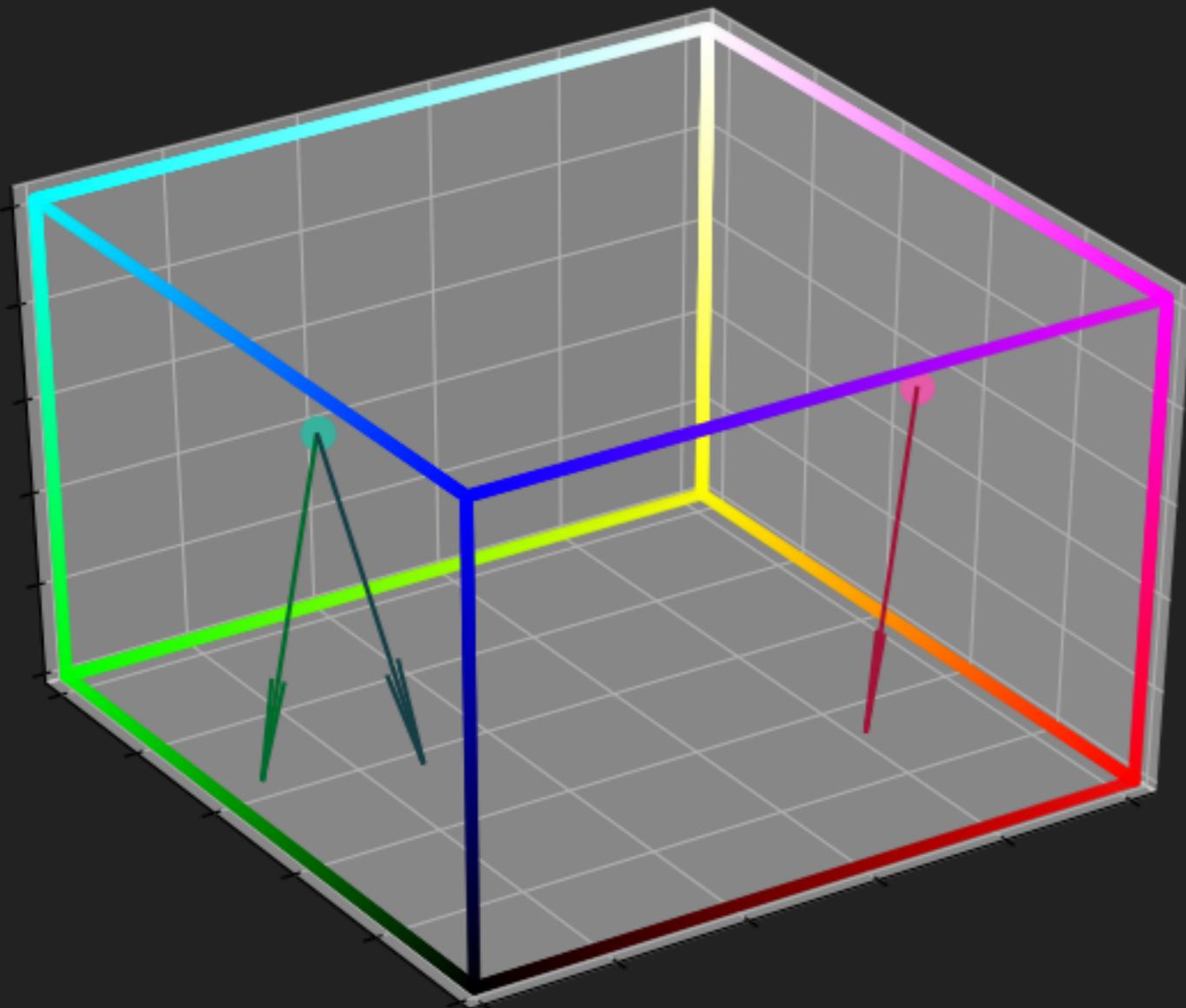
REFERENCE–BASED COMPARISONS

DARKER [TEAL]

DARKER [PINK]

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REFERENCE–BASED COMPARISONS

DARKER [TEAL]

DARKER [PINK]

DARKER [FOR PINK]

GOAL

Ground comparative adjectives as **directions** in colorspace, **dependent on the reference color**, such that colors along the vector, when rooted at the reference color, satisfy the comparative

RELATED WORK

▸ Contextual color descriptions

   [McMahan and Stone 2015, Monroe et al 2017]

▸ Image ranking

   [Parikh and Grauman 2011, Yu and Grauman 2014]

▸ Comparisons of set sizes

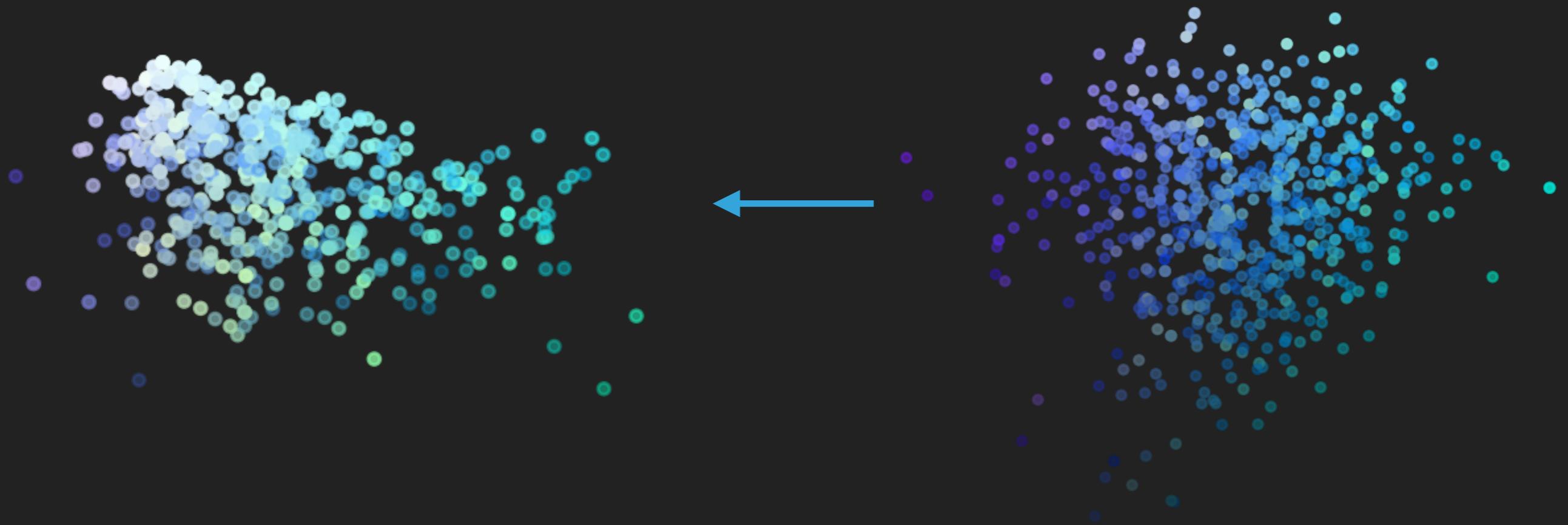   *[Pezzelle et al 2018]*

▸ Size ranking via knowledge graph

   [Bagherinezhad et al 2016]
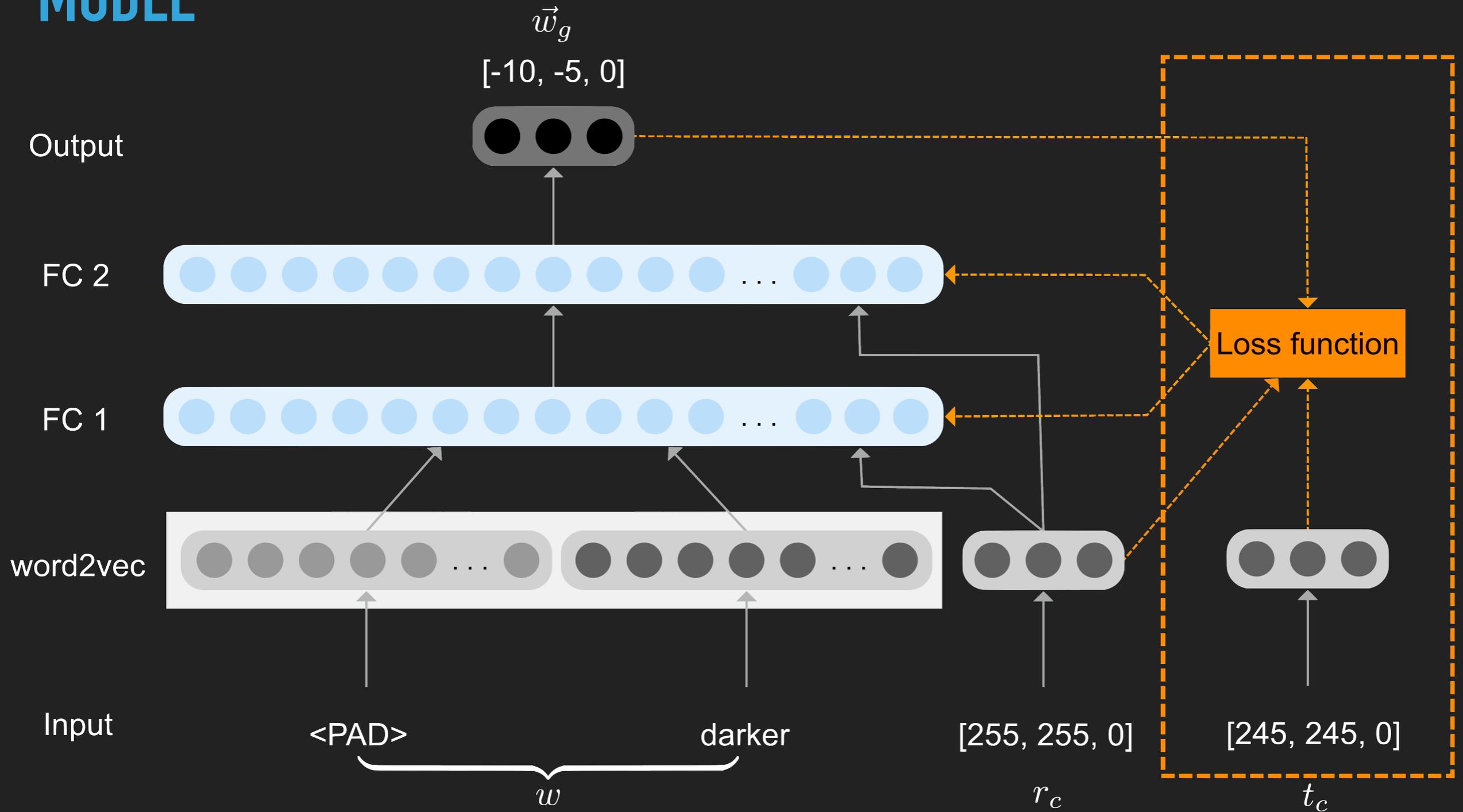
DATA

LIGHT BLUE **LIGHTER** **BLUE**
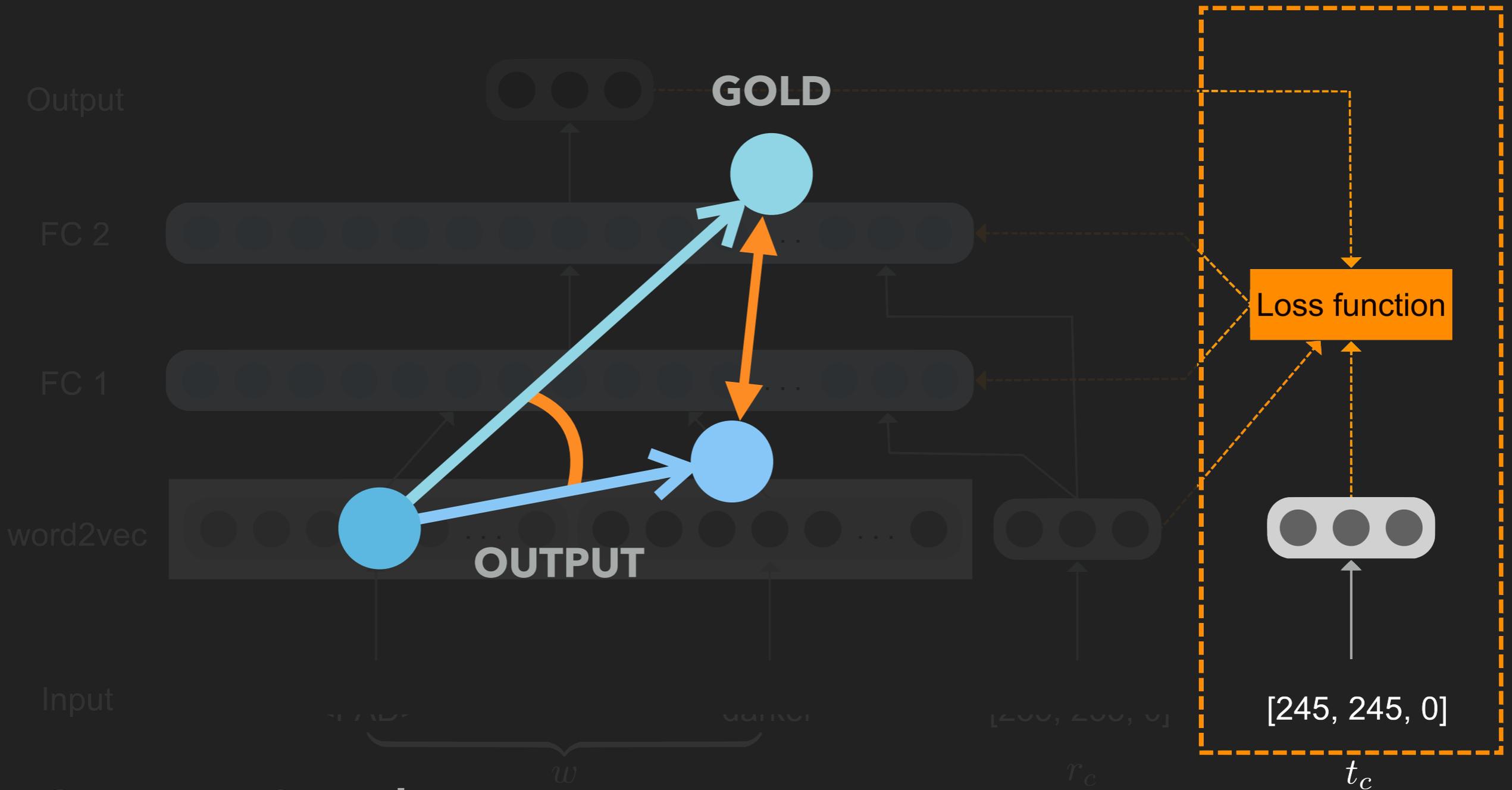
415 comparative tuples

79 unique reference labels   81 unique comparatives

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MODEL

$\vec{w}_g$

[-10, -5, 0]

Output

FC 2

FC 1

word2vec

Input

<PAD>   darker

w

[255, 255, 0]   [245, 245, 0]

r_c t_c

Loss function

comparative adj: 300 dim. word2vec

reference color: 3D RGB datapoint

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MODEL

GOLD

OUTPUT

Output

FC 2

FC 1

word2vec

Input

Loss function

[245, 245, 0]

t_c

w

r_c

Cosine Similarity

Distance

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EVALUATION METRICS

1. Cosine Similarity

2. Distance

Delta-E	Perception
≤ 1.0	Imperceptible
1 - 2	Requires close observation
2 - 10	Percievable
11 - 49	More similar than opposite
100	Exact opposites

RGB Dist: 15
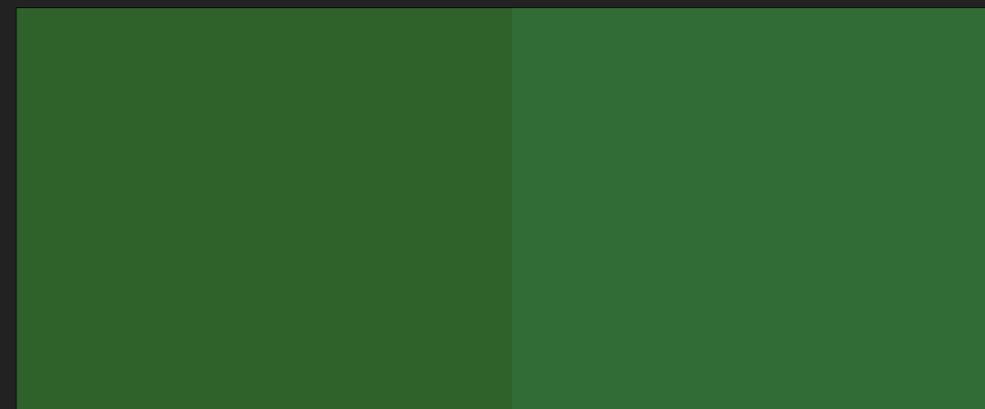
Delta-E: 6

RGB Dist: 15

Delta-E: 45

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EXPERIMENTAL SETUP

Data	# Tuples	# Dtpts
Training	271	15.3M
Test (Seen Pairings)	271	2.4M
Test (Unseen Pairings)	29	0.29M
Test (Unseen Ref.)	63	2.4M
Test (Unseen Comparative)	41	0.38M
Test (Fully Unseen)	11	58k

"Seen" Reference

BLUE

Training

Testing
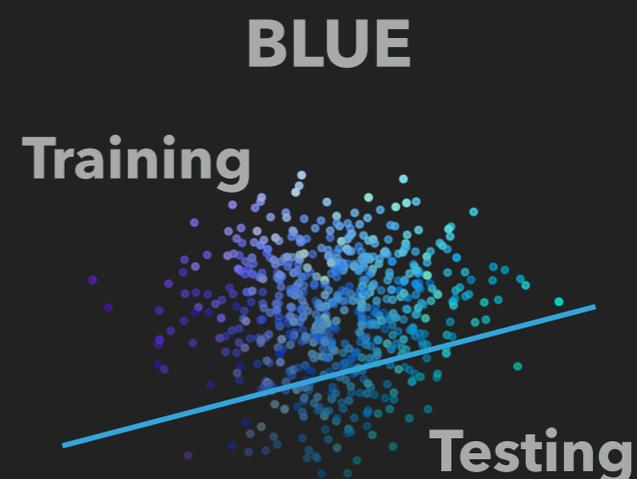
RESULTS

Test Condition	Avg Cos	Avg Delta-E
Test (Seen Pairings)	0.68	6.1
Test (Unseen Pairings)	0.68	7.9
Test (Unseen Ref.)	0.40	11.4
Test (Unseen Comparison)	0.41	10.5
Test (Fully Unseen)	-0.21	15.9
Overall	**0.65**	**6.8**

Avg Cos: 50% above 0.80; 30% above 0.90

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RESULTS

TEST TYPE	REF	COMPARATIVE	GOLD	COS SIM	DELTA-E
Seen in training		darker		0.97	0.9
		more greenish		-0.76	20.0
Unseen pairing		lighter		0.94	4.2
		darker		0.77	12.3
Unseen reference		lighter		0.93	2.7
		bluer		-0.93	17.4
Unseen comparative		more neon		0.96	1.3
		more neon		-0.14	26.1
Unseen reference & unseen comparative		paler		0.99	3.5
		rustier		-0.73	18
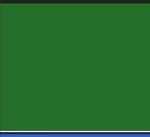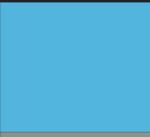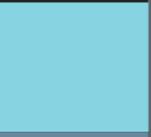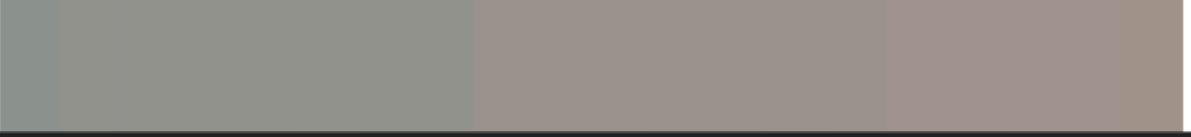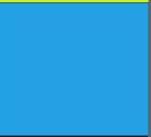
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REF	COMPARATIVE	GOLD

greener —>

yellower —>

lighter —>

darker —>

COMPARING COLORS

REFERENCE

paler

pastel

powder

tanner

lighter

TARGET

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CONCLUSION

▶ New paradigm for grounding comparatives in colorspace

▶ New dataset of comparative colors

▶ Average cosine similarity: **0.65**, with **50% above 0.80**

▶ Model provides plausible comparative descriptions

FUTURE WORK

▶ Apply to fine-grained object recognition

▶ Expand to other attribute domains

THANK YOU!

QUESTIONS?

Dataset available at: https://bitbucket.com/o_winn/comparative_colors

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