Novel method to modify avian-habitat perception using LED illumination: a proof-of-concept study

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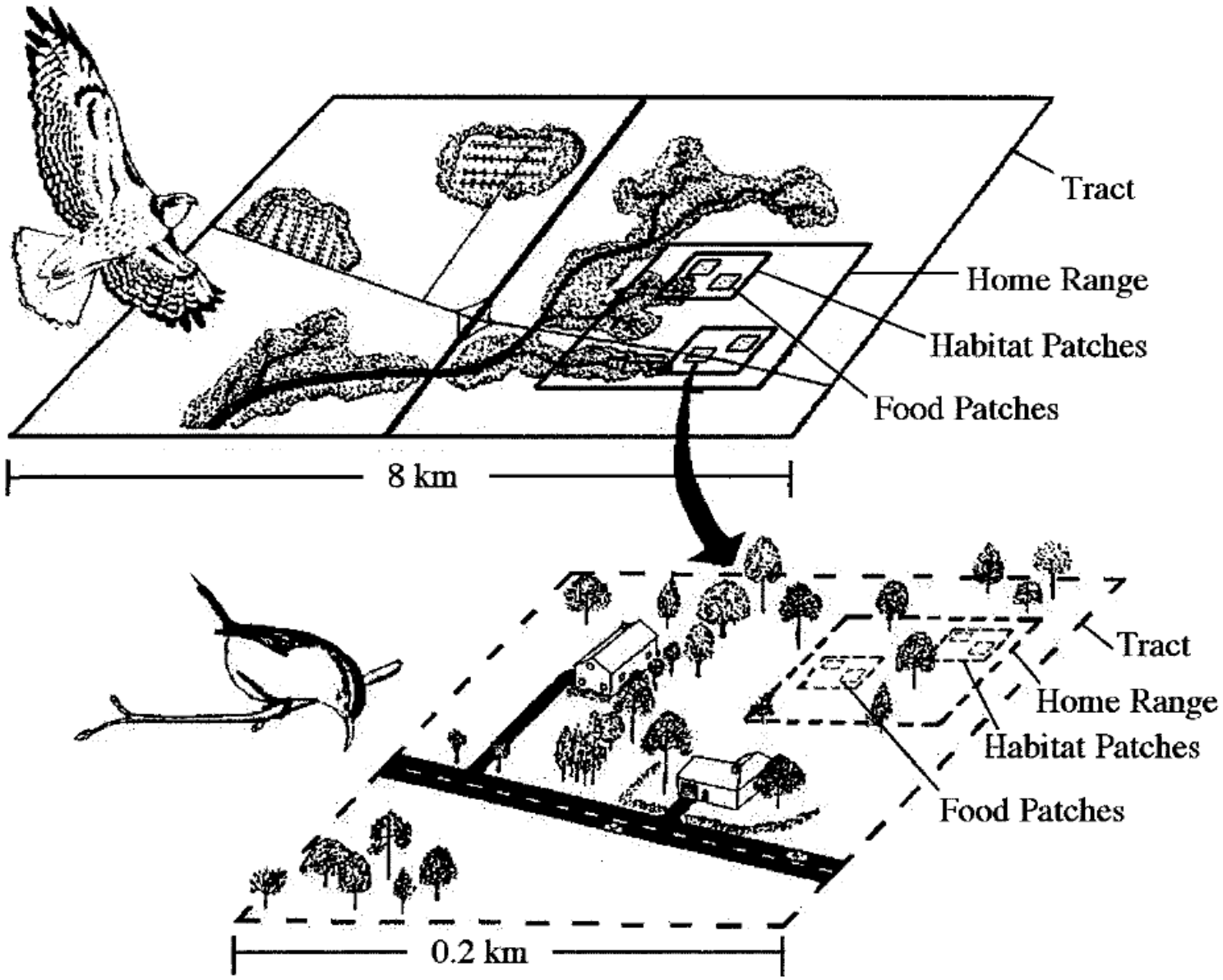
ATL

BKL/KBKL

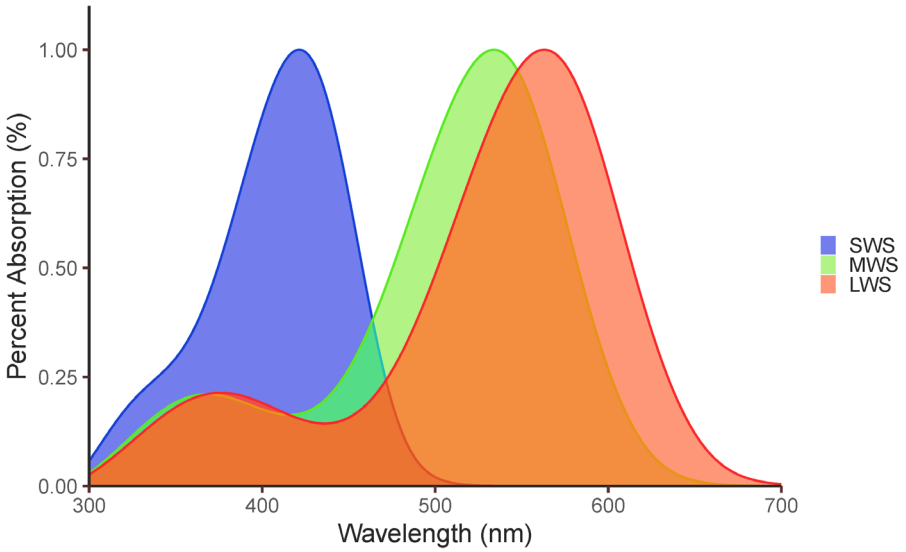
Scale-dependent Decisions of a Red-tailed Hawk and a Carolina Wren



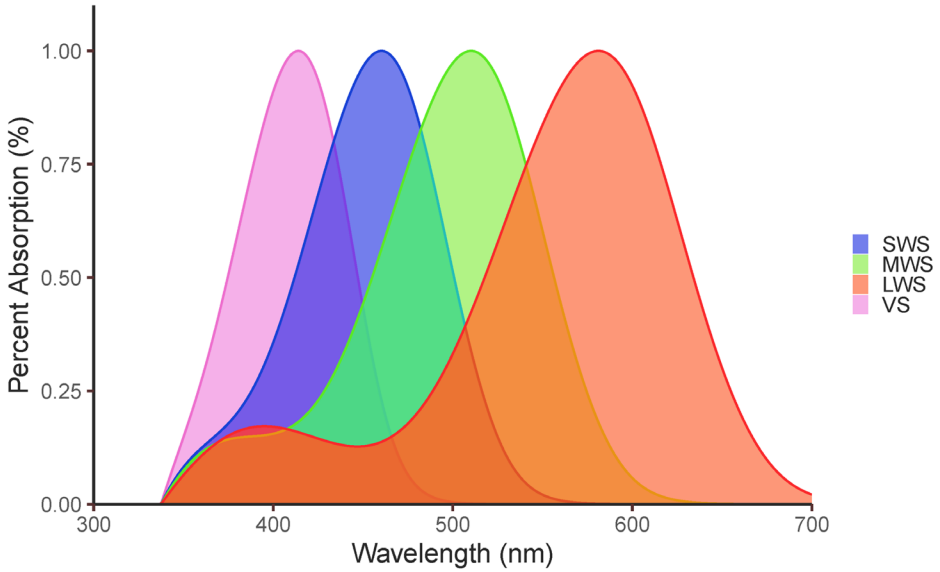
Hostetler & Holling 2001

Avian vision is different from human vision

Human Vision

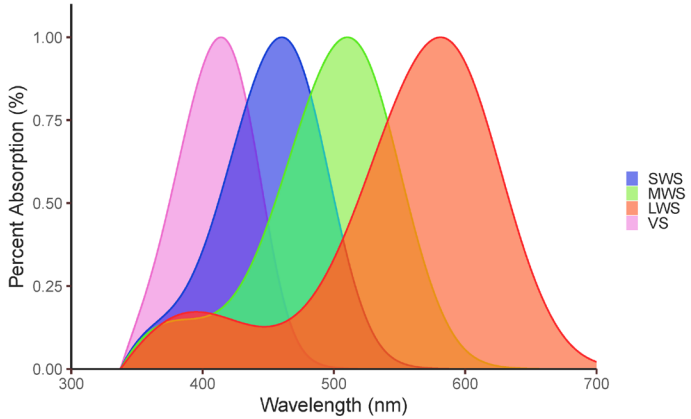


Bird Vision



More cone types

More colors perceived

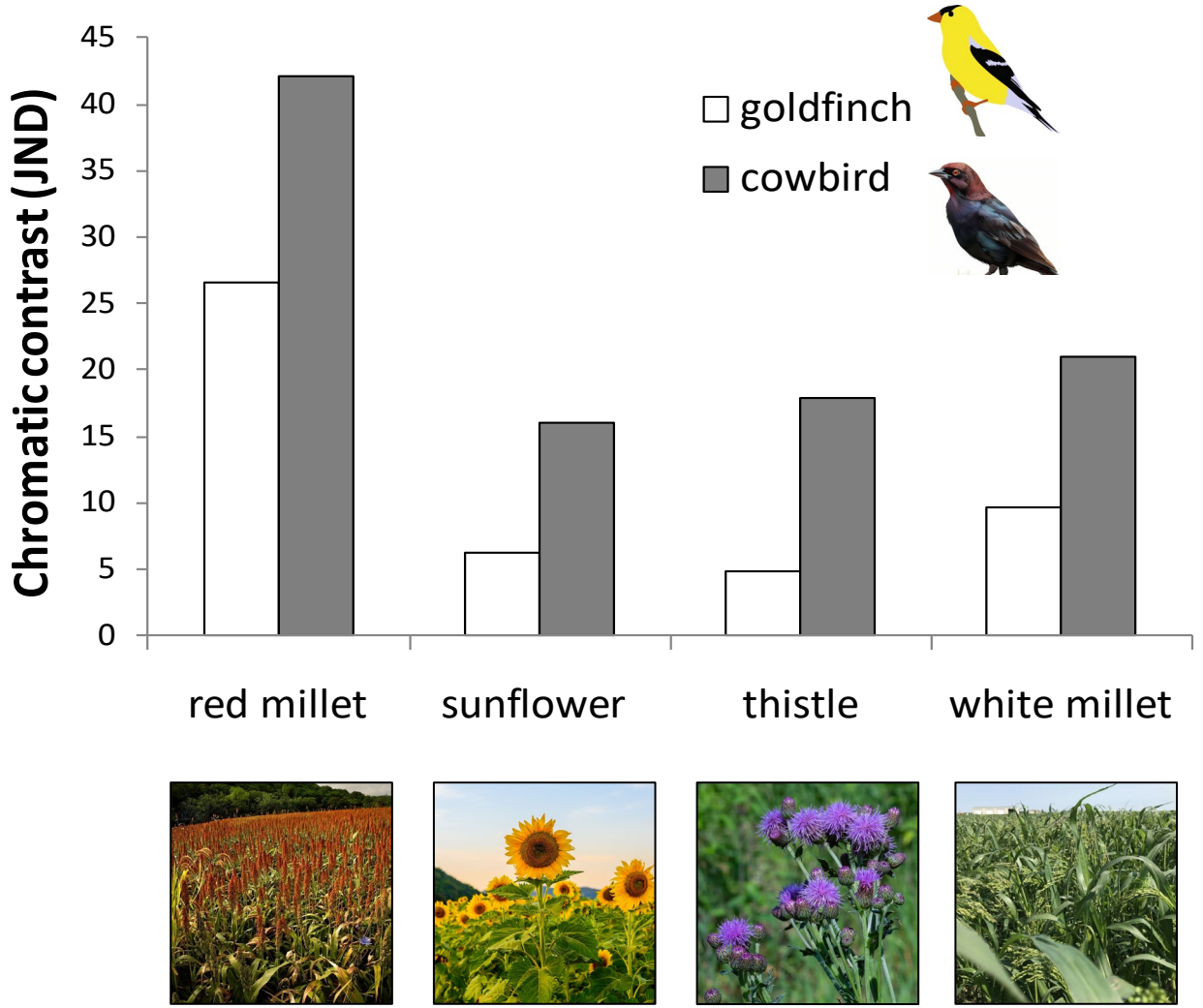


Having four types of cones increases the visual contrast of the vegetation

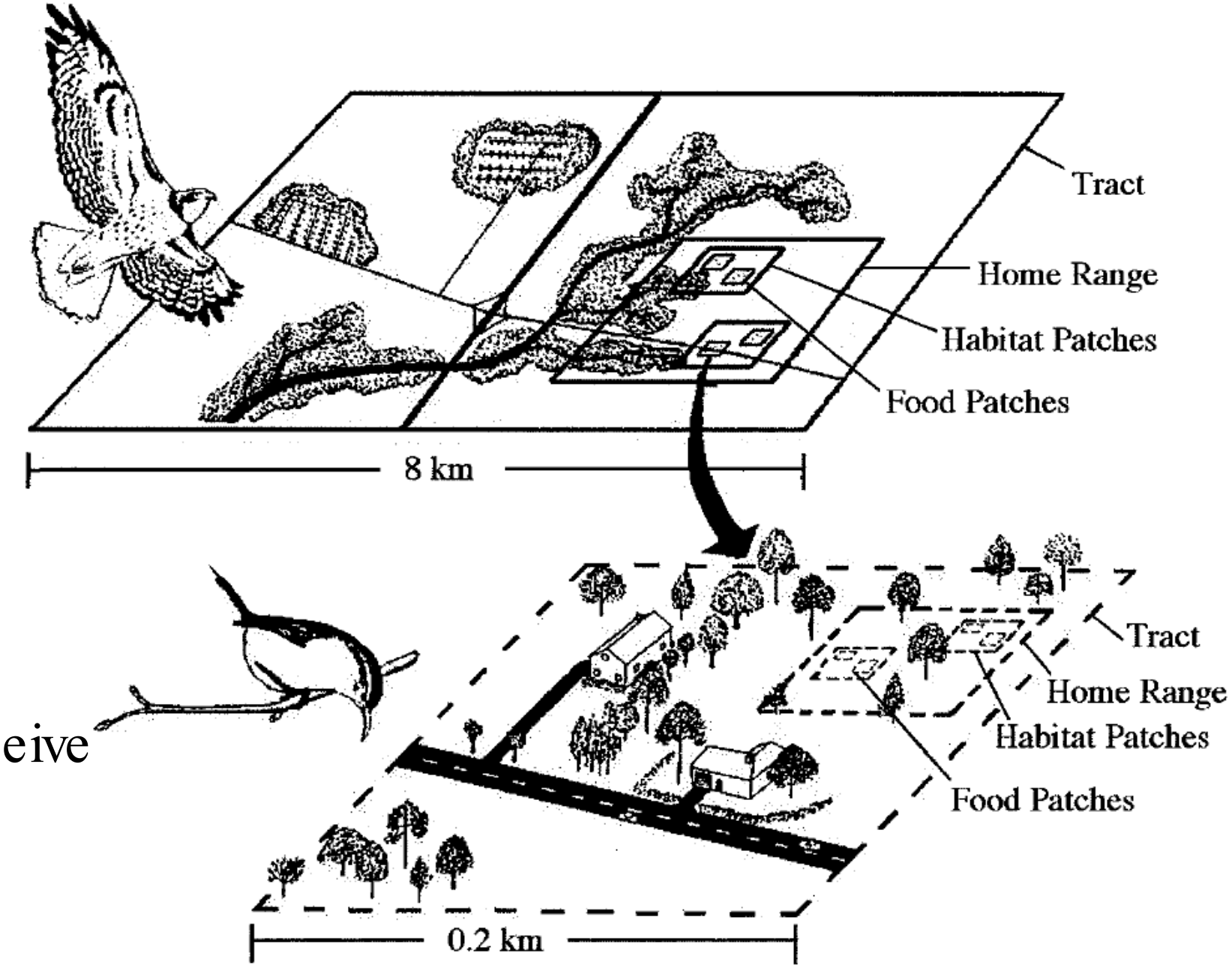
Generating a unique visual signature

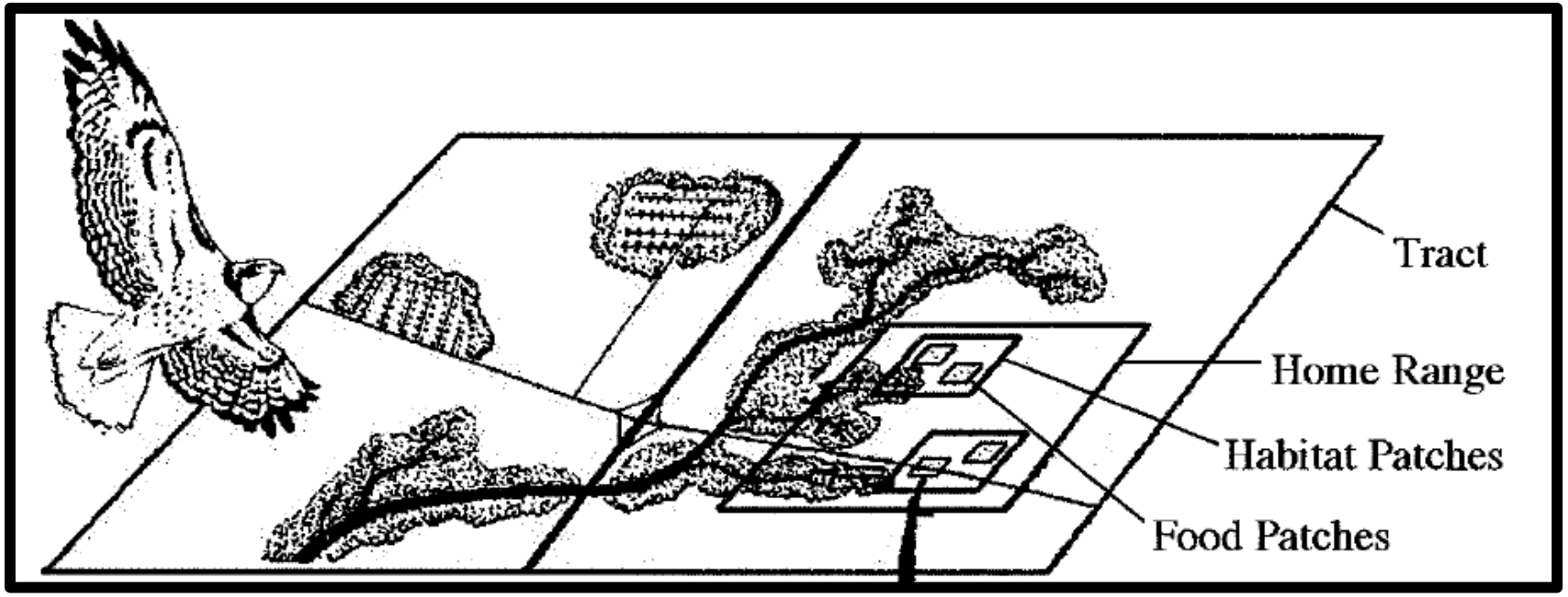
Tedore & Nilsson 2019

There is considerable between-species variation in visual physiology and visual perception



Different bird species perceive slightly different visual signatures on landscape elements





Can we shift the visual signature of a landscape element from the visual perspective of a bird species?

To what extend can this shift influence the species' behavior?

Brain Behav Evol. 2011;77(3):147-58. doi: 10.1159/000326053. Epub 2011 May 6.

Testing the terrain hypothesis: Canada geese see their world laterally and obliquely

Esteban Fernández-Juricic [1], Bret A Moore, Megan Doppler, Joseph Freeman, Bradley F Blackwell, Steven L Lima, Travis L DeVault

The Journal of Experimental Biology 215, 3442-3452
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RESEARCH ARTICLE

Oblique color vision in an open-habitat bird: spectral sensitivity, photoreceptor distribution and behavioral implications

Bret A. Moore[1,*], Patrice Baumhardt[1,*], Megan Doppler[1], Jacquelyn Randolet[1], Bradley F. Blackwell[2], Travis L. DeVault[2], Ellis R. Loew[3] and Esteban Fernández-Juricic[1,†]

PeerJ

Light wavelength and pulsing frequency affect avoidance responses of Canada geese

Ryan Lunn[1], Patrice E. Baumhardt[1], Bradley F. Blackwell[2], Jean Paul Freyssinier[3] and Esteban Fernández-Juricic[1]

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Research

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https://doi.org/10.1098/rsos.250047

Light tuned to the avian eye elicits early detection and escape from an approaching aircraft

Ryan Bradley Lunn[1], Bradley Blackwell[2], Patrice Baumhardt[1], Anne Talbot[1], Isaac Di Domenico[1] and Esteban Fernández-Juricic[1]

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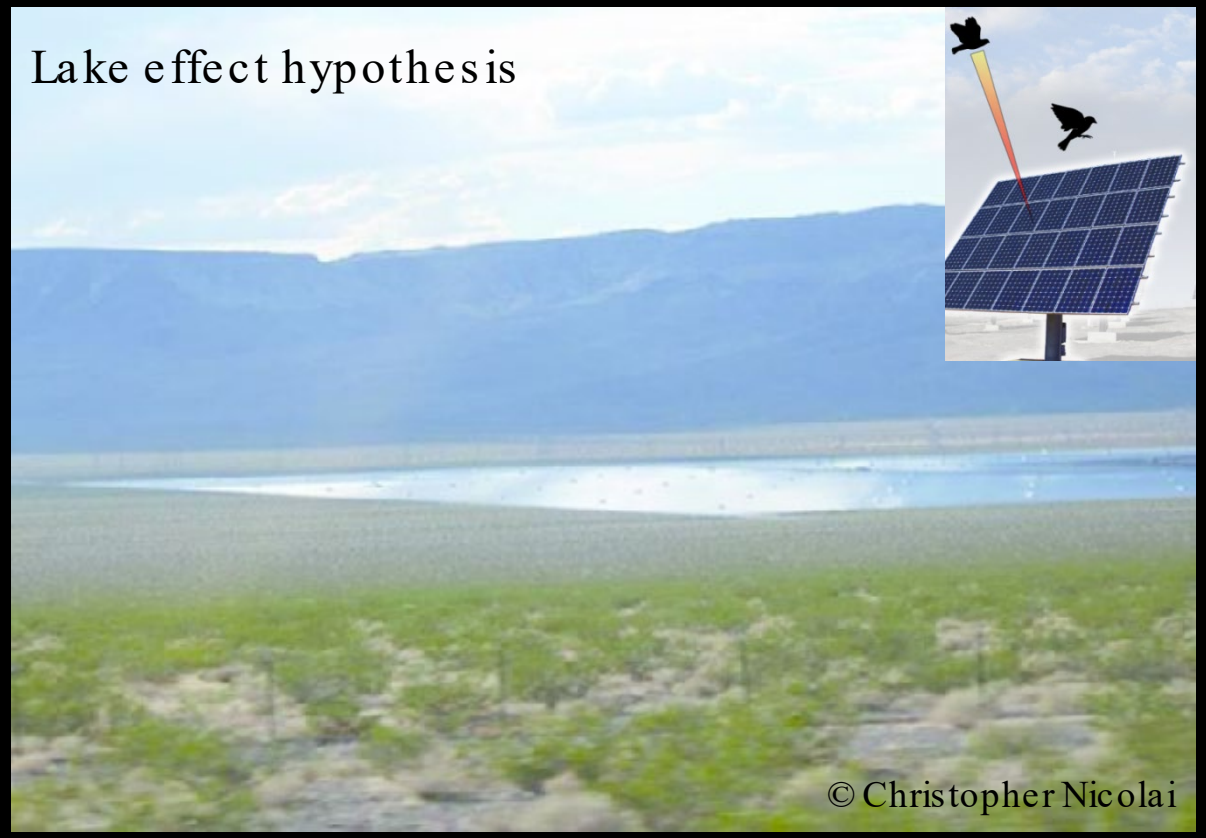
RBL, 0000-0001-9998-3200

LED lights illuminating an area could alter the visual signature of a landscape element to either increase or decrease its visual conspicuousness to the avian eye, prompting a change in behavior

Proof-of-concept study: bird-solar interactions

Funded by the US Air Force

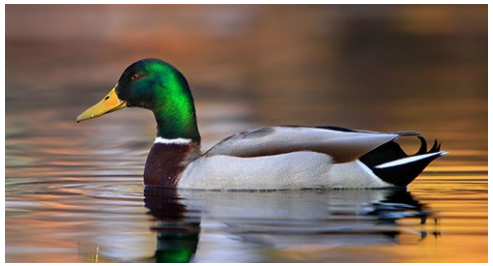


Solar facilities and bodies of water have similar visual signatures from the perspective of birds

Birds may be “attracted” to solar facilities, which may act as sensory “traps”

Can we shift the visual signature of solar panels so birds avoid them?

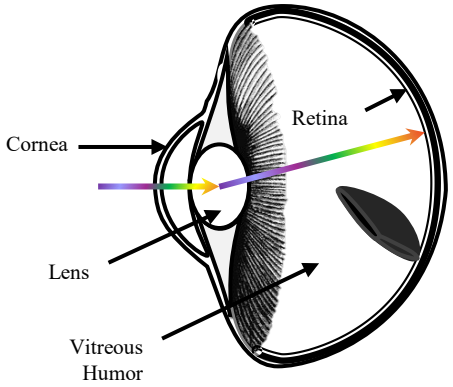
- Model species: mallard (Anas platyrhynchos)

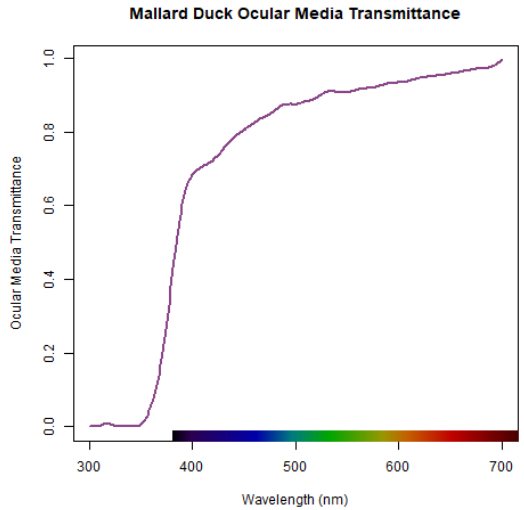


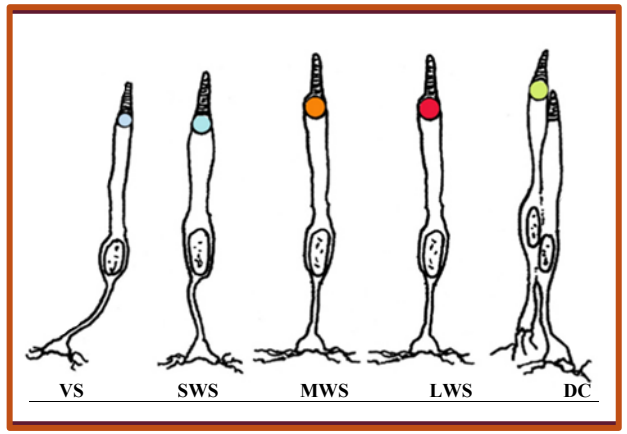
- Mallard visual system components
- Visual models to quantitatively assess mallard visual perception
- Behavioral experiment 1:
  - Visual signature of solar panel vs. water source
  - Attraction/avoidance responses to solar panels vs water source

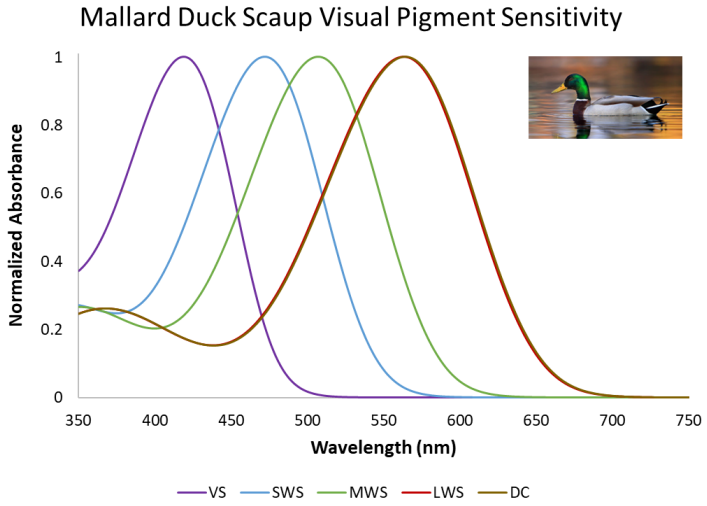
- Behavioral experiment 2:
  - Visual signature of the solar panel shifted with an LED light veil
  - Attraction/avoidance responses to solar panels with light veil vs solar panels without light veil

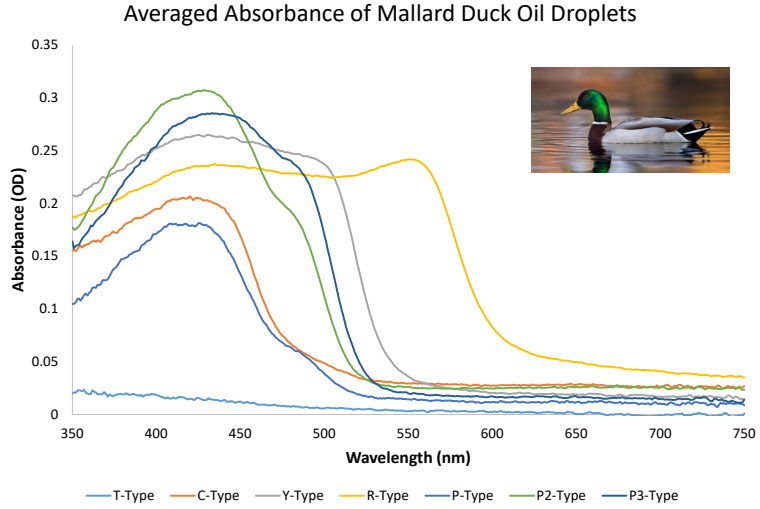
Mallard visual system

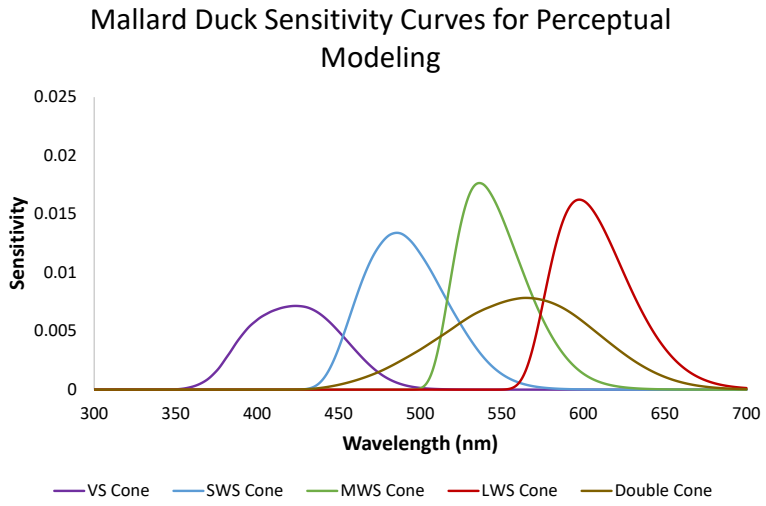








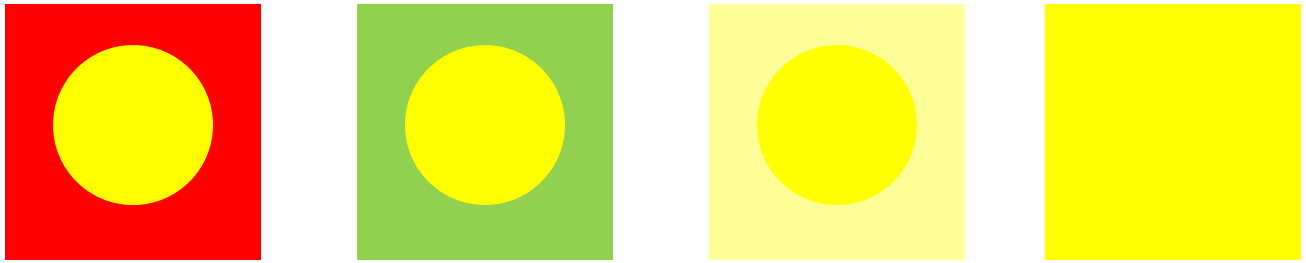




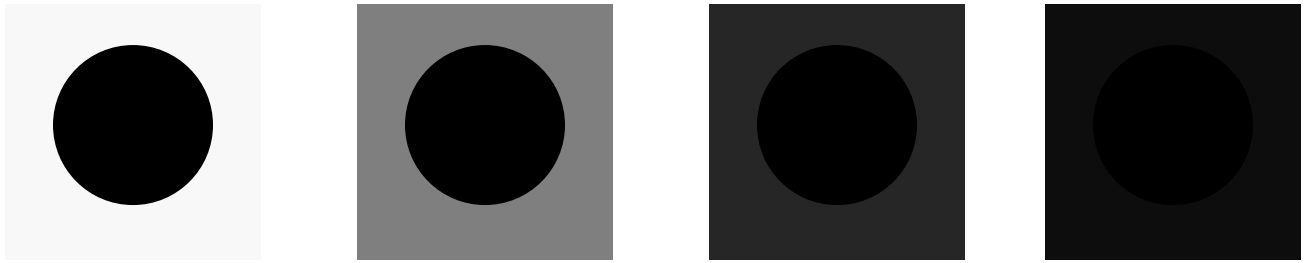
Violet sensitive visual system

Visual models estimate quantitively how much an object stands out from the background

Chromatic contrast



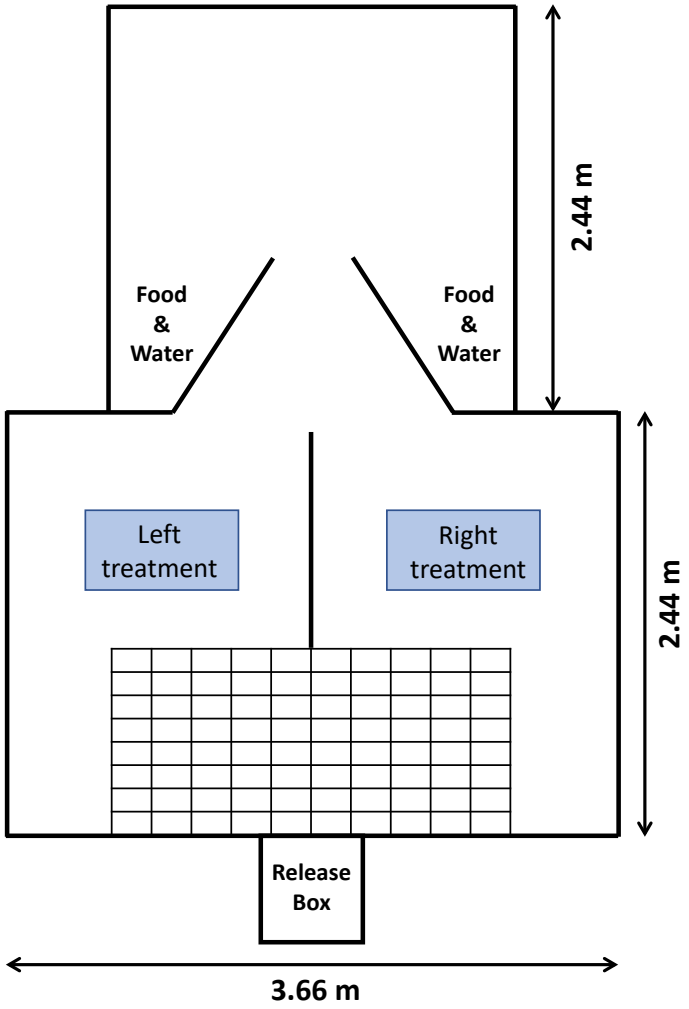
Achromatic contrast

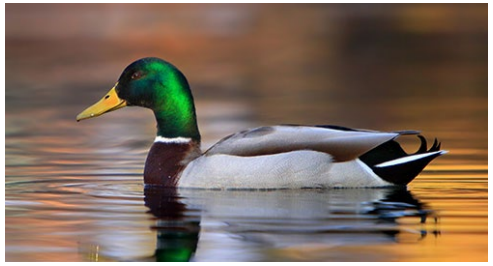


High → Low

Photon catch and receptor noise model
(Osorio & Vorobyev 1998)

Behavioral experiment 1

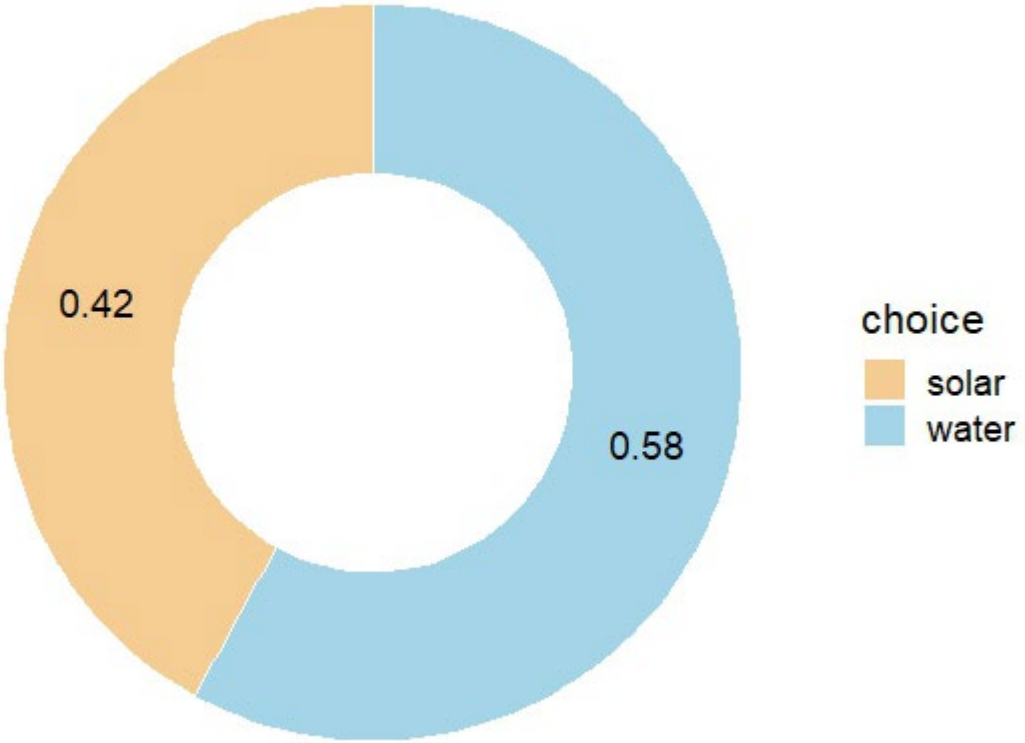




20 adult wild-type mallards

solar vs. water

Proportion of individuals that chose a treatment



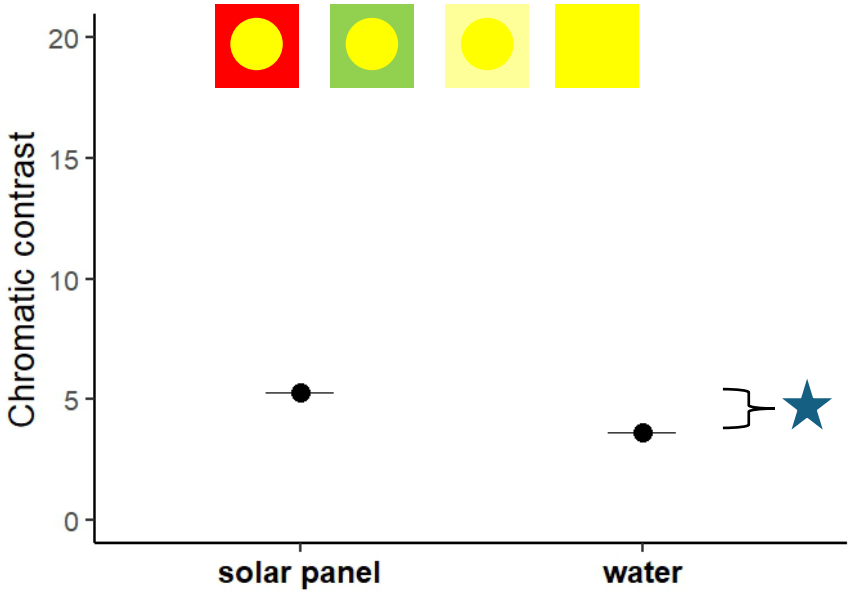
No significant difference choosing water vs. solar panel

Generalized Linear Mixed Model with intercept only and individual ID as random factor ($z = 0.95$, $P = 0.345$)

Mallards did not discriminate behaviorally between water and solar panels

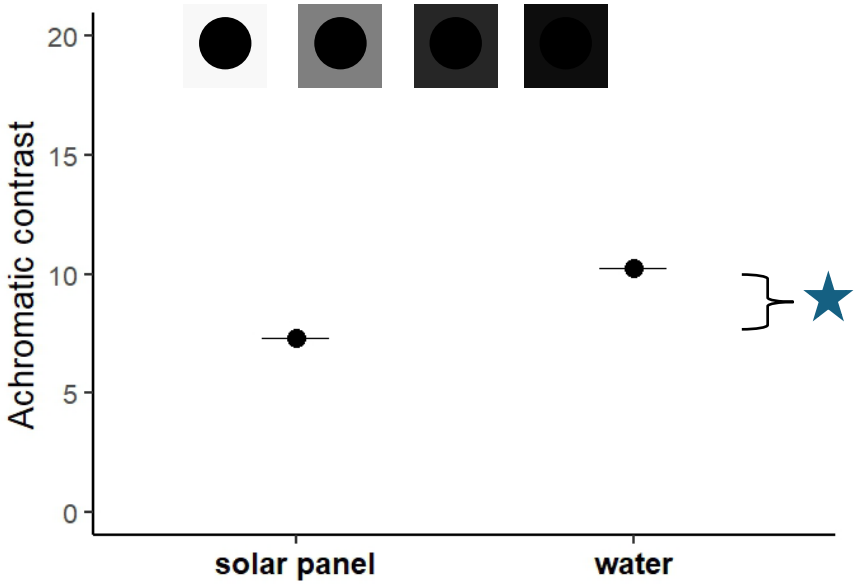
Sensory mechanism?

Chromatic contrast solar panel vs. water



($F_{1,78} = 95{,}913$, $P < 0.05$)

Achromatic contrast solar panel vs. water

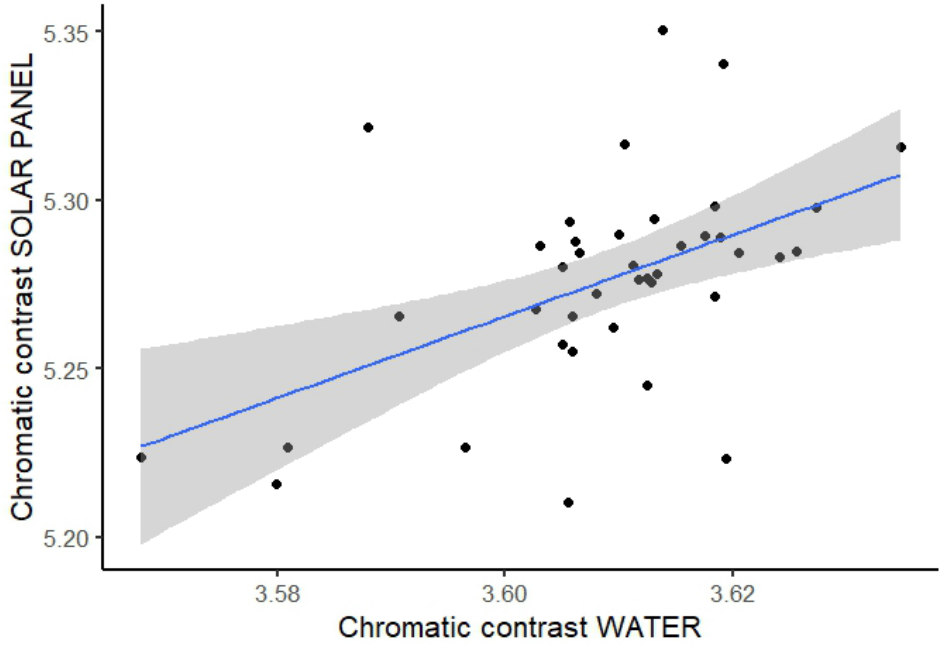


($F_{1,78} = 21{,}295$, $P < 0.05$)

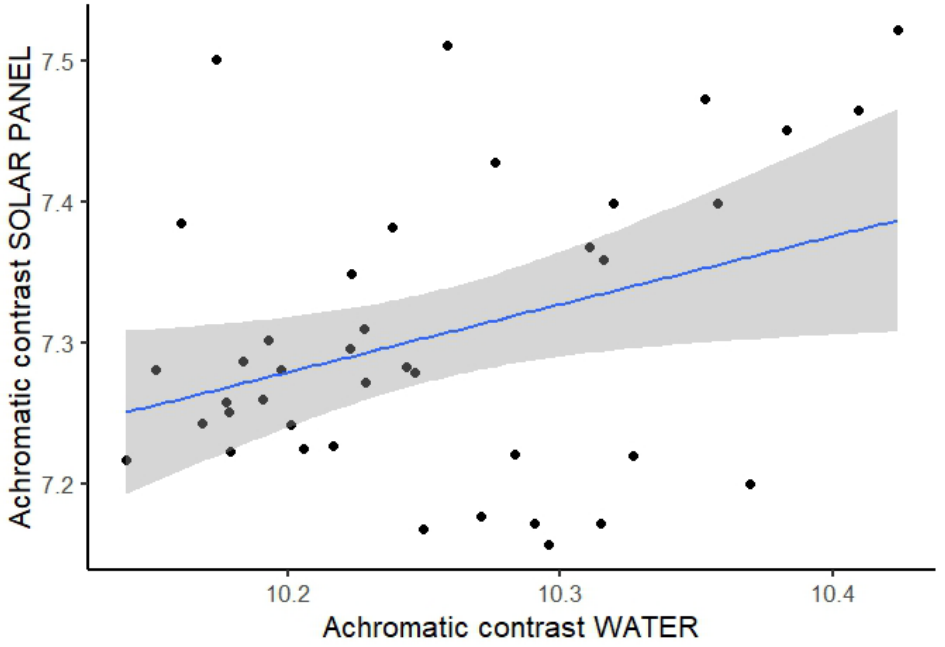
★ small differences

Chromatic contrast

Achromatic contrast



Person's correlation r = 0.51, P < 0.001



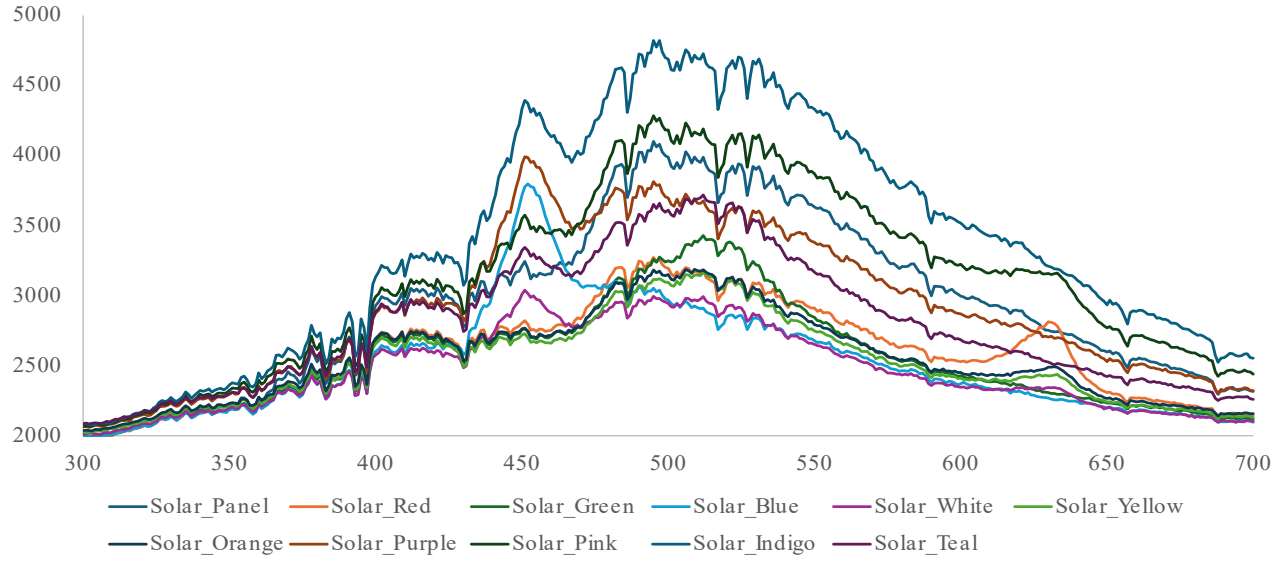
Person's correlation r = 0.35, P = 0.028

Take-homes (I)

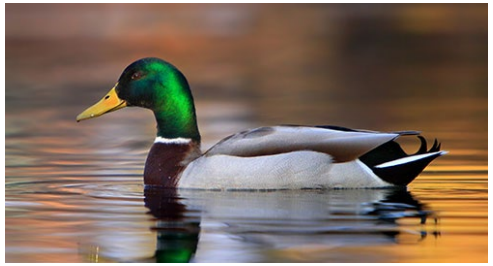
- The visual differences between the water and the solar panel may not have been enough (from the mallard viewpoint) to affect choice behavior.

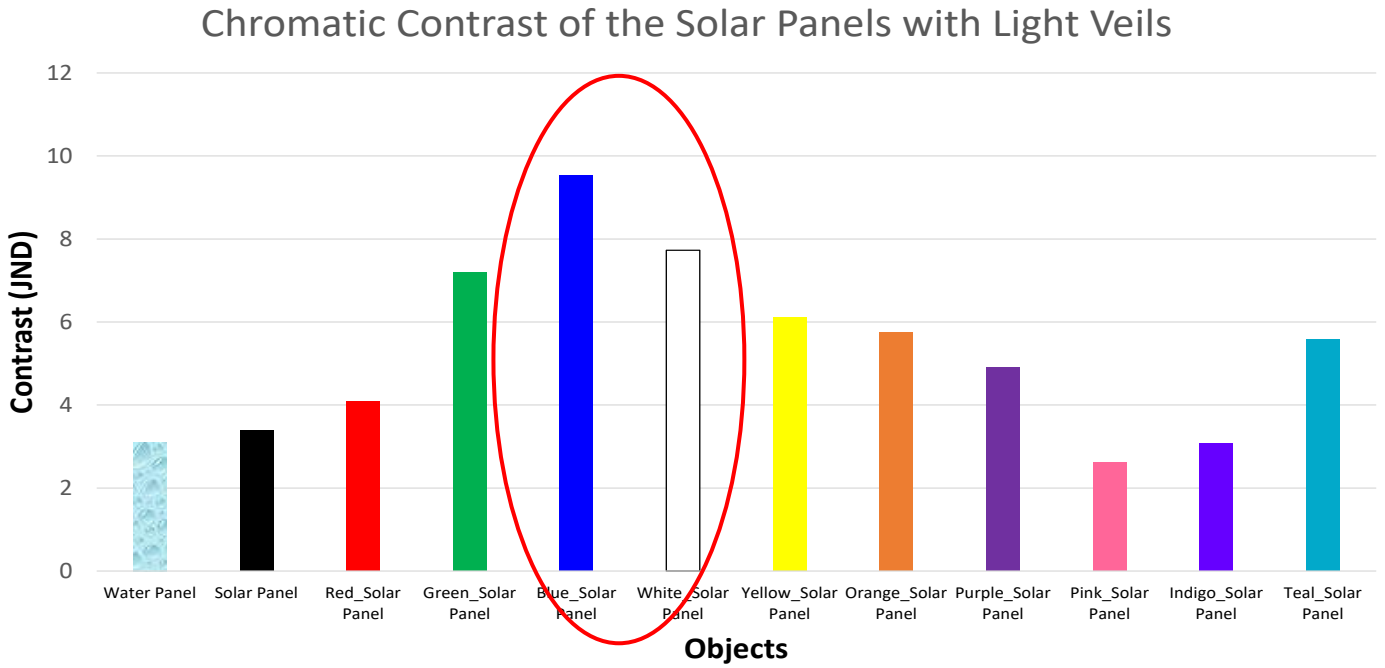
- We found a potential sensory mechanism (chromatic contrast) to explain the visual similarity between water and solar panels.

Shifting the solar panel visual signature with LED illumination

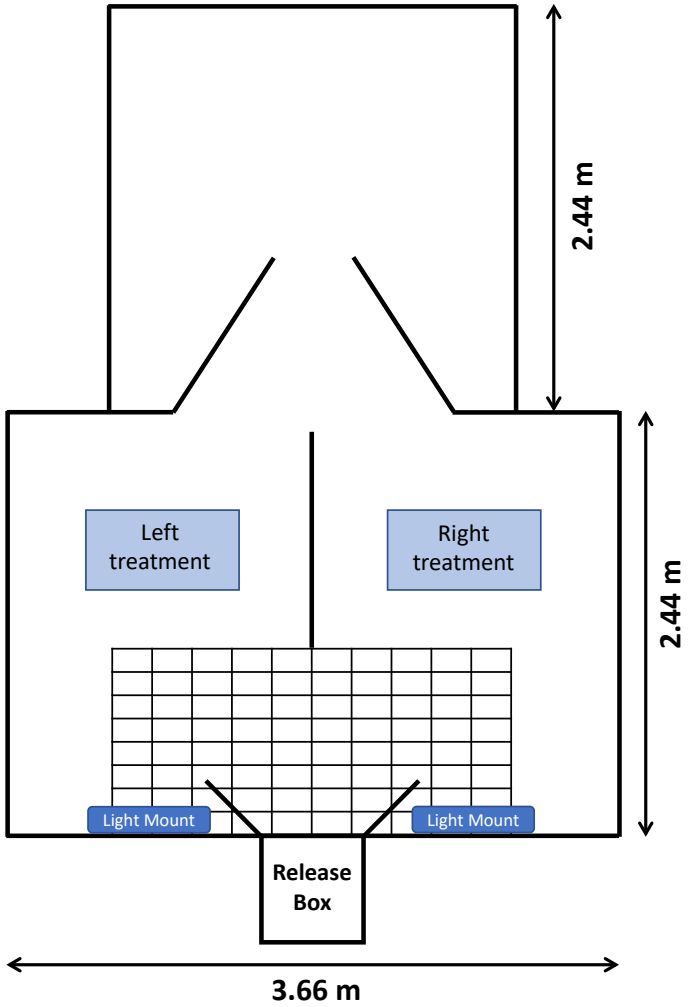


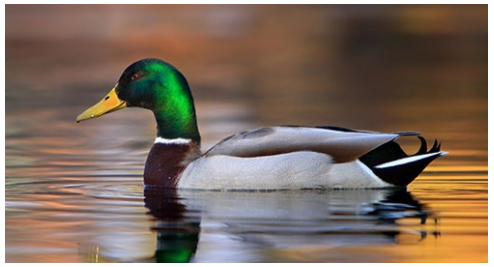
Chromatic contrast





Behavioral experiment 2





30 adult wild-type Mallards

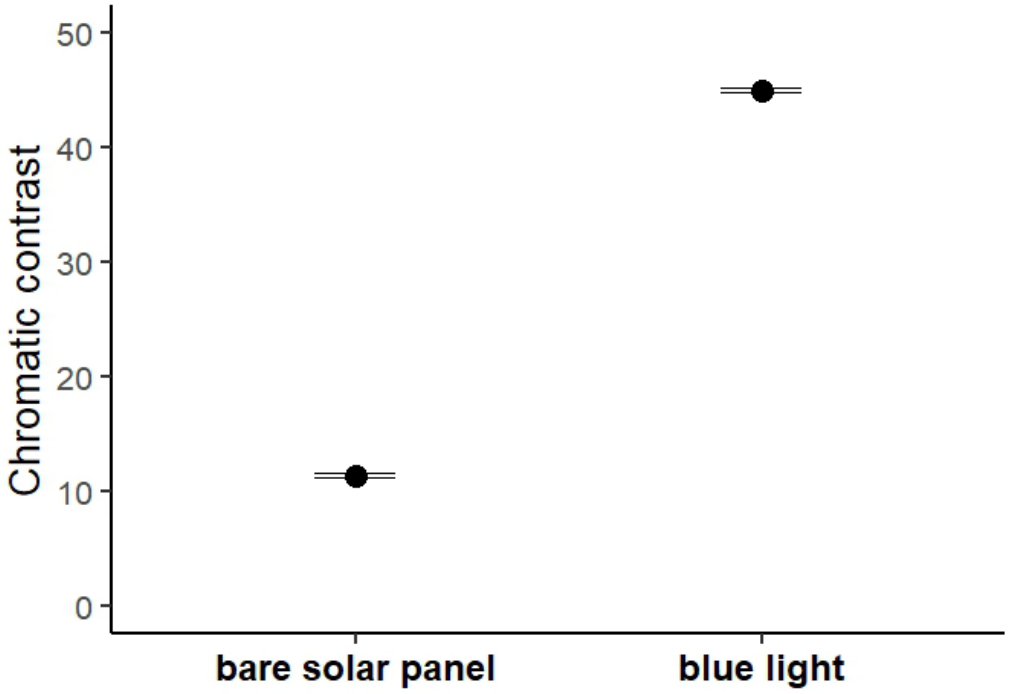
Blue LED light veil vs. bare solar panel

Bare solar panel vs. blue LED light veil

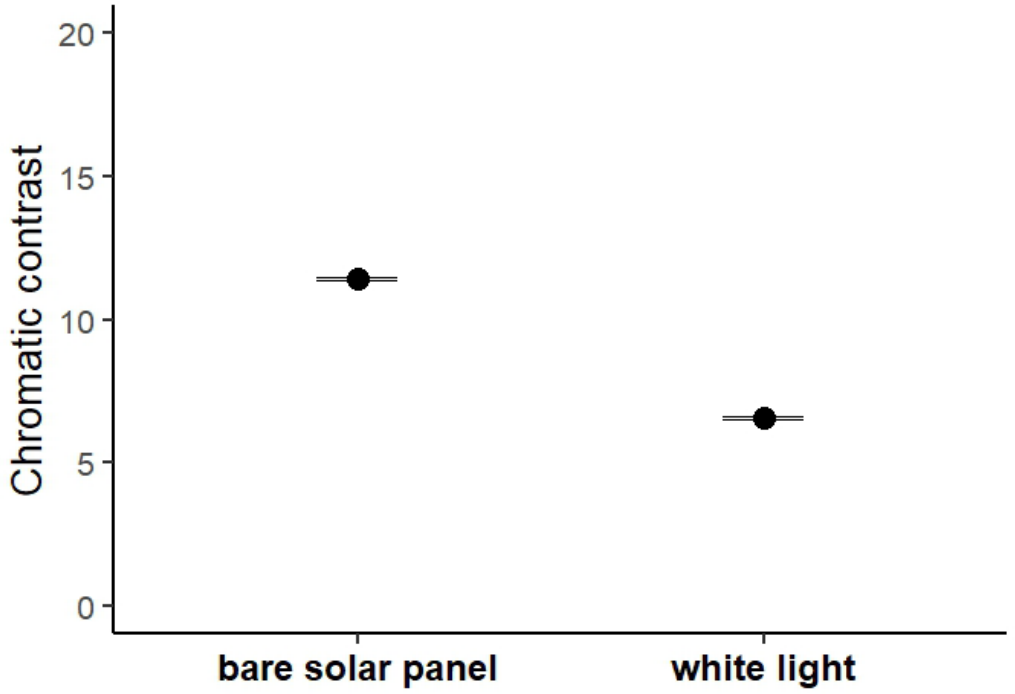
White LED light veil vs. bare solar panel

Bare solar panel vs. white LED light veil

LED light veils changed the visual signature of the solar panels



($F_{1,118} = 13,098$, $P < 0.001$)

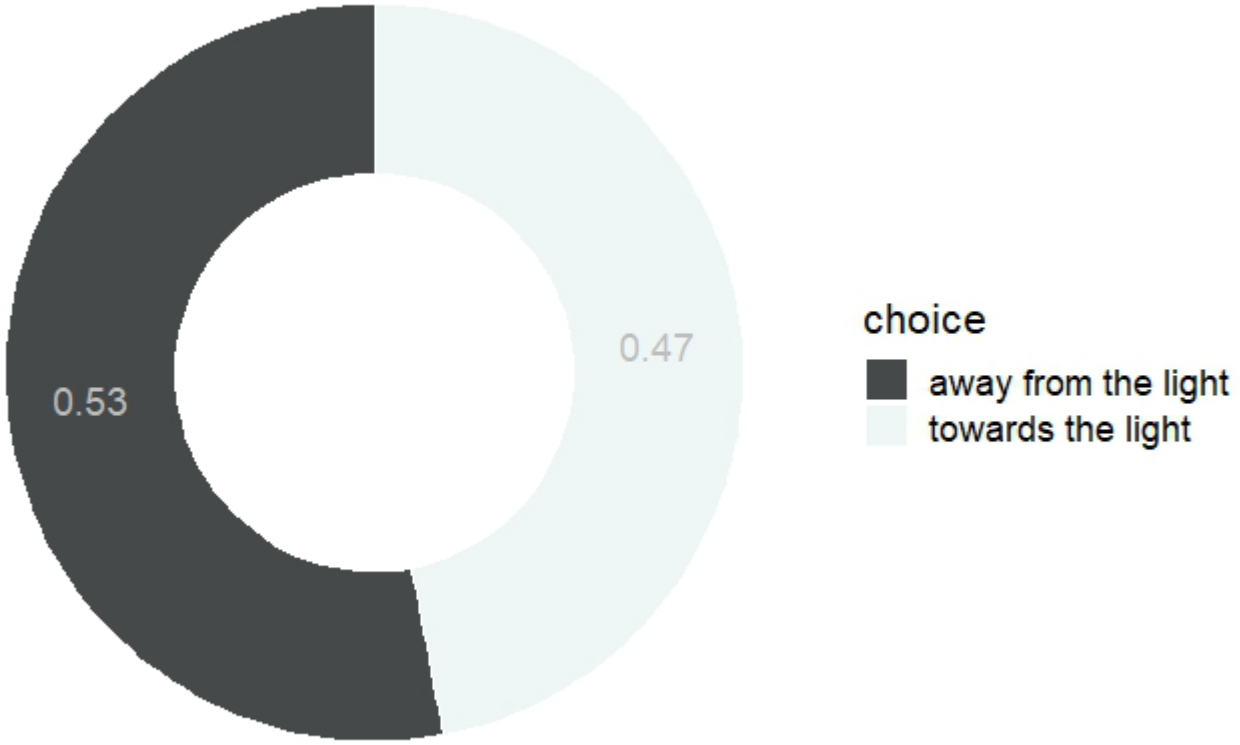


($F_{1,118} = 5,204$, $P < 0.001$)

Chromatic contrast

~40Klux

Behavioral responses to white LED light veil

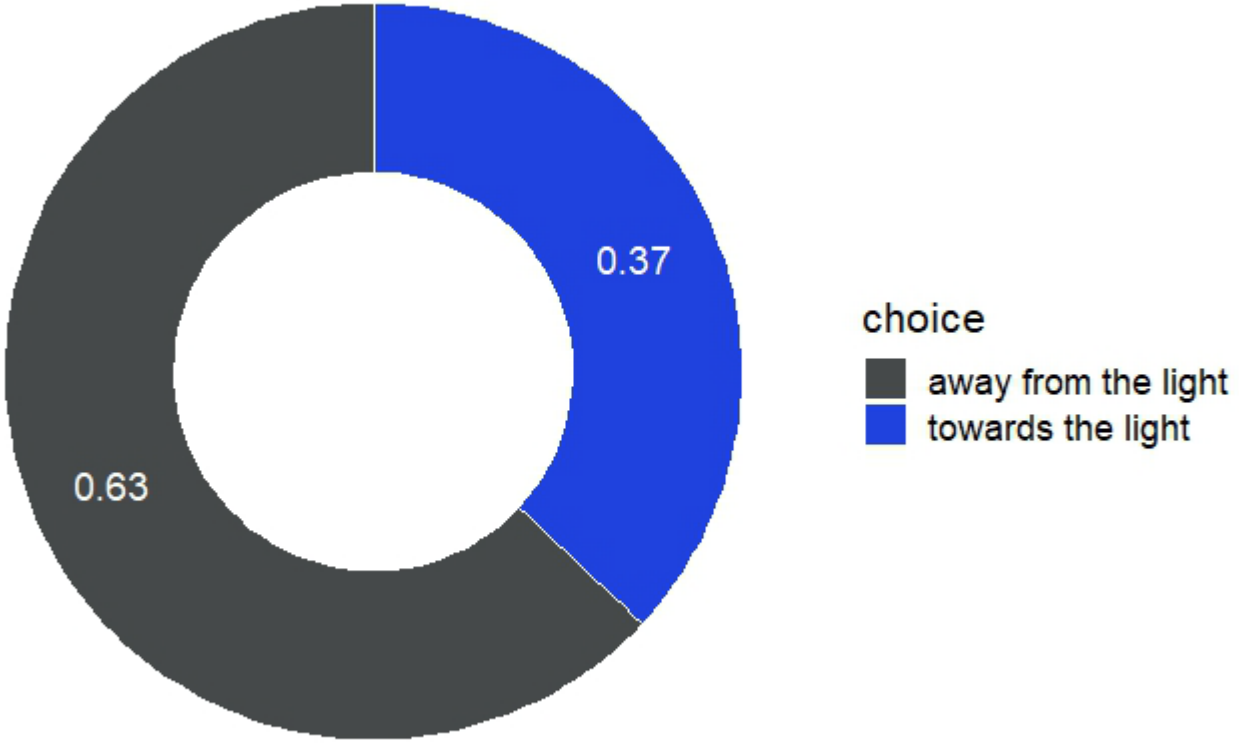


Mallard ducks did not prefer or avoid the white lights significantly ($z = -0.52$, $P = 0.606$)

Behavioral responses to blue LED light veil

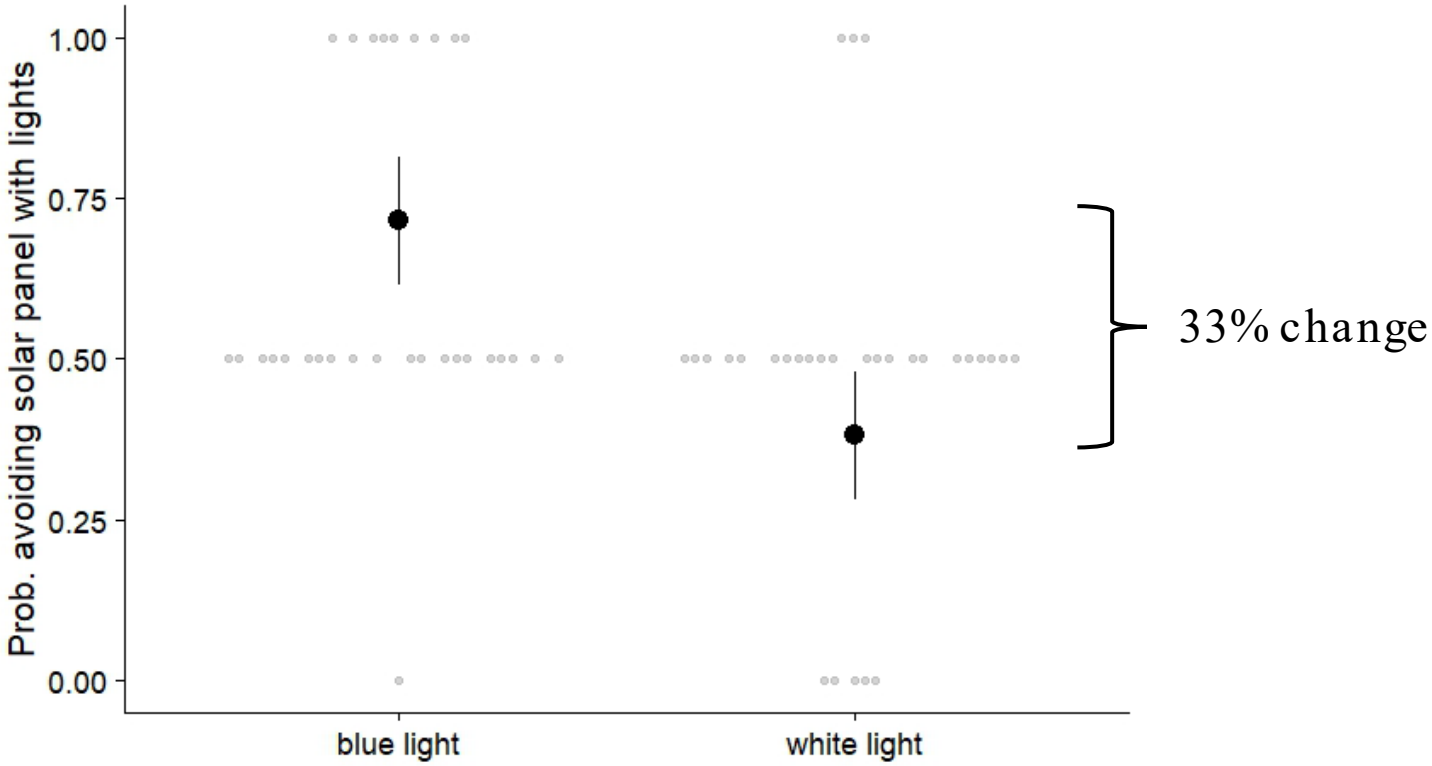
~40Klux

Peak wavelength: 462 nm



Mallard ducks <u>avoided</u> the side of the arena with the blue light veil ($z = 2.04$, $P = 0.041$)

The blue light performed significantly better than the white light in generating duck avoidance responses



Generalized Linear Mixed Model with individual ID as random factor ($X^2 = 6.78$, $P = 0.009$)

Take-homes (2)

- High intensity (~40Klux) blue (462 nm) LED lights appear to not only shift the visual signature of the solar panels but also generate avoidance behavior.

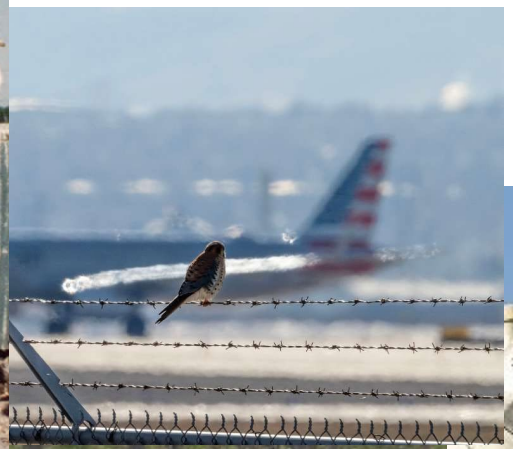
- Ducks do not respond to all lights equally, as white LED lights led to a random behavioral response.

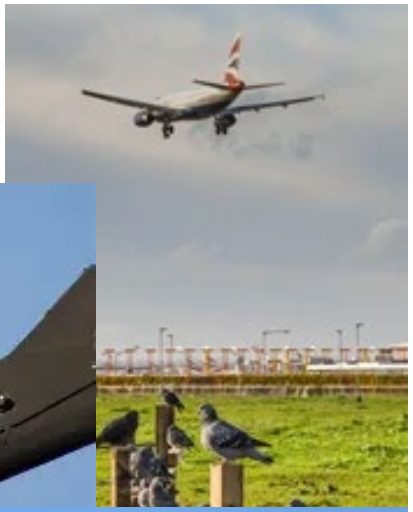
Applications to airports

- Based on FAA data (1990- 8/20/2025)
  - Number of reports where strikes occurred near ground level (0-50 ft AGL): 87,681 out of 326,195 strikes (26.9%)
- Example species:

Species	Strikes 0-50 ft AGL	Percentage of strikes that occurred 0-50 ft AGL
Mourning dove	4,221	25.2
American kestrel	2,388	24.0
European starling	2,057	30.5
Rock pigeon	1,629	35.4
Red-tailed hawk	1,589	36.2
Bald eagle	268	46.7

Birds are using different landscape elements (perching, nesting, or foraging) in the airport





LED illumination tuned to the visual system of target species might be used to shift the visual signature of key elements in the airport environment and potentially generate avoidance behavior

ANY QUESTIONS?