Learning to escape robotic spiders: predator avoidance learning in bumblebees

Tom Ings & Lars Chittka

Queen Mary University of London

Syngenta Bioline Bees

NATURAL ENVIRONMENT RESEARCH COUNCIL

Outline

- Challenges facing bees
  - Finding food BUT avoiding predators
- Colour change in spiders
- Impact of crab spiders on bees
- Dynamics of predator avoidance
  - Avoidance learning paradigm
  - Predator crypsis, learning & memory

Finding food

- Complex landscapes – too much choice!

Avoiding predators - invertebrates

Sit-and-wait ambush predators

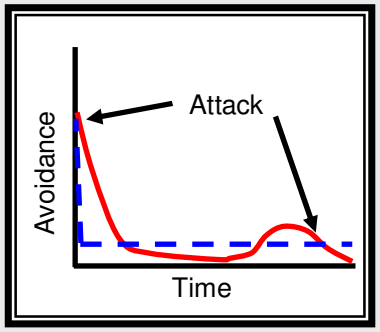
Misumena vatia – colour change

Yellow

White

Aims

- Does predator crypsis disrupt avoidance learning?



- Quantify dynamics of predator avoidance learning – bumblebees

- Does the foraging behaviour of bees alter in response to predation risk?

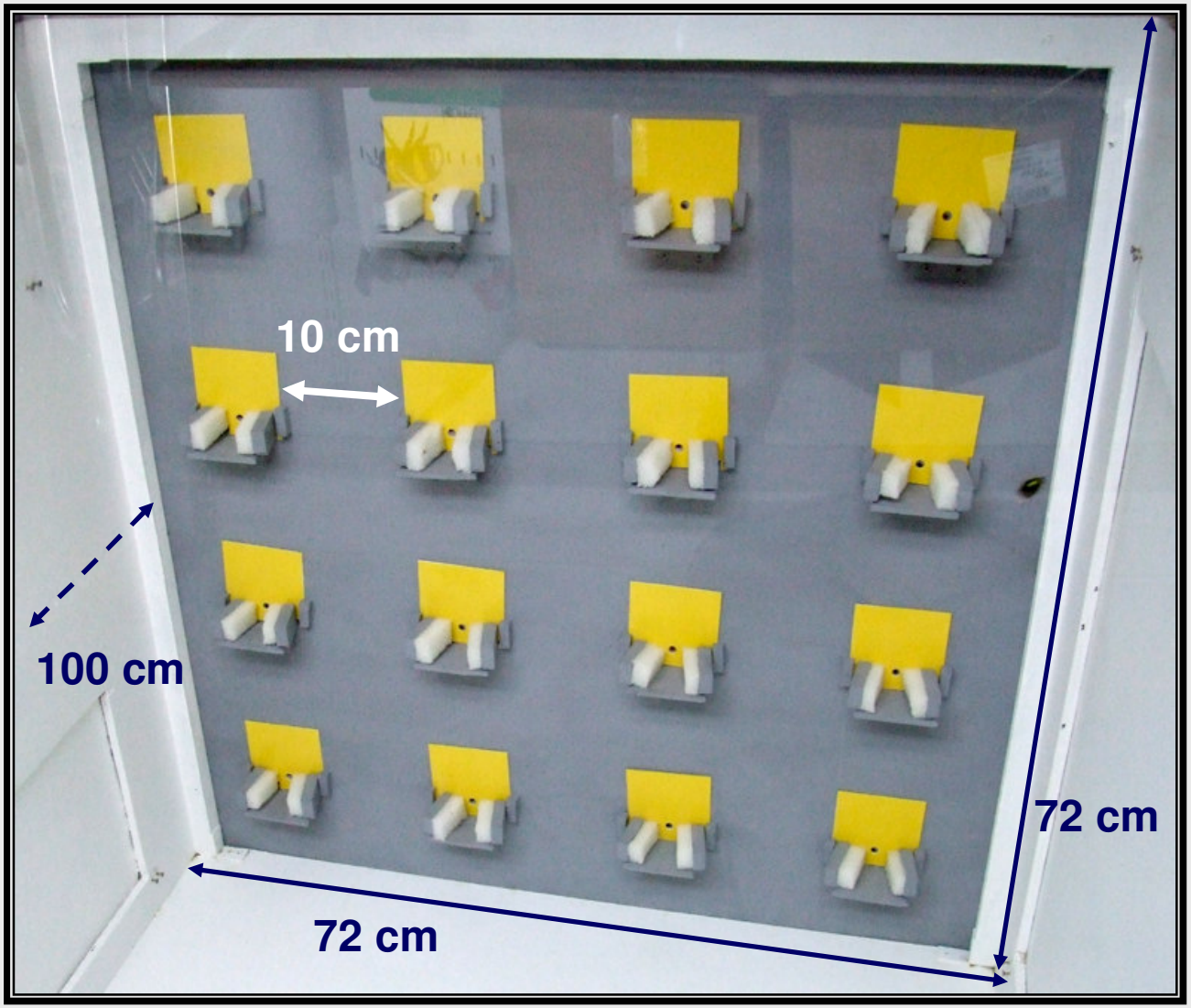
Effects of crab spiders on bees & plants

- *Consumptive* – reduce density & visitation
  - Most (>90%) attacks unsuccessful (ample opportunity to learn)
- *Non-consumptive* – FEAR
  - Avoid flowers with dead bees & spiders
  - Avoid flower patches with high densities of spiders (sometimes)
- Lower seed set when spiders present

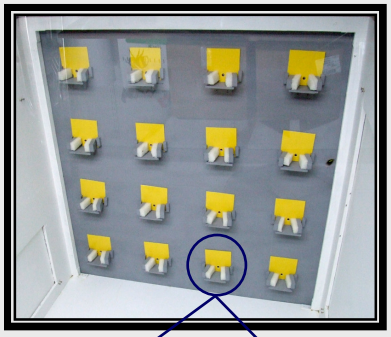
e.g. Dukas (2001), Gonçalves-Souza *et al* (2008)

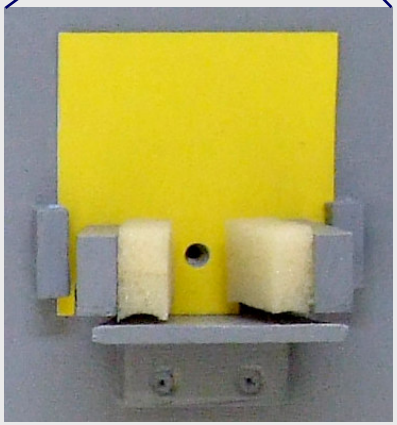
Avoidance learning paradigm

Meadow of artificial flowers



Avoidance learning paradigm

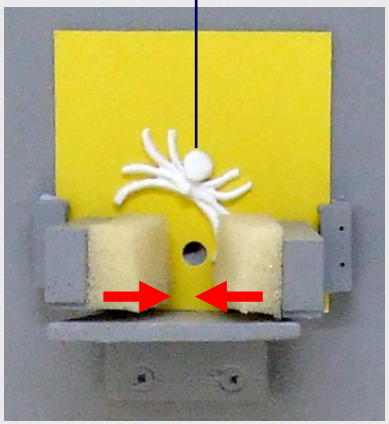




"Safe" flowers
(trap inactive)

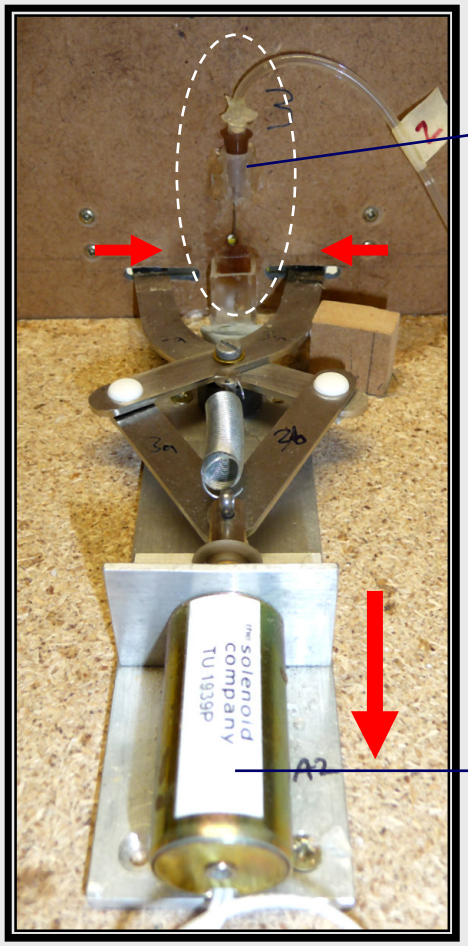
"Robotic" spiders

Life-sized 3D
spider model



"Dangerous"
flowers
(active trap)

+

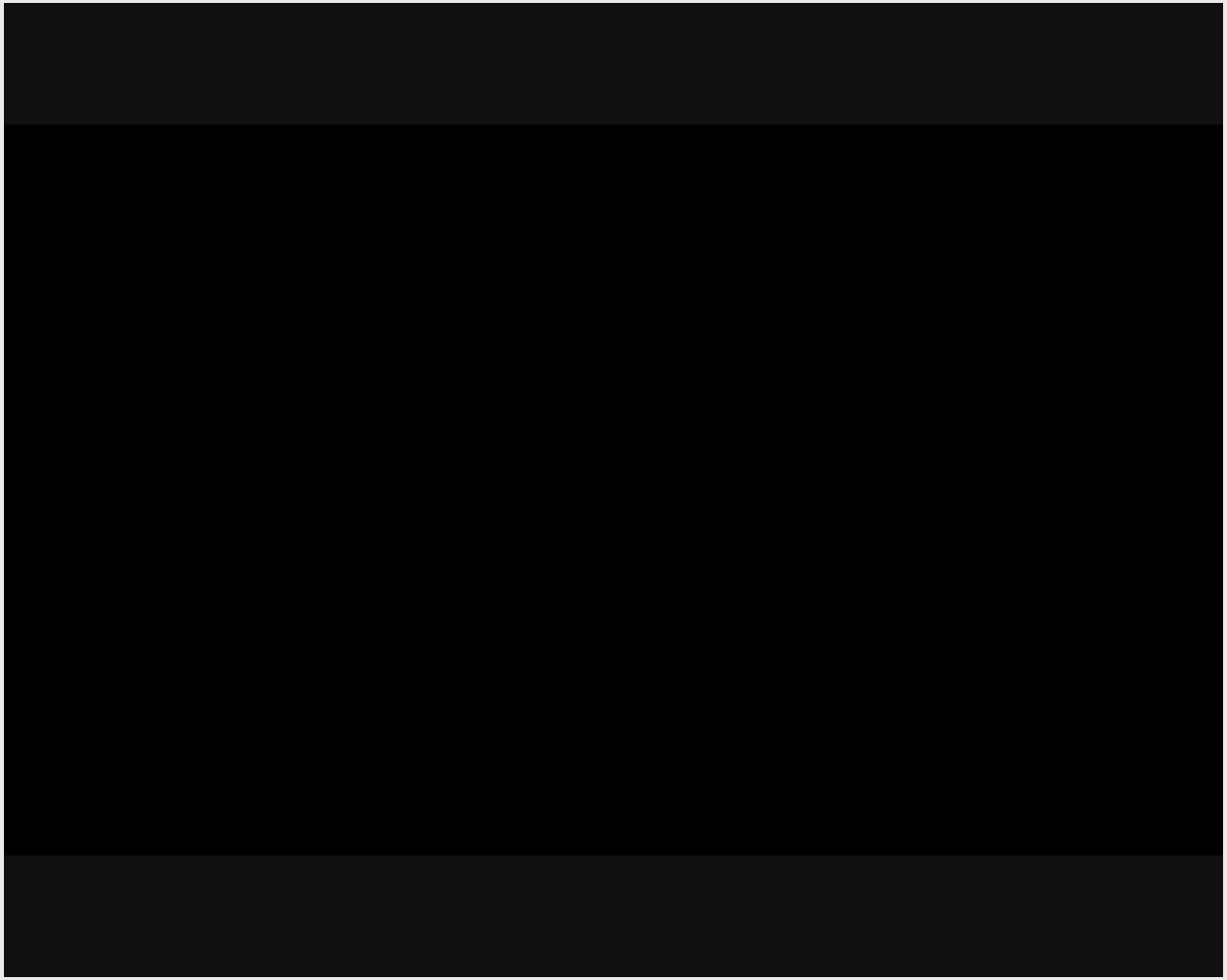


Feeding
mechanism

Remotely
controlled
solenoid

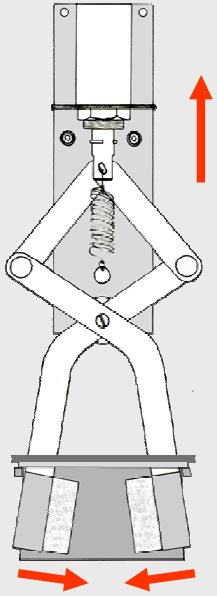
Trapping mechanism

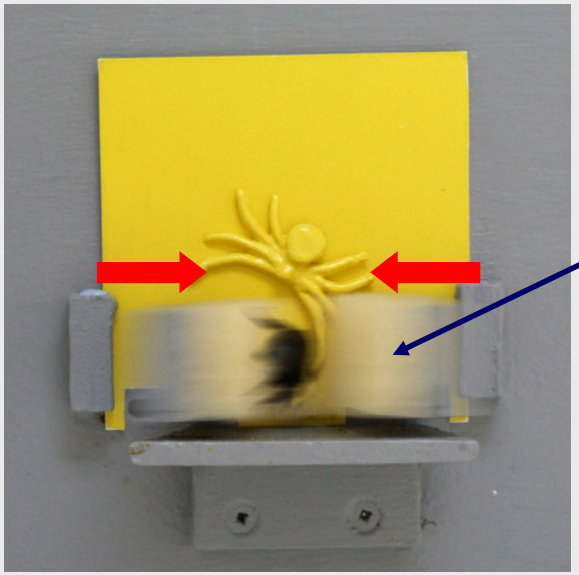
Simulated predation attempts



Simulated predation attempts

1) Bee lands to feed





2) Trap closed by remote control

3) Bee held for 2s

1) Learning to avoid predators in a single flower species meadow

vs

Questions

- Does spider crypsis affect avoidance learning & memory?

Hypotheses

- Bees are less accurate when spiders are cryptic
- Avoidance of spiders is well maintained

Design: avoidance learning

2 treatment groups

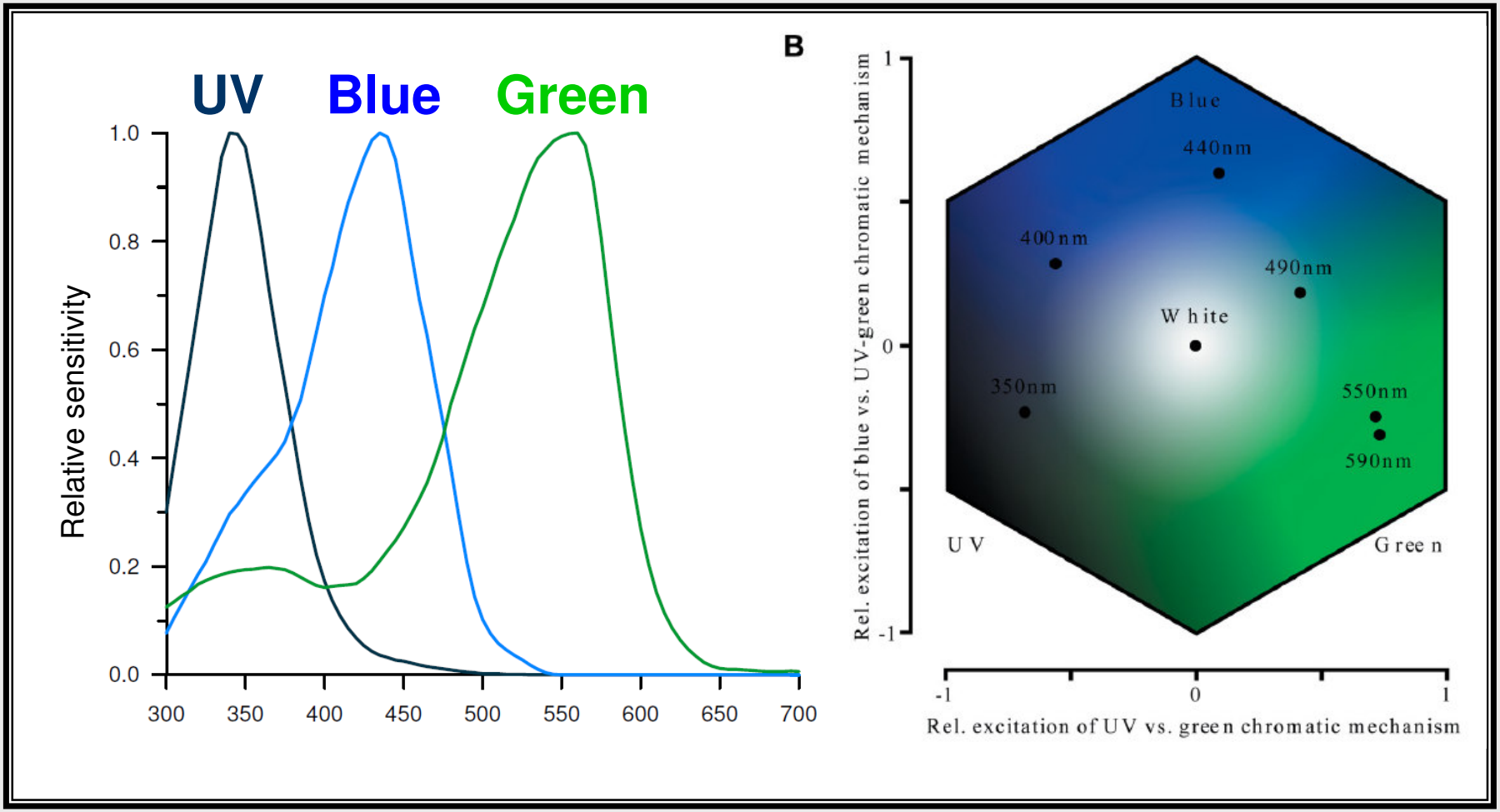
cryptic
(16 bees)

conspicuous
(16 bees)

Ings & Chittka (2008) *Current Biology*, 18

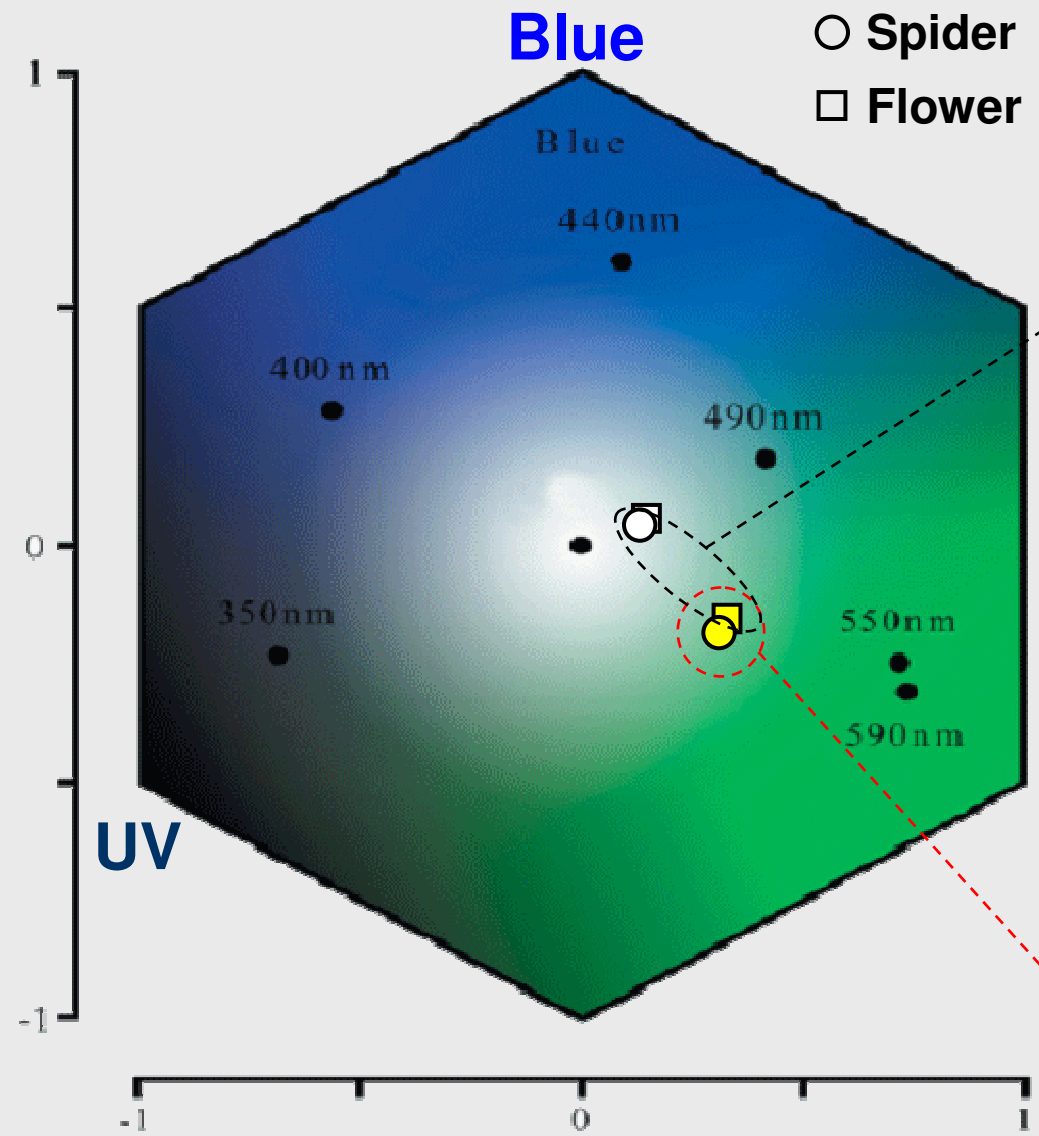
Colour vision in bees

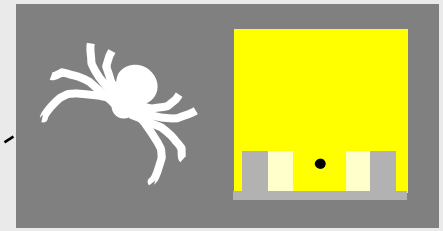
- 3 colour receptors



Adapted from: Chittka & Brockmann (2005) *PLoS* Biology, 3

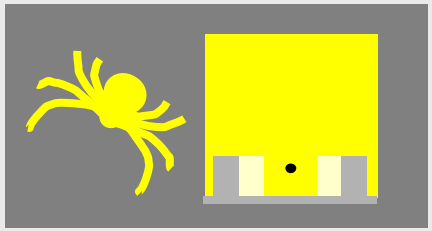
Colour differences: bee colour space





0.26 units

Bees can discriminate 0.1 units



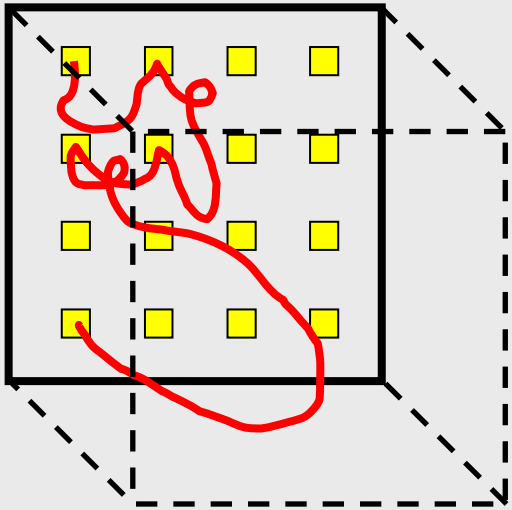
0.03 units

Design: avoidance learning

2 treatment groups

cryptic
(16 bees)

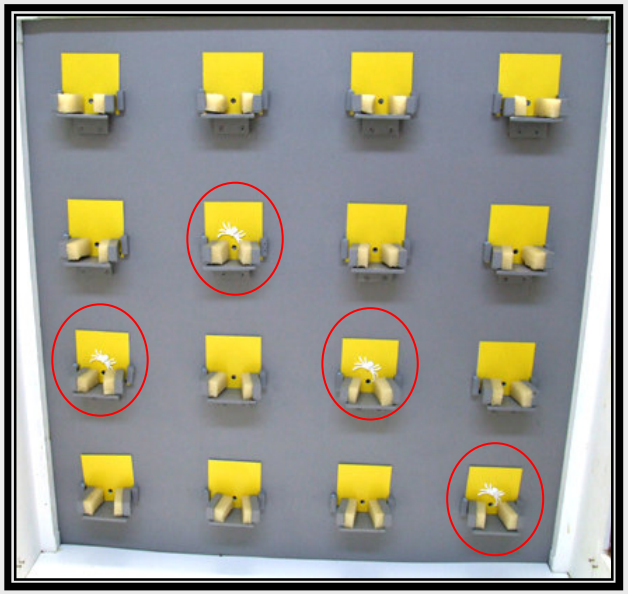
conspicuous
(16 bees)



- 25% chance of attack
- Learning curves
- Flight behaviour (3D video tracking)

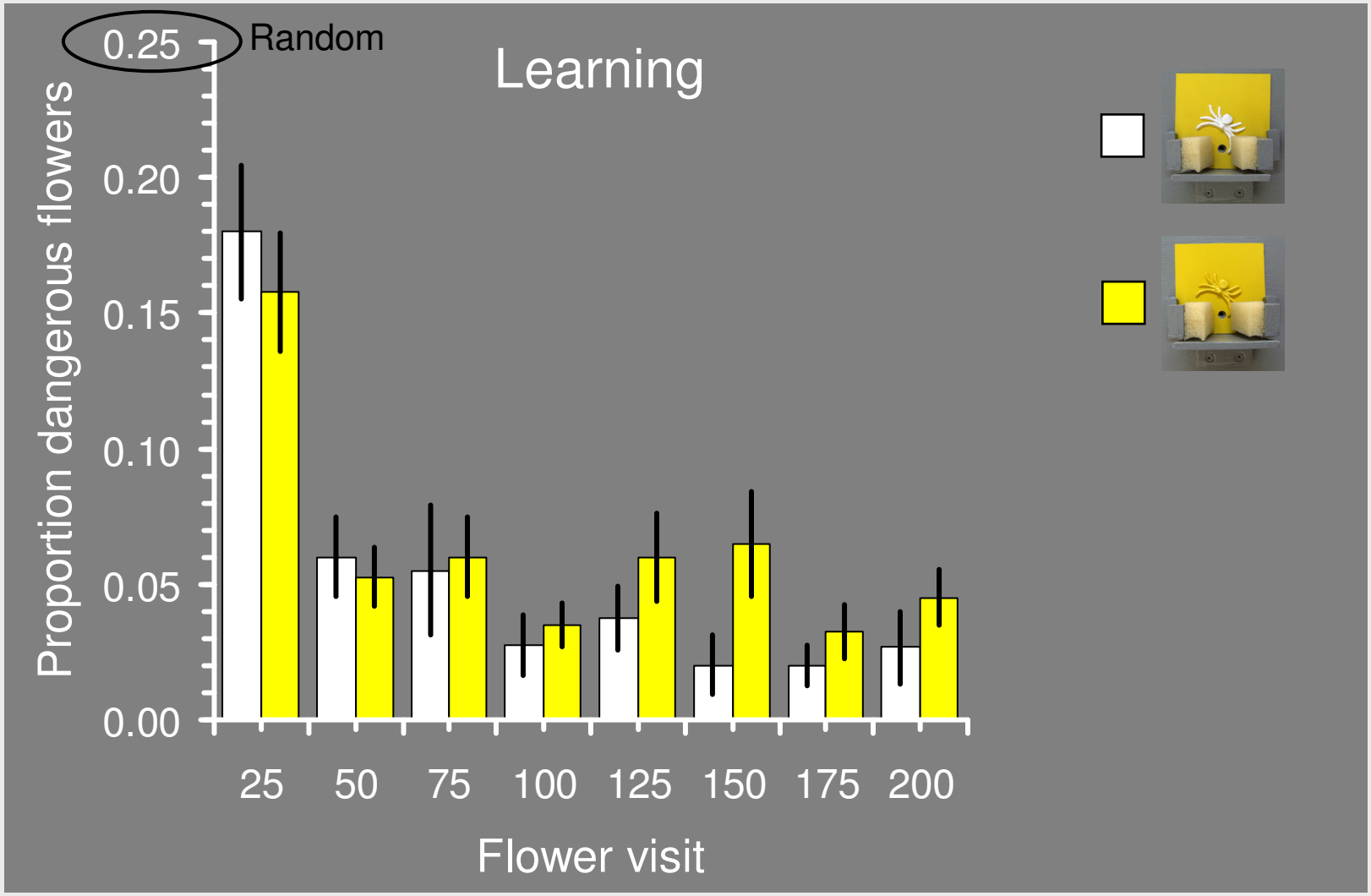
Ings & Chittka (2008) *Current Biology*, 18

Procedure

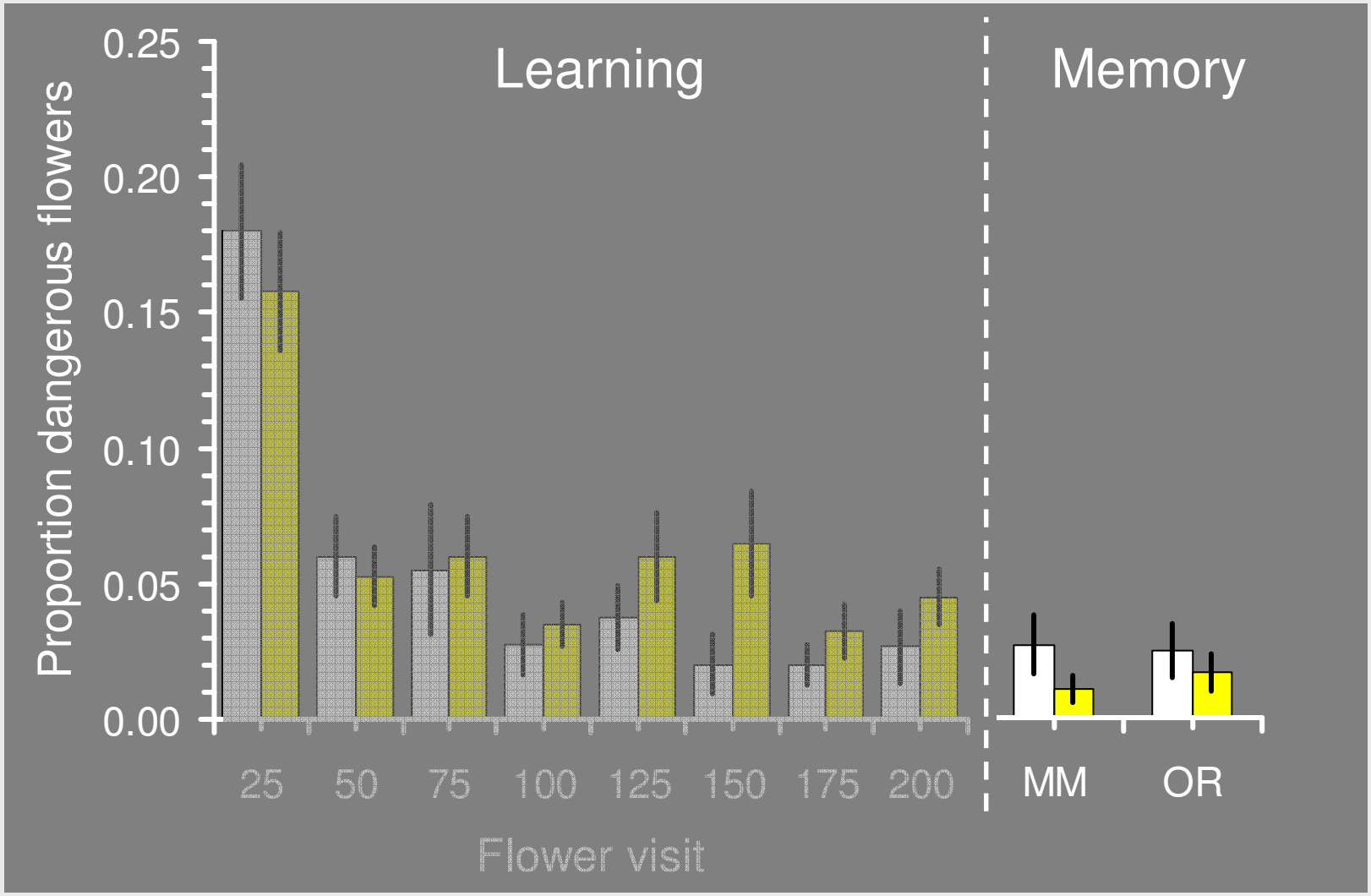


- **pre-training** (no spiders)
- **learning** (4 spiders & attacks)
- **mid-term memory** (spiders, no attacks)
- **reinforcement** (as training)
- **overnight memory** (spiders, no attacks)

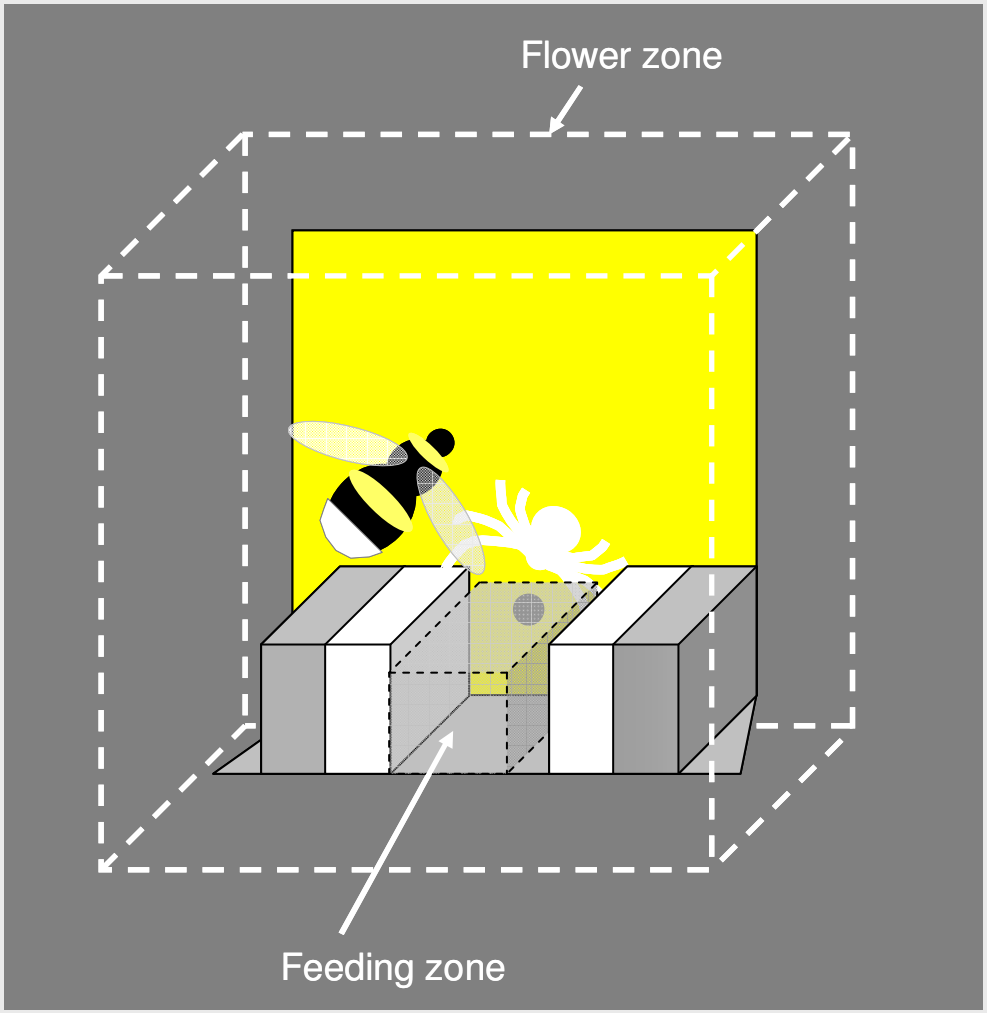
Accuracy: probability of attack



Accuracy: probability of attack

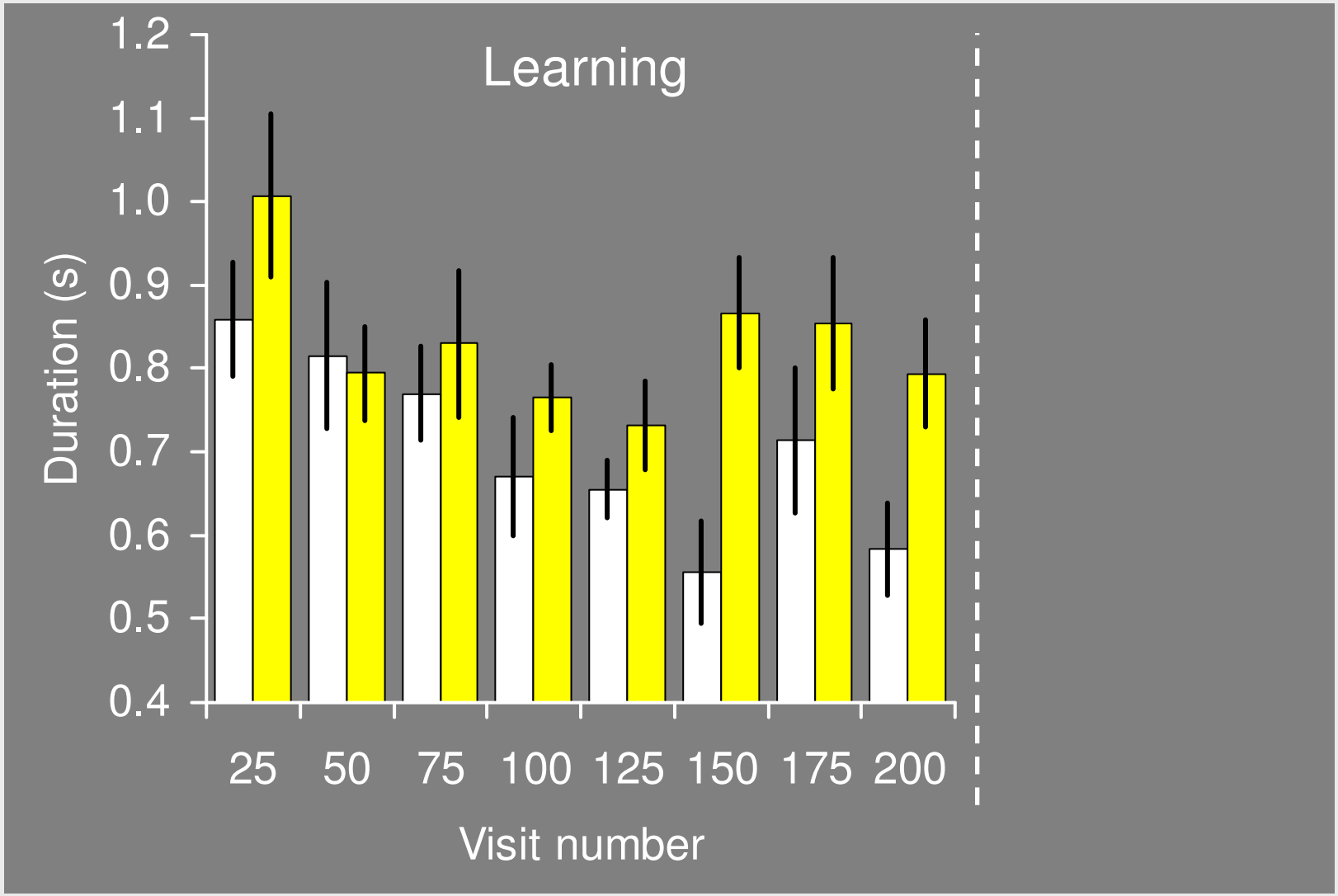


Flight data: rejection of flowers

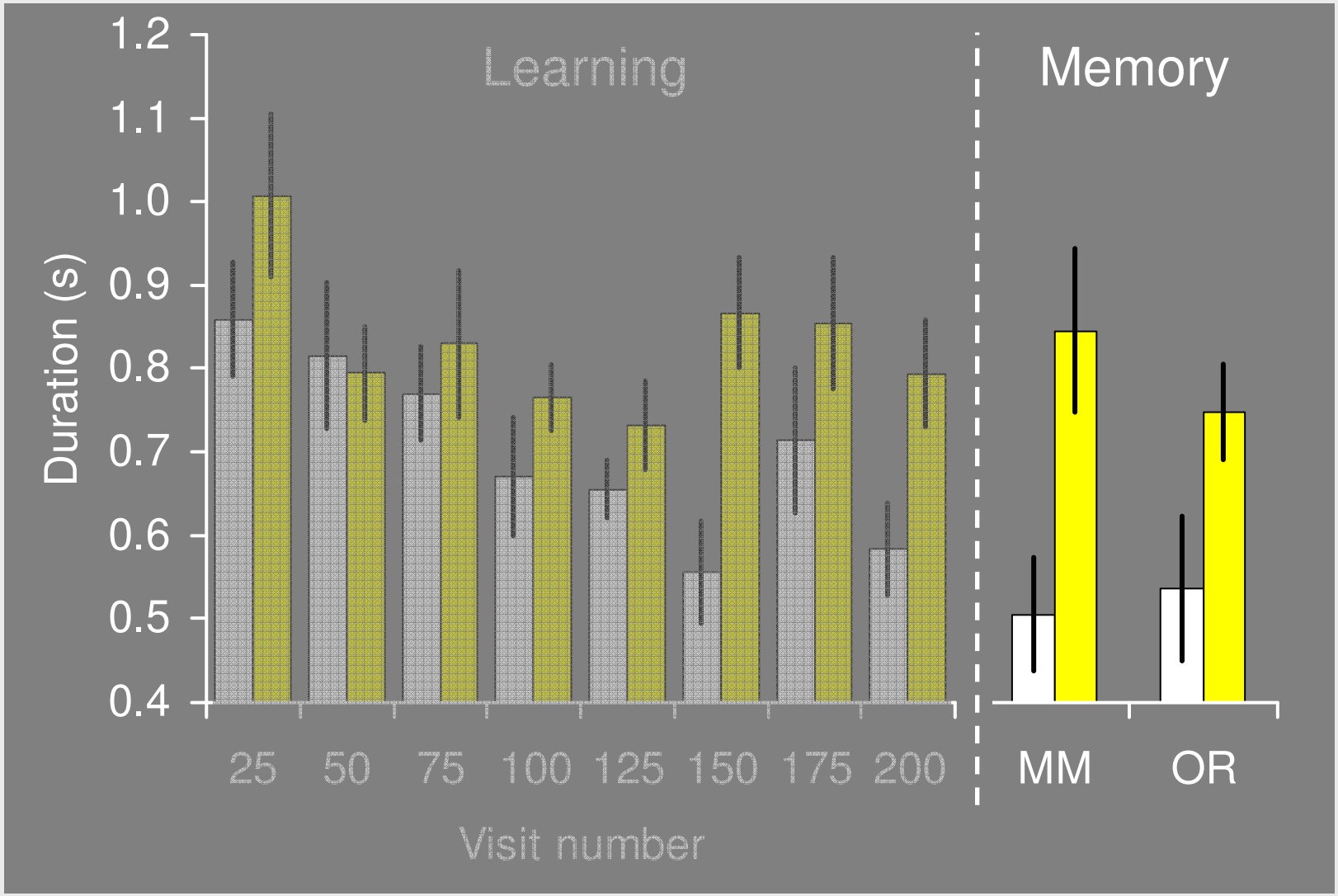


- Bee enters flower zone
- Inspects flower
- Does not land & feed
- Time in flower zone

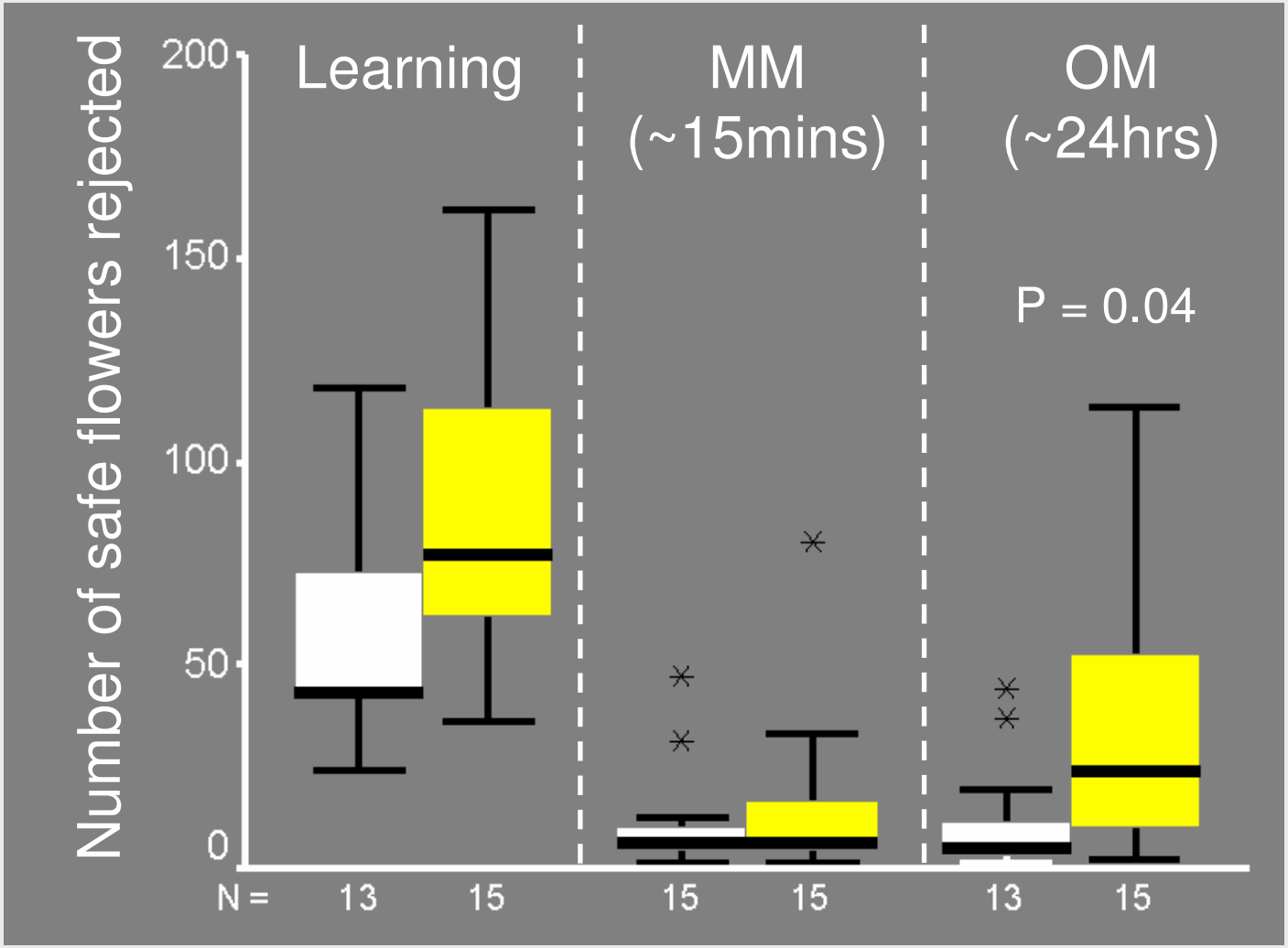
Speed: rejection of dangerous flowers



Speed: rejection of dangerous flowers



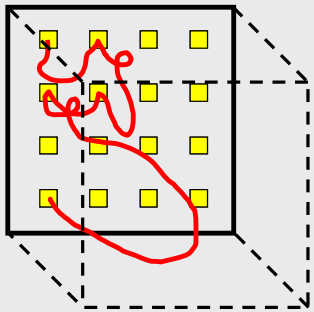
‘False alarms’



Summary: speed-accuracy trade-off

- Bees rapidly learn to avoid conspicuous & cryptic spiders
- Bees do **not** make more mistakes when spiders are cryptic
- Rejecting dangerous flowers takes longer if spiders are cryptic
- Bees reject more safe flowers when spiders are cryptic

Conclusions



- Reduced foraging efficiency
- Reduced fitness
- Cryptic spiders have no advantage - why use camouflage?
- How does flight behaviour change in response to spiders?