



Mutant Bees:

Making colour choices in different illuminations

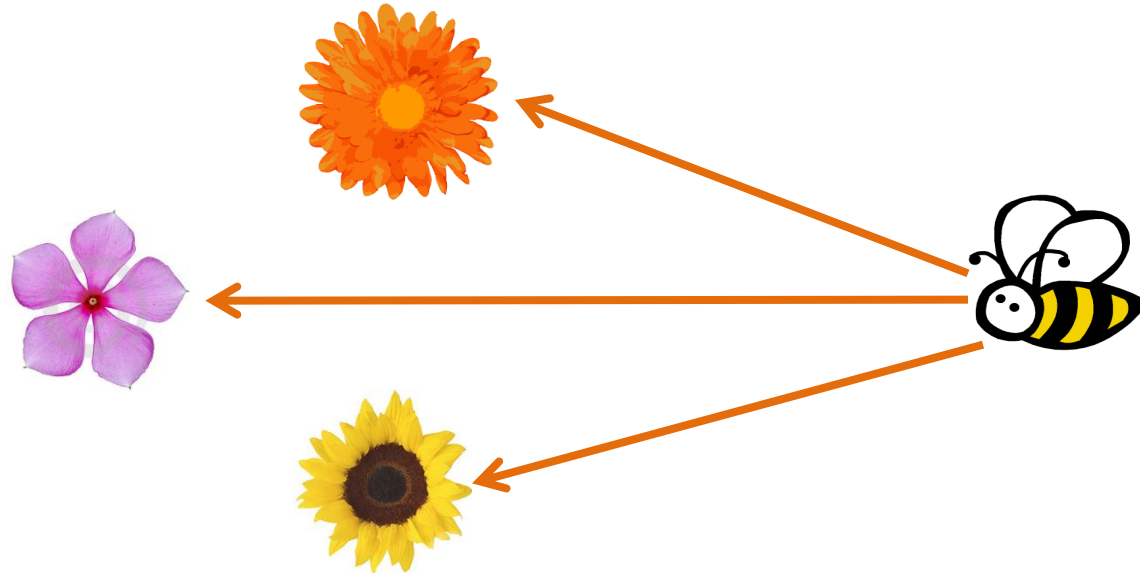
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Computer Science, Biological Sciences
Computer Vision/Chittka Bee Lab
Funded by EPSRC

A little about bee research

- Sniffing out explosives *Los Alamos National Lab, 2006*
- Geographic profiling of criminals *Raine N.E., et al (2009)*
- Recognise human faces *Dyer AG, et al (2005)*

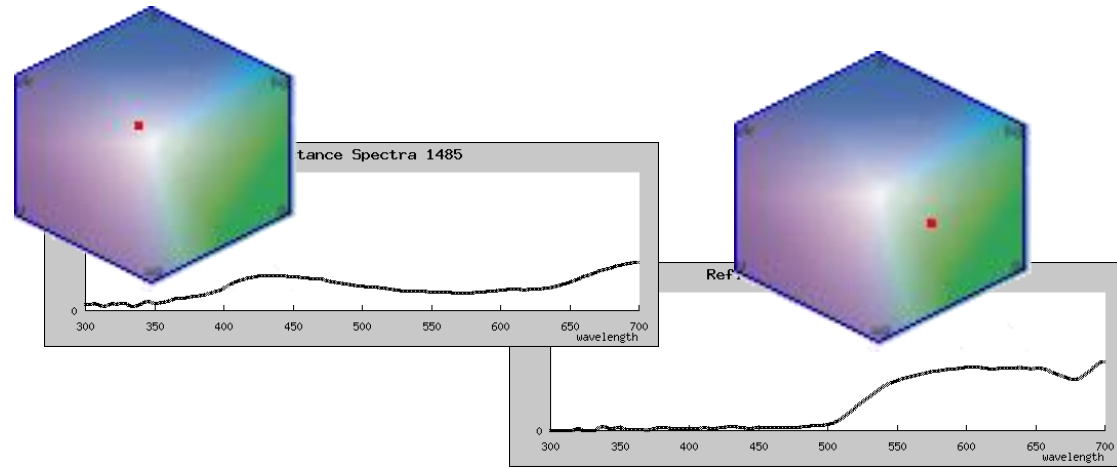
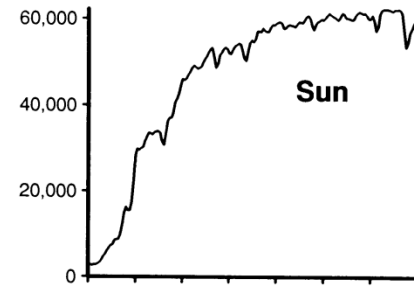
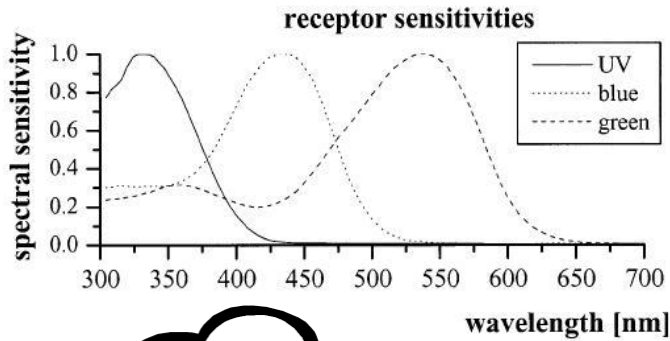
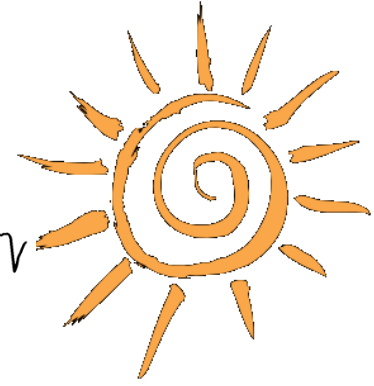
Training bees

- Bees can be trained to a flower species based on nectar reward:



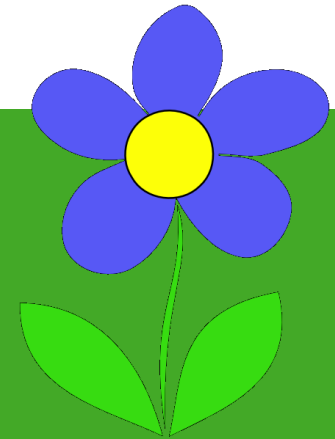
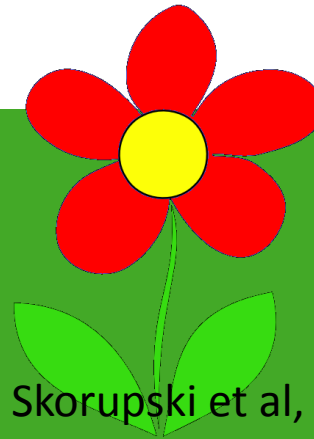
- However, flower species can only be distinguished based on some cue, like **colour**, **pattern** or **scent**
- **Bees are Flower Constant**

Bee Colour Vision



$$P = R \int_{300}^{700} I_s(\lambda) S(\lambda) D(\lambda) d\lambda$$

R = Adaptation to background



ticker 299	beeCropSize 50	hiveX 175	hiveY 175
numOfBees 1			
bee1_Nectar_Monitor avgNectar vs time (0 to 116)			
setFlowers	setup	go	flowRatePerTick 0.01
globalNectarQuantity 0.1	markDecay 8	detectionDistance 7	
flowerdist mathematica file	sensitivityfactor sensitivityfactor65	number of flower types random distribution numOfFlowerItems 364	flowerSaturation 22
numOffFlowerTypes 2	probability 94	fixStrategy 50	nectaramount 50
foragingStrategy nectar-avg			
f1386 49102	f1426 936	f1161 4172807	f2560 58841
f1403 4027			
v1386	v1426	v1161	v2560
v1403			

PATCHINESS = 0

Bee Agent

Flower

patch 163 155

watch-me

pxcor 163
pycor 155
pcolor 71
plabel ""
plabel-color 9.9
flowerid "1426"
isflowering? "1"
nectarquantity 0.5324907171582853
marked 0
occupied? 0

bee 1

watch-me

who 1
color 65
heading 169.86902492568447
xcor 178.80559522627604
ycor 134.08797505877973
shape "bee"
label ""
label-color 9.9
breed bees
hidden? false
size 1
pen-size 1
pen-mode "down"
issearching? 1
nectarcarryingamount 17.630000000000001
memory (patch 179 133)
foragespot agentset, 3 patches)
returning 0
found 0
prevflower "1426"

Command Center

```

observer: "finish creating flowers"
observer: "finish creating hive"
(bee 1): false
observer: "finish creating bee"
observer> watch bee 1
observer> inspect bee 1
observer: "finish creating environment"
observer: "finish creating flowers"
observer: "finish creating hive"
  
```

Experiment 1: Colour Choice Behaviour: Flowers

Vicia



Lythrum



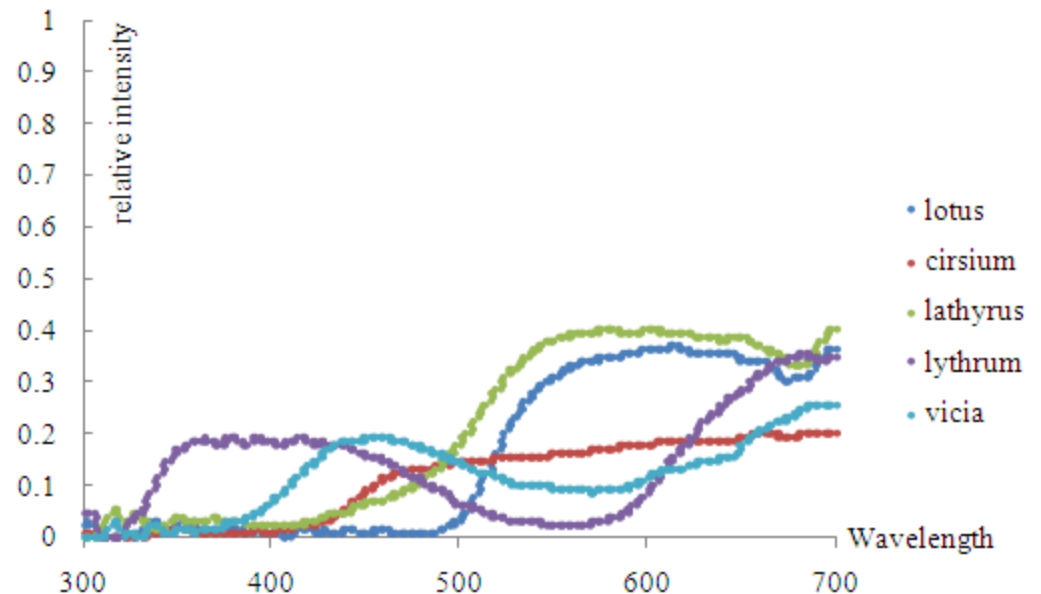
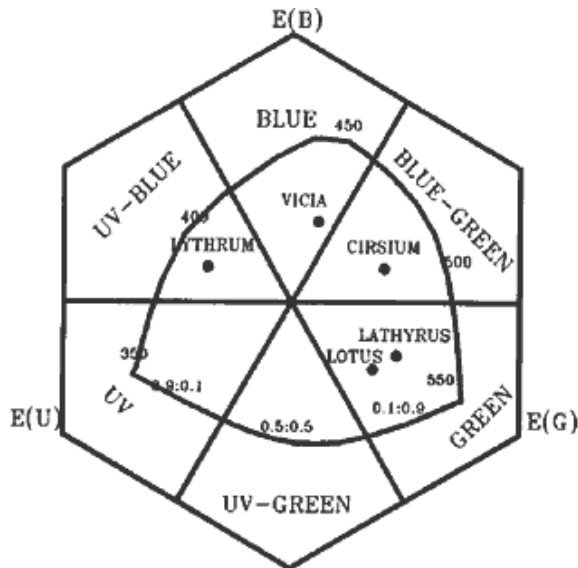
Cirsium



Lotus



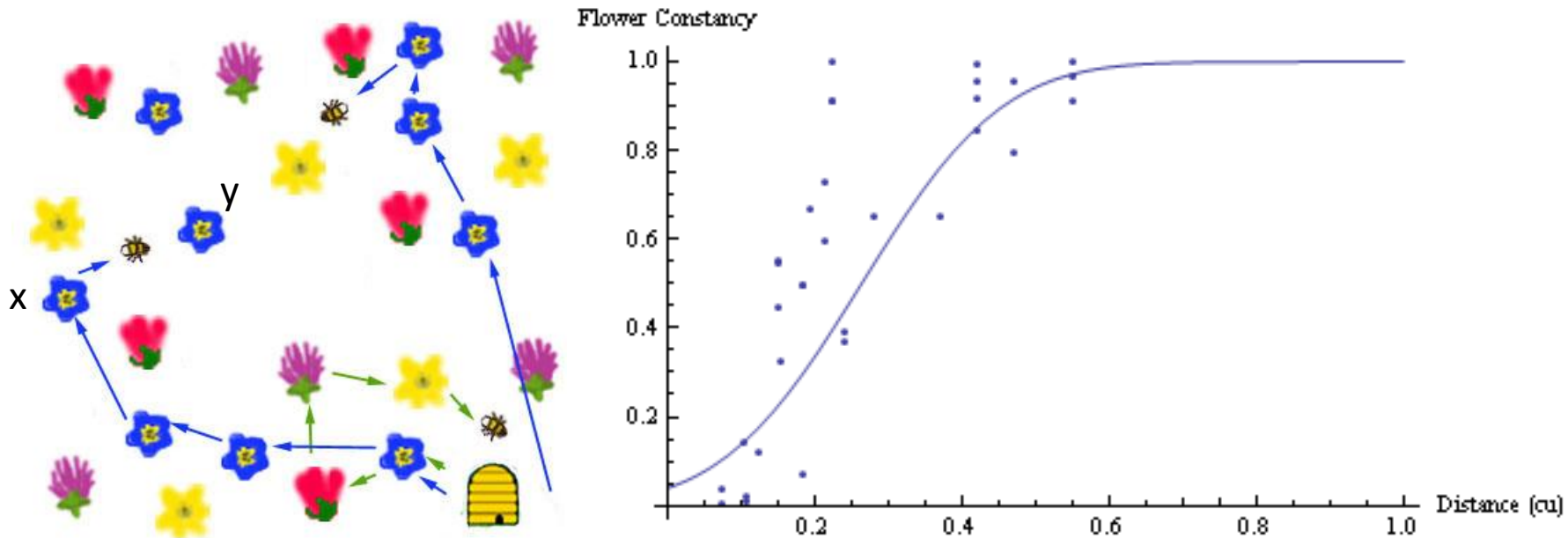
Lathyrus



Bee Colour Vision:

JND-Just noticeable difference

- Just Noticeable Differences can be seen on the colour space model:

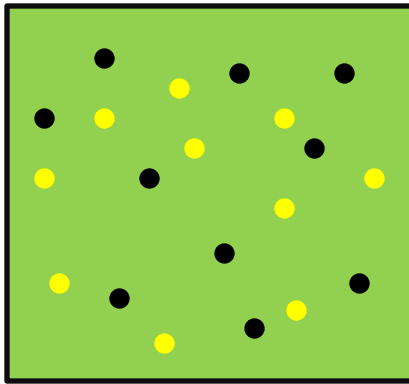


**15 flowering plants,
6 aphid bee species perception**

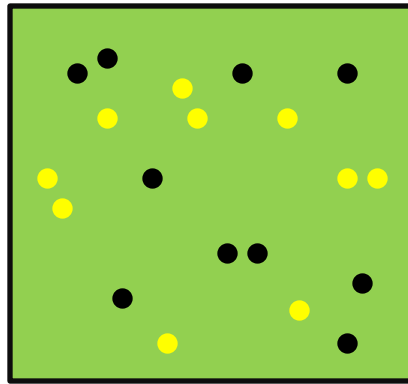
Adapted from Chittka et al, 2001

Experiment 1:

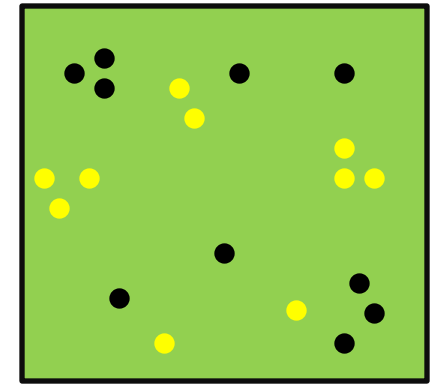
Colour Choice Behaviour: Patchiness



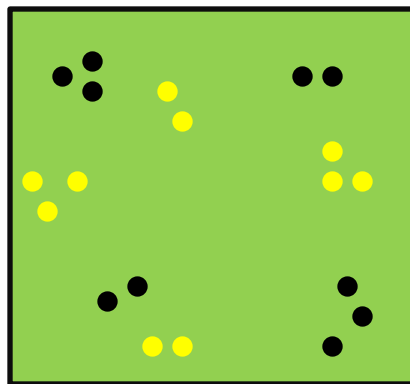
$P = 0$



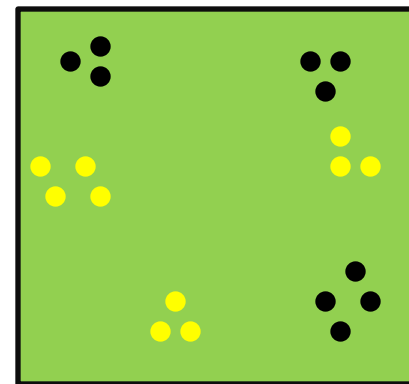
$P = 0.2$



$P = 0.4$



$P = 0.6$



$P = 0.8$

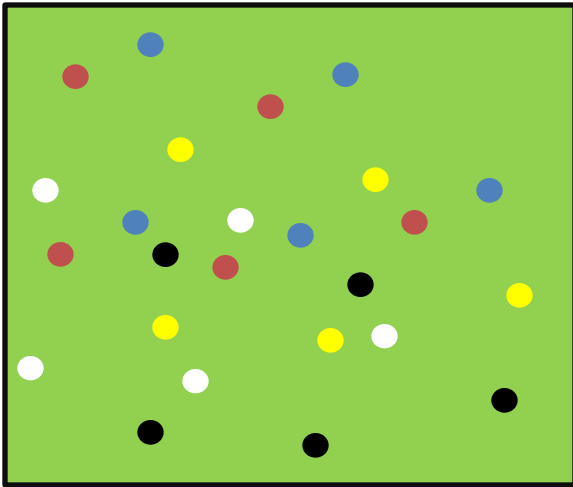
$P = \text{Patchiness}$

Modelling the Environment

measuring colour choice (1 of 3)

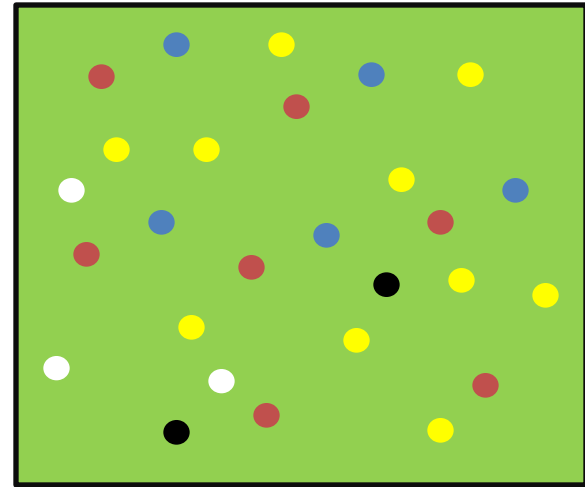
MEADOW P

5 species occur in the same frequency



MEADOW Q

5 species occur in the different frequency



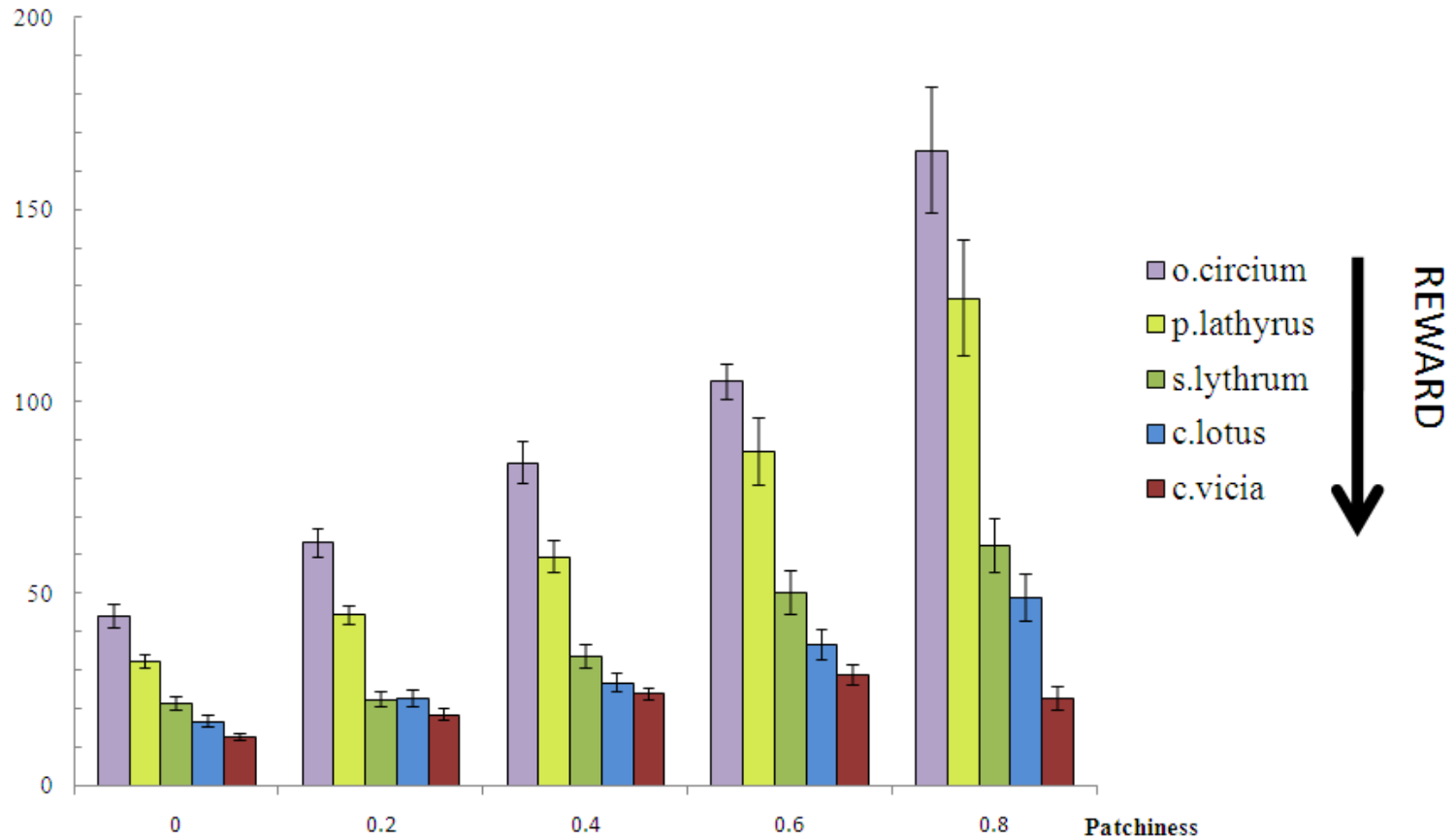
Is visitation to flower species based on if a flower species is
REWARDING or occurring FREQUENTLY?
(Or both?)

Modelling the Environment

measuring colour choice (2 of 3)

MEADOW P – Flowers occurring in the same frequency

Constant Flights

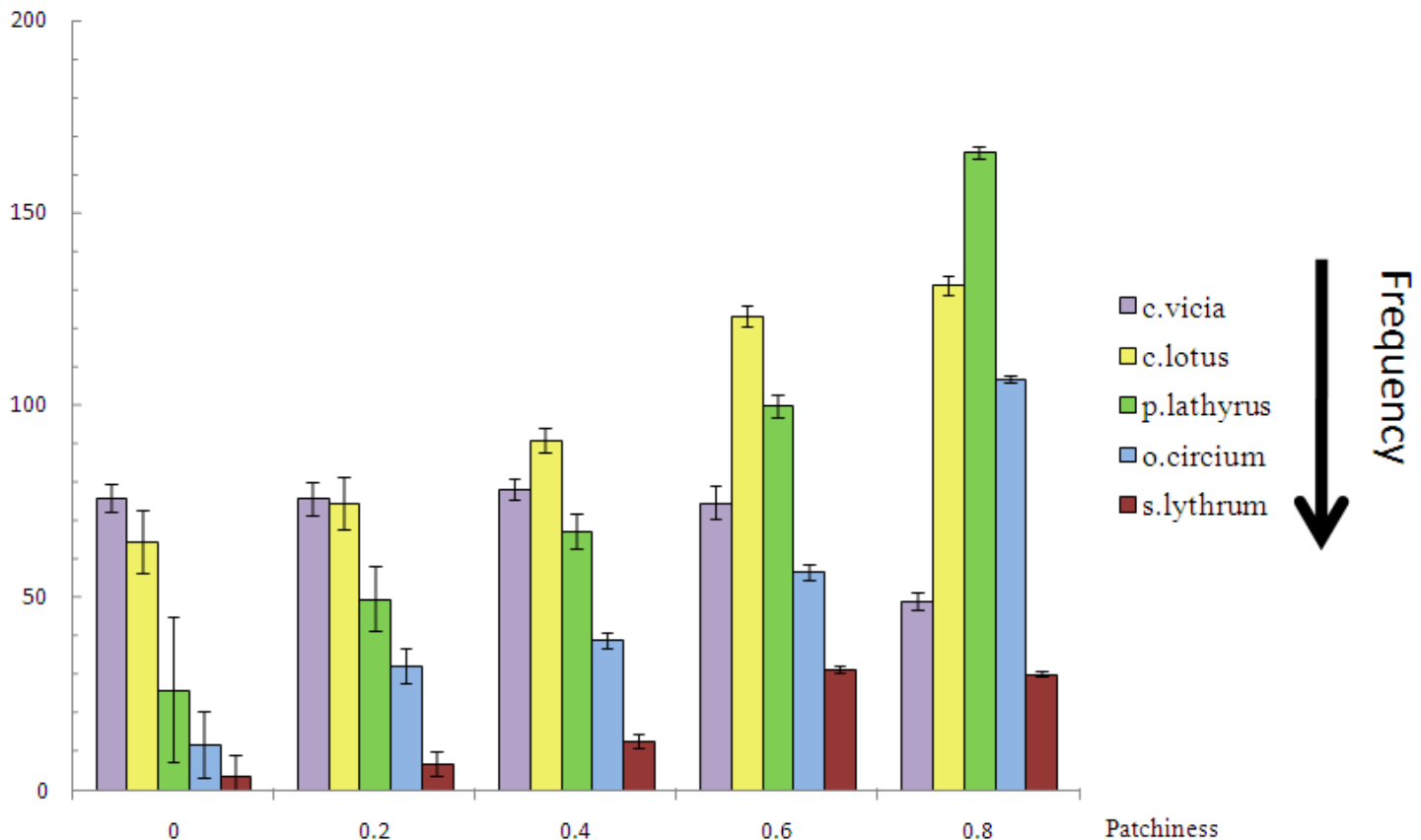


Modelling the Environment

measuring colour choice (3 of 3)

MEADOW Q – Flowers occurring in different frequencies

Constant Flights



Experiment 1: Summary

- Nectar Reward is a better incentive (than high frequency of the flower species) to visit the flower
- Patchiness encourages flower constancy
- Different flower distribution strategies can be established to optimise the mutual plant-pollinator interaction

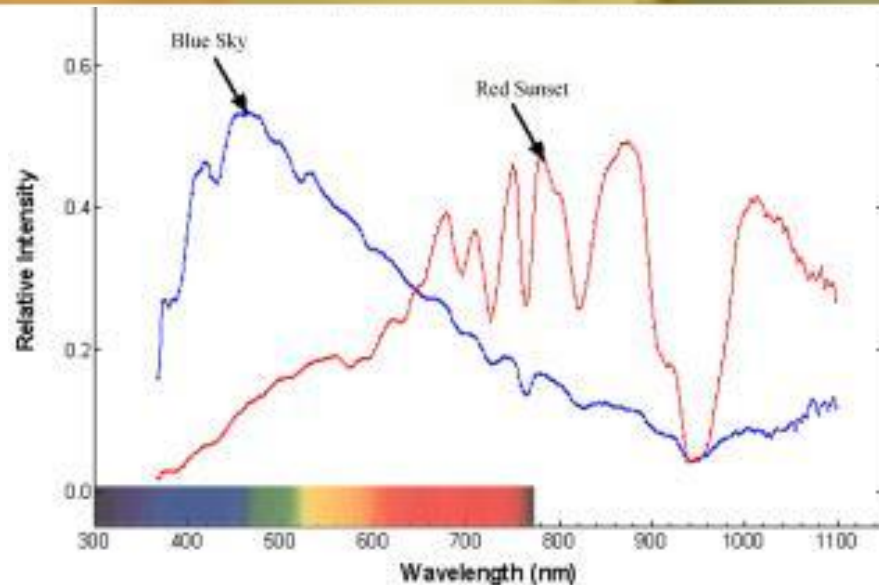
So, what affect does changing light have on colour perception?

Change in illumination

Different lighting conditions caused by weather or different times of day can change reflected object colour

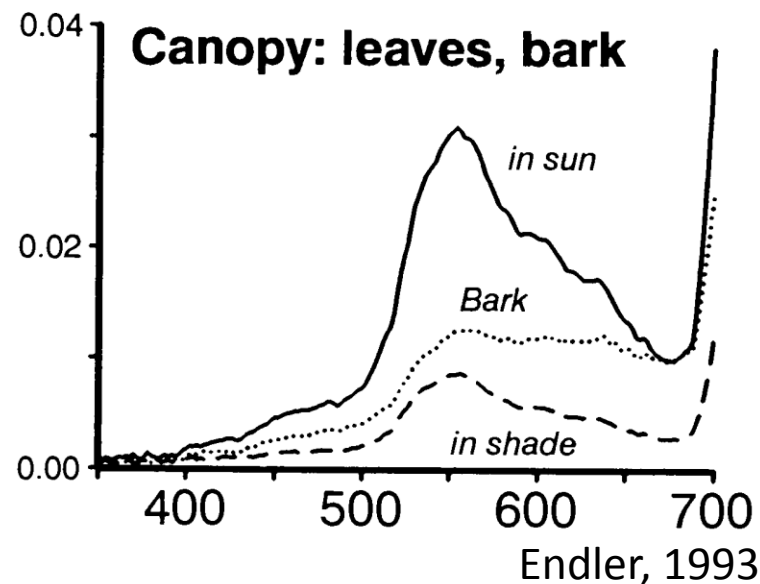


Banana
sample

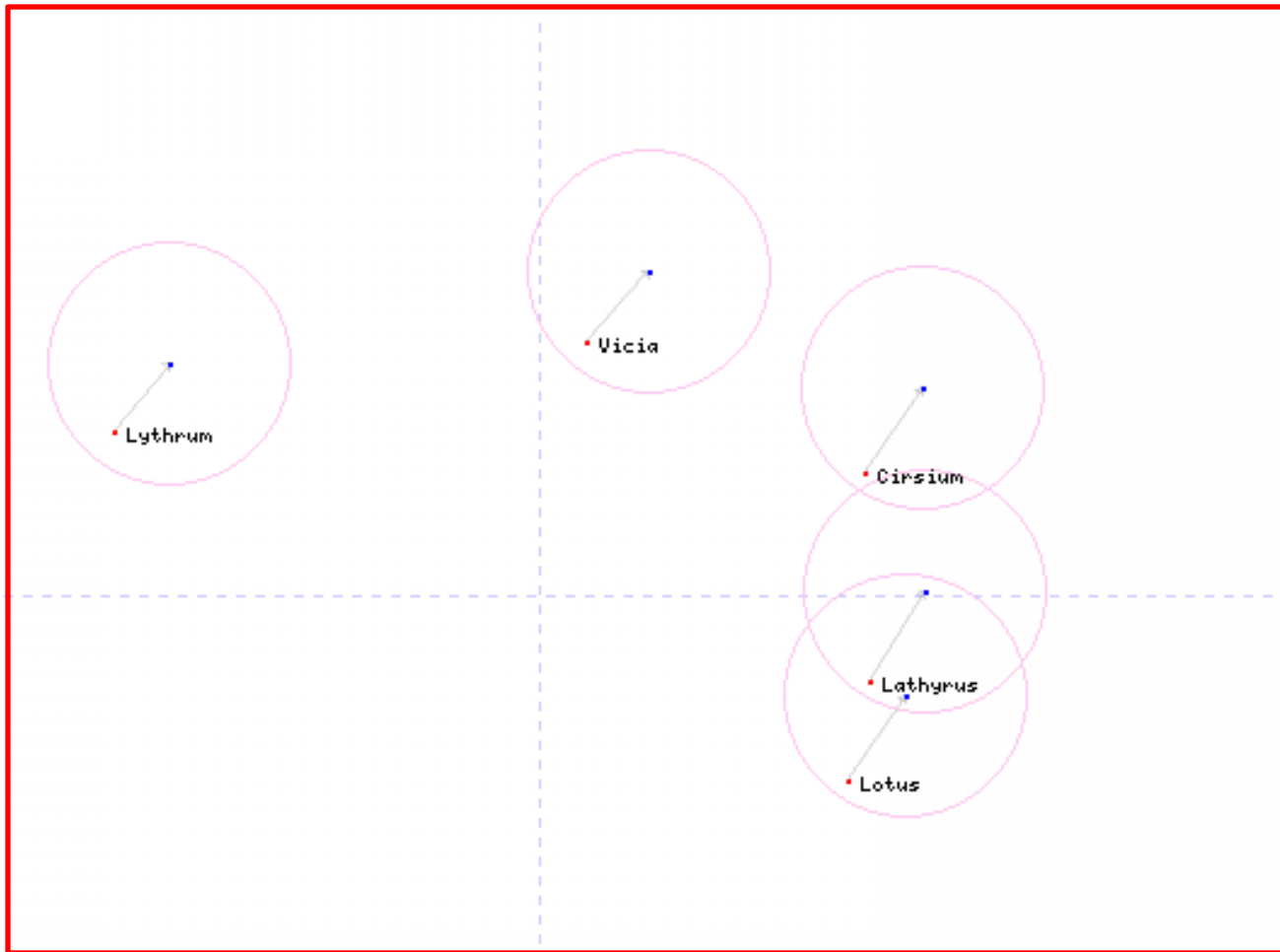


Change in Illumination: faced by honeybees (1-4)

- This would be a problem in honeybee colour vision **without COLOUR CONSTANCY**:
- What is the **severity** of the **errors** made by bees when light changes?

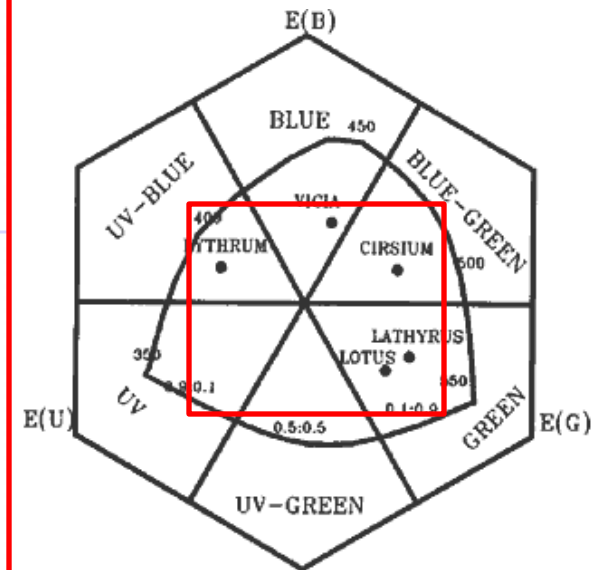


Change in Illumination: faced by honeybees (2-4)



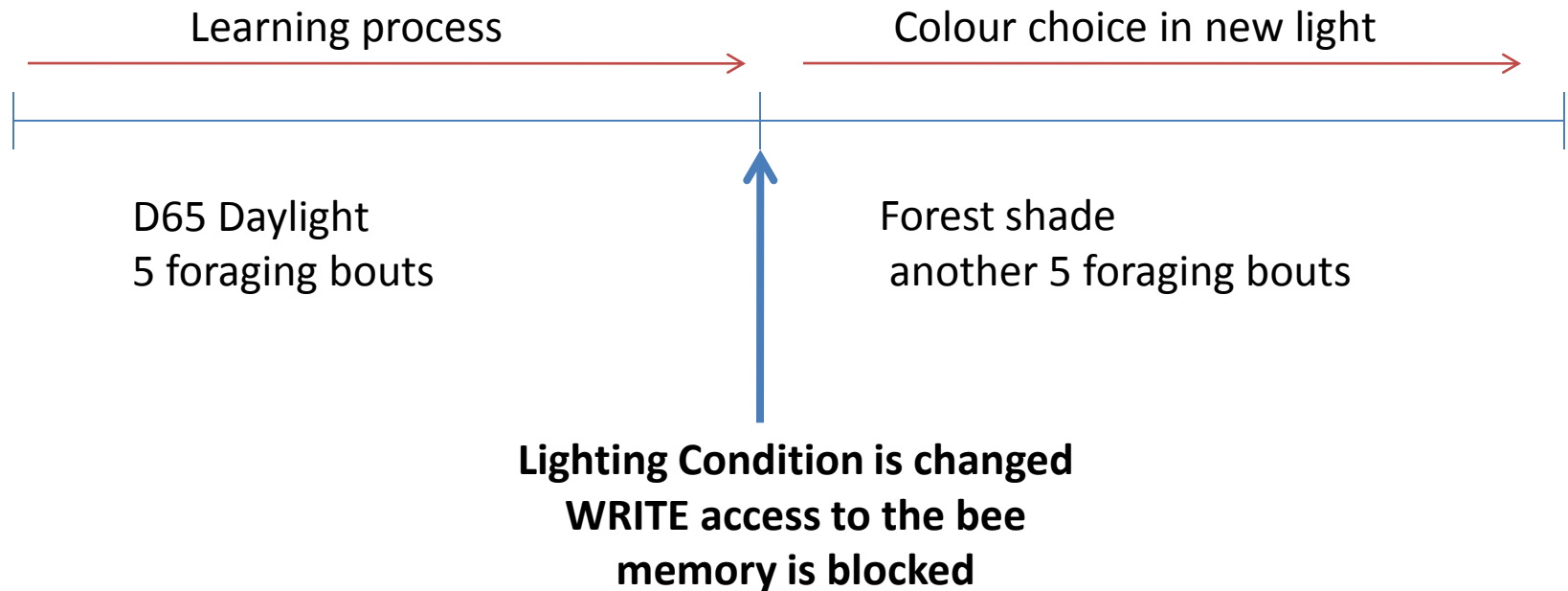
- Daylight (D65)
- Forest Shade

Circle = 0.1 radius



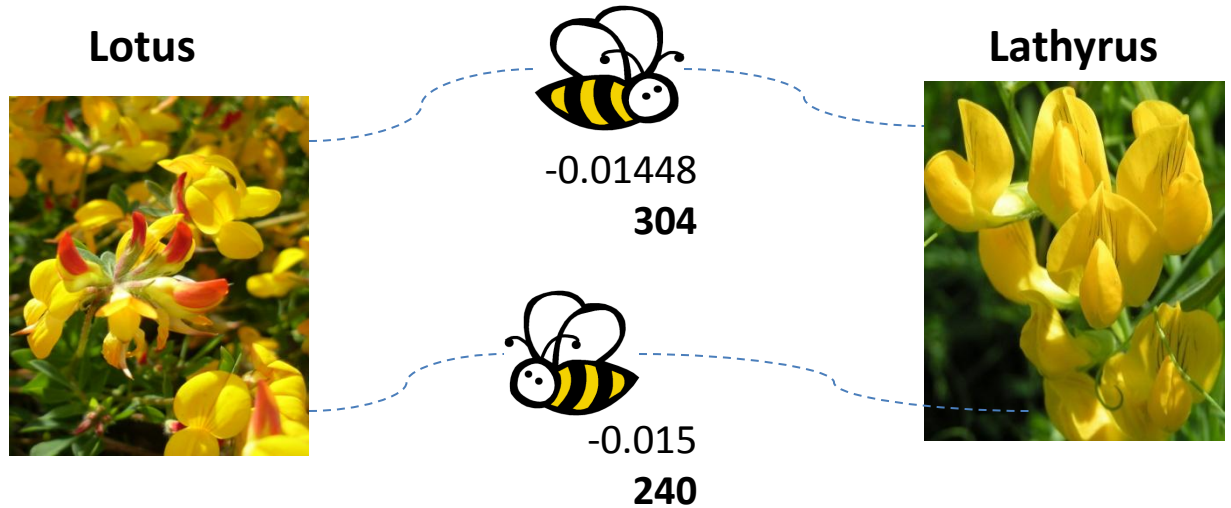
Change in Illumination: faced by honeybees (3-4)

- Training timeline (for 1 simulation run):

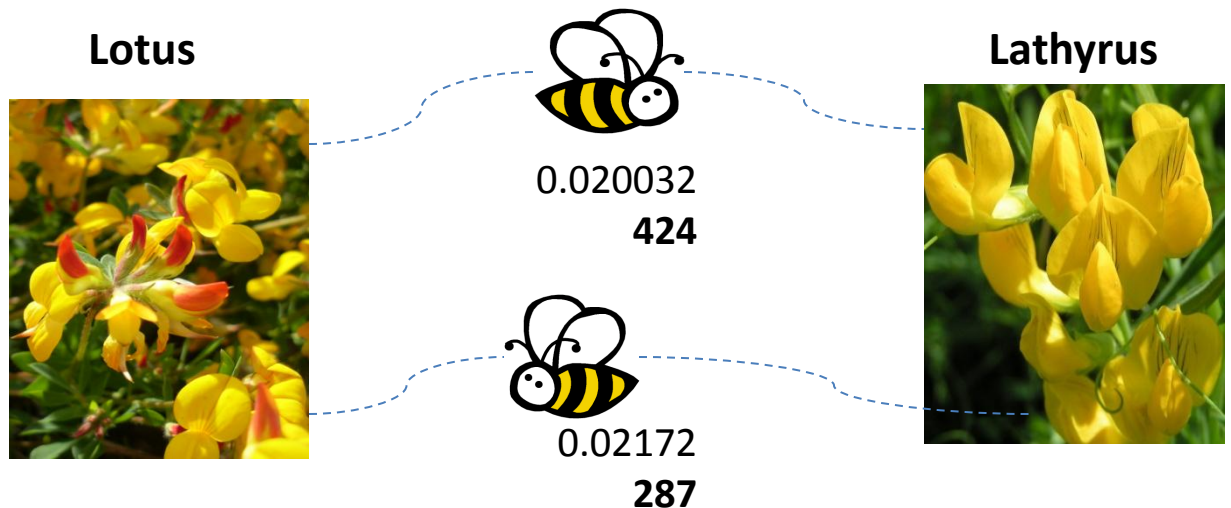


Change in Illumination: faced by honeybees (4-4)

D65 Daylight
Flower Constancy index



Forest Shade
Flower Constancy index



$P < 0.001$

Experiment 2: Summary

- Biological relevance of having flower constant bees and colour constancy
- Flower Constancy measurement only shows one side of the story – nectar influx?
- Only tested one lighting condition, showing shift and one divergence of colour

Conclusions (1-2)

- Bees and flowers have evolved in a mutual plant-pollinator relationship
- Bees visual system must have some colour constancy if it is to collect nectar efficiently
- We can measure costs when there is “no colour constancy”
- Modelling teaches us what is important: patchiness, reward/frequency of reward etc...

Conclusions (2-2)

“You don’t really understand it until you’ve built it” (words of Barbara Webb)



Thank you!

Questions?