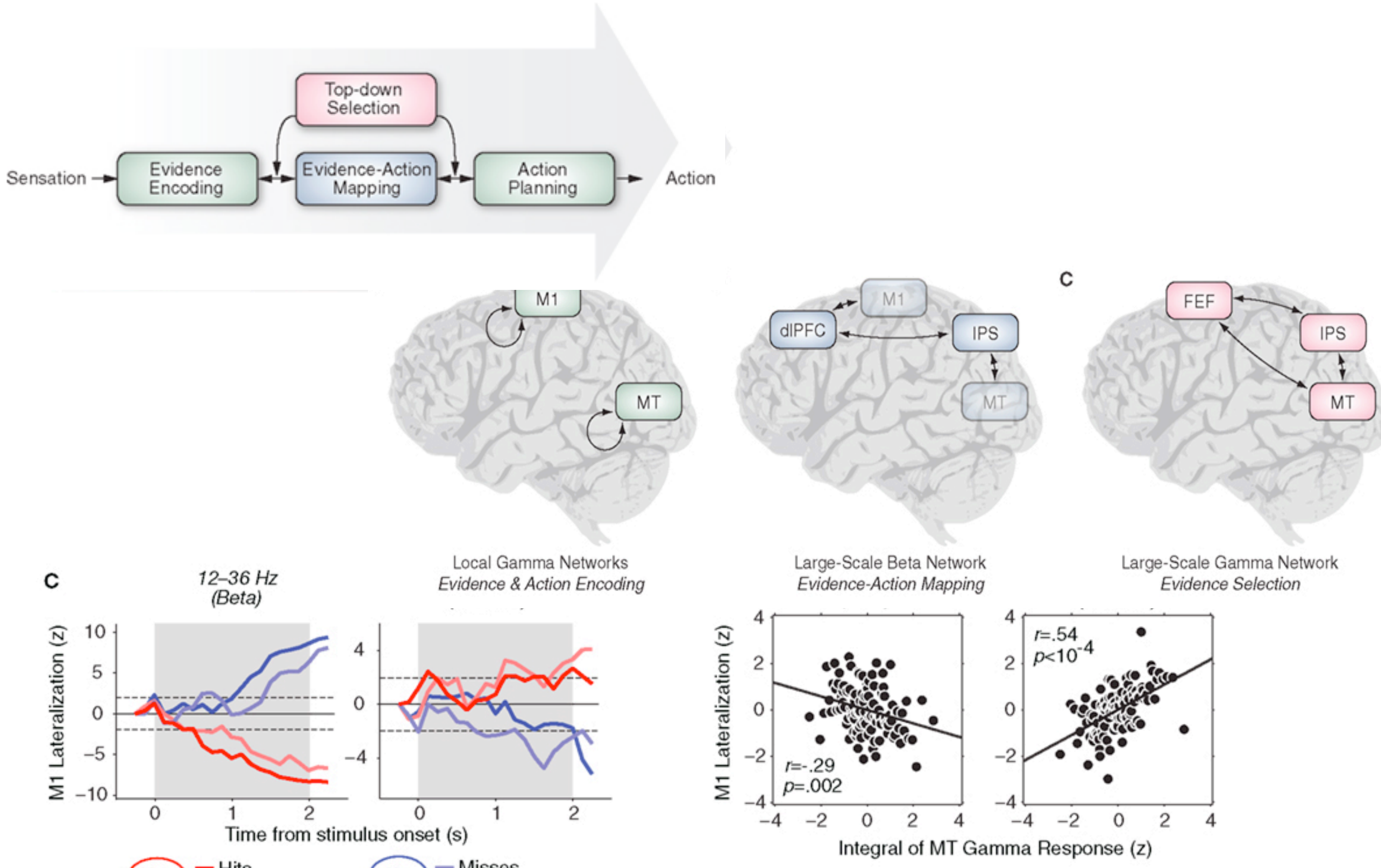
How your brain makes decisions

Motion discrimination

http://www.youtube.com/watch?v=hpvbZxDtXSY (1:40)



Siegel et al Frontiers in Human NeuroScience 5 (2011)

Usher-McClelland Model

Change in activation of a population of neurons
= input signal + noise – decay – inhibition from alternative population

$$\begin{cases} \dot{y}_1 = I_1 + c\eta_1 - y_1 k - y_2 w, \\ \dot{y}_2 = I_2 + c\eta_2 - y_2 k - y_1 w, \end{cases} \quad (4.1)$$

where y_i is the activity of population i; $\dot{y}_1$ is the change in that activity over time; I_i is the strength of the input signal for alternative i; $c\eta_i$ is the noise in that input signal described as a Wiener process with mean zero and standard deviation proportional to c; w is the rate at which one population inhibits the activation of the other; and k is the rate at which a population's activation level decays. The decision is made by the model if the activity of either of the populations reaches a threshold value.

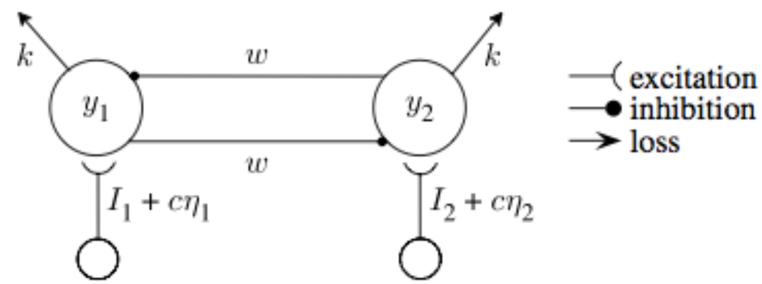


Figure 2. In the Usher–McClelland model of decision-making in the primate visual cortex, neural populations represent accumulated evidence for each of the alternatives. These populations y_1 and y_2 integrate noisy inputs I_1 and I_2, but leak accumulated evidence at rate k. Each population also inhibits the other in proportion to its own activation level, at rate w. When $w = k$ and both are large, the Usher–McClelland model reduces to the diffusion model of decision-making (figure 3).

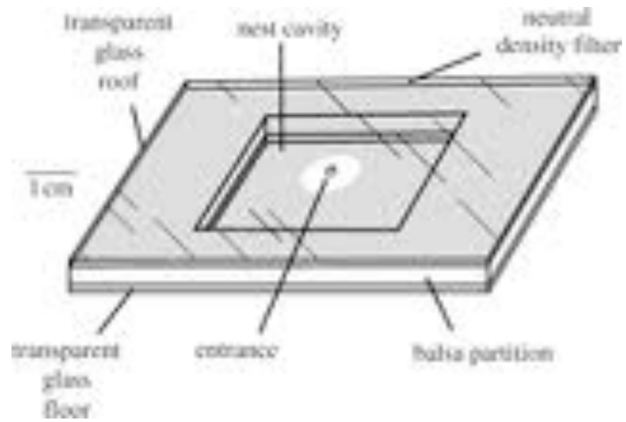
Eqn 4.2 transforms Eqn 4.1 to decouple the Eqns
and show the UM model approximates diffusion model & optimal decision making
when w = k & both are large

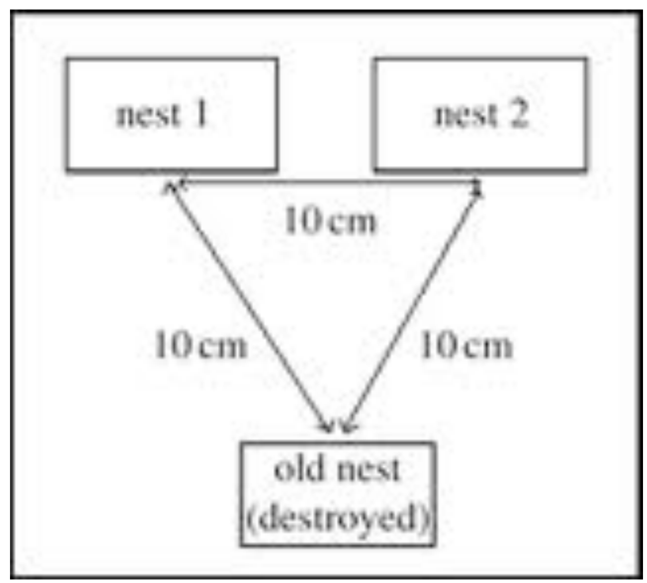
- Write 5 integers between 1 & 10 in Column 1
  repeats are OK
- Write 5 integers between -2 and 2 in Column 2
  repeats are OK

How ants choose a new nest site

Destroy old nest

Watch ants choose new nest





How ants choose a new nest site

http://www.youtube.com/watch?v=X2C7Sy2oPik

(Tandem run of different ants to food)

Tandem Run
(Assessment)

Tandem Carry (committed)

Bee decision-making model

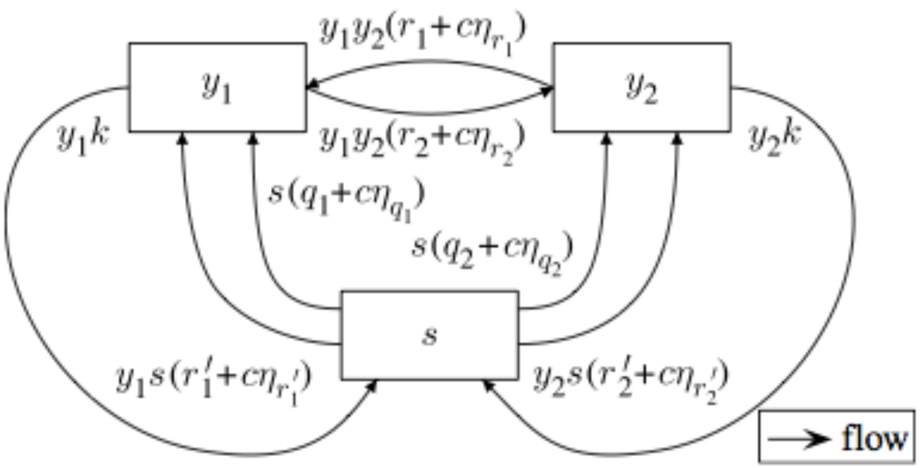


Figure 4. In the direct-switching model of decision-making during emigration by the honeybee *A. mellifera*, populations of scouts y_1 and y_2 discover two alternative potential sites and compete with each other to recruit uncommitted scouts s and scouts committed to the other alternative. If there is no decay from commitment ($k=0$), then once all scouts are committed to one alternative or the other subsequent decision-making is exactly equivalent to the statistically optimal diffusion model of decision-making (based on a model by Britton *et al.* (2002)).

Ants: no direct switching

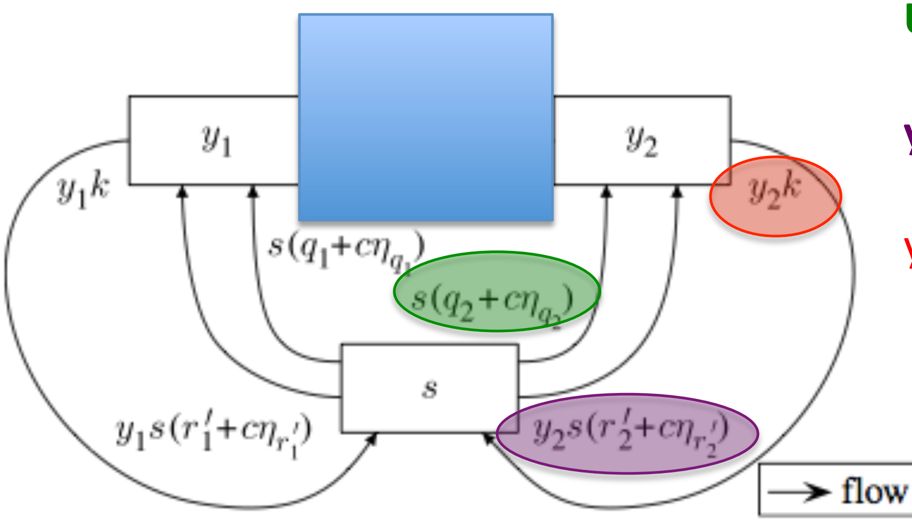


Figure 4. In the direct-switching model of decision-making during emigration by the honeybee *A. mellifera*, populations of scouts y_1 and y_2 discover two alternative potential sites and compete with each other to recruit uncommitted scouts s and scouts committed to the other alternative. If there is no decay from commitment ($k=0$), then once all scouts are committed to one alternative or the other subsequent decision-making is exactly equivalent to the statistically optimal diffusion model of decision-making (based on a model by Britton *et al.* (2002)).

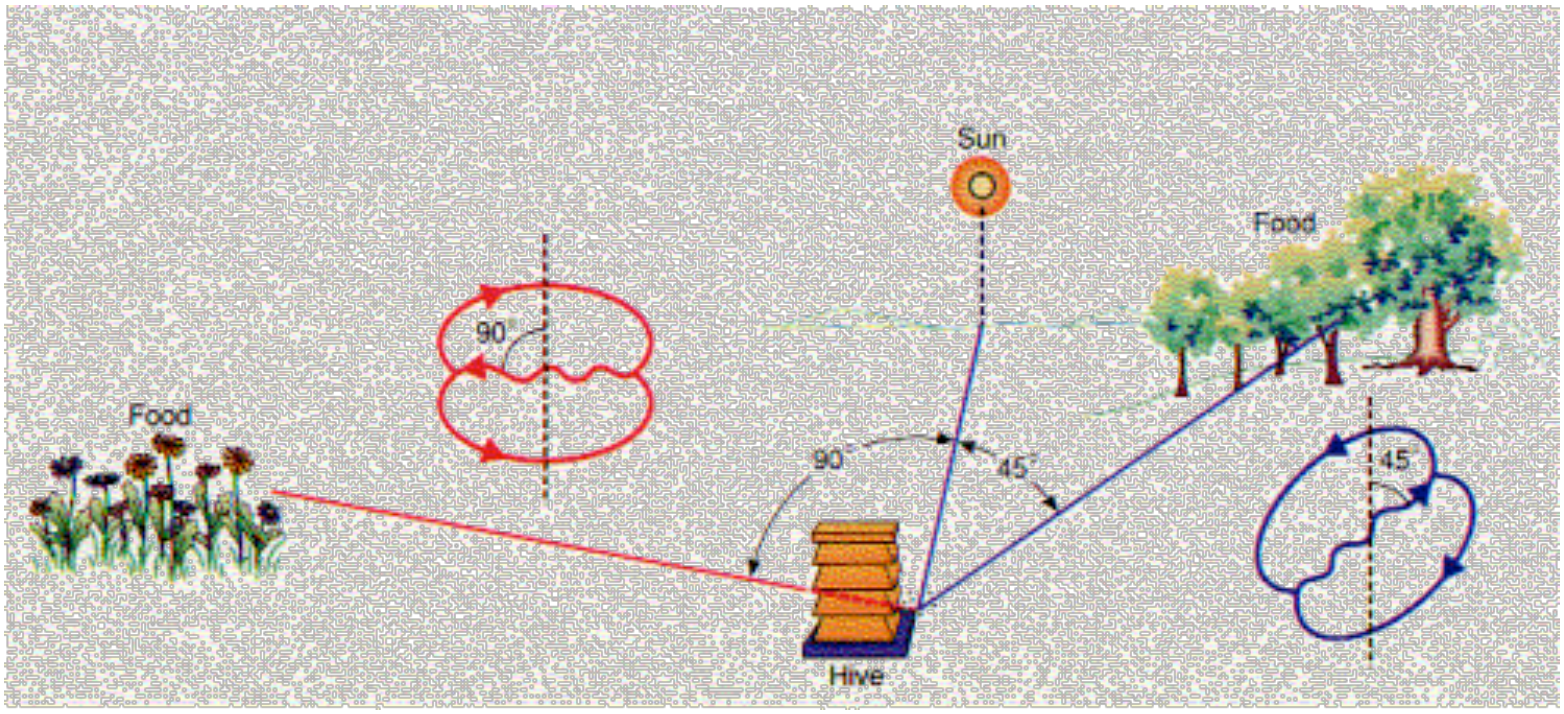
Undecided Scouts choose y2

y2 committed scouts recruit new scouts

y2 scouts decay from y2

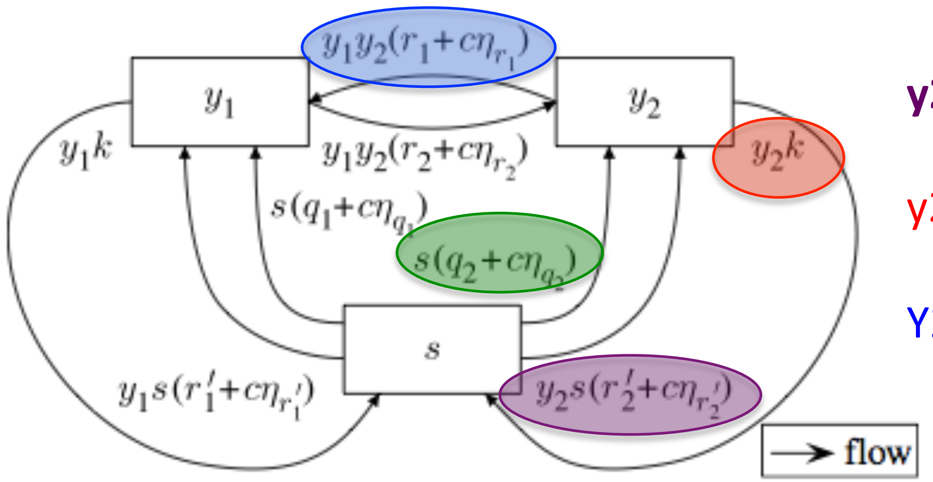
How bees choose a new hive: the waggle dance

http://www.youtube.com/watch?v=-7ijI-g4jHg



http://users.rcn.com/jkimball.ma.ultranet/BiologyPages/B/BeeDances.html

Bee decision-making model



Undecided Scouts choose y2

y2 committed scouts recruit new scouts

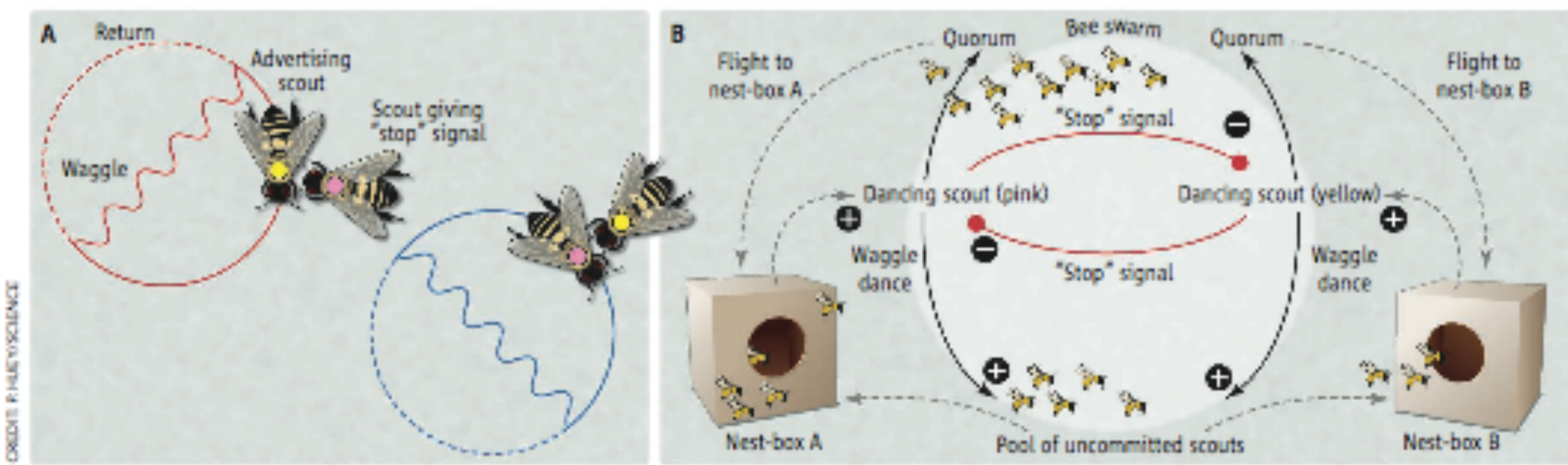
y2 scouts decay from y2

Y2 scouts directly switch to y1

Figure 4. In the direct-switching model of decision-making during emigration by the honeybee *A. mellifera*, populations of scouts y_1 and y_2 discover two alternative potential sites and compete with each other to recruit uncommitted scouts s and scouts committed to the other alternative. If there is no decay from commitment ($k=0$), then once all scouts are committed to one alternative or the other subsequent decision-making is exactly equivalent to the statistically optimal diffusion model of decision-making (based on a model by Britton *et al.* (2002)).

Stop Dancing!

- http://www.youtube.com/watch?v=n4ogqyi2WIg
- Dance duration indicates ‘distance’
  - Bees measure distance by the flicker of images—as more images are seen, dances are repeated faster
- Search 7 km in every direction (150 km^2)



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Information
gathering, evaluation, deliberation, consensus, choice, implementation

- Bees commit all at once; waggle dances are broadcast in a crowded hive (only a few see it at at time)

- Ants go one at a time with no opportunity (usually) to assess multiple nests; commit based on a quorum at one nest site

- How ants assess nest size:
- Ant lays a trail; leaves, returns, counts number of times it crosses its trail

- Ants show preferences, consistent rankings, transitivity, weighing of all attributes
- Ants se a 'weighted additive Strategy' prefer bright, thick and narrow over dark thin and wide (with constant area) even though dark is most important

- Pratt showed quorum sensing ---switch from tandem running to carrying (full commitment) once a (changeable) threshold # of ants have chosen to stay in a nest

The ant has made himself illustrious
Through constant industry industrious.
So what?
Would you be calm and placid
If you were full of formic acid?
by Ogen Nash

In an emergency, ants release Formic acid & make fast, more error prone decisions

Wednesday March 20

- Read Mitchell Chapter 12
- Midterm Review

Monday March 25

- Midterm