




### Tracking a Changing Environment


**When to track change?**

Use the process of learning to sample and track changes

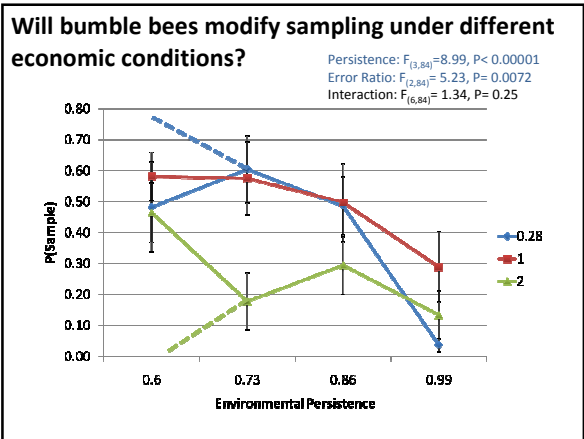
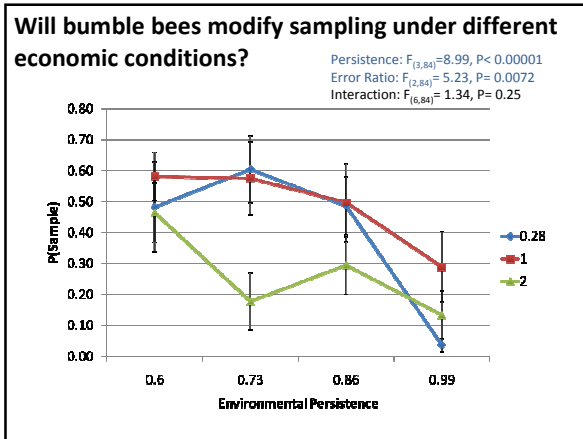
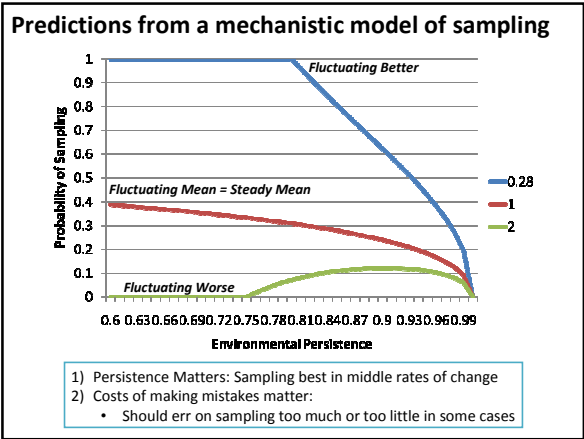
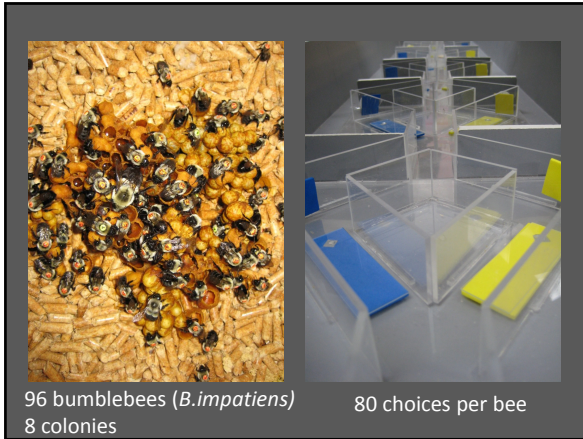


**When to not track?**

Use flower constancy to stick with one flower type  
Or simply choose randomly



- ❖ Rate of change in the environment
- ❖ Relative costs and benefits of the available choices



## Not tracking, but constancy of choice...

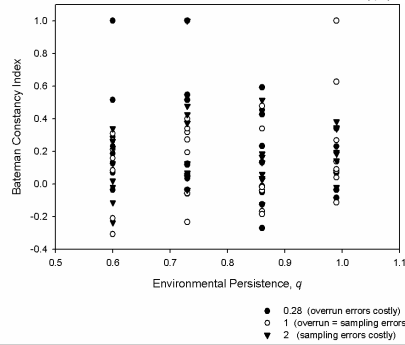


In a world of possibilities, why stick with only one option?

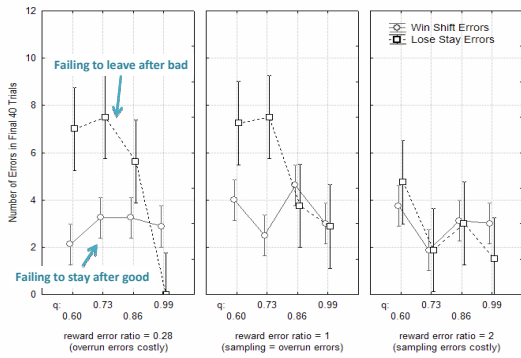
Darwin's interference hypothesis:  
 costs to switching (cognitive and handling time)  
 Limits to search images  
 Limits to working (short-term) memory  
 Trait variability hypothesis  
 Costly Information Hypothesis

## Our economic conditions have no discernable effect on constancy of choice

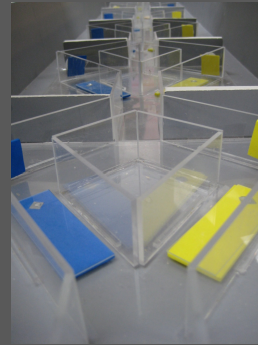
Persistence:  $F_{(3,84)} = 1.08, P = 0.361$   
 Error Ratio:  $F_{(2,84)} = 0.41, P = 0.959$   
 Interaction:  $F_{(6,84)} = 1.13, P = 0.351$



## Economic conditions do affect how quickly bees give up on a crummy resource...



## Bees respond to changing economics in a dynamic way: variability matters and reward structure matters



- Bees learn about global rates of change
- Bees use sampling and not constancy to adjust to these changes
- Bees acquire new information but don't always use it in tracking change
- Bees also adjust the types of errors they make, and when they will "ride out runs of bad luck."

Information you are born with

Information gained from experience

Information from others

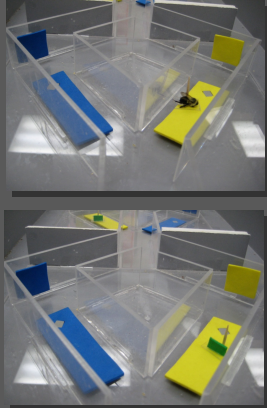
## Social Information

### Predicted to:

- Reduce sampling rates
- Allow better tracking

### Predicted to be used:

- When you are naïve
- When you are uncertain

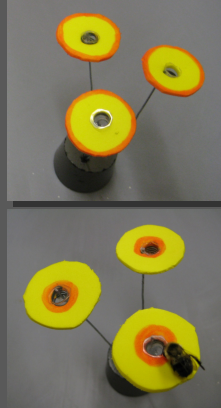


**Sampling Experiment**

- Social Cue
- Non-social Cue
- No cue

**No effects of information type on:**

- Sampling events
- Overall tracking ( $P=0.9978$ )



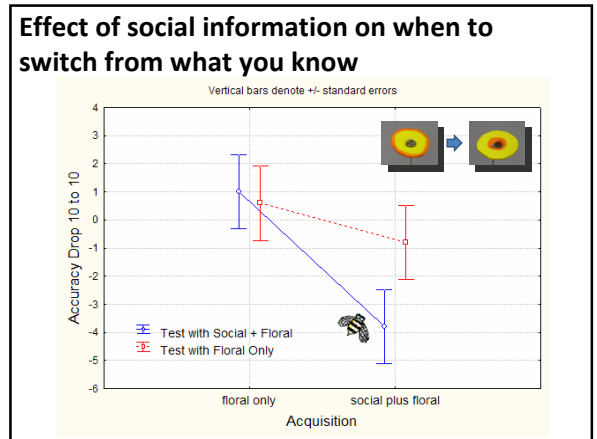
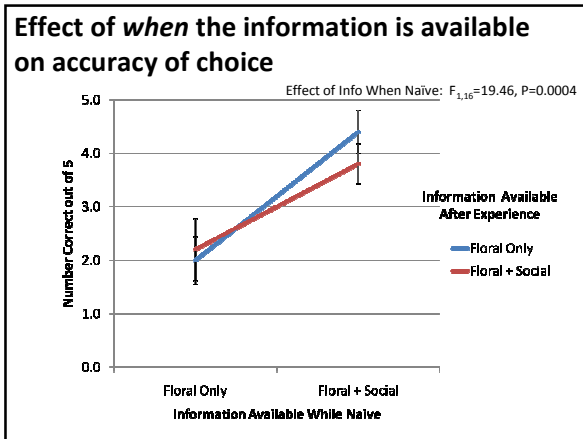

**When to Use Social Information**

*Social information is more useful when you are naive*

- Bees can forage with:
  - Flowers only
  - Flowers plus social information

**Naïve Bees:** information while gaining experience

**After Experience:** information while assessing learning from before

**Social Information**

**Predicted to:**

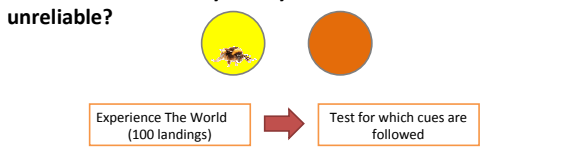
- Reduce sampling rates
- Allow better tracking

**Predicted to be used:**

- When you are naïve
- When you are uncertain

**Effects of Certainty**


How “special” is social information?  
What information do you rely on when the world is unreliable?



Floral Cue Reliability

	50%	83%	100%
50%			
85%			
100%			

Social Cue Reliability

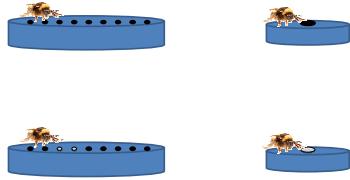




## Effects of Competition

### Physical competition

#### Competition effects on the reliability of resources



Bumble bees learn about change, and are plastic in how they respond to that change with sampling and tracking.

How should animals integrate and use different sources of information to better track change?

Information gained from experience

Information from others

Information you are born with



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