Lecture 8b: CULTURE IN INSECTS
Applying this mechanistic definition to a given animal model

By testing the 4 + 1 criteria in that system
Criterion 1

SOCIAL LEARNING
SOCIAL TRANSMISSION
AMONG INDIVIDUAL ANIMALS
One live **Demonstration** of one female choosing between **1 green** and **1 pink** males

- **Demonstrator female** $F_d$
- **Observer female**
- **Glass partition** (Transparent or opaque)

**1 green** & **1 pink** male

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Mery et al. 2009 *Current Biology*; Dagaeff et al. 2016 *Anim Behav*
After seeing a demonstration for one colour, observer females showed a bias for males of the colour that was selected during the demonstration. The results were replicated many times:

- Mery et al. 2009 *Curr Biol*
- Dagaeff et al. 2016 *Anim Behav*
- Danchin et al. 2018 *Science*
Criterion 1

SociAL LEARNING
SociAL TRANSMISSION
AMONG INDIVIDUAL ANIMALS
Criterion 2

ACROSS AGE-CLASSES
TRANSMISSION

ONLY INFORMATION THAT IS TRANSMITTED ACROSS AGE-CLASSES CAN Evolve
A female of age $x$

- Younger
  - Younger
    - Younger
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1 generation

1 generation

$D. melanogaster$
Design

**Horizontal**

Demonstrator female (3-day)

Larval development: 11 days

Observer female (3-day)

Across age-classes

Demonstrator female (14-day)
Across age-classes

$P = 0.025$

Type of transmission

Mate-copying index

Horizontal

3-Day teach

3-Day

65
Across age-classes

Transmission also works across-age-classes => information can persist

Danchin et al. 2018. Science

\[
P = 0.807
\]

\[
P = 0.025
\]

\[
P = 0.011
\]
Criterion 2

ACROSS AGE-CLASSES

TRANSMISSION

ONLY INFORMATION THAT IS TRANSMITTED ACROSS AGE-CLASSES CAN Evolve
Criterion 3

LONG LASTING SOCIAL EFFECTS

WE ONLY TRANSMIT HABITS TO WHICH WE STICK
=> Flies do build long-term memory (24h and above)

implying *de novo* protein synthesis

=> memorized for a long time
Criterion 3

LONG LASTING SOCIAL EFFECTS
WE ONLY TRANSMIT HABITS TO WHICH WE STICK
Criterion 4

trait-based copying

only trait-based preferences can be transmitted
Drosophila females do not only learn to prefer a given male over another male but learn to

“Prefer any male of a given color phenotype”
Criterion 4

**Trait-Based Copying**

Only trait-based preferences can be transmitted.
Drosophila social learning meets the 4 criteria that had been claimed important

Is it enough to create and maintain cultural traditions?

- The main marker of culture,
- and main approach to study animal culture

Danchin et al. 2018. Science
Model of a **transmission chain** in which learners of step $t$ become demonstrators of step $t+1$.

- => 4 criteria: **NO traditions emerge**

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**Graph: 100,000 transmission steps, 100 observer females, MCI = 0.68**

- Matings with Pink
- 50%

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Danchin et al. 2018. Science
Social learning is not perfect (at best 80% learn)
  - which should strongly hamper the emergence of a collective preference

Except if females are **conformist**: Behave as the majority

Prefer Green
Adding conformity => Long periods of preferring one color (traditions). Up to 20,000 transmission steps.

Is it the case that Drosophilas’ social-learning is conformist?

Danchin et al. 2018. Science
Criterion 5

ANIMALS LEARN CONFORMISTICALLY

CONFORMITY FACILITATES CULTURAL TRANSMISSION
**Demonstrations**
*(9 Possibilities)*

- **0G, 6P** 100%
- **1G, 5P** 83%
- **2G, 4P** 67%
- **2G, 3P** 60%
- **3G, 3P** -------  Control
- **3G, 2P** 60%
- **4G, 2P** 67%
- **5G, 1P** 83%
- **6G, 0P** 100%

**Majority**

- 100%
- 83%
- 67%
- 60%

**More Pink**

**More Green**

**All Green demonstrations**
Majority: 100% 83% 67% 60% 60% 67% 83% 100%

Danchin et al. 2018. Science
Majority: 100% 83% 67% 60% — 60% 67% 83% 100%

Danchin et al. 2018. Science
Majority: 100%  83%  67%  60%  60%  67%  83%  100%

Danchin et al. 2018. Science
Majority: 100%  83%  67%  60%  60%  67%  83%  100%

Danchin et al. 2018. Science
Proportion of matings with pink males

Majority: 100% 83% 67% 60% 60% 67% 83% 100%
Majority: 100% 83% 67% 60% 60% 67% 83% 100%

Danchin et al. 2018. Science
Majority: 100%  83%  67%  60%  60%  67%  83%  100%  
Danchin et al. 2018. Science
Females learned to prefer the most commonly chosen male phenotype equally well, independently from the level of majority (down to 60%).

Danchin et al. 2018. Science
Criterion 5

ANIMALS LEARN
CONFORMISTICALLY
CONFORMITY CORRECTS
TRANSMISSION ERRORS
6- Traditions?

CAN DOCUMENTED COGNITION FOSTER TRADITIONS?
PERSISTENCE IN A TRANSMISSION CHAIN EXPERIMENT
Transmission chain

- Transmission chain in which learners of step $t$ become the demonstrators of step $t+1$
- Starts with 100% for one color. Then Free choice
- Stops when gets to 50% or less
- 36 such trials

Step $t$  

Teachers  

Learners  

Step $t+1$  

Free choice
Number of chains that persisted

Step in the transmission chain

36 transmission chains

Step by step comparisons

Ratio of observed to random

Danchin et al. 2018. Science
Chains lasted much longer than expected by chance

Model validated

Danchin et al. 2018. Science
long-lasting traditions

Traditions up to 25,000 transmission steps
~ 2000 generations

Traditions for Pink

Traditions for Green

MCI=0.68

Danchin et al. 2018. Science
- With 150 observer flies

- 100,000 days: > 274 years i.e. >9,000 generations

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Single tradition for Pink lasting quasi forever

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100,000 transmission steps, 150 observer females, MCI=0.68+Conformity
Drosophila melanogaster females have all the cognitive capacities to transfer their mating preferences culturally, potentially creating long lasting local traditions of preferring a given male phenotype => speciation

Considerably expands the taxonomic range of cultural processes: incorporates invertebrates
General conclusion
The part of phenotypic variation inherited through:

1) a form of social learning
2) occurs across age classes,
3) memorized for sufficient time to be copied,
4) trait-based copying (not individual-based),
5) incorporates repair/reinforcement mechanisms (conformity, punishment, digitalisation) correcting for learning imperfections,
6) five conditions collectively leading to long-lasting local traditions, the most striking marker of culture.

Mechanistic definition

= An ‘experimental toolbox’ transposable to many organisms

& Connected to previous definitions
Current insect examples => Insects **CAN transmit behavior culturally**, but **Not that they actually DO SO** in nature.

- Such evidence is still lacking in insects.
- In vertebrates, although we know that persistent traditions exist in nature, usually we only have suspicion that these are produced by social learning.
- While in insect we have better knowledge on transmission mechanisms.
- These taxa are thus complementary.
Challenges for the future

- Run **experiments** on animal culture
- The only way to study **mechanisms/causality**
- Apply these to **many species**
- Seek **evidence for insect culture in nature**
- Integrate **culture** into **biology**
Cited references

- Danchin & Wagner 2010. Inclusive heritability: combining genetic and nongenetic information to study animal behavior and culture. *Oikos*.
- Plus references therein
Live demonstration of a F choosing between M and M => no control on demonstration

=> Transfer copulating pairs of the desired color + Male of the other color
Chapters 4 and 20