

$$2 * \frac{1}{2} > 1 ?$$

Evolution and function of brain & behavioural lateralisation

1. Plasticity of lateralisation

Bernd Riedstra & Ton Groothuis

Behavioural biology

University of Groningen

Jessica Lust, Reint Geuze & Anke

Bouma

Neuropsychology

University of Groningen

Brain & behavioural lateralisation

1) Functions are specialised in one hemisphere

Loss of language is associated with damage to the left hemisphere



Language is a faculty located in the left hemisphere

Observations on patients

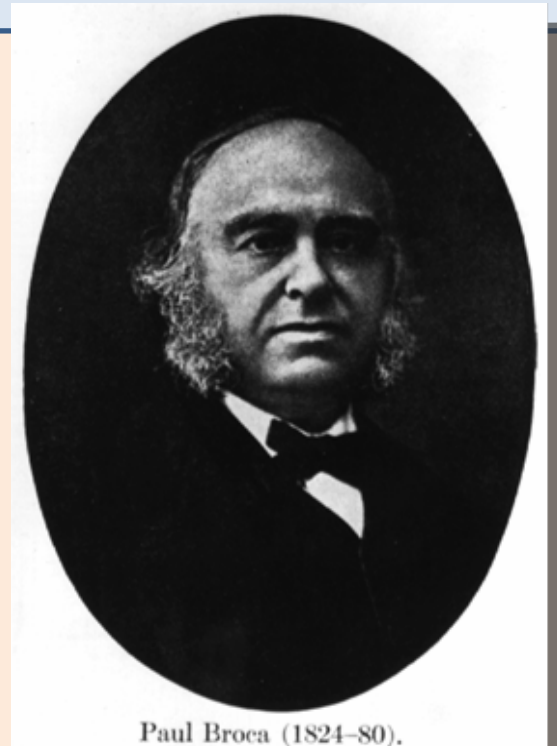
1836 Dr. Marc Dax (1770-1836)

1865 Gustave Dax (1815-1893)


Post mortem evidence

brain damage

1865 Dr. Paul Pierre Broca (1824-1880)



brain & behavioural lateralisation

- 1) Functions are specialised in one hemisphere
- 2) hemisphere is dominant in a set of functions with similar properties
- 3) Behavioural output  side preferences (e.g. handedness)
- 4) Morphological differences
- 5) Long thought to be unique to humans

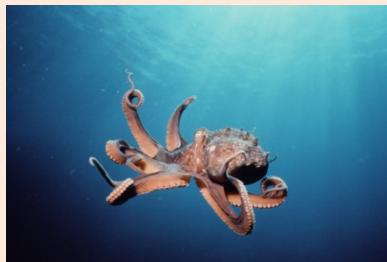
Language, one of the possible unique characters of humans, has played a major role in thinking about the function of lateralisation. The topic has long been the domain of (neuro)psychologists.

From the mid 1970's it gradually became clear that brain & behavioural lateralisation is not a unique human faculty

{Lateralisation in the nervous system (1977) Harnard et al. Eds.}



Laterality is present in all classes of vertebrates and even in animals with more 'primitive' nervous systems



Possibility to experimentally test hypotheses about the function and evolution of Lateralisation

Darwinian fitness advantages of lateralisation for the individual

1) Specialisation

higher neural capacity

2) Conflict avoidance

2 captains = trouble

3) Increased speed

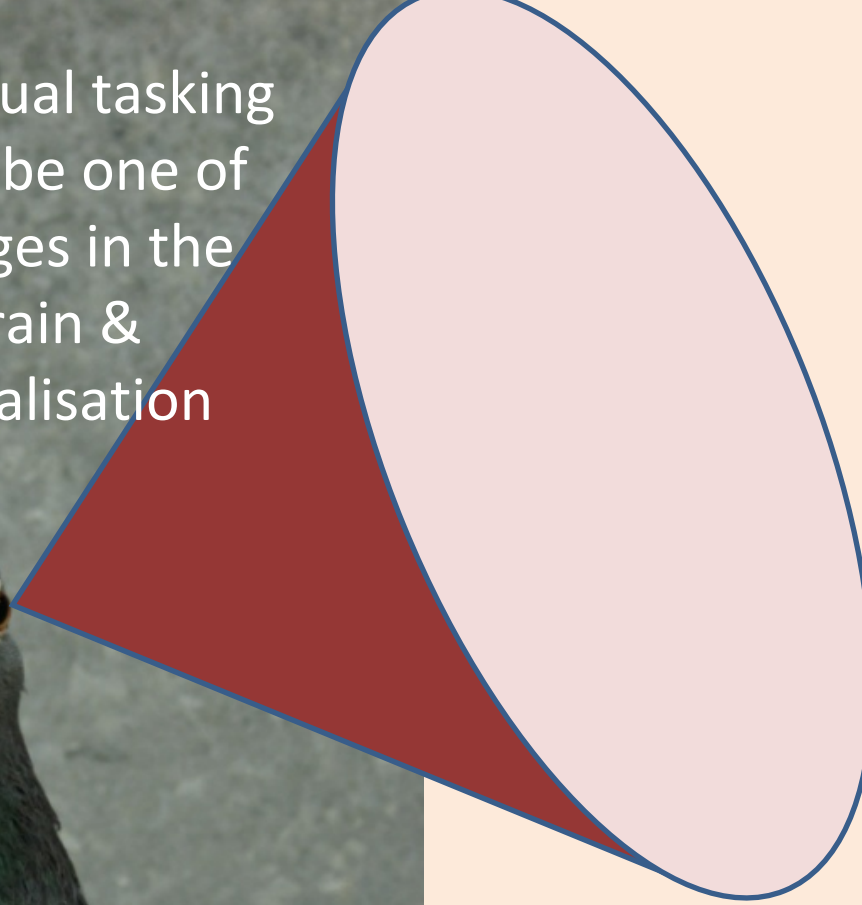
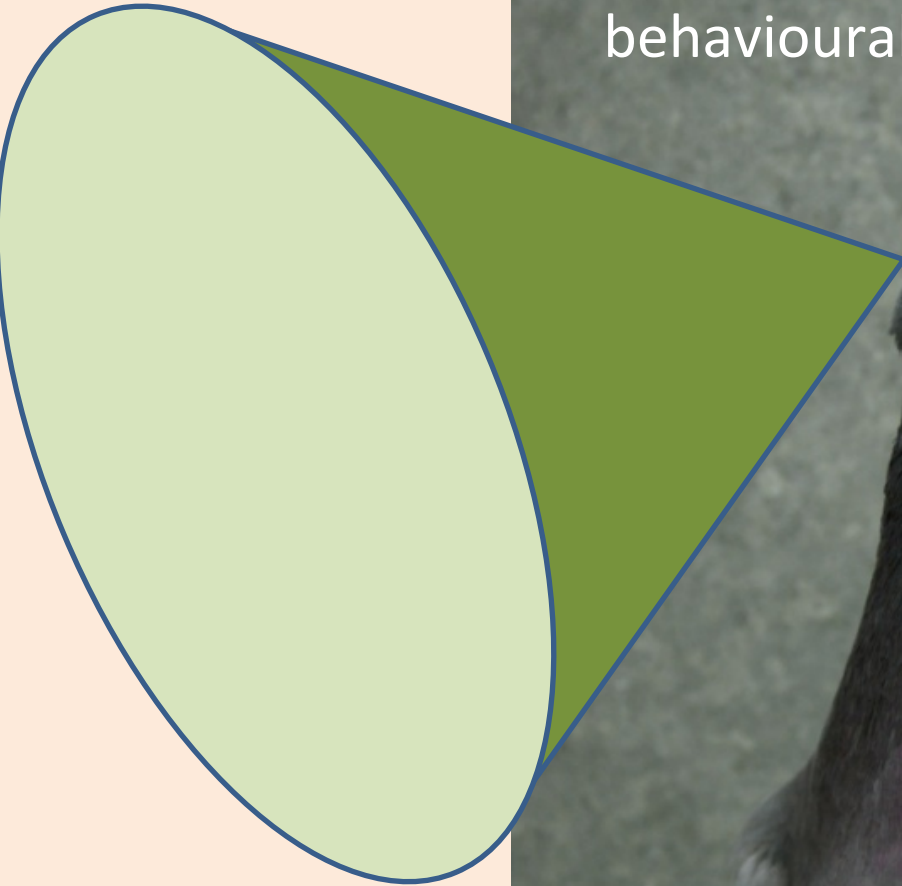
no inter-hemispheric comm.

4) Parallel processing

dual tasking possible



The possibility for dual tasking is hypothesized to be one of the main advantages in the evolution of brain & behavioural lateralisation



The right eye projects mainly
to the left hemisphere,

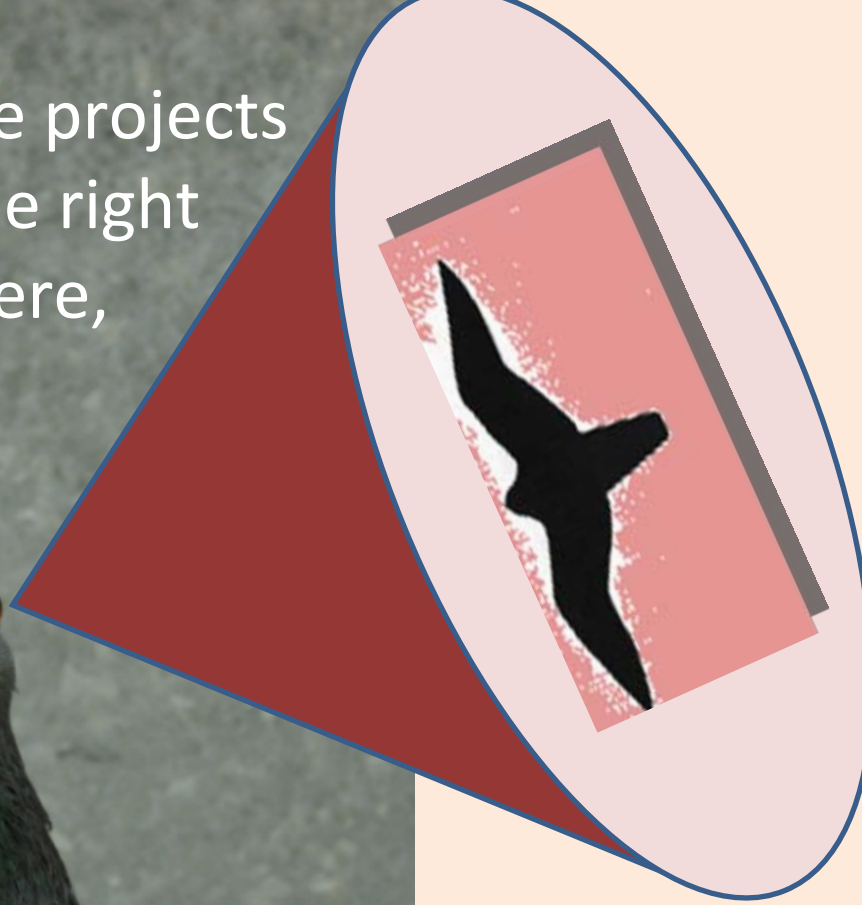


**Food
discrimination**

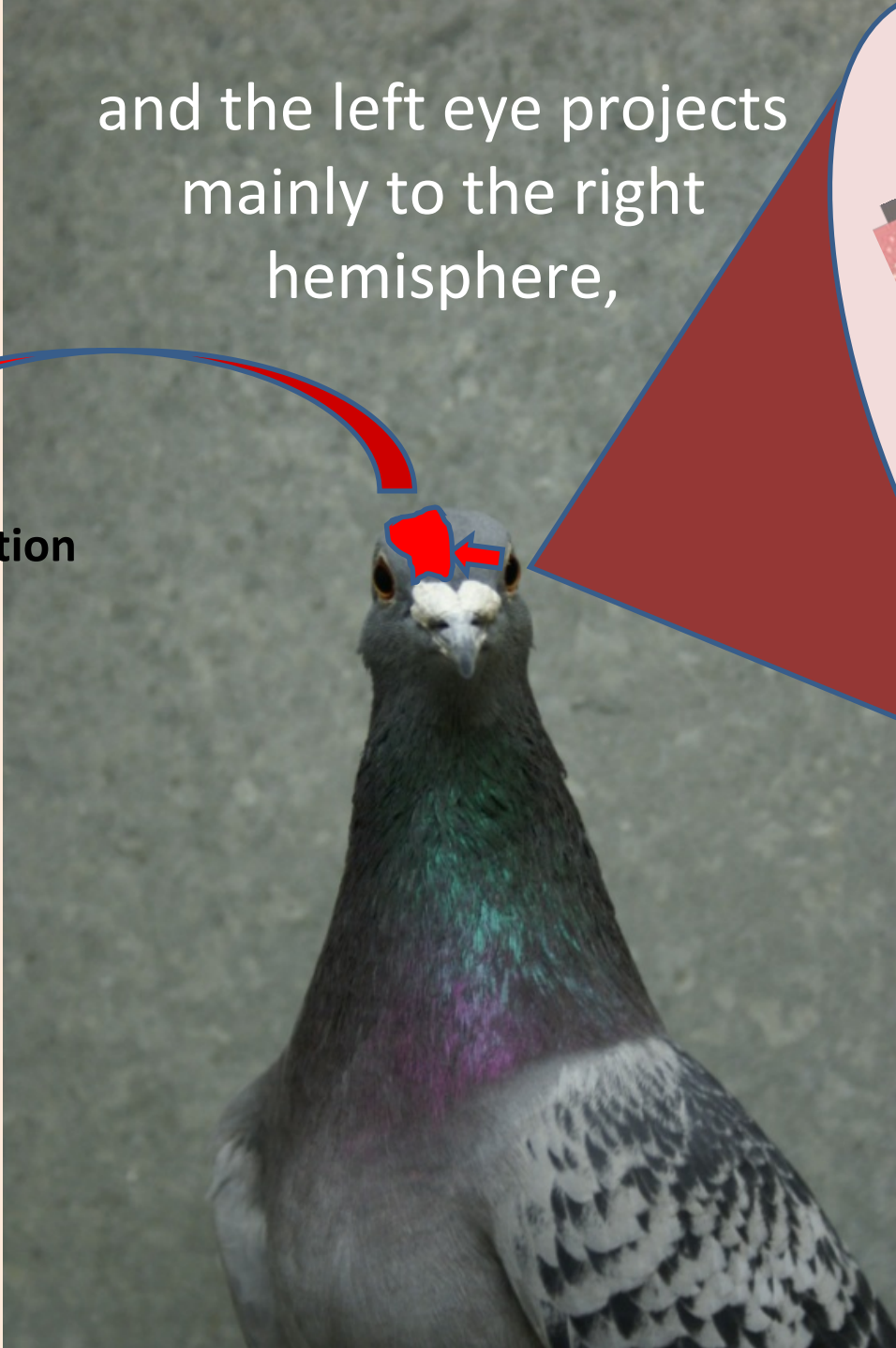


and the left eye projects
mainly to the right
hemisphere,

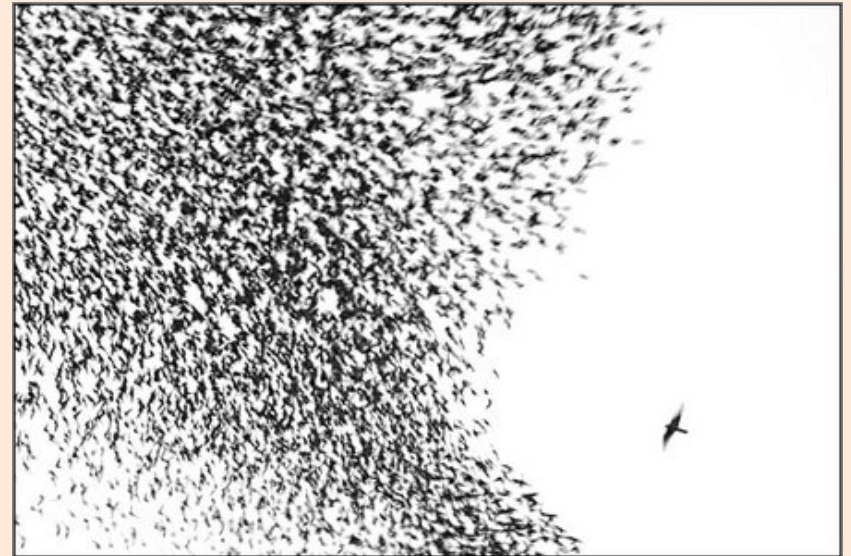
Predator recognition



Literature indicates
that strongly
lateralised animals
do better than
weakly lateralised
animals in both
single tasks as well
as dual tasks



Individual lateralisation & population lateralisation

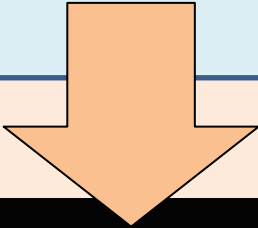


Why are not all individuals lateralised in one direction, *or* why is there no 50/50 distribution?

Does frequency dependent selection play a role?

	<i>N</i>	% Left handers	<i>P</i> -value
All sports			
male	208	16.4	0.097
female	142	14.8	0.080
all			0.046
noninteractive sports			
male	57	14.0	0.21
female	69	10.1	0.32
all			0.25
interactive sports			
male	151	17.2	0.084
female	73	19.2	0.022
all			0.013

Fighting hypothesis
 % Left-handed top combat contestants is much higher than the normal 10%

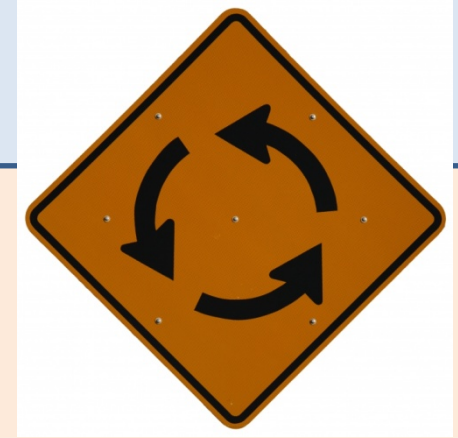
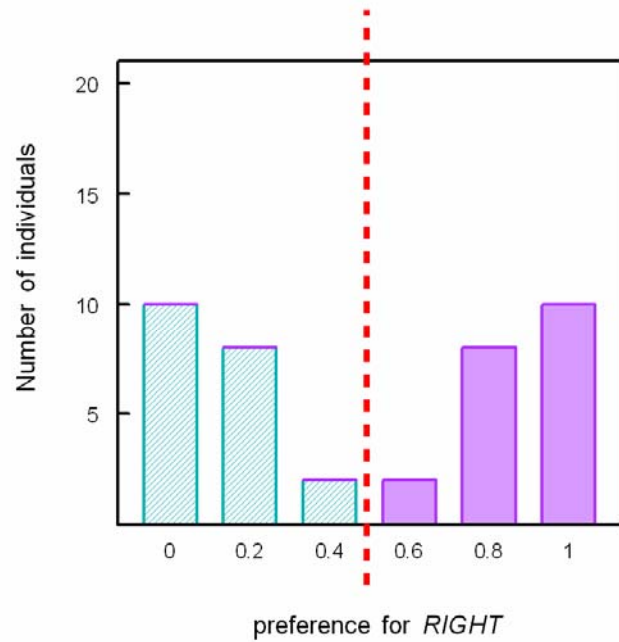


The negative effects of left handedness are 'counter-balanced' by advantages in fights



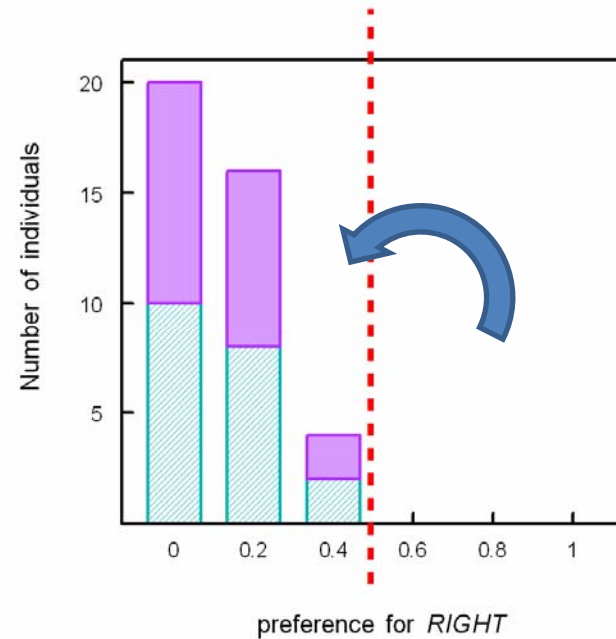
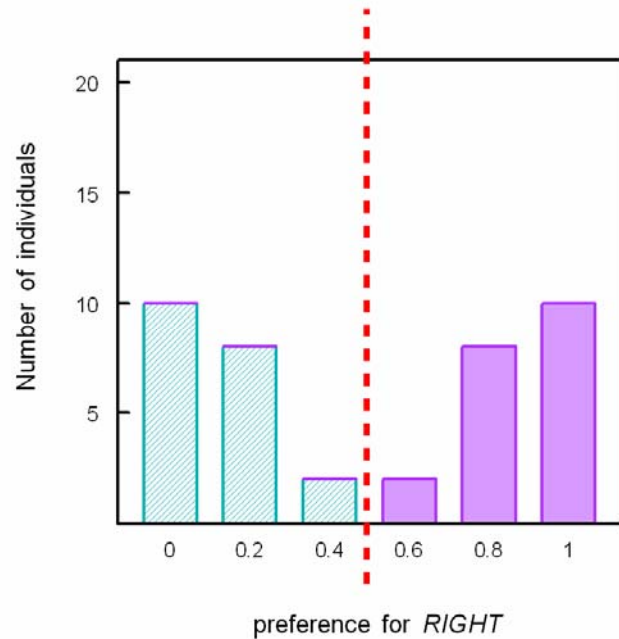
Measures of lateralisation

1) the *direction* of lateralisation



Sin Uimh. 114,
Sign No. 115.

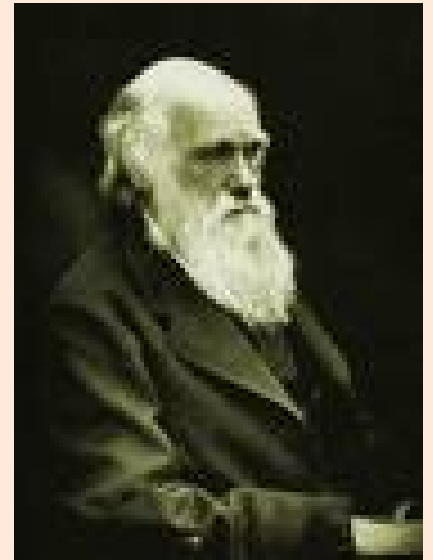
2) the *strength* of lateralisation, how strong is this preference?



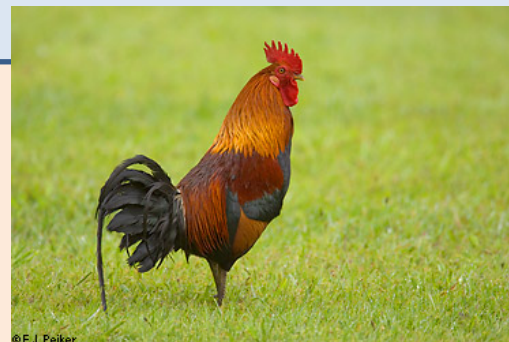
Strength of lateralisation is the 'absolute' deviation from chance

Main questions

- 1) To what extent is the development of brain and behavioural lateralisation plastic?
 - 2) Is lateralisation advantageous in terms of Darwinian fitness at the individual level?
- Focus in this presentation on Q1



ontogeny



Prenatal

Growth

Maturity

*characterise
manipulate individuals
Manipulate setting*

Fitness parameters

*Reproductive output
Immunocompetence etc.*

Non genetic influences on the development of lateralisation

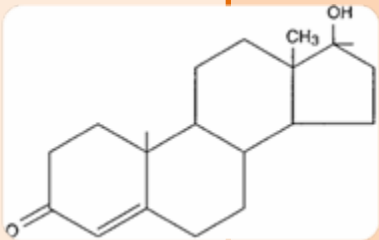
Animal models

Light

Hormones

Social factors

Behavioural biology group



Humans

Hormones

cradling

Neuropsychology group

In birds light strengthens the neuronal projections from one eye to the contra-lateral hemisphere

Recapitulate:

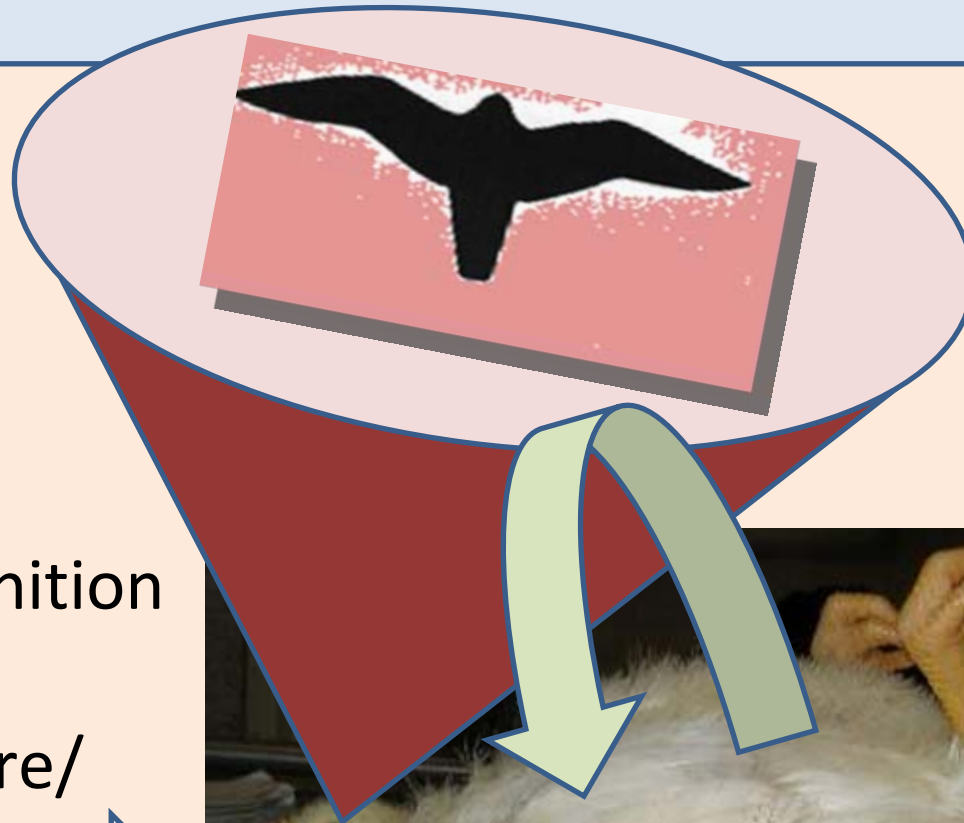
complete cross-over of the projections from the eyes to the thalamus

small overlap in the frontal visual field (except raptors, herrons etc.)

no Corpus callosum

- *Turning bias in the egg
- *One eye is located against the egg shell
- *Majority the right eye
- *Light influences lateralisation of visually guided behaviours

Tonic Immobility: anti-predator behaviour



Predator recognition

right hemisphere/
left eye

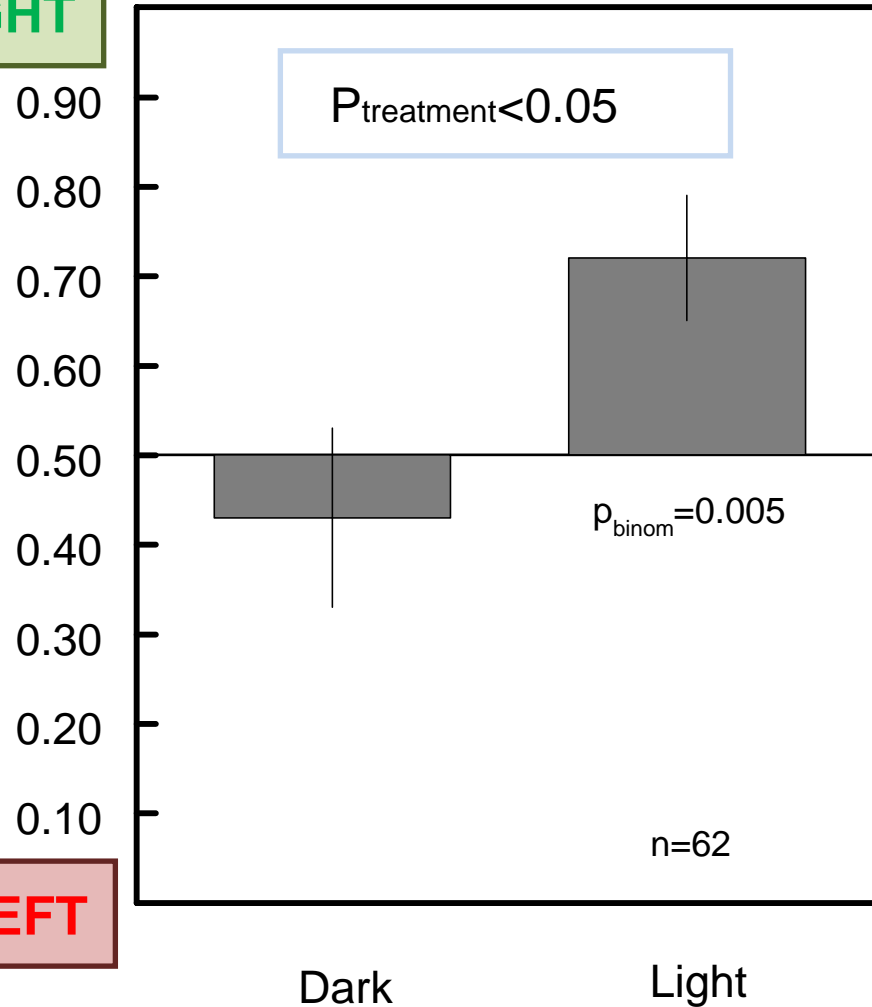


Role over the right side

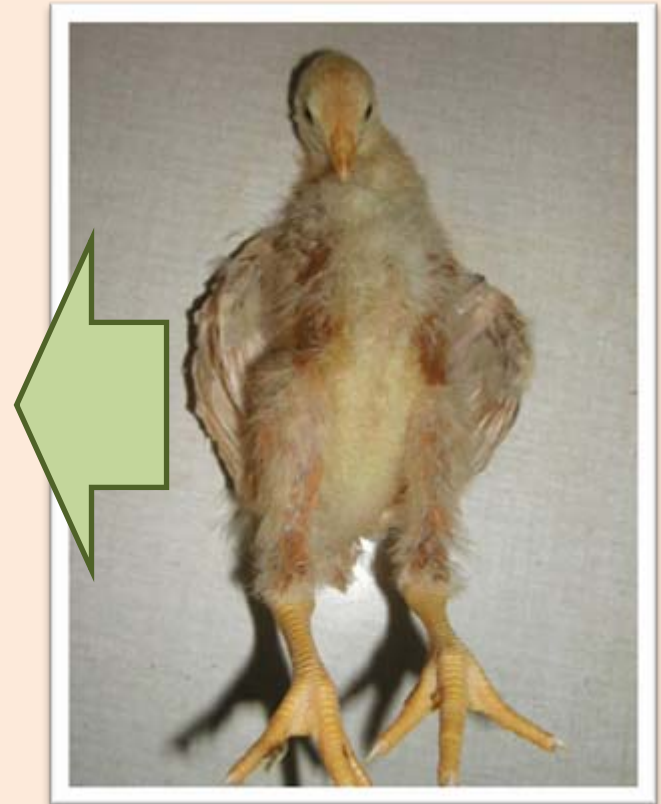


light /dark incubation affects the direction of lateralisation

RIGHT



LEFT



In humans, *androgens* levels are positively associated with the strength of lateralisation

Footedness in birds:
the sticker test

Requires 'fine' manipulation
& balance

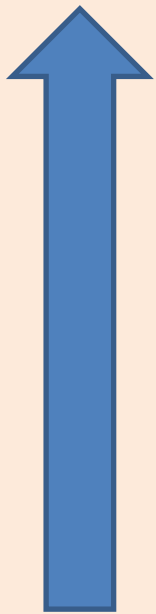
Inject testosterone within
the physiological range at
the onset of incubation



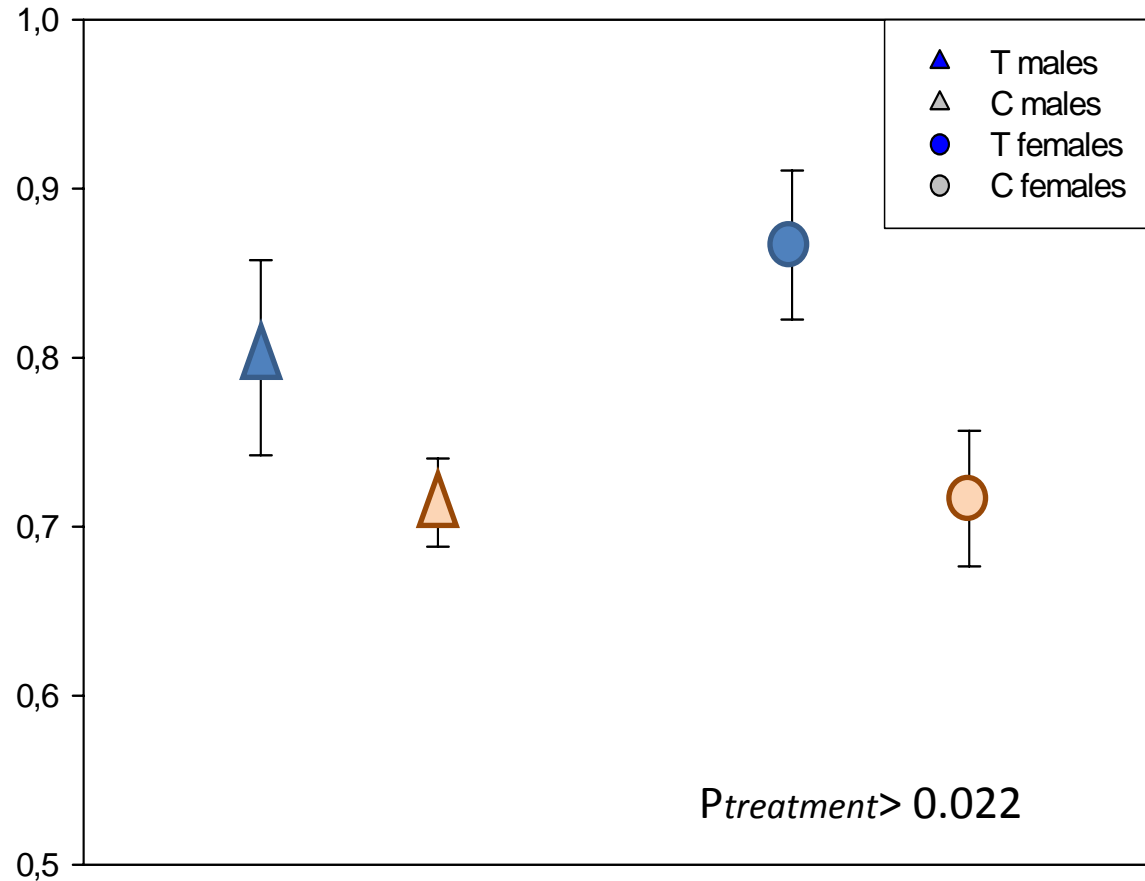
Incubate in 'light' conditions & test at >6 months after hatching

Stronger preference to use a particular foot in the testosterone treated animals

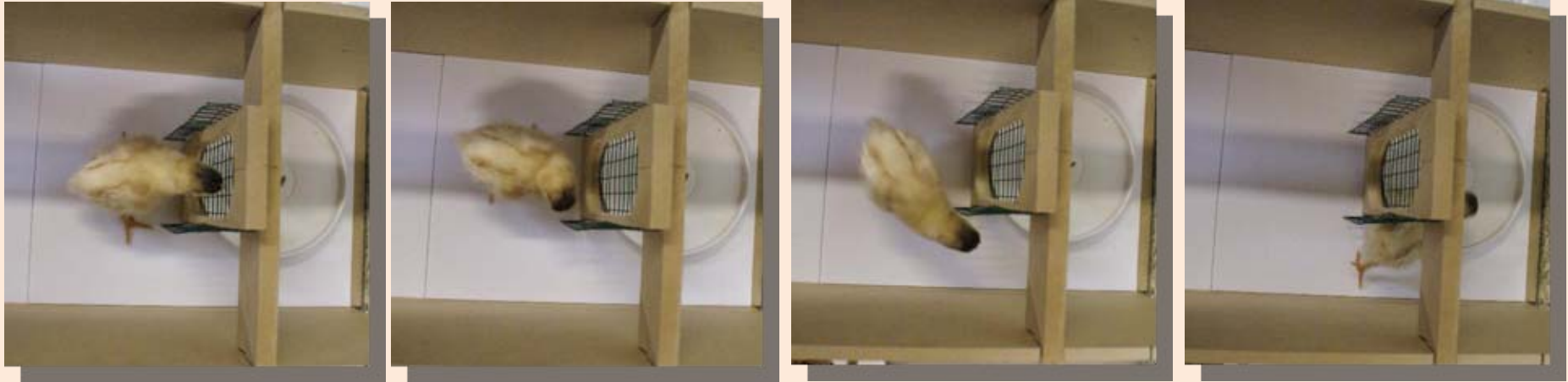
strong preference



weak preference



Animals keep the stimulus as long as possible
in the preferred eye

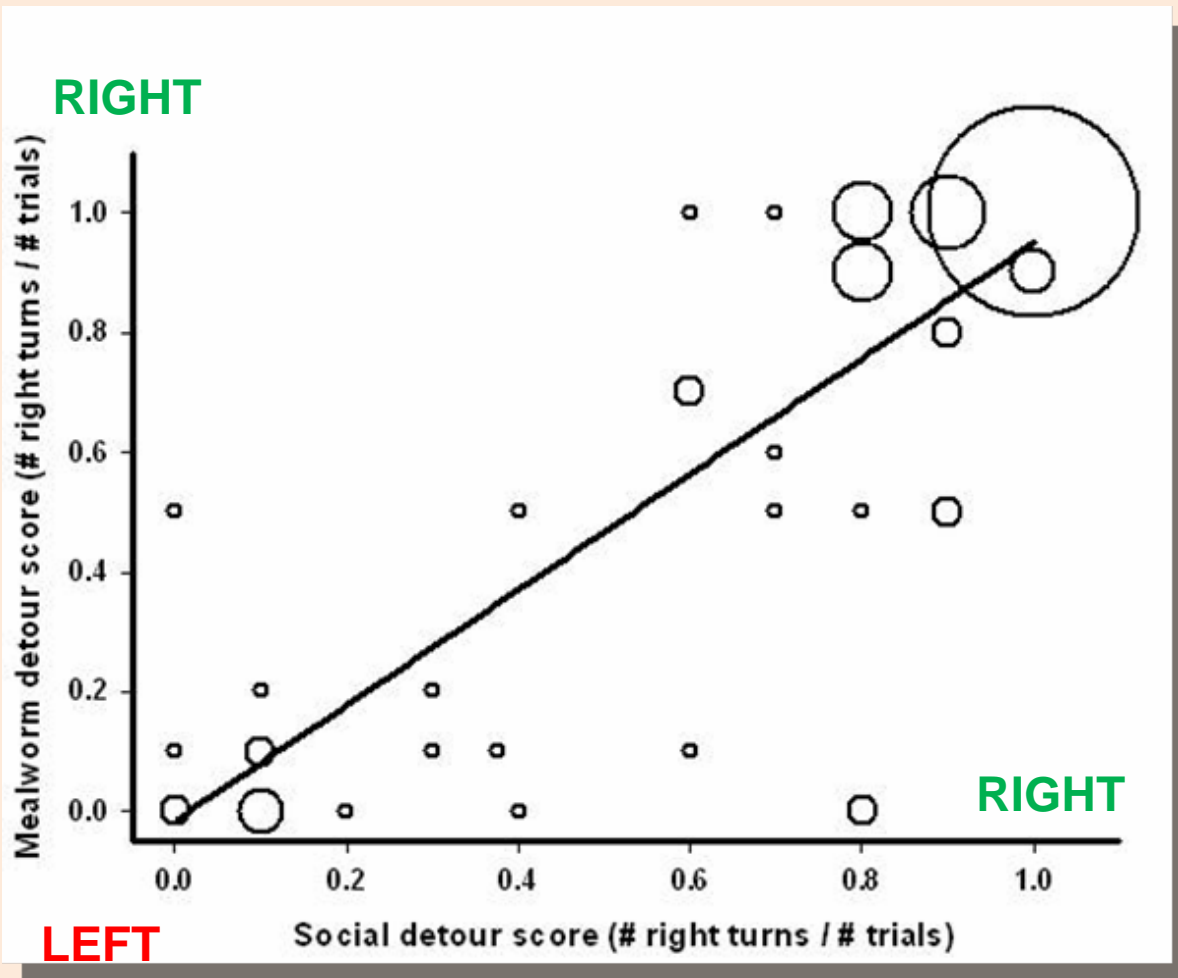


Stimuli:

- 1) a mealworm (food)
- 2) group of unknown conspecifics (social)

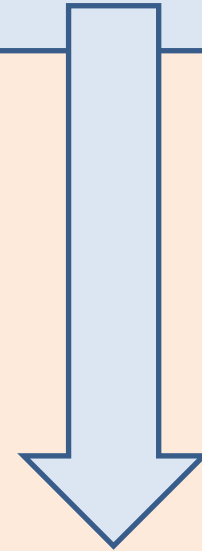
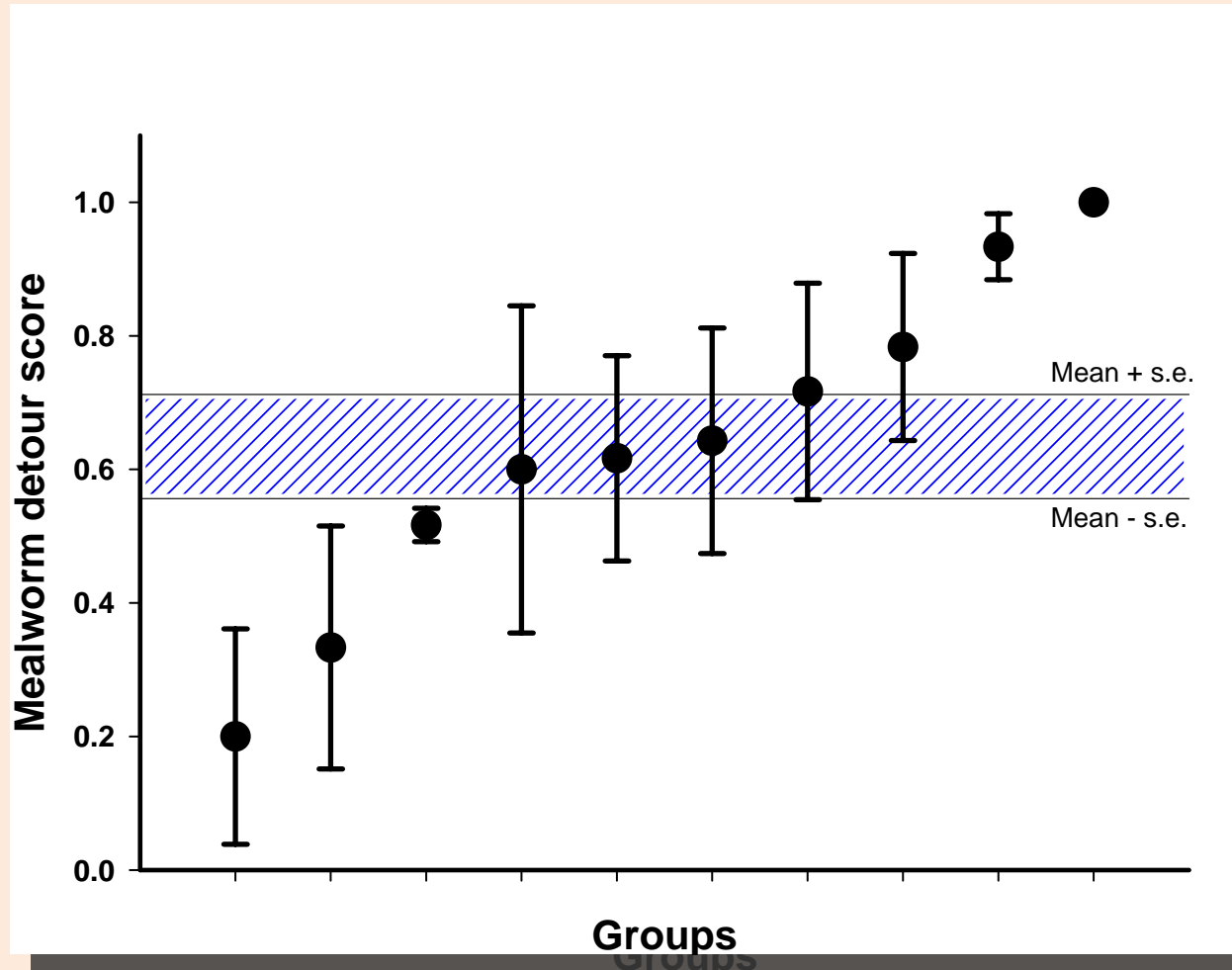
10 trials per stimulus at age 4-6 days

All chicks were equal,
But some turned out more equal than others.



- I) Individuals show consistent turning preferences between different stimuli.
- II) But not all animals show the same preference.

Within group variation < between group variation

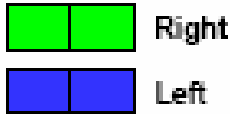
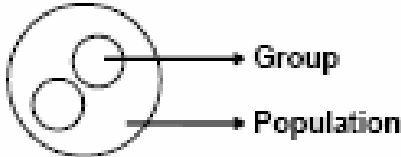
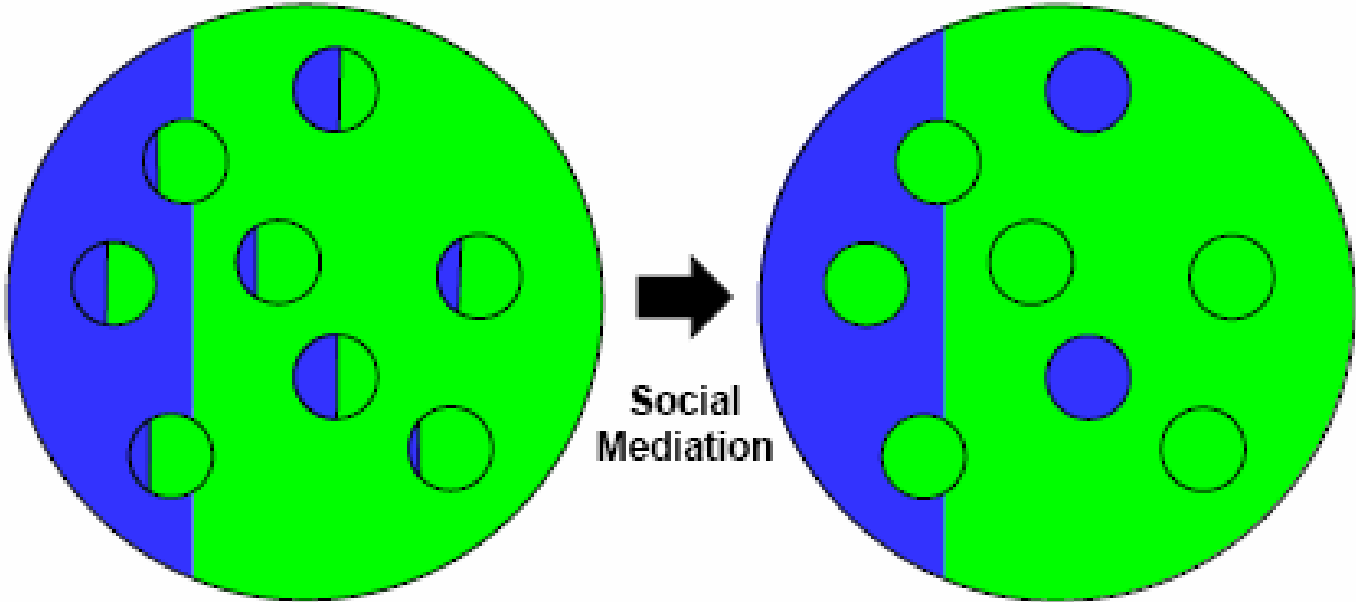


First *evidence* of post-hatching modulation of lateralisation in a precocial species, likely via social interactions

Social modulation of lateralisation

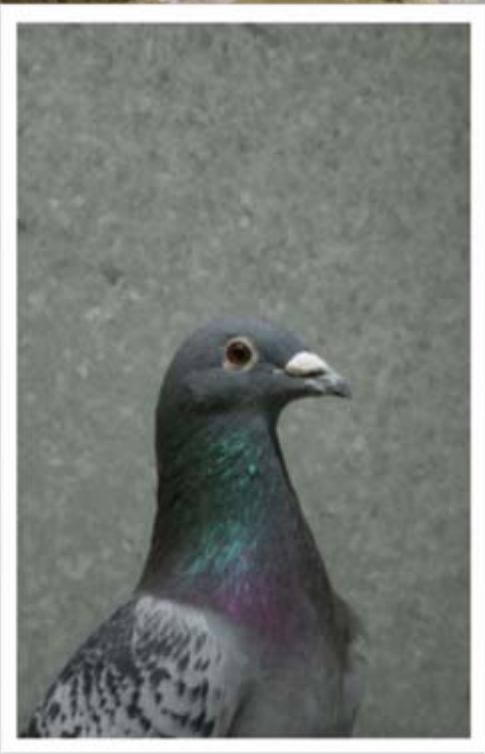
Pre-hatching Lateralisation

Post-hatching Lateralisation





Rock pigeon



Homing pigeon



