



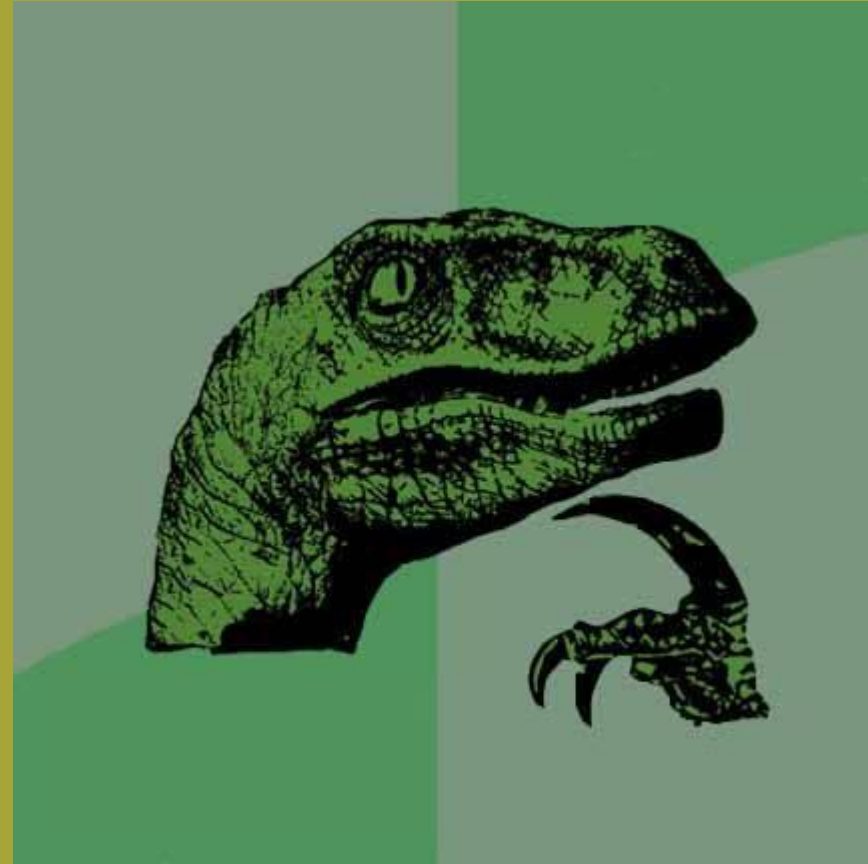
# Animal communication and cognition

Origins and Evolution of  
Language

Week 3

# RECAP

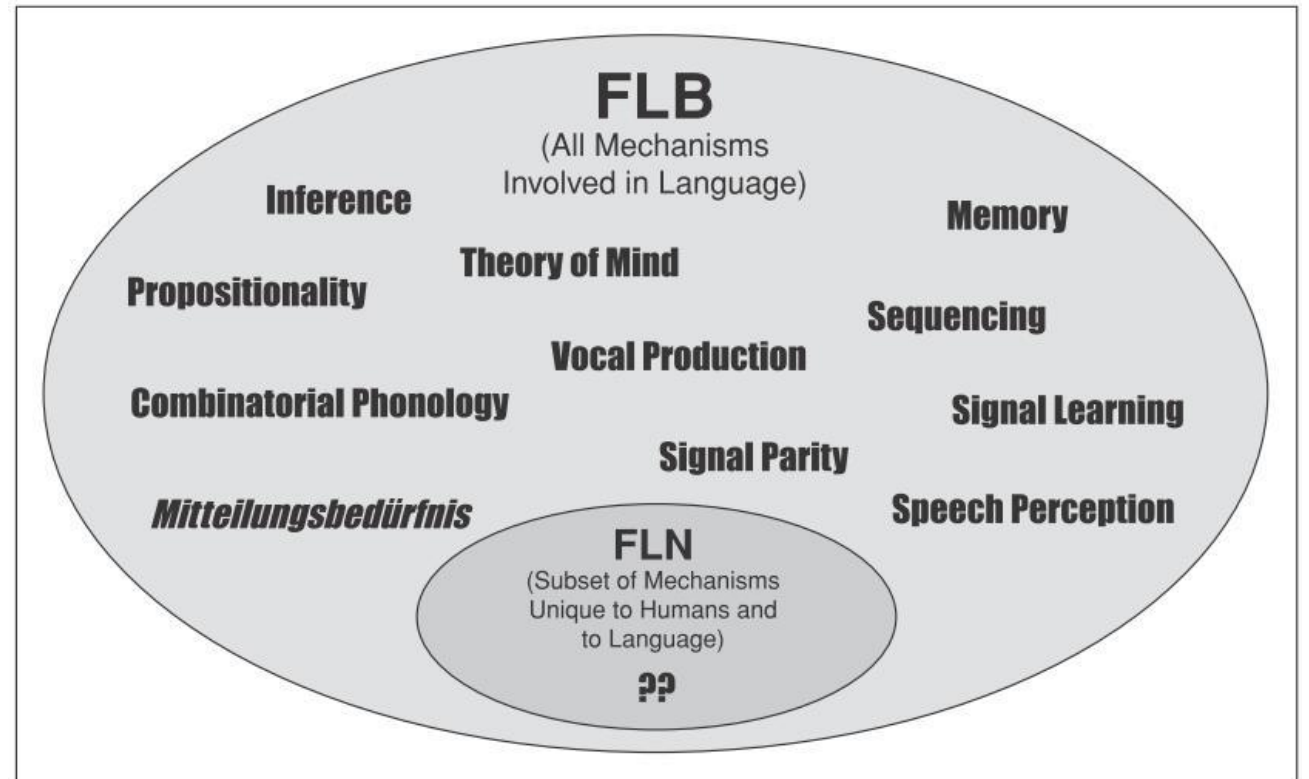
- ◆ Tutorial groups *should* be sorted
  - ◆ (but not on Learn)
  - ◆ You will have a **team** for the readings
- ◆ Reading quiz:
  - ◆ Everyone did well, but any questions?
- ◆ Tutorial recap:
  - ◆ Reflections on Boeckx?
- ◆ Back to Adaptations (Lecture 2) and then on to **the animals**



An obsolete meme

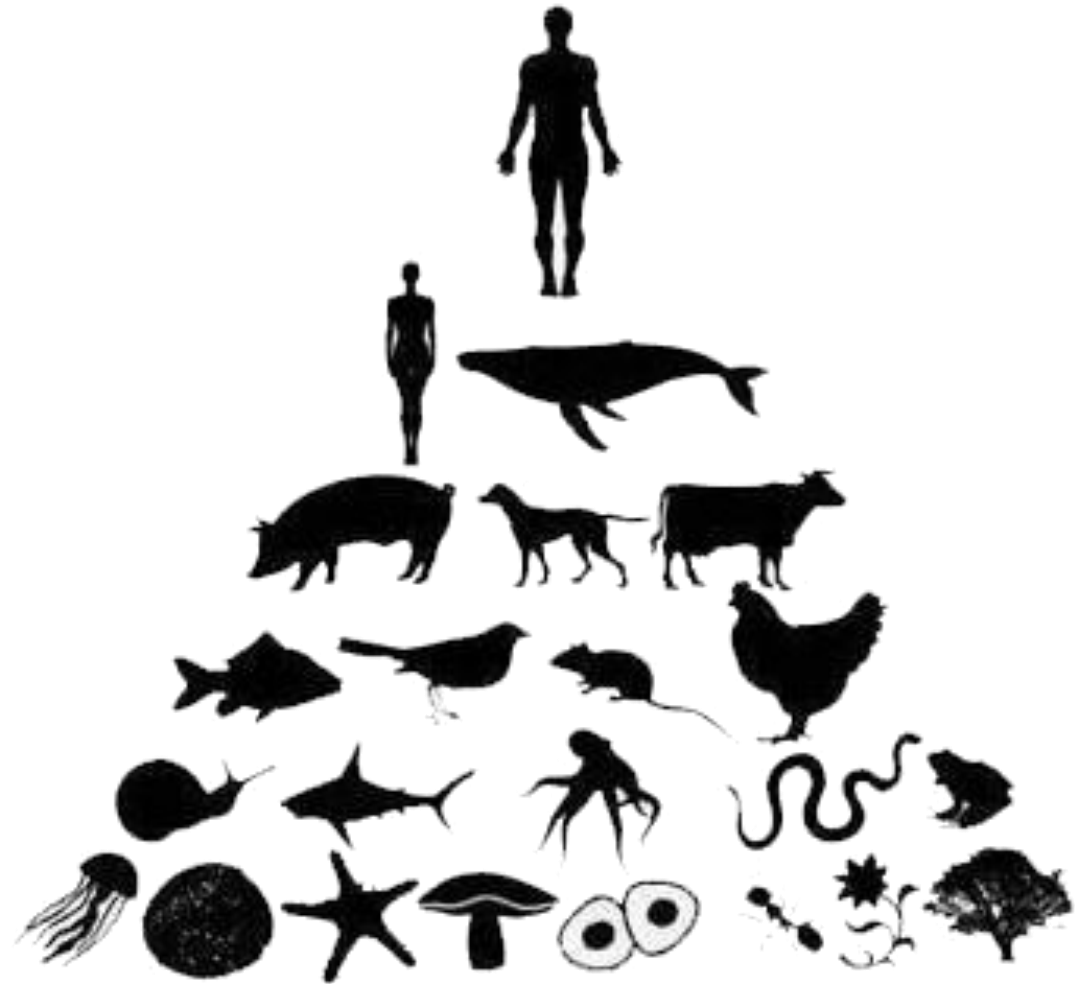
# Faculty of Language

- Memory
- Sequencing
- Inference
- Impetus to share
- Theory of Mind
- Signal learning
- Propositionality
- Vocal Production
- Combinatoriality
- Signal parity
- Speech perception



## Human uniqueness

- ◇ The old hypothesis: Humans are unique, we need to seek out explanations for what makes us so
  - ◇ Culture is unique to humans
  - ◇ Tool use is exclusively human
  - ◇ Language is exclusively human



## Human uniqueness

- ◇ The new (null) hypothesis: Humans may be unique, but much of our cognitive suite is not
  - ◇ Culture found in many species, from meerkats to fish
  - ◇ Tool use from crows to chimpanzees
  - ◇ Language...?



# Human uniqueness

“Valid claims of human uniqueness must be based on empirical data showing absence in multiple nonhuman species. If such a claim is intended as a scientific hypothesis, the claimant should specify how the trait in question could plausibly be demonstrated empirically in a non-human animal.”

- Fitch (2010), p.146

# Cognitive Capacities

The comparative method walks a fine line between...



Rigorous scepticism



Accepting animals might be pretty smart





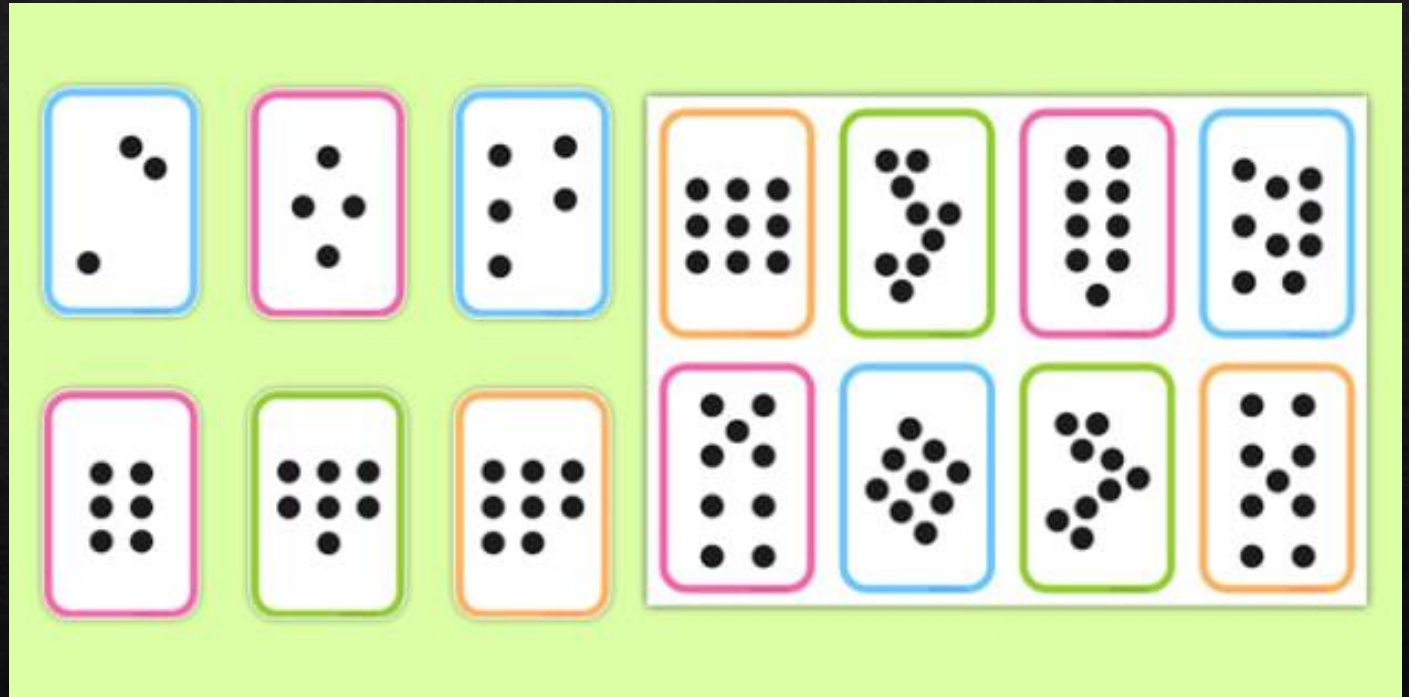
## Temporal planning

- ◇ Many animals **cache** food, which is evidence of temporal planning
- ◇ However - this behaviour seems to be confined to food



# Number sense

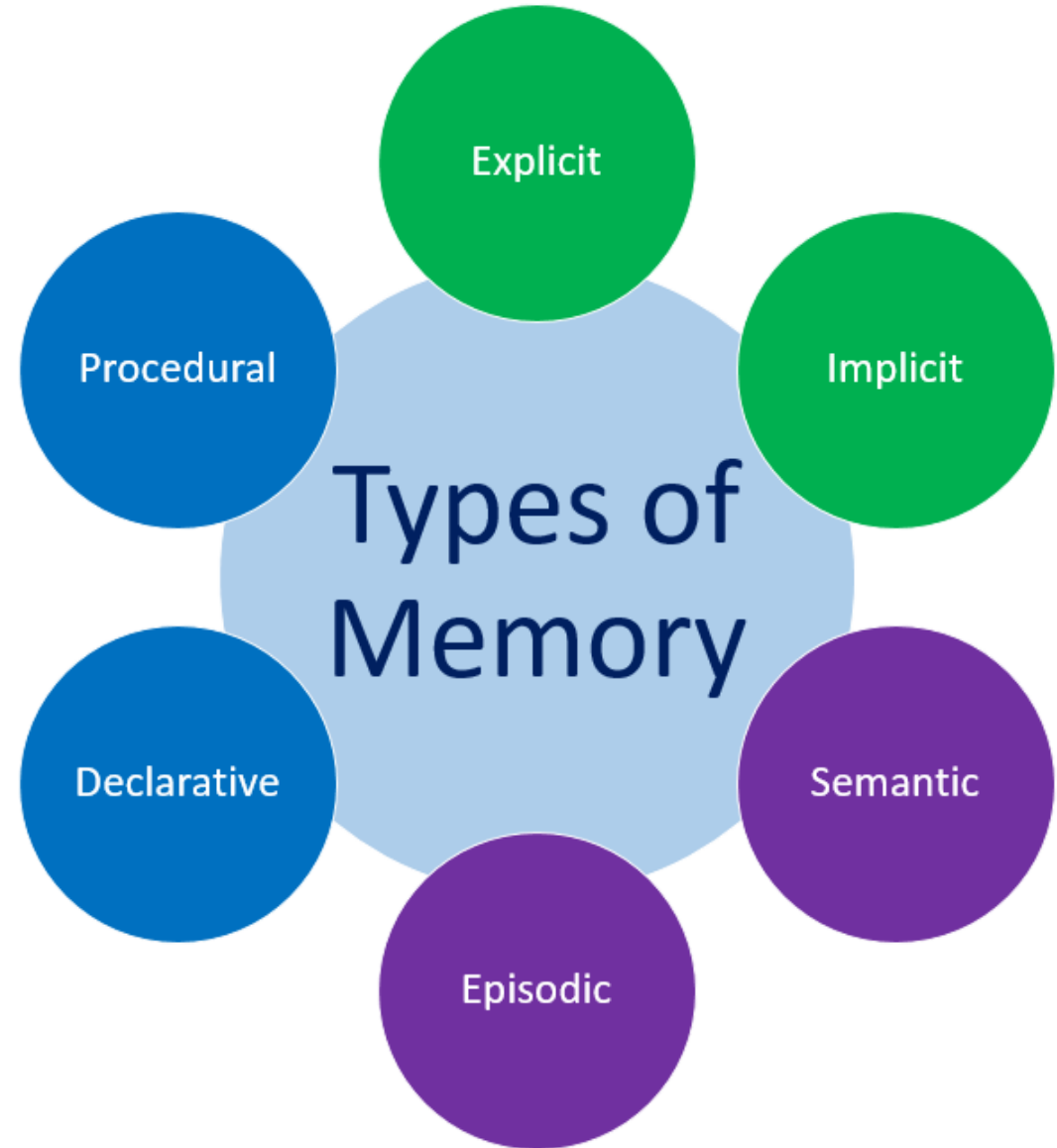
- ◇ *Small exact and large approximate* shared with many animals
- ◇ Subitising
- ◇ Large exact appears to be unique to humans - language enabled?
- ◇ However, still a considerable bit of cross-linguistic and cross-cultural variation



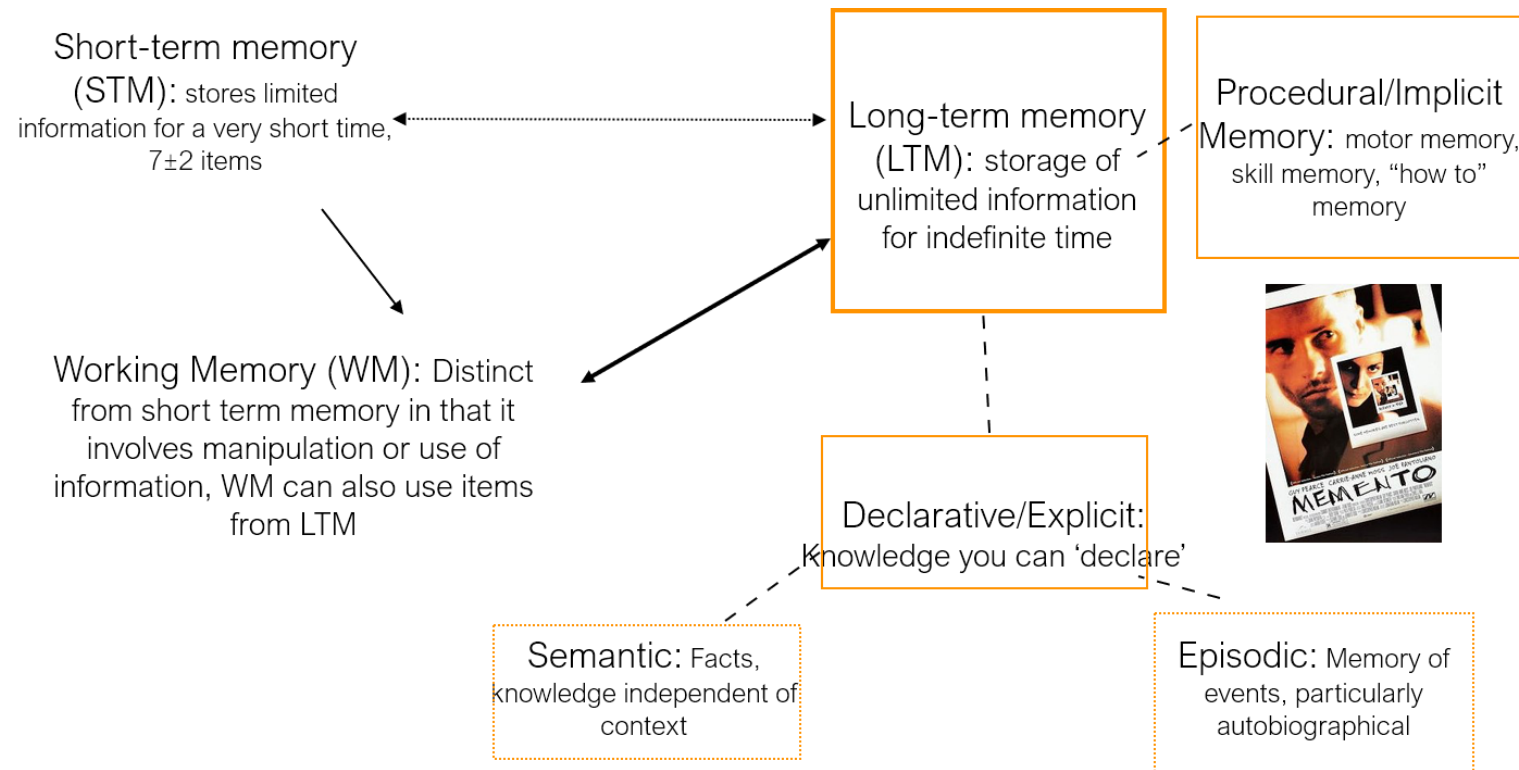
Cross-cultural differences in representations and routines for exact number. M.C. Frank  
<https://scholarspace.manoa.hawaii.edu/bitstream/10125/4566/1/frank.pdf>

# Memory

- ◇ Memory is an essential component of language
- ◇ The study of memory has primarily focused on humans
- ◇ This has perhaps led to models of memory which are sub-optimal for comparative approaches



# (A) model of human memory



# Semantic vs Episodic Memory

- ◇ Semantic well established in animals: many birds, dogs, all primates tested
- ◇ Episodic: Most rigorous test involves free recall - this is not possible without language
  - ◇ do we abandon it as untestable?
- ◇ Semantic memory is embedded in episodic memory
  - ◇ Ontogenetically, semantic memory develops before episodic
- ◇ Episodic memory requires self-awareness (autobiographical component)

# Memory: a comparative perspective

- ◇ Strong disagreement about whether episodic memory is uniquely human (Fitch takes a v. strong position here)
  - ◇ If language is uniquely human, episodic memory (as defined) must be
- ◇ Problem may be semantic: why apply this model (specifically designed for human memory) to animals?
- ◇ Episodic-like memory: “Stored information acquired through individual experience about temporally dated events and the spatial-temporal relation inherent in the event” (Schwartz, Hoffman & Evans, 2011)

# Scrub jays

- ◇ Recall **where** of food (not unusual)
- ◇ Also recall combination of **what** type of food it is and **when** they stored it
  - ◇ e.g., will not return to food that rots in 2 weeks after 3
- ◇ Can't be tested in free recall; requires finite choices

Clayton, N. S., & Dickinson, A. (1998). Episodic-like memory during cache recovery by scrub jays. *Nature*, 395(6699), 272.



# Elephants



- ◇ **Where** water is, **when** it will be there, **who** else will want it
- ◇ Follow/socially transmit long, complex paths to water holes
- ◇ Groups seem to know not to arrive at a watering hole at the same time as another large group
- ◇ Not a lot of data...

Moss, C. J. (2012). *Elephant memories: thirteen years in the life of an elephant family*. University of Chicago Press.

# Language trained apes

- ◆ Language trained apes can be tested with free recall (e.g., open ended question about what happened yesterday)
- ◆ Kanzi (trained with lexigrams) can remember who, what, where, and when of events in the past
  - ◆ Highly anecdotal, under very specific conditions, N=1





# Language trained apes

◇ Michael, friend of Koko's

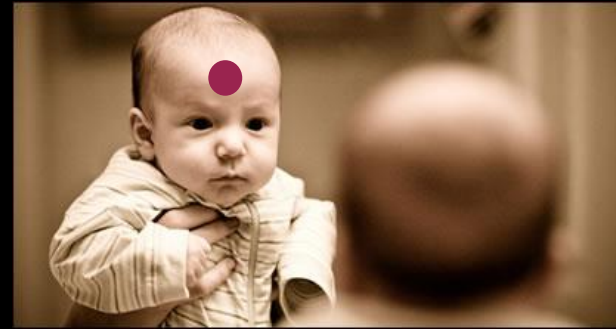


# Theory of mind

- ◇ The impetus to share information requires some notion of theory of mind:
  - ◇ The ability to attribute mental states - beliefs, intents, desires, emotions, knowledge, etc - to oneself, and to others.
- ◇ More on this in week 5 - but ToM entails self-awareness (as does episodic memory). To what extent is this shared with other animals?

# Self-awareness

- ◆ The Gallup Test or Mirror test: place a mark on the individual, sedate them, show them their reflection when they wake
- ◆ Most apes, though may be captivity dependent?
- ◆ Elephants



# Dolphins



# Magpies



# Dogs

- ◆ Fail the classic mirror test...
- ◆ Might be an issue of modality: dogs are not very visual, far more olfactory
  - ◆ Bekoff (2001) performed an experiment with his dog's urine, moving to locations where the dog hadn't actually been
  - ◆ Dog reacted markedly different to its own scent, particularly in an expected location



Cats?



# Cats?





# Pointing and gaze detection

- ◇ Whites of human eyes allow gaze following
- ◇ Children follow pointing from about ~12-18months
- ◇ Dogs (prosocial, domesticated) will follow pointing, cats will not

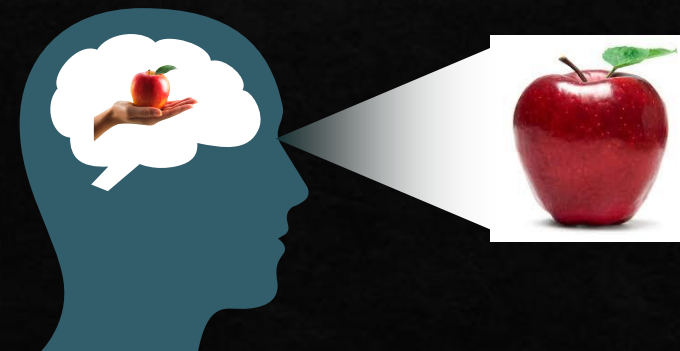
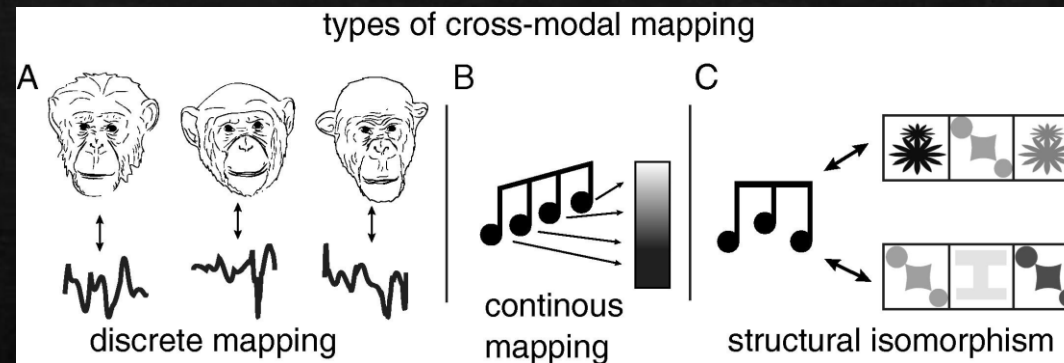


# Cross-modality

The ability to map properties from one modality (e.g., touch) to another (e.g., vision)

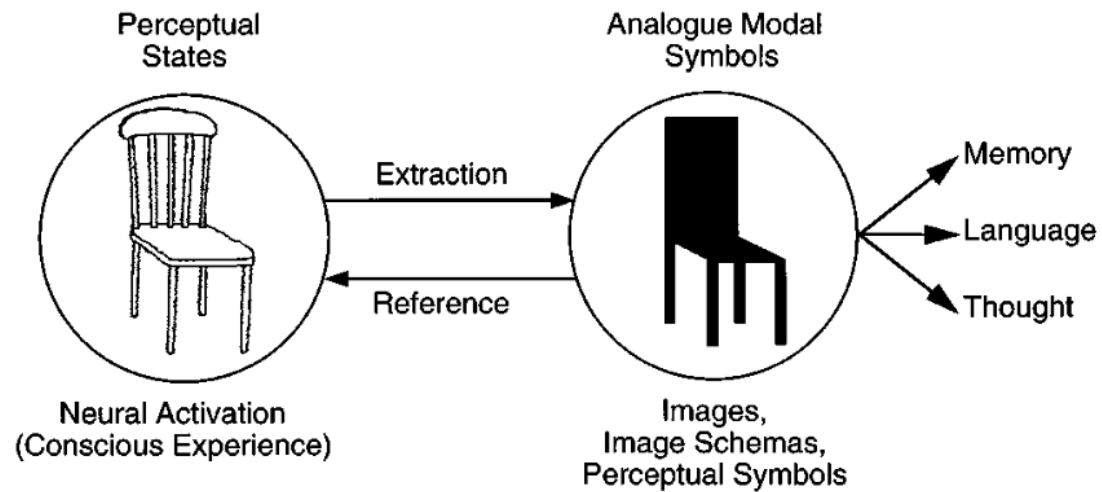
Ludwig et al., 2012

Ravignani & Sonnweber, 2016



Widespread: cross-modal transfer

e.g., Davenport et al., 1973

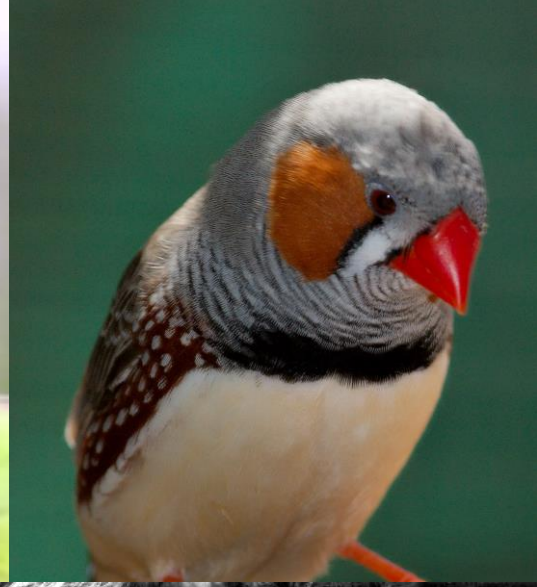


# Cross-modality

Key for symbolic  
reference and cognition

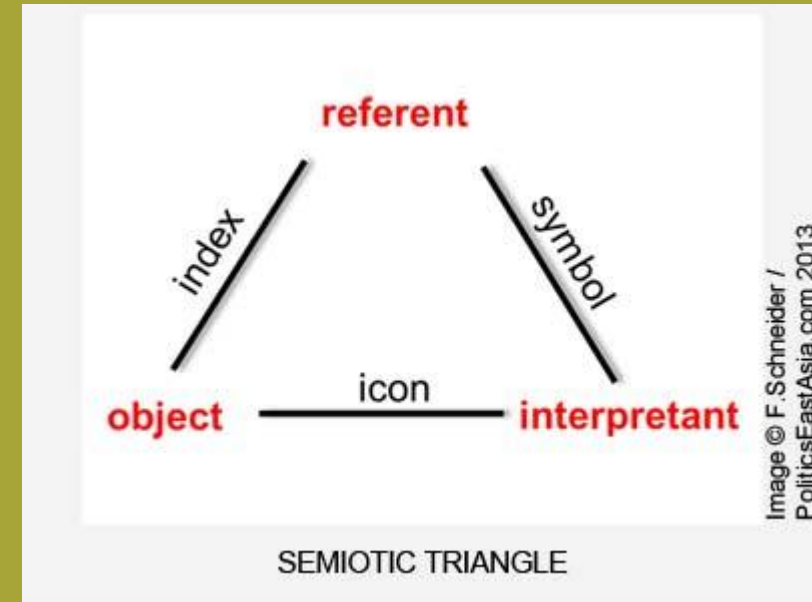
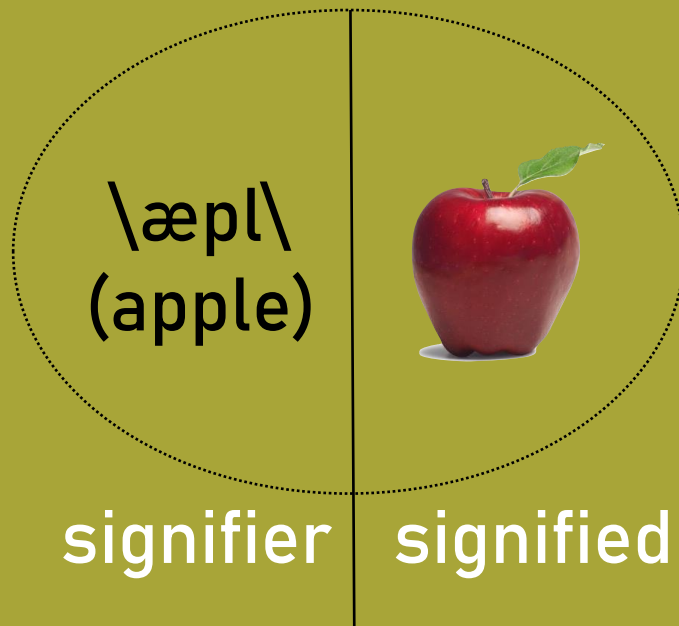
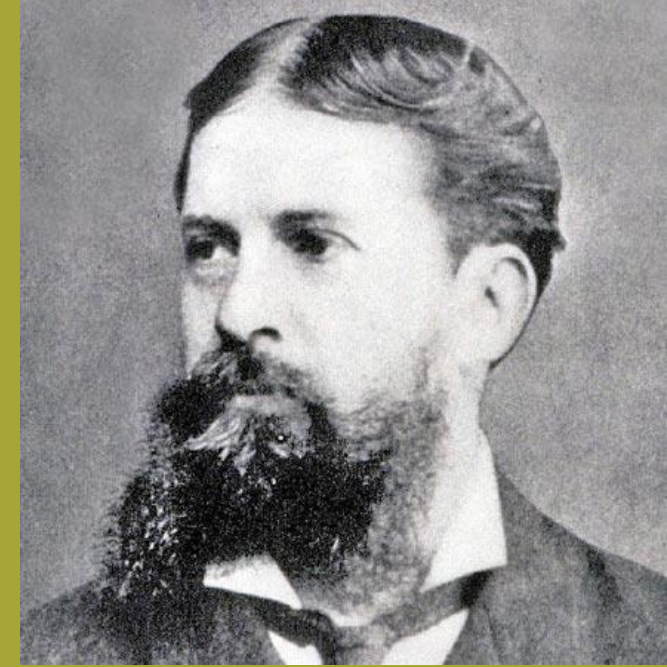
Break

# Communication is ubiquitous, language is unique



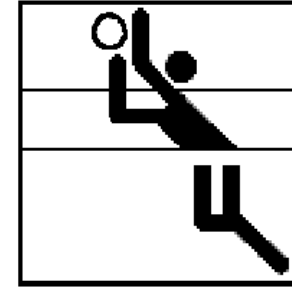
# Semiotics

- ◇ Communication takes place by the sending of signals between communicating parties. A signal involves a **signifier** and the **signified** (Saussure)
- ◇ We can divide these signals into three distinct types, based on the relationship between the signifier and signified (Peirce):
  - ◇ Icons
  - ◇ Indices (an index)
  - ◇ Symbols



# Icons

- ◆ In icons, the relationship between the signifier and the signified is one of resemblance; as such the relationship is obvious, but...
- ◆ Very strong influence of *culture*
- ◆ Perceptual issues
- ◆ Systematic iconicity?



# Indices

- ◆ In an index, there is a **causal or mechanical relationship** between the signifier and the signified



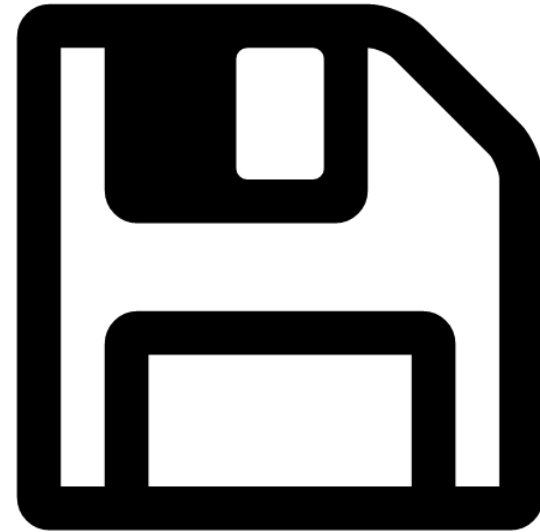


# Symbols

- ◇ In symbols, the relationship between the signifier and the signified is arbitrary, i.e., there isn't one...
- ◇ Or, connection is not obvious.
- ◇ The relationship between the signifier and the signified holds through convention among communicators.
- ◇ Icons can undergo gradual change until they become symbols.



fire  
feugo  
φωτιά

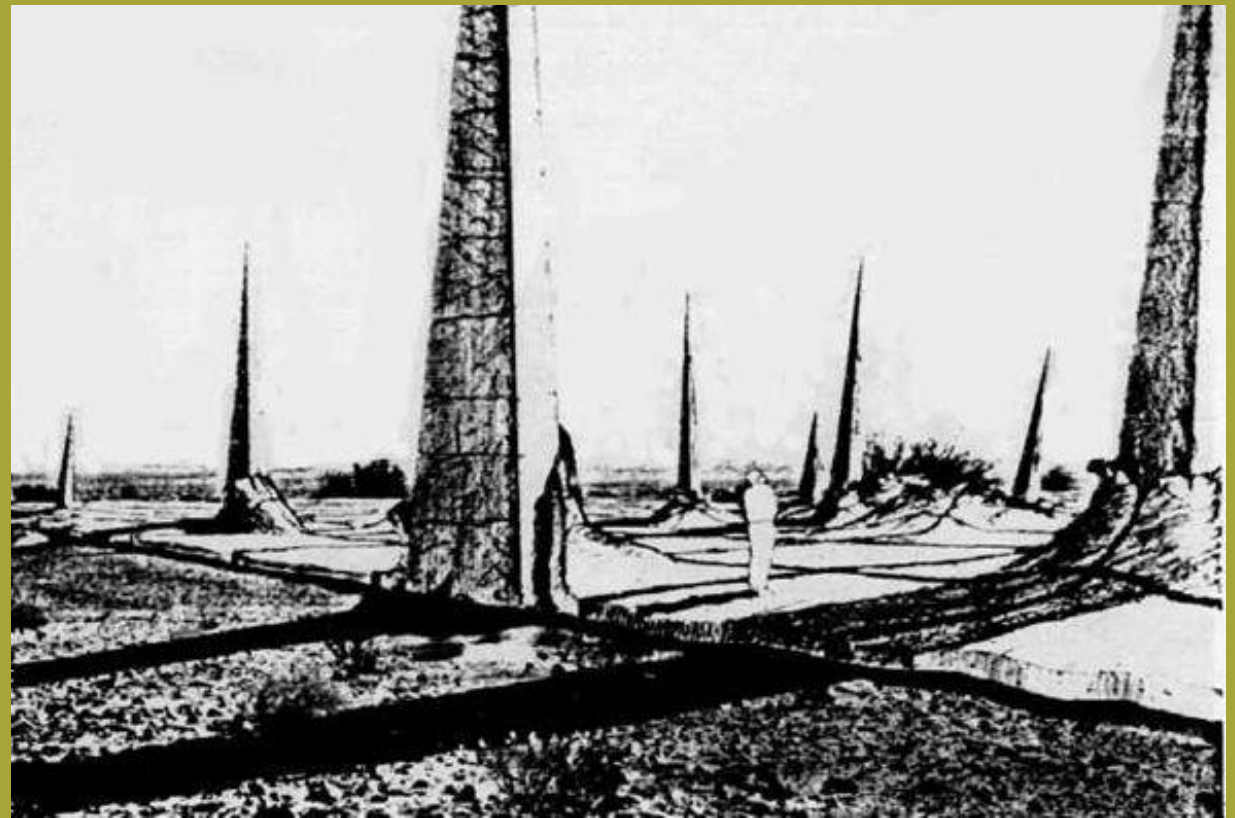


# Icon, index, or symbol?

- ◆ How do you warn people 10,000 years in the future about a radioactive dump?
- ◆ Many signals are quite problematic!
- ◆ Skull & Crossbones? Originally signified *rebirth*, then *momento mori*, then *piracy*...
- ◆ Terrifying 'landscape of thorns' art?
- ◆ Mythical colour-changing radiation cats!

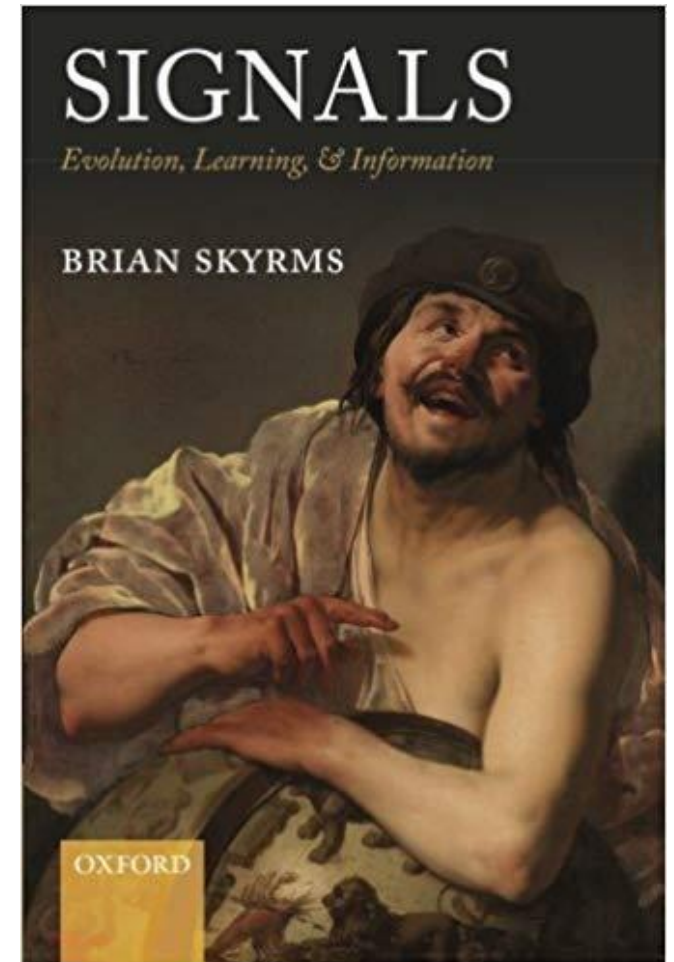
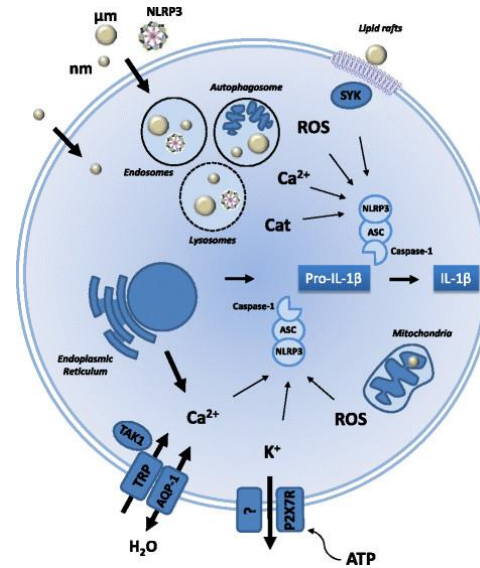
"They proposed that we **genetically engineer a species of cat that changes color in the presence of radiation, which would be released into the wild to serve as living Geiger counters**. Then, we would create folklore and **write songs** and tell stories about these "ray cats," the moral being that when you see these cats change colors, run far, far away."

[http://www.slate.com/blogs/the\\_eye/2014/05/14/\\_99\\_percent\\_invisible\\_by\\_roman\\_mars\\_designing\\_warning\\_symbols\\_for\\_the\\_nation.html?via=gdpr-consent](http://www.slate.com/blogs/the_eye/2014/05/14/_99_percent_invisible_by_roman_mars_designing_warning_symbols_for_the_nation.html?via=gdpr-consent)



# Explaining signals in biology

- ◇ For signalling to evolve, it must be mutually beneficial (according to some)
- ◇ Stabilised by:
  - ◇ Genetic relatedness
  - ◇ Physical binding
  - ◇ Strong mutualism
- ◇ BUT:
  - ◇ Deception
  - ◇ Cheating



# Honest Signalling

- ◇ If communication is a form of cooperation, then it has to be resistant to cheaters in order to remain stable (an ESS).
- ◇ Nature has solved this in most communication systems by making signals **honest** - that is, they cannot be faked.
- ◇ Works well with icons and indices - the relationship between the signifier and the signified means you cannot fake the signifier without changing the signified.
- ◇ Thus, most animal signals are inherently honest.

# Honest Signal Systems

- ◇ The classic example is the peacock's tail
- ◇ Also holds for predation



Behav Ecol Sociobiol (2005) 58: 552–557  
DOI 10.1007/s00265-005-0958-y

## ORIGINAL ARTICLE

Adeline Loyau · Michel Saint Jalme ·  
Cécile Cagniant · Gabriele Sorci

**Multiple sexual advertisements honestly reflect health status  
in peacocks (*Pavo cristatus*)**

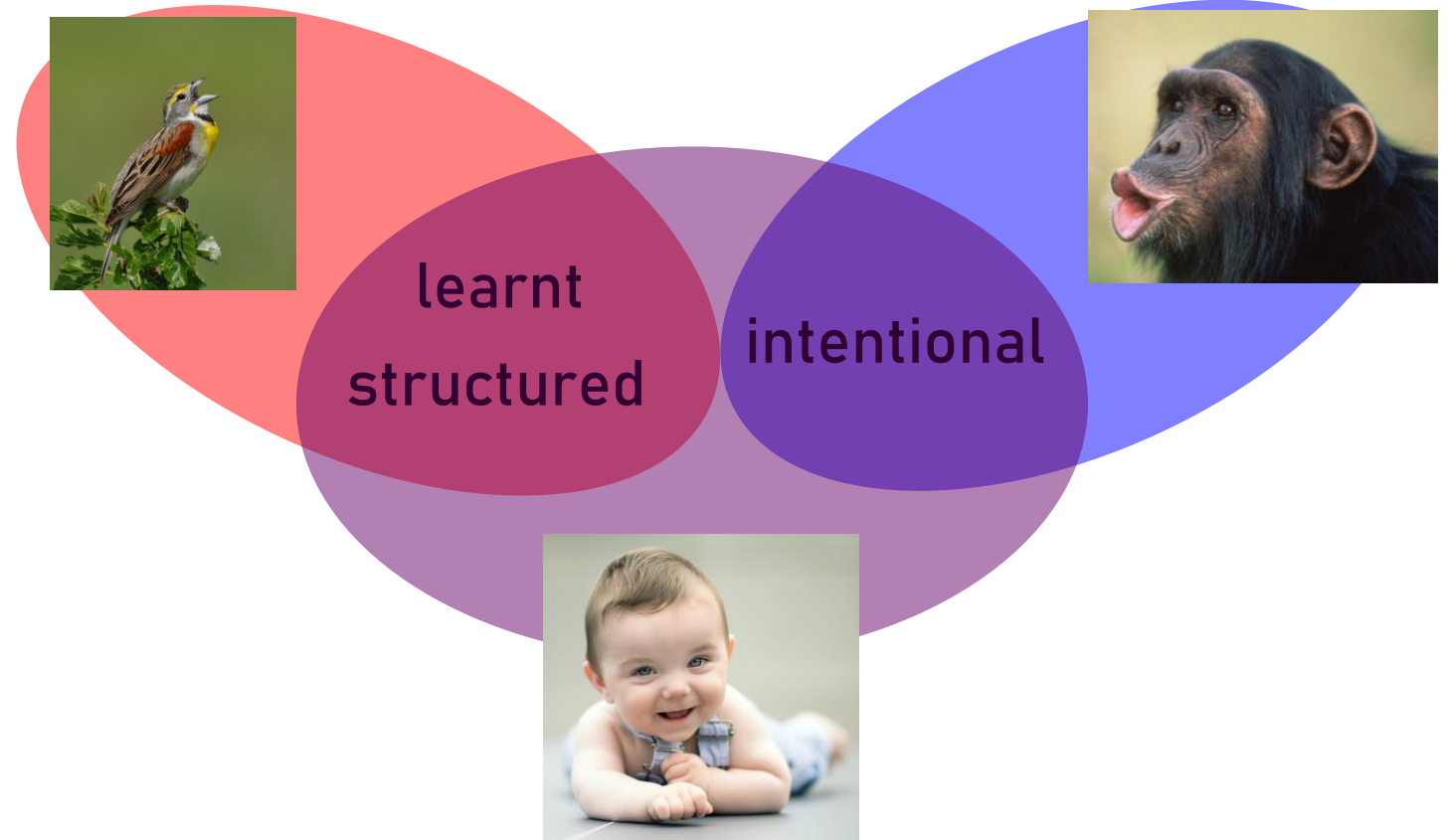
# What about language?

- ◇ Honest signalling is a (huge) problem for human language.
- ◇ Because we use symbols, and symbols are arbitrary, there is no connection between the sign and the signifier to prevent faking. We can and do lie.
- ◇ Some aspects of language that are somewhat honest, e.g., accent
  - ◇ function for the critical period of lang acquisition?
- ◇ If we think of culture generally as an honest system of which language is only one component, this *might* make it slightly less problematic



# Animal communication

- ◇ Communication is widespread: any transfer of information between individuals or groups
- ◇ Focus on the intersection of **intentionality** and **structure**



# Animals have rich mental lives

Episodic(-like) memory

Number sense

Self-awareness

Temporal sense

(some elements of) Theory of Mind (maybe)





# Alex the parrot

(1976-2007)

30 year experiment by Irene Pepperberg

Avian Language EXperiment

Alex was a definitely a smart bird

BUT interpretation is disputed:  
imitation or language?





Communicating  
with dolphins?

## DOLPHIN PHRASEBOOK

### The Side-Flop

**What it is:** Dolphin jumps clear out of the water before landing on its side with a large splash

**When it's seen:** More experienced dolphins execute side-flops just before the group swim into fresh waters

**What it means:** 'Let's go' or 'I want to go now'

### The Upside-down Lobtail

**What it is:** Dolphin rolls on its back with its belly in the air and slaps its tail on the water

**When it's seen:** The upside-down lobtail is spotted just before a group of dolphins come to a halt

**What it means:** 'Let's stop' or 'I want to stop now'



# Dogs

- ◆ Lack dexterity for speech (unlike parrot), signs, or lexigrams
- ◆ Bred to be social - impressive receptive language
- ◆ Rico (~200 distinct objects) and Chaser (>1000)
- ◆ Display mutual expressivity

Kaminski, J., Call, J., & Fischer, J. (2004). Word learning in a domestic dog: evidence for "fast mapping". *Science*, 304(5677), 1682-1683.

Pilley, J. W., & Hinzmann, H. (2013). Chaser: Unlocking the genius of the dog who knows a thousand words. Houghton Mifflin Harcourt.



# Communicating with animals

- ◇ See also, Kanzi, Koko, Washoe
- ◇ However, keep in mind that this is **a strange thing to do**
  - ◇ Animals are usually in captivity (dolphins the exception)
  - ◇ Intentional interspecies communication is very rare (though in case of dogs, it is evolved)
  - ◇ Usually effort for them to come to us (dolphins the exception)

...but natural  
communication  
*relatively*  
restricted



(as far as we know)



Innate signal repertoires, particularly  
among primates



Functionally referential, but not  
intentional



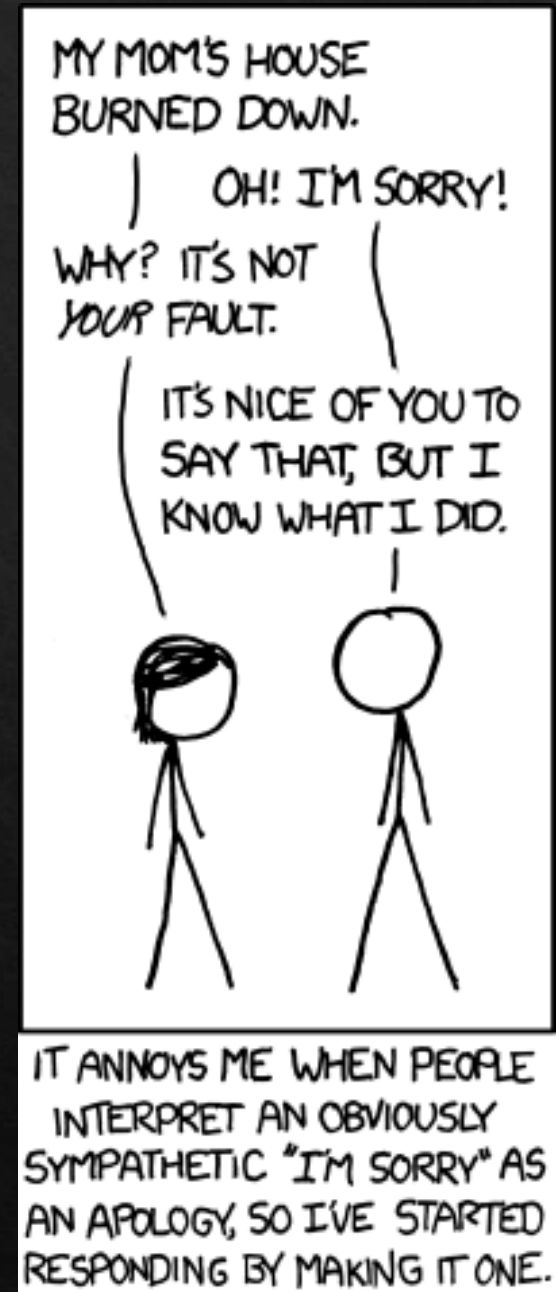
Complex  
vocalisations, but

Rarer in primates (more  
common in birds)

Not (obviously) propositional

# Intentional communication

- ◇ Grice (1957): the meaning of an utterance is defined in terms of the speakers' intention, and recognition of that intention by the hearer
  - ◇ Grice (1975): Maxims - be cooperative, be informative
- ◇ When engaged in communication, keep each other's mental states in mind
- ◇ Functional reference vs intention to inform



# Functional reference



# Functional reference in macaques

- ◊ Studied mothers and infants
- ◊ Ignorance condition: mother knows something infant doesn't (e.g., presence of food, predator)
- ◊ Knowledge condition: They both know
- ◊ Mothers vocalisations don't differ between conditions.

Cheney, D., & Seyfarth, R. (1990). Attending to behaviour versus attending to knowledge: examining monkeys' attribution of mental states. *Animal Behavior*, 40, 742-753.

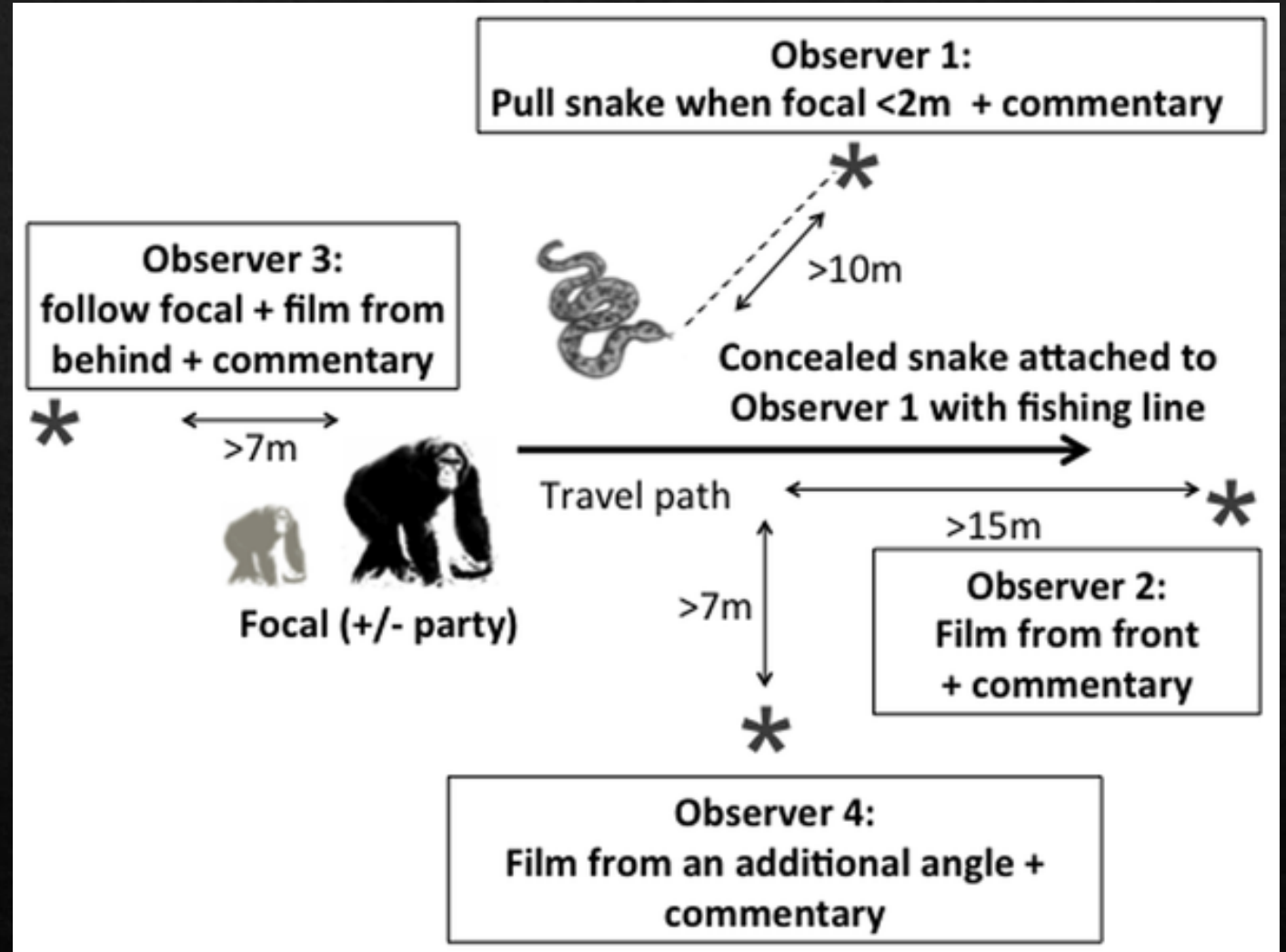




# Intentional communication in chimpanzees

- ◇ Wild chimpanzees, surprised with a fake snake, either
  - ◇ alone
  - ◇ as part of a group
- ◇ Does the presence of others matter? Do they persist until others are safe?

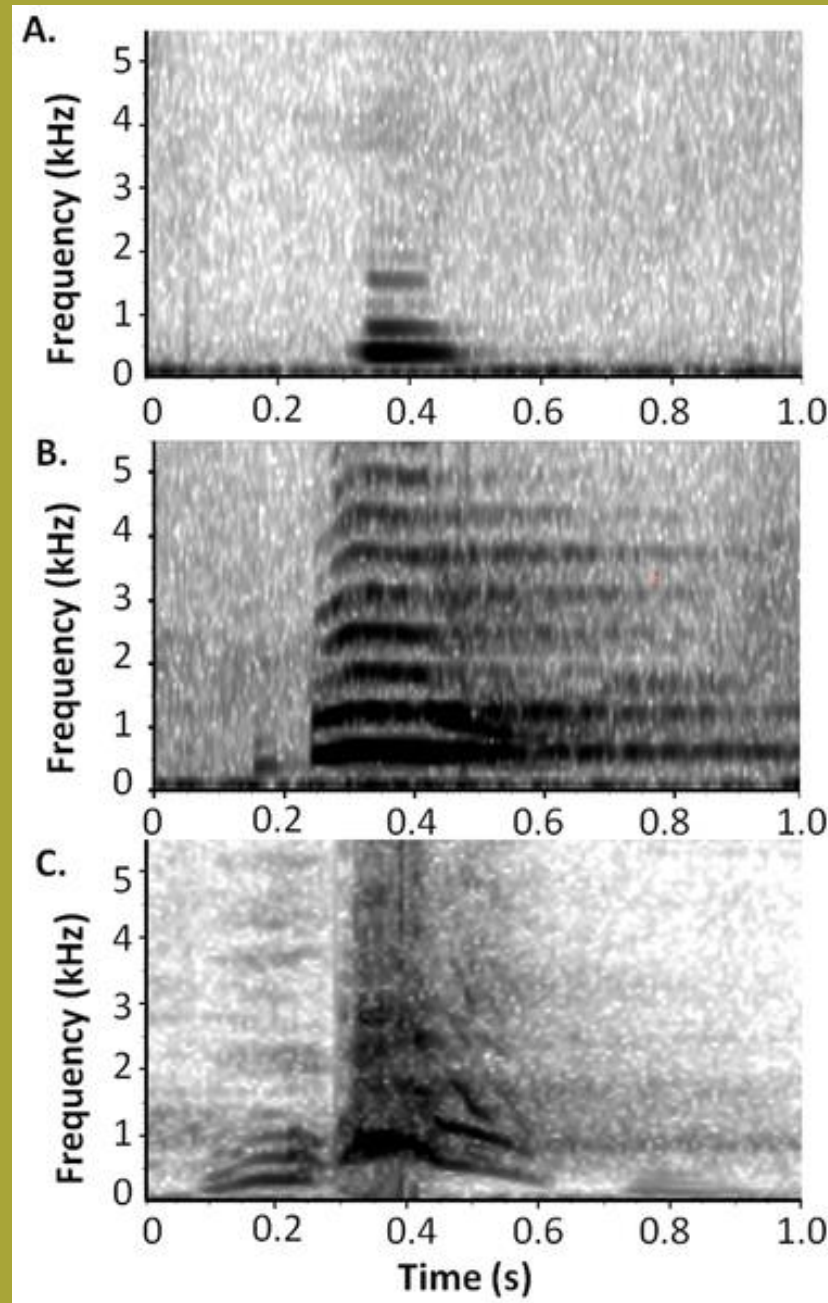
Schel, A. M., Townsend, S. W., Machanda, Z., Zuberbühler, K., & Slocombe, K. E. (2013) Chimpanzee Alarm Call Production Meets Key Criteria for Intentionality. *PLoS ONE*, 8, e76674



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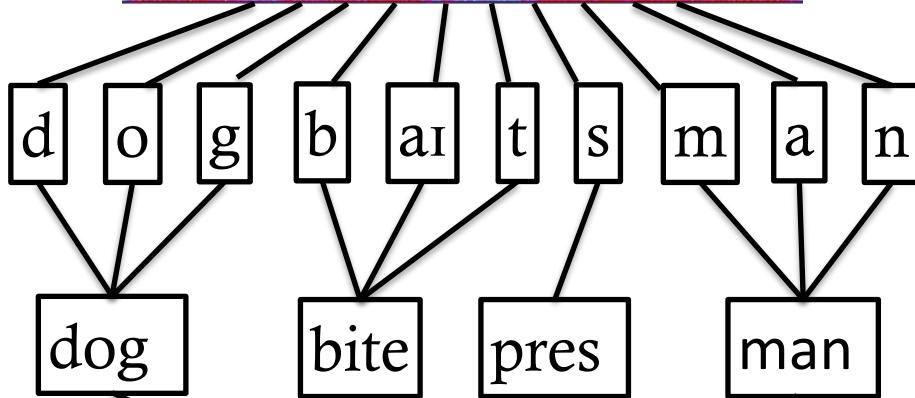
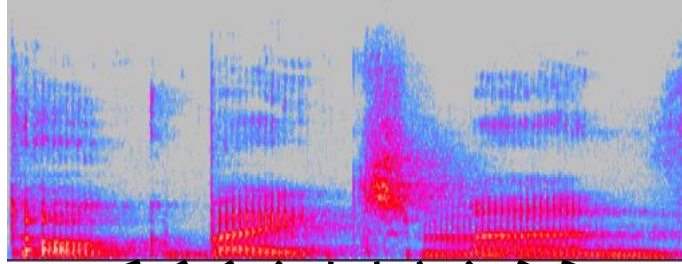




A complex network diagram consisting of numerous white nodes connected by thin white lines, set against a dark blue background. The nodes are distributed across the frame, with a higher density in the upper right quadrant. The lines represent connections between the nodes, creating a web-like structure.

# Structure in communication

# Language structure



Combinatorial phonology

Compositional syntax



# Putty nosed monkey: combinatoriality compositionality?

- ◇ Pyow: Leopard
- ◇ Hack: Eagle
- ◇ Pyow-hack: move

Arnold, K. & Zuberbuhler, K. (2006). Language evolution: semantic combinations in primate calls. *Nature*, 441, 303

Zuberbühler, K. (2018). Combinatorial capacities in primates. *Current opinion in behavioral sciences*, 21, 161-169.





# Campbells monkey and Diana monkey

- ◇ Campbells has leopard alarm and eagle alarm
- ◇ Dianas use these
- ◇ Somtimes, alarm is modified with a 'boom'
  - ◇ For Campbell's, reads "not urgent"
  - ◇ For Dianas, no difference in reaction



# Gibbon song

- ◆ Primarily used for
  - ◆ Pair bonding
  - ◆ Mating
  - ◆ Territorial defence/warning predators
- ◆ In other words, not propositional



# Gibbon song



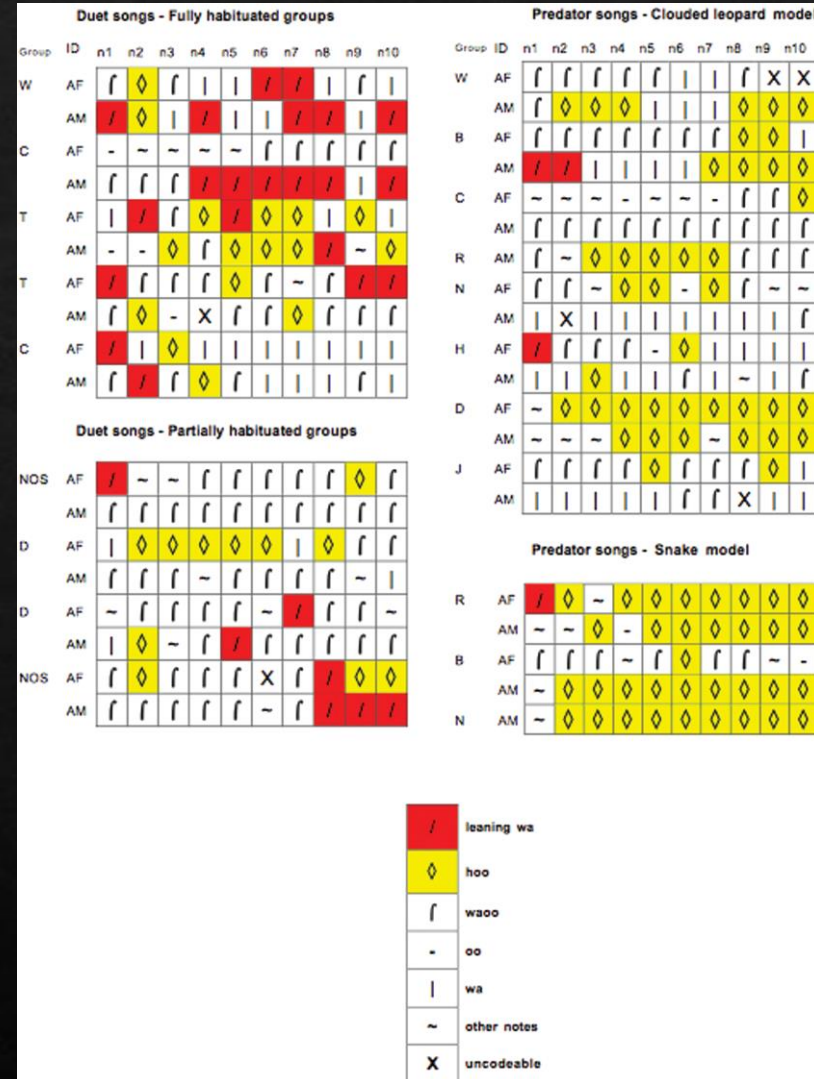
0:40 / 0:40 360p

A video player interface showing a hand cursor icon, a volume icon, a play/pause icon, and a full screen icon. The video progress is at 0:40 / 0:40 and the resolution is 360p.

# Structure in Gibbon Song

- ◆ Same elements contained in predation defence and mating/pair bonding
- ◆ Seem to be recombined in different ways for different situations

Clarke, E., Reichard, U. H., & Zuberbühler, K. (2006). The syntax and meaning of wild gibbon songs. *PloS one*, 1(1), e73.



# Latent capacity for syntax in apes?



Savage-Rumbaugh, E. S., Murphy, J., Sevcik, R., Brakke, K., Williams, S., Rumbaugh, D., & Bates, E. (1993).  
Language comprehension in ape and child. *Monographs of the Society for Research in Child Development*, 58, 1–252.

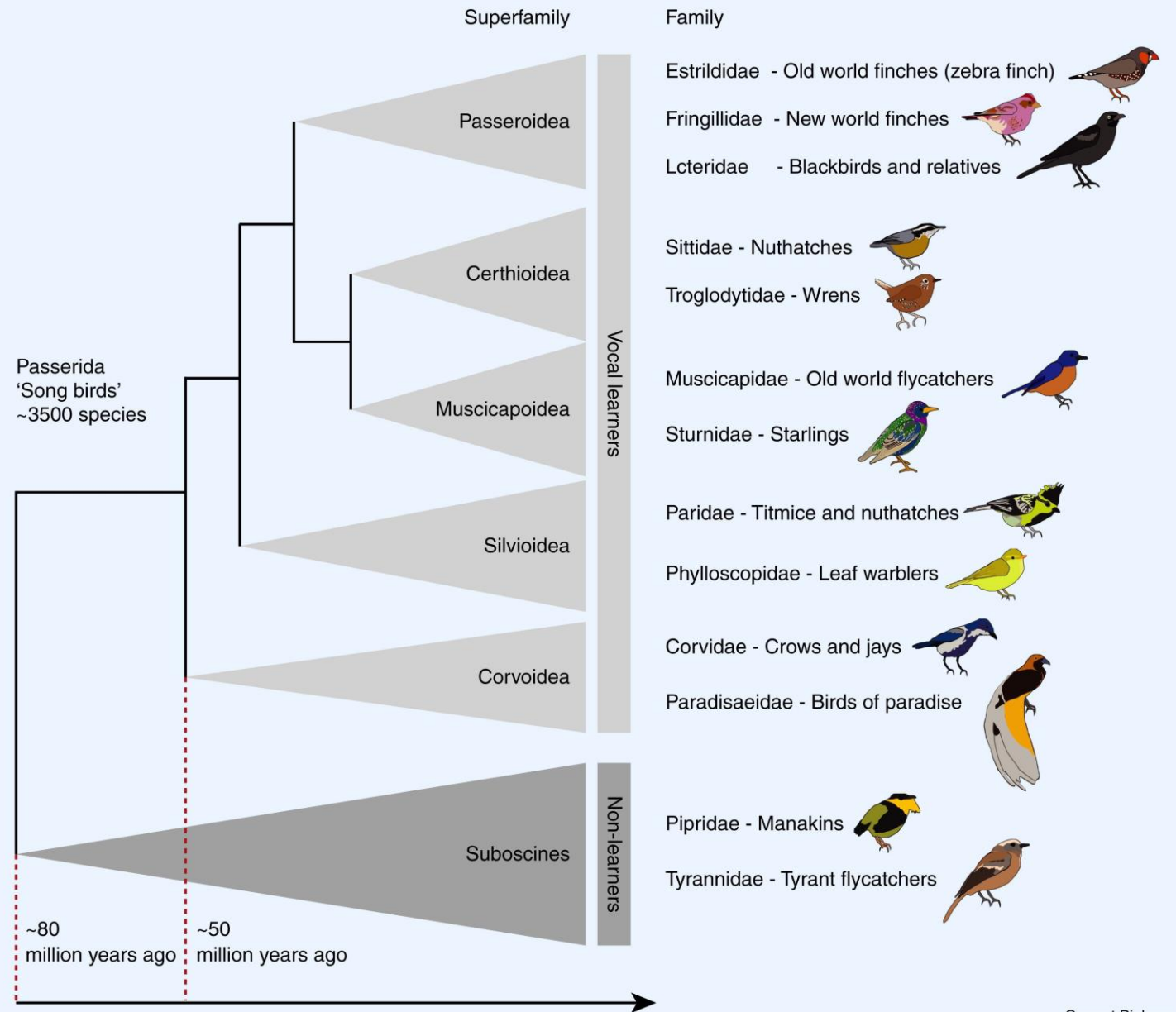
# Latent capacity for syntax in apes?

- ◇ Could just be 'semantic soup' plus smart interpretation?
- ◇ Cut the onions with your knife
- ◇ Put the pine needles in the refrigerator
- ◇ But he can handle reversible events
- ◇ Put the tomato in the oil
- ◇ Put some oil in the tomato [Kanzi pours oil in a bowl with the tomato]
- ◇ But no strong evidence for hierarchy
- ◇ Give the water and the doggie to Rose. [Gives dog only]
- ◇ Give the lighter and the shoe to Rose. [Gives lighter only]
- ◇ Give me the milk and the lighter [Responds correctly]

Truswell, R. (2017). Dendrophobia in bonobo comprehension of spoken English. *Mind & Language*, 32(4), 395-415.

# Structure in avian communication

- ◇ Songs consist of sequences of notes, including sub-parts
- ◇ Constraints on the ordering of parts
  - ◇ but, structure in the signal does not convey structured (or any) meaning
- ◇ Socially learned, rather than innate
  - ◇ most primate vocal behaviour is innate
- ◇ Ultimate functions
  - ◇ Territorial defence
  - ◇ Courtship
  - ◇ Pair/group bonding and duetting
  - ◇ ...just like gibbons



# Chaffinch

Each bird has 1-6 song types

- Mean 2-3

Order of notes in each song fixed

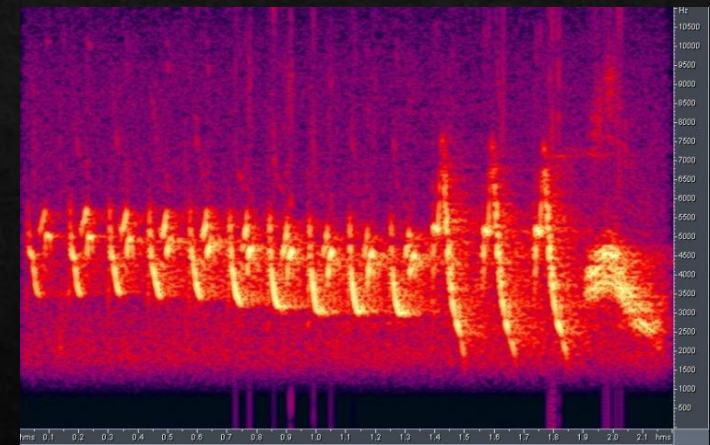
2-5 trill phrases, followed by a flourish

- Trill: sequence of 2 or more near-identical units
  - Number of repetitions can vary
- Flourish: no repetition
- Transitional notes: single notes between trill phrases
- Re-use of notes
  - Different songs may share, e.g., a flourish

Slater, P. J. B., & Sellar, P. J. (1986). Contrasts in the Songs of Two Sympatric Chaffinch Species. *Behaviour*, 99, 46-64.

Slater, P. J. B., Clements, F. A., & Goodfellow, D. J. (1984). Local and regional variations in chaffinch song and the question of dialects.

*Behaviour*, 88, 76-97.



Trill 1

Trill 2

Flourish

# Sedge warbler

Large repertoire of syllables

- 40-60 (?)

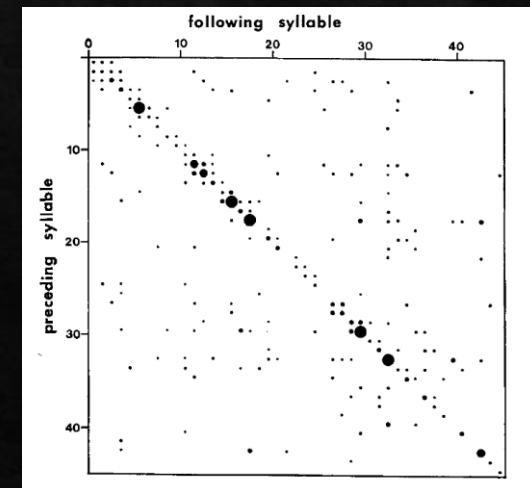
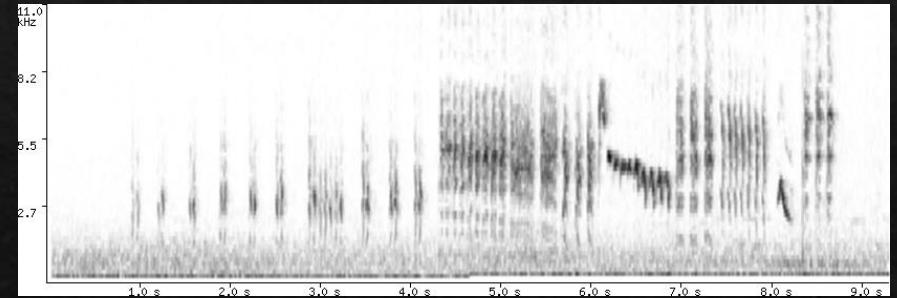
Highly variable

- No two songs are the same (probably)

General organising principles

- Song start: long complex sequence of repetitions of 2 syllable types
- Middle: Multiple new syllable types introduced in quick succession
- End: similar to start, but using 2 syllables selected from middle

Catchpole, C. K. (1976). Temporal and sequential organisation of song in the sedge warbler (*Acrocephalus schoenobaenus*). *Behaviour*, 59, 226-245.

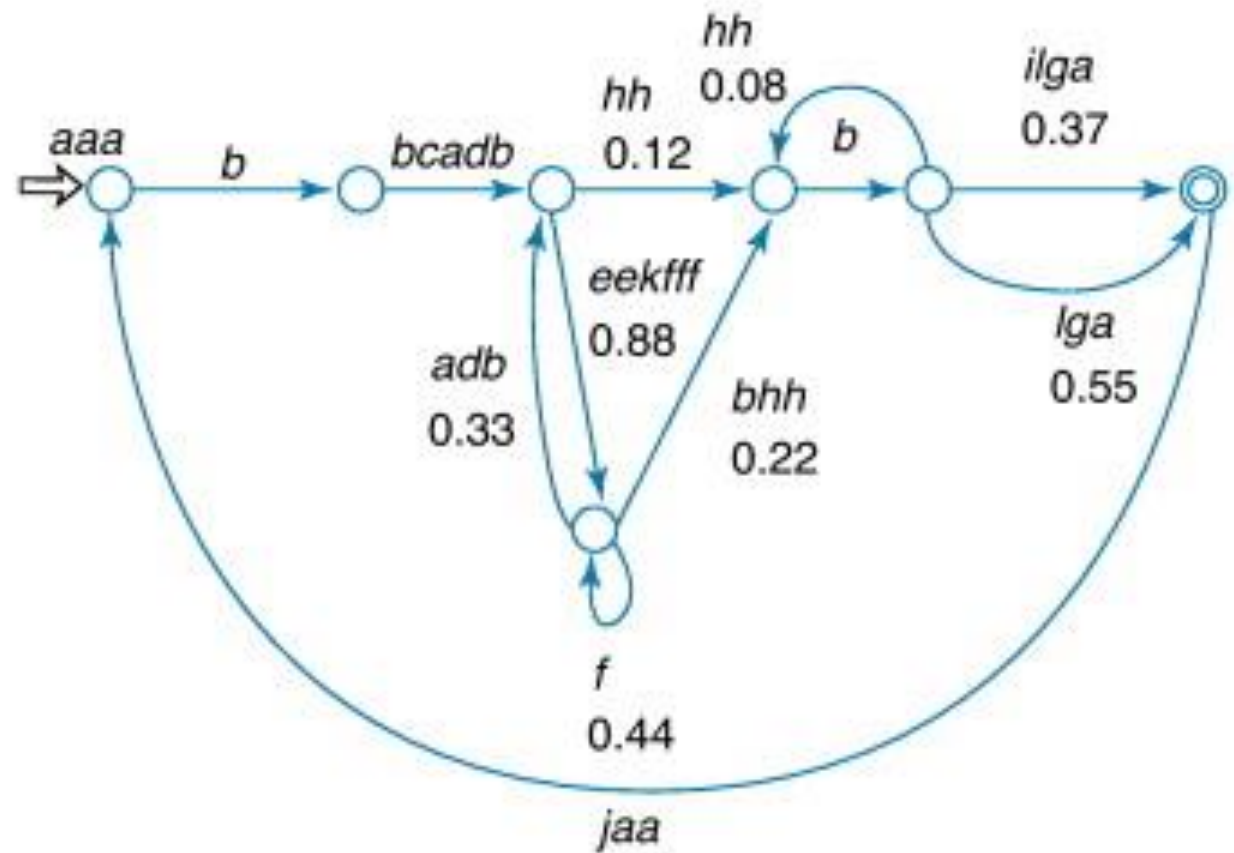




# Avian song structure: Overview

- ◆ Beyond bigram dependencies
- ◆ No nested dependencies
- ◆ Crucially: no compositional semantics

Berwick, R. C., Okanoya, K., Beckers, G. J., & Bolhuis, J. J. (2011). Songs to syntax: the linguistics of birdsong. *Trends in cognitive sciences*, 15(3), 113-121.



# Vocal communication in bats

- ◇ Complex vocalisations for navigation (e.g., echolocation)
- ◇ Also used for social bonding and interaction
- ◇ In some species , learned and open-ended
- ◇ Exhibits turn-taking

Vernes, S. C. (2017). What bats have to say about speech and language. *Psychonomic bulletin & review*, 24(1), 111-117.



# Summary

- ◇ Animals exhibit many aspects of complex cognition:
  - ◇ memory, including episodic and episodic-like
  - ◇ self-awareness (may be more widespread than we think?)
- ◇ Where they don't, if they don't, burden of proof has shifted - uniqueness cannot be assumed
- ◇ Communication is widespread - but analogues to language are rare
- ◇ Systems where intentionality, learning, and structure **intersect** are rare