LING 1010


# Language and Mind

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04.28.21: Animal Communication

# Big questions for today

Everybody agrees that animals have **communication systems**. It is very clear that animals can communicate with each other. But there are real open questions about the nature of that communication. Specifically, does it show the same properties as human language?

1. Do animal communications show the same complexity as human languages? (such as a phonology, morphology, syntax, or semantics)

2. To what extent do animal communication systems rely on innate knowledge, and to what extent do animal communication systems rely on experience/input?

3. For systems that rely on experience, to what extent is there a critical period for learning?

Today we will look at the following species: bees, birds, parrots, monkeys, chimpanzees/bonobos, and gorillas

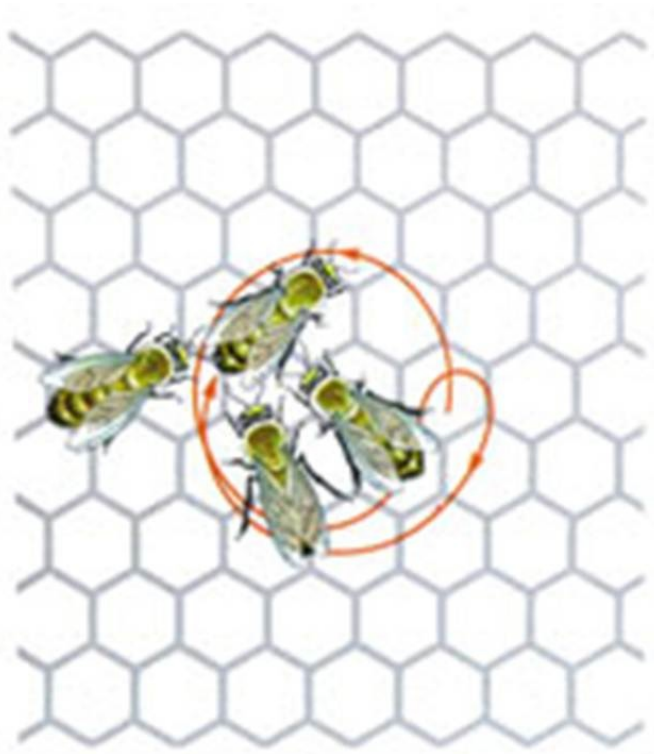
# The bee dances: round and waggle

Female scout bees go out and search for pollen and nectar.

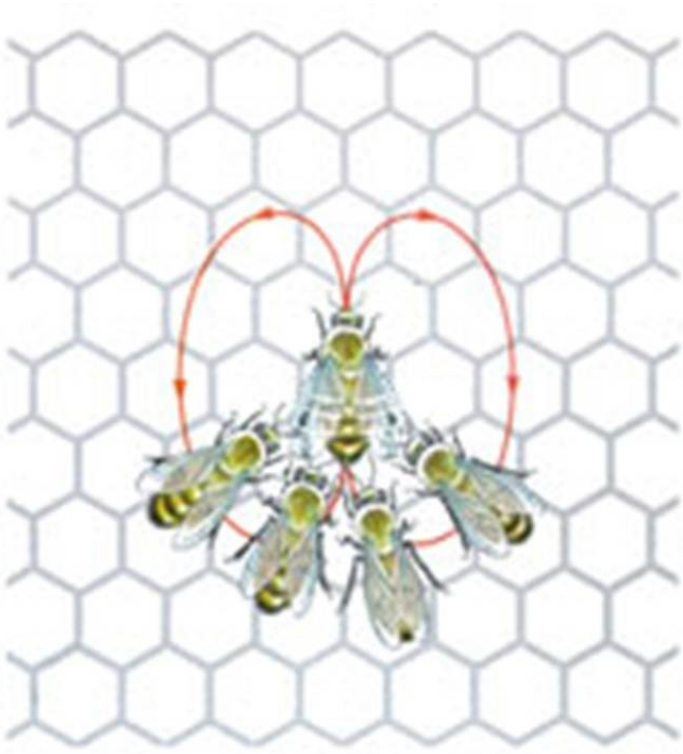
After they find this “food source”, they come back to the hive to tell the other bees about it. They do this with dances.

During the **round dance**, other bees simply smell the nectar on the scout, and then go out and try to find that smell near the hive!

The more interesting dance is the **waggle dance**!



**The Round Dance**
If the food is nearby, they do the round dance



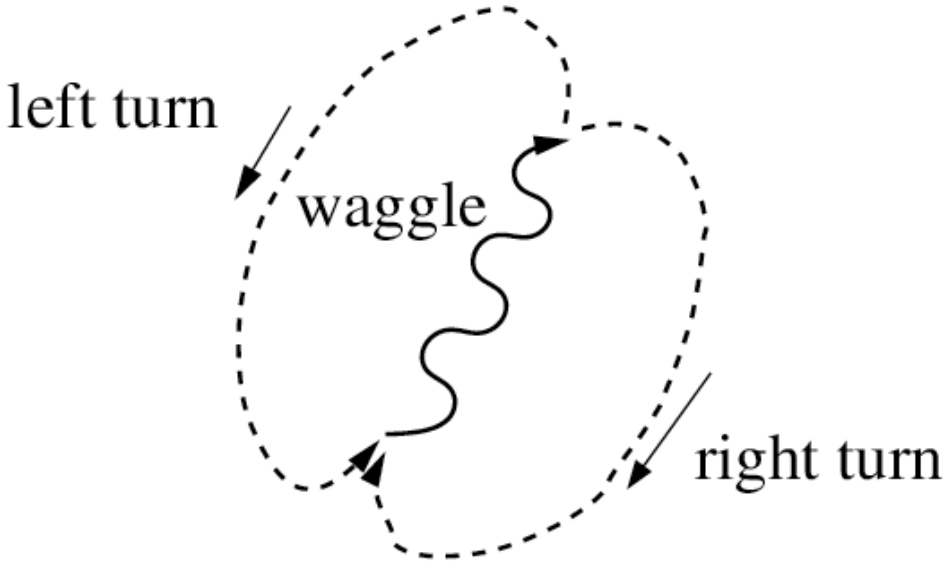
**The Waggle Dance**
If the food is far, they do the waggle dance

# The bee “waggle” dance

When the distance to the food is relatively far, the scout bees do the waggle dance.

The waggle dance has two parts: a straight section during which the bee waggles, and loops that the bee uses to re-start the straight/waggle section.

https://kaltura.uconn.edu/media/Bee+Dance+%28Waggle+Dance%29.mp4/1_2fy3trl8

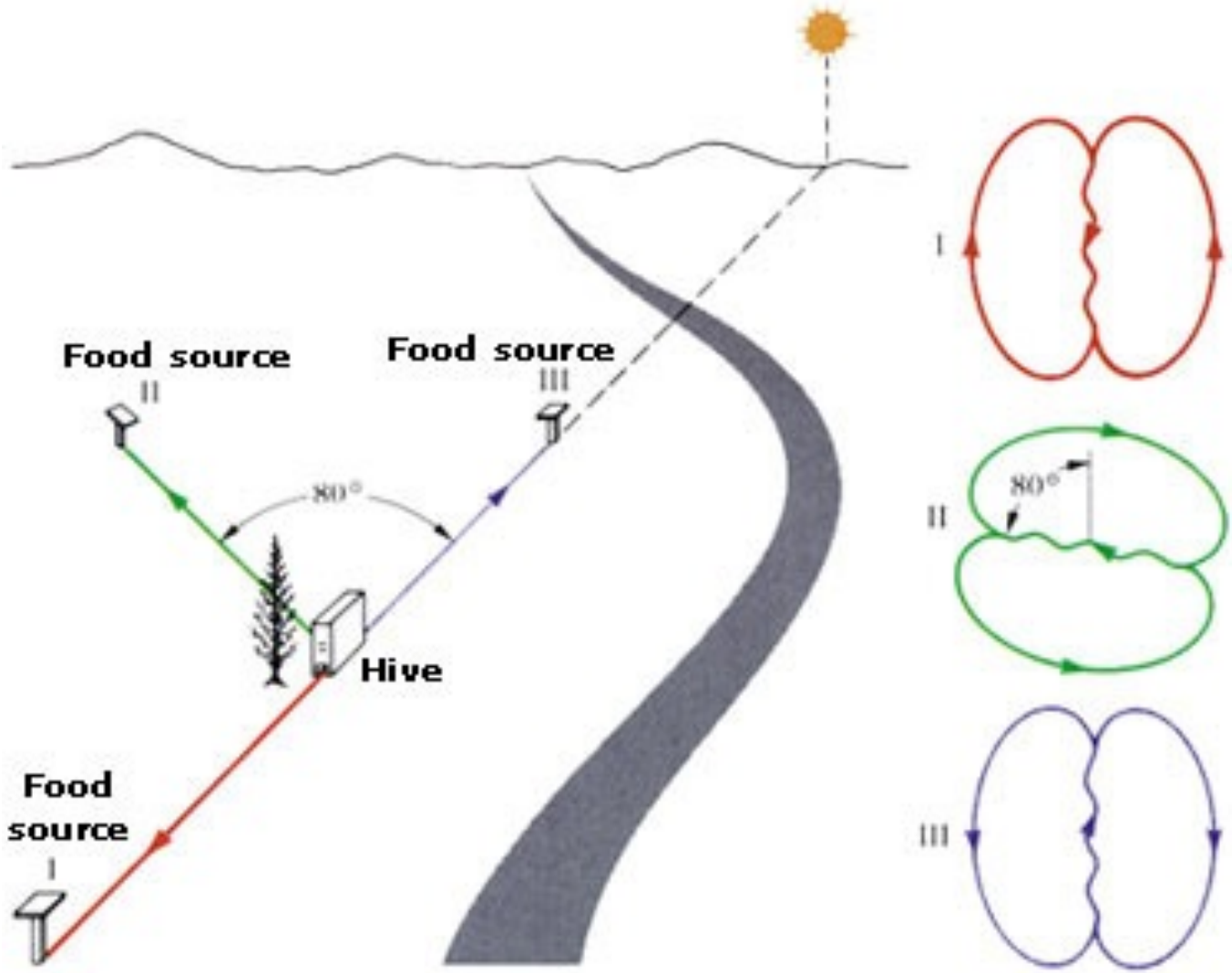



# The bee “waggle” dance

The direction of the waggle portion of the dance relative to vertical indicates the direction of the food relative to the sun.

The length of time of the waggle portion indicates the approximate distance.

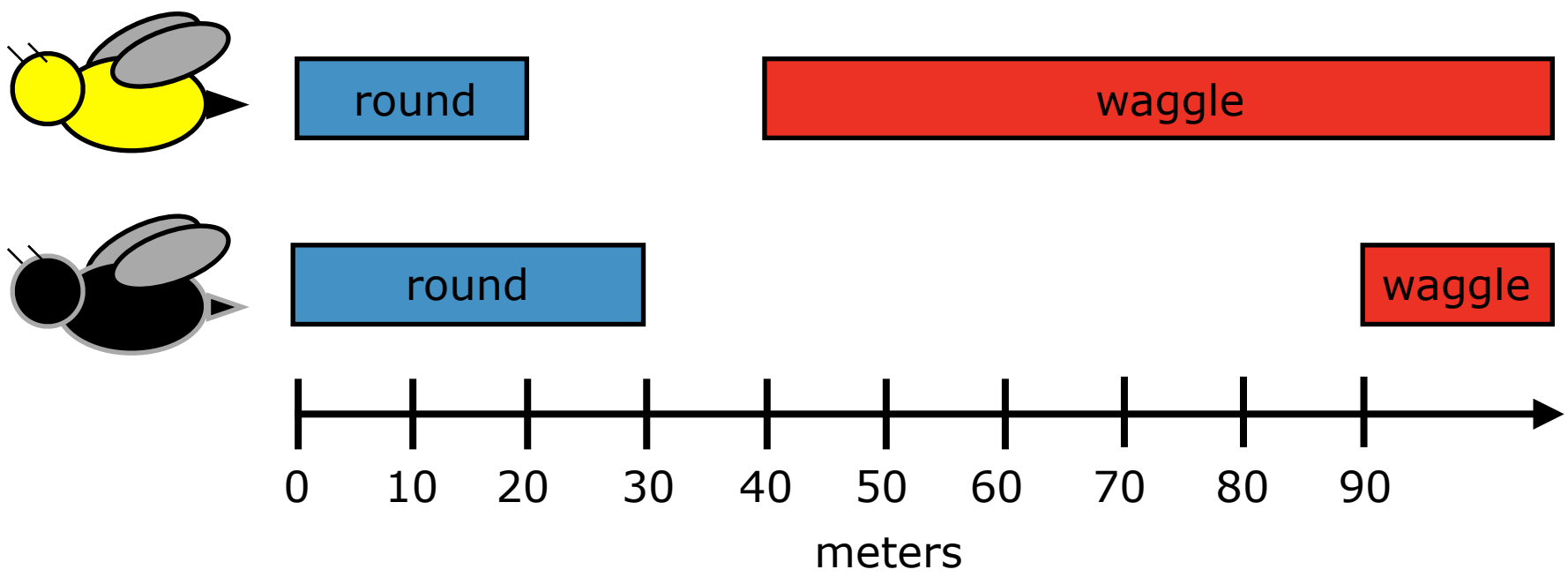
The energy of the waggling indicates the quality of the food source.



# The bee dance is genetic (innate)

The bee dance appears to be **genetic**. Here's why we think this.

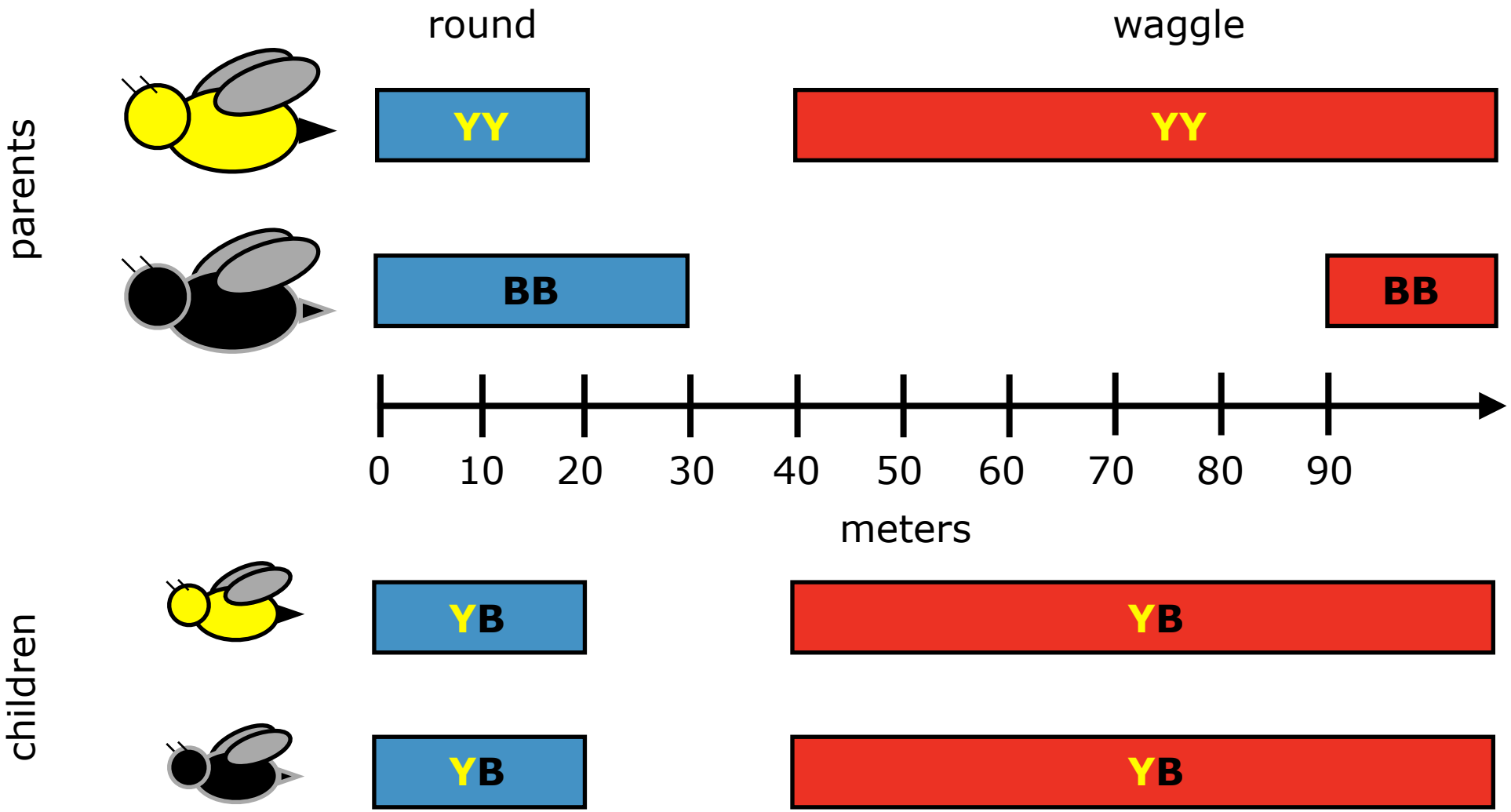
First, different species of bees have different "dialects" of dance:




To prove that this is genetic, we can cross-breed the bees to see how the dance is inherited by the children!

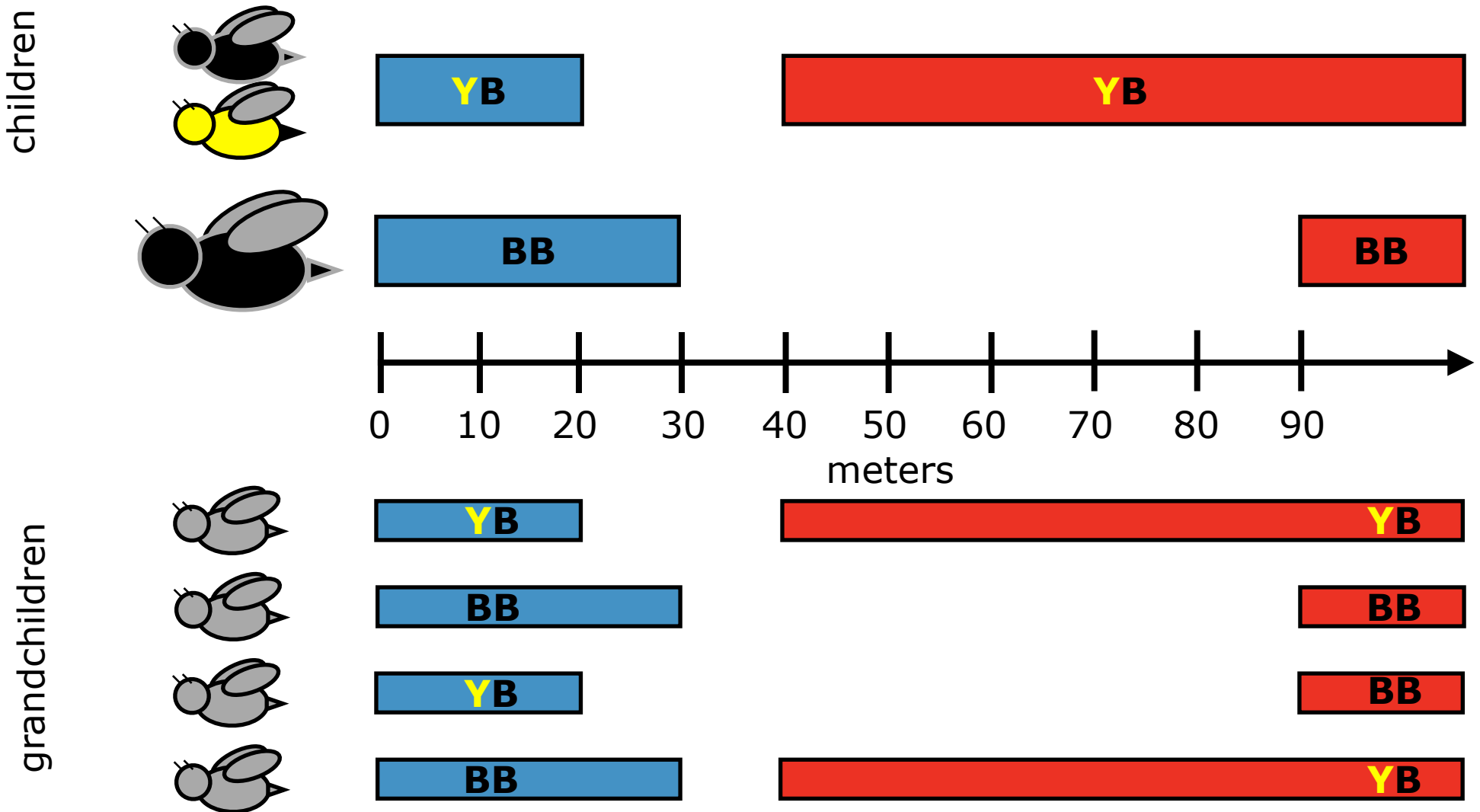
# The bee dance is genetic (innate)

If you cross yellow and black bees, you get children that are 1/2 yellow and 1/2 black, but all have the yellow dance dialect. This suggests that the yellow dialect is a dominant gene (Y is dominant over B):



# The bee dance is genetic (innate)

If you cross the children with pure black bees (to get away from the dominant yellow gene), you get four different combinations of bees: two that look just like the pure yellow and pure black, and two that combine the round and waggle portions of the two! This pattern is a classic indicator of genetics!



# The bee dance requires complex innate knowledge

So if the bees use the sun for direction, what do they do on a cloudy day?

# The bee dance requires complex innate knowledge

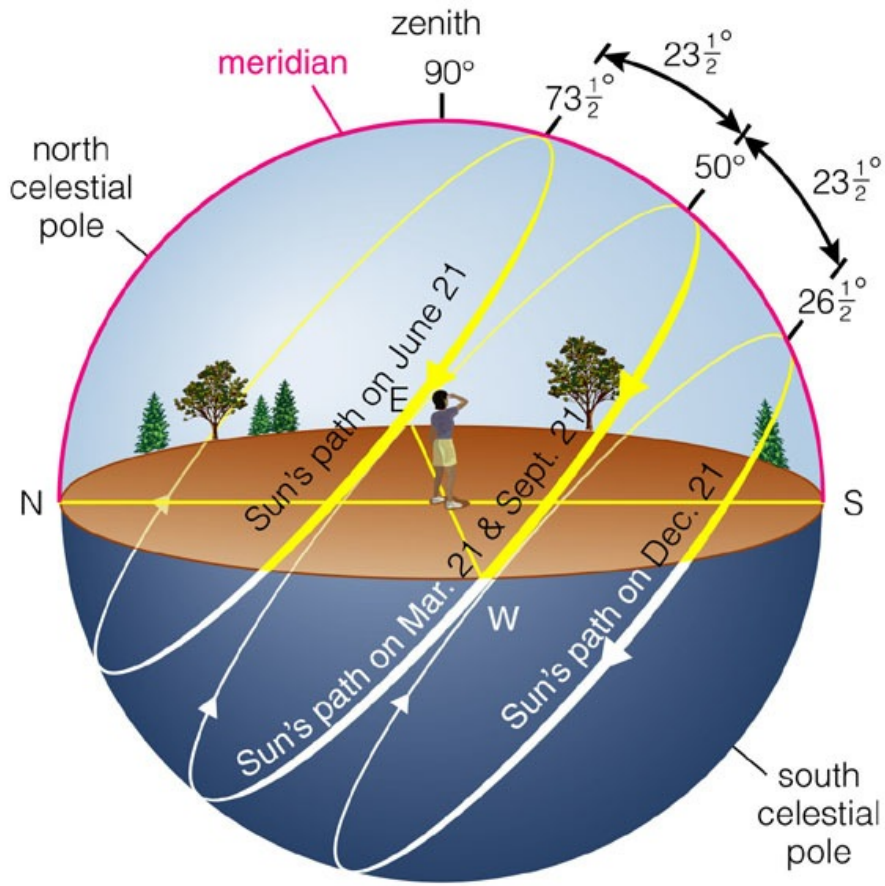
It turns out that bees actually know where the sun is on a cloudy day. They appear to have the **motion of the sun memorized**!

But this is an incredibly complex thing to memorize. The position of the sun changes based on the following properties:

1. Your location on the globe (latitude)

2. The position of the earth in its revolution around the sound (time of year)

3. The position of the earth in its rotation (time of day)




The function that predicts the location of the sun is called the solar ephemeris function. **How do bees know this function?**

# The bee dance requires complex innate knowledge

To put this in perspective, you have been alive for about 20 years.

That means you have lived approximately 7300 days.

Assuming you have seen the sun an average of once per day, that means you have seen the sun approximately 7300 times.

Has this been enough for you to learn the ephemeris function? Can you predict the location of the sun in the sky based on the time of day and the time of year that it is? My guess is that you can't. Are bees smarter than you?

The typical bee can predict the location of the sun after **only a few flights outside of the hive**.

Given the complexity of the ephemeris function, it seems unlikely that bees learn it from only a few exposures to the sun. Instead, it seems much more likely that **the ephemeris function is part of the bee's innate knowledge**!

# Bird Calls: simple and genetic (innate)

Bird calls are a rudimentary communication system that most bird species have. They tend to report properties about themselves:

1. I am taking off/landing
2. I exist
3. I have food
4. I am dominant/submissive

etc..

This is not to say that bird calls cannot be used for fairly complex meanings.

For example the Black-capped Chickadee has a set of calls for inter-bird conflict that is composed of 4 notes: A, B, C, D

The actual call takes the form A* B* C* D*, which means that any number of A notes is followed by any number of B notes, which is followed by any number of C notes, which is followed by any number of D notes.

What is interesting is that the number of each note conveys a message: for example, the number of A's indicates the likelihood of attack, the number of D's indicates the likelihood of retreat.

# Bird Songs: complex and genetic (innate)

**Bird songs** are different from calls -- they tend to be much longer, involve more notes, and exhibit more complex patterns

The function of bird song is related to territory-marking and mate-attraction -- therefore males tend to be the singers and both females and males tend to be the listeners.

**song sparrow**

**swamp sparrow**

http://www.biology.duke.edu/nowicki/

# Bird Songs: complex and learned (with a critical period!)

For most birds, the songs that they sing are genetically specified.

This isn't to say that they can't learn variability. In fact, many birds demonstrate regional dialects: small variations in the song that they learn from their local neighbors.

However, in 3 (out of 27) orders of birds, the songs must be learned from other birds, or they won't be able to sing them properly! (songbirds, parrots, and hummingbirds)

For example, white crowned sparrows go through the following learning stages:

**0-35 days**: no singing (but probably lots of learning)

**25-40 days**: subsong (like babies babbling)

**35-80 days**: "plastic" singing -- closer and closer approximations of the full song

**> 90 days**: crystallization of the song

# Alex the Parrot

Though parrots can be taught to mimic strings of human speech sounds, they don't really use those sounds as complex communication.

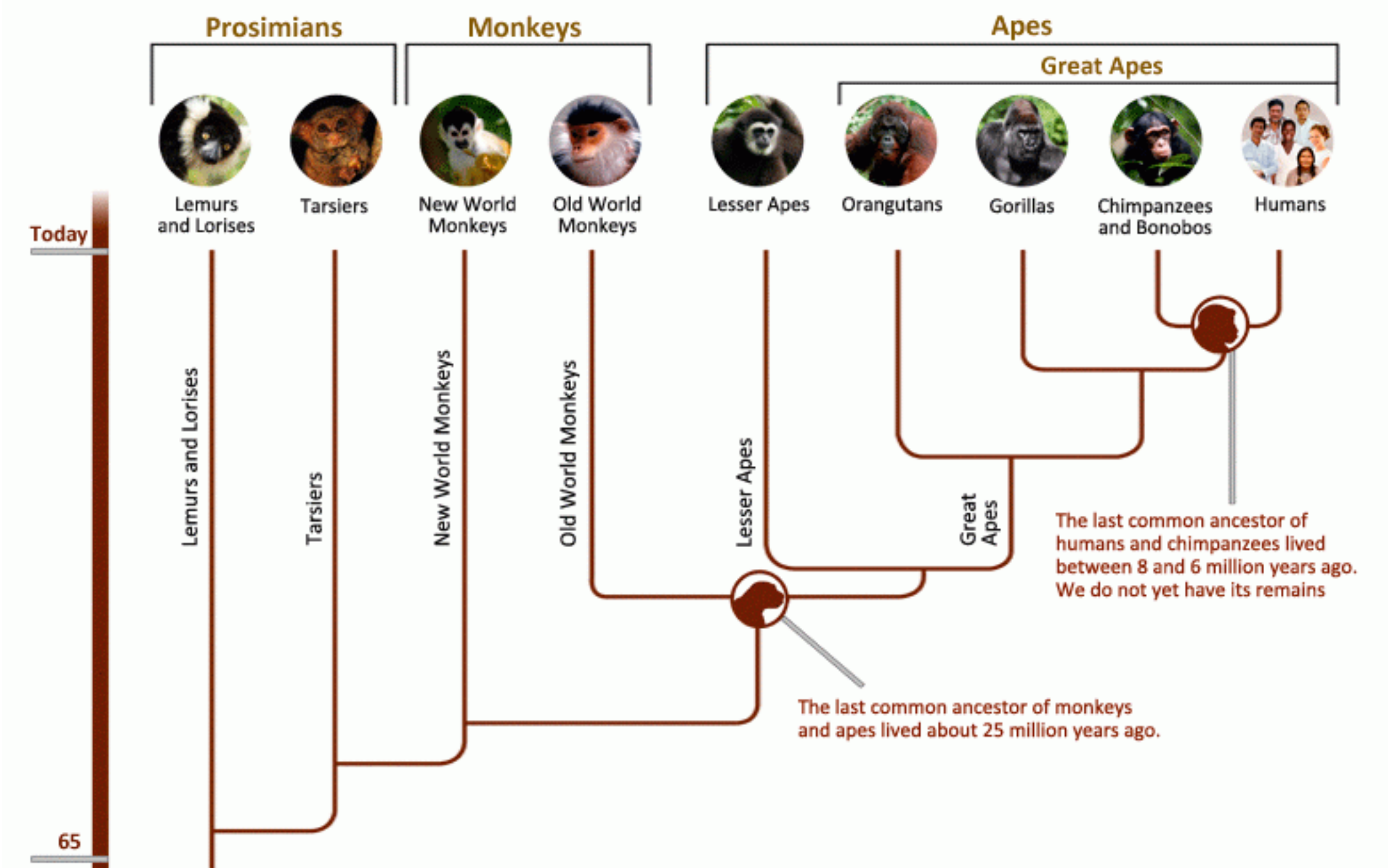
However, there is one example of a parrot who was taught to use human-sounds in a relatively complex way:

Alex was an African Grey Parrot that was taught an extensive vocabulary of color terms, number terms, shape terms, etc.

He demonstrated the ability to use those terms to answer complex questions about the world.

https://kaltura.uconn.edu/media/ALEX+-+One+of+the+most+smartest+parrots+ever%21.mp4/1_88wg3n8m

# Primates


Prosimians
Monkeys
Apes
Great Apes
Lemurs and Lorises
Tarsiers
New World Monkeys
Old World Monkeys
Lesser Apes
Orangutans
Gorillas
Chimpanzees and Bonobos
Humans
Today
65
Lemurs and Lorises
Tarsiers
New World Monkeys
Old World Monkeys
Lesser Apes
Great Apes
The last common ancestor of humans and chimpanzees lived between 8 and 6 million years ago. We do not yet have its remains
The last common ancestor of monkeys and apes lived about 25 million years ago.

# Vervet Monkeys - precursor to words?

3 types of calls: eagles, leopards, snakes

http://www.psych.upenn.edu/~seyfarth/Baboon%20research/vervet%20vox.htm

Are they three distinct calls, or just three versions of "danger"?

Record a specific monkey's leopard call, and play it back to a group of other monkeys over and over again, **even when no leopard is present.**

Over time, the group will ignore that monkey's leopard call, but will still respond to the eagle and snake calls. This suggests that they are 3 distinct calls.

Is it a scream? Or is it really a warning to other vervets?

Vervets don't make alarm calls when they are alone.
Submissive vervets make fewer alarm calls than dominant vervets.

# Nim Chimpsky, a chimpanzee - words and messages, but no syntax

Born in 1973 and raised by a family in NYC as part of a research project to teach chimpanzees sign language.

Learned about 125 signs over three years!

**Major conclusions:**

1. All (or nearly all) signs were performed when the referenced object was visually or auditorily present in the environment. No discussion of non-present objects except for requests for rewards (food, tickling, etc).

2. Though Nim could create several signs in a row, they tended to be repetitive and without ordering constraints (no syntax):

GIVE ORANGE ME GIVE EAT ORANGE ME EAT ORANGE GIVE ME ORANGE

# Matata and Kanzi, bonobos (possibly another critical period)

Matata was a bonobo (related to chimpanzees) that Sue Savage-Rumbaugh tried to teach to use a special keyboard. This keyboard used colored keys with shapes to symbolize words (instead of signs).

The idea was to teach them both the spoken English words AND the keys for the words. That way they could both hear and "speak".

Matata was really bad at this. But she had a son named Kanzi who was too young to be left alone. So Kanzi was present during Matata's training.

Though Kanzi was never explicitly trained, when he became an adult (~2.5 years old), he demonstrated impressive abilities to use the special keyboard in response to spoken English.

Kanzi can now use a keyboard with 256 words on it, and he can recognize many more than 256 spoken English words!

https://kaltura.uconn.edu/media/Kanzi+with+lexigram.mp4/1_5f21554u

# Kanzi - a hint of syntax?

There is even some evidence that Kanzi knows some word-order constraints.

For example, the order of actors in an English sentence matters for the interpretation of "who is doing what to whom":

Make the doggie bite the snake.

Make the snake bite the doggie.

https://kaltura.uconn.edu/media/Kanzi+and+Novel+Sentences.mp4/1_1m8k5xgt

Kanzi can distinguish these two sentences of spoken English.

However, his syntax abilities seems to be restricted to these types of ordering relationships.

For example, he has never learned that words like *and* mean that both actors worked together:

The doggie and the snake bit the cat

# Putting it all together (with lots of caveats)

| | bees | birds | monkeys | great apes | |
|---|---|---|---|---|---|
| | | | | non-human | human |
| complex messages | yes | yes | yes | yes | yes |
| innate knowledge | yes | yes | yes | yes | yes |
| critical period | (no) | yes | (yes) | (yes) | yes |
| words/ symbols | no | no (maybe Alex!) | yes | yes | yes |
| complex syntax | no | no | no | no | yes |

This is all under active investigations, so the conclusions are revised and expanded almost daily Here is a recent symposium talk about the evolution of language between humans and other great apes by a professor of linguistics at UC San Diego: https://carta.anthropogeny.org/events/sessions/language-1

# Some Conclusions

No animals have the system of representations and processes that humans have. And so far, we haven't been able to teach that system to any other animals.

But many species do have relatively complex communication systems that involve complex representations:

Bees represent direction, distance/energy, and quality of food sources in their waggle dance. This dance is genetic (innate).

Bees also have complex innate knowledge in the form of the solar ephemeris function so that they can navigate on cloudy days.

Birds and monkeys have various types of calls that represent danger or other "maintenance" functions, all of which are genetic (innate).

Bird songs have complex representations and may require complex learning, though songs don't have complex meanings. There appears to be a critical period for learned birdsongs.

Primates can be taught large inventories of signs (100-250), and can combine them in meaningful ways, though not as complex as language