جامعة نيويورك أبوظبي

NYU | ABU DHABI

PSYCH-UH 2218: Language Science

Class 25: Animal communication systems

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Psychology

An imprecise question

Do animals have language?

This is a popular question to ask, but it is not scientifically precise enough. We have to define what we mean by "language".

> If "language" means a communication system, then the answer is obviously yes. Nearly all animals have some sort of communication system.

> If "language" means the complex combinatorial system that humans have in their minds, then the answer is obviously no. Nobody seriously believes that any other animals have the same complex system as humans.

Once we do this, this question as posed becomes way less interesting (from a scientific point of view). We already know the answer. It is either obviously yes or obviously no.

Reformulating the question

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, we can do some comparative cognitive science, and ask how the properties of animal communication systems compare to 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

Bees: Finding pollen/nectar

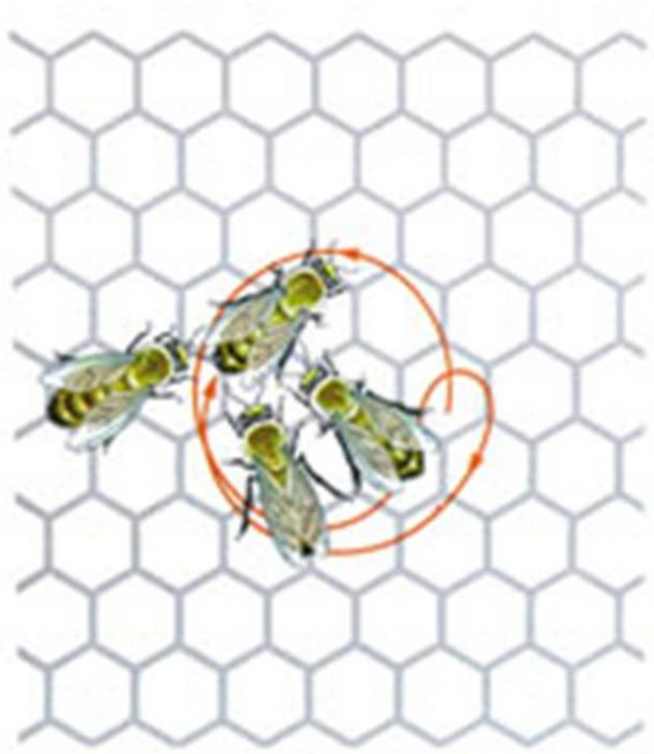
The bee dances: round and waggle

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

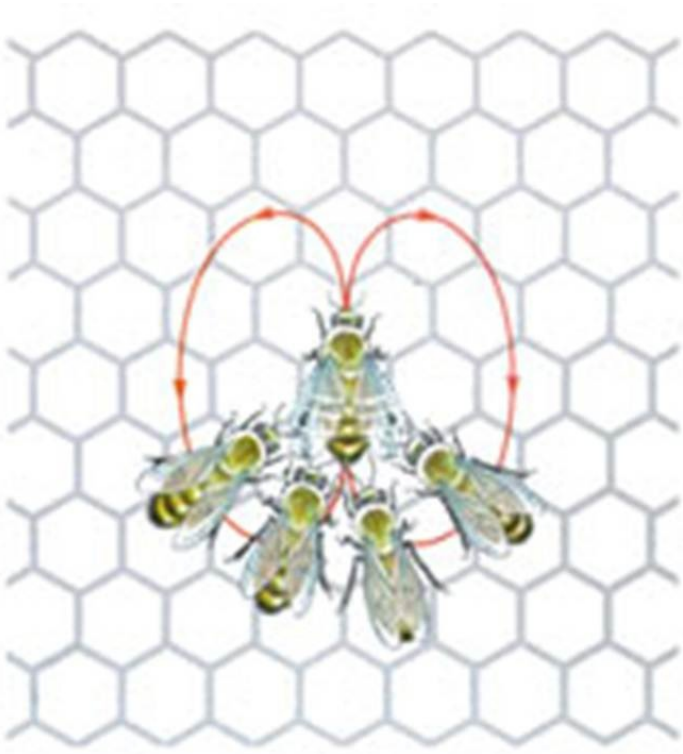
After they find this “food source”, they come back to the hive to tell the other bees about it. They do this with dances.

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



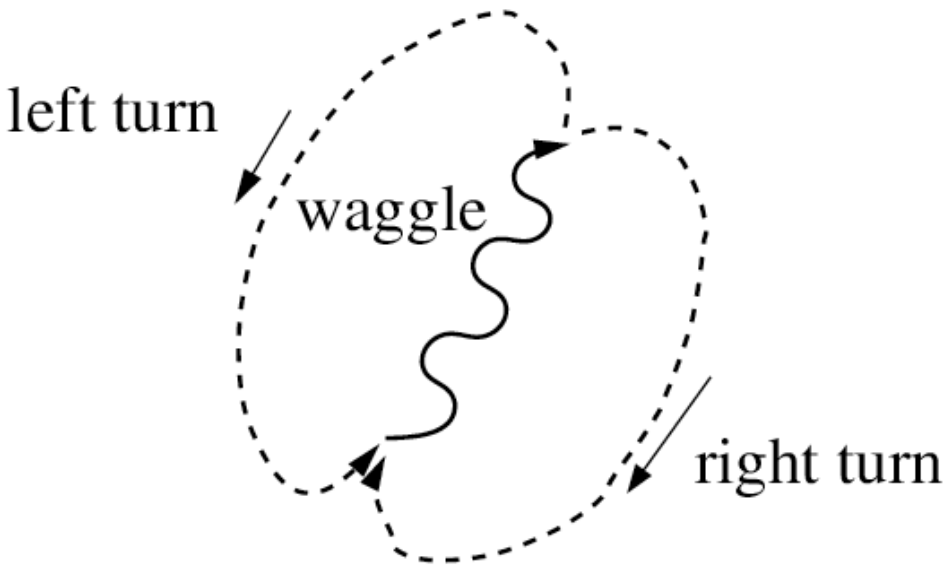
The Waggle Dance
If the food is far, they do the waggle dance

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://www.youtube.com/watch?v=-7ijI-g4jHg&ab_channel=BienentanzGmbH

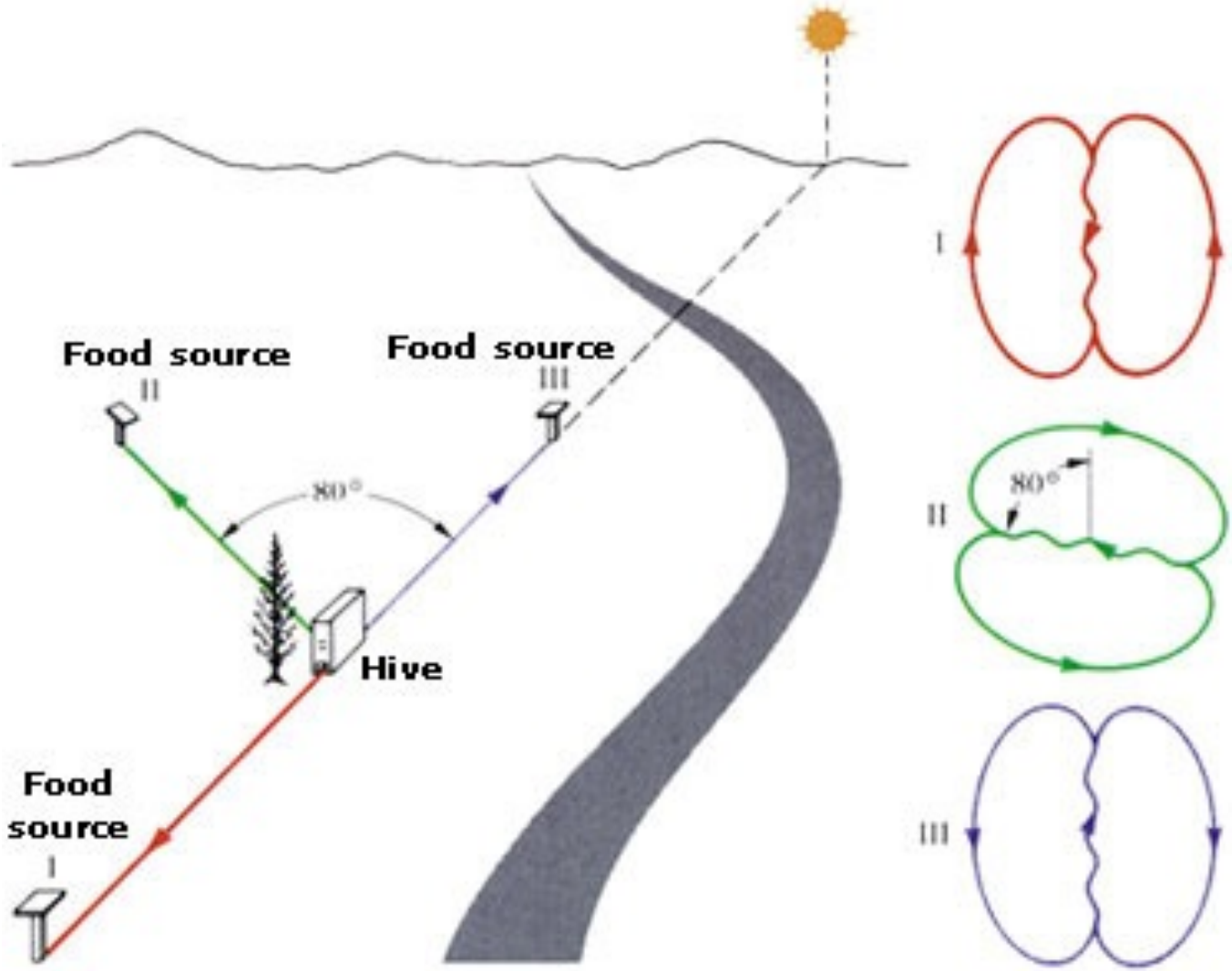


The bee “waggle” dance

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.

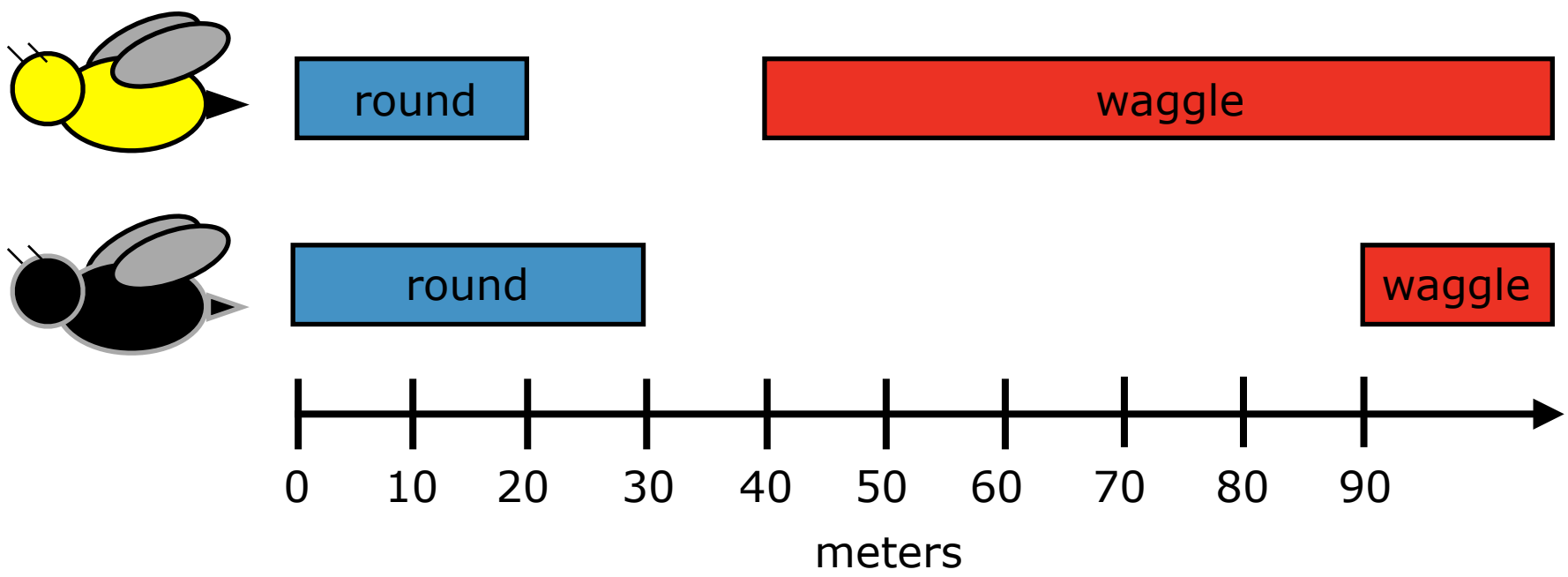
The energy of the waggling indicates the quality of the food source.



The bee dance is genetic (innate)

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

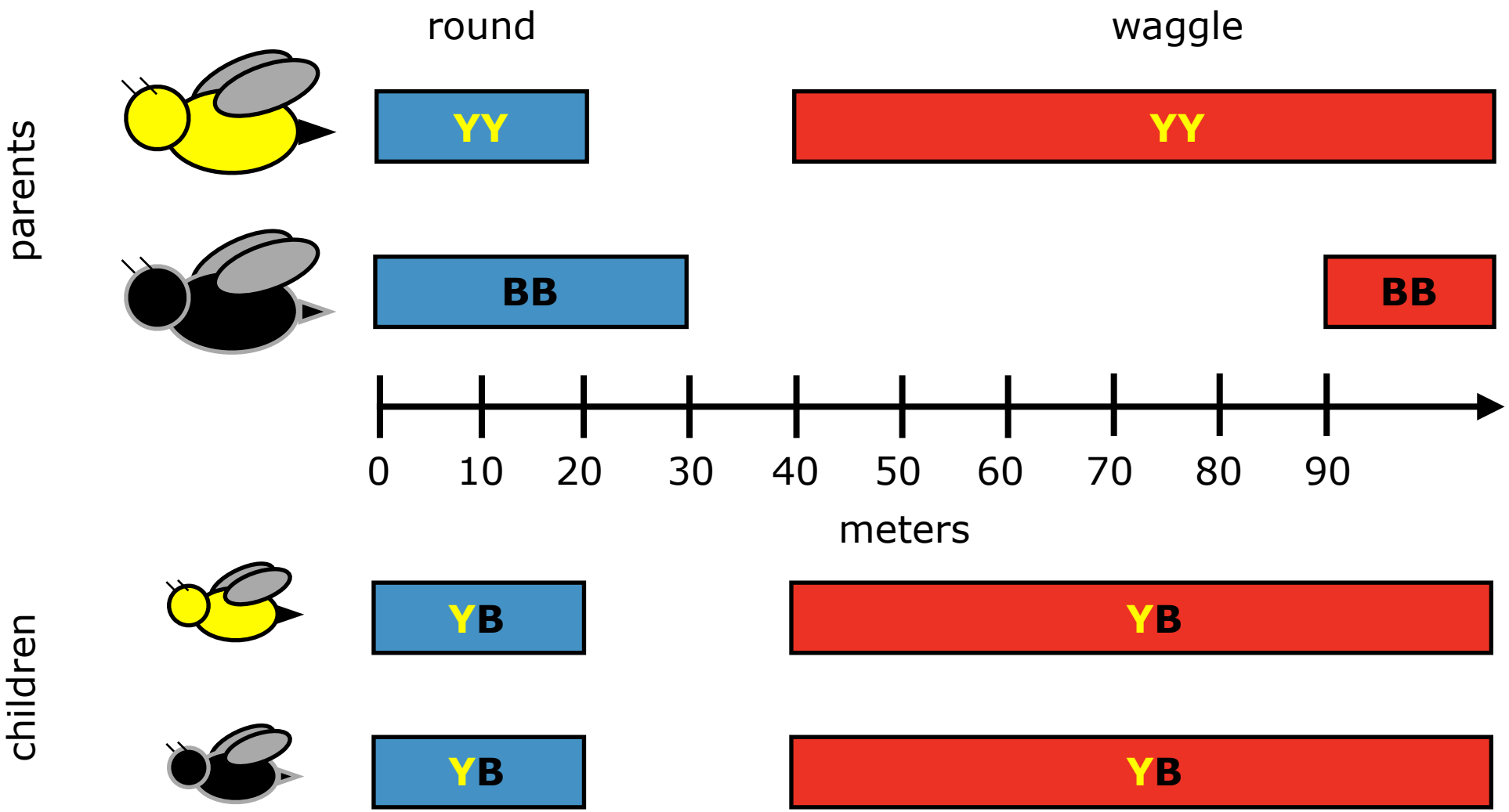
First, different species of bees have different "dialects" of dance:



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

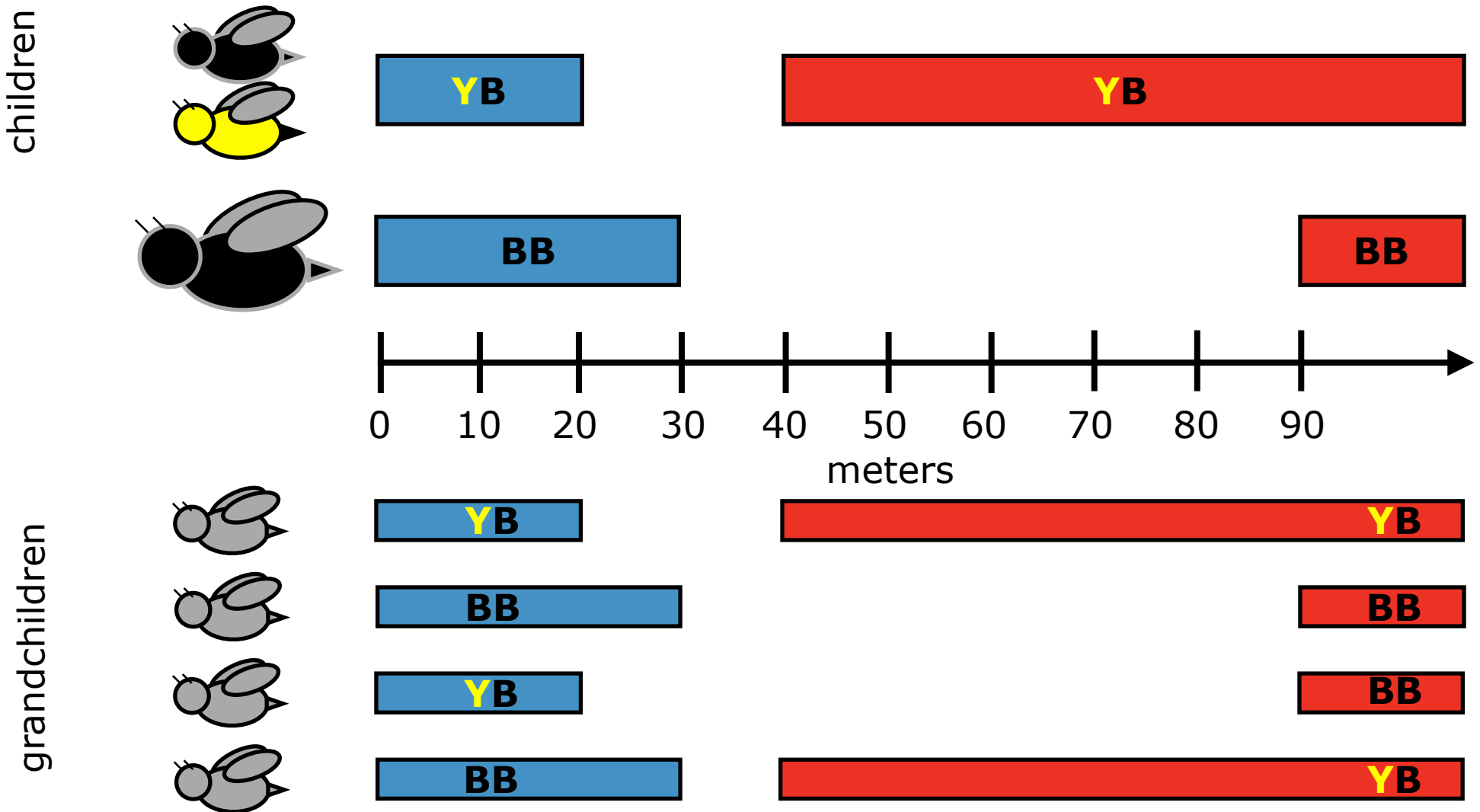
The bee dance is genetic (innate)

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

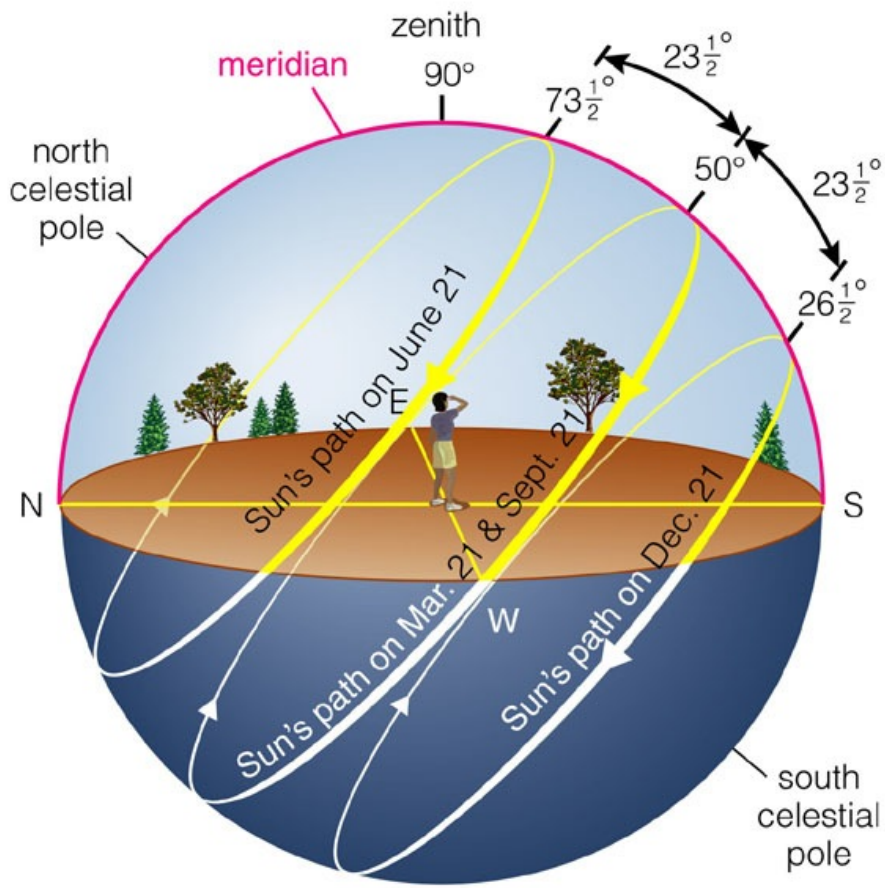
It turns out that bees actually know where the sun is on a cloudy day. They appear to have the **motion of the sun memorized**!

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**!

Birds: Calls vs Songs

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 the communication of complex messages!

Perhaps the most often studied call system is that of the black-capped chickadee. They have a series of different calls, and within those calls, there can be some interesting complexity specifically around the number and types of notes that they use:

https://www.youtube.com/watch?v=reKoV7pD9CA&ab_channel=LesleytheBirdNerd

Bird Songs: more complex, some are 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: more complex and some are learned during a critical period

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

For some birds, like mockingbirds, songs can be learned throughout life.

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

(Similar studies have been done on zebra finches.)

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:

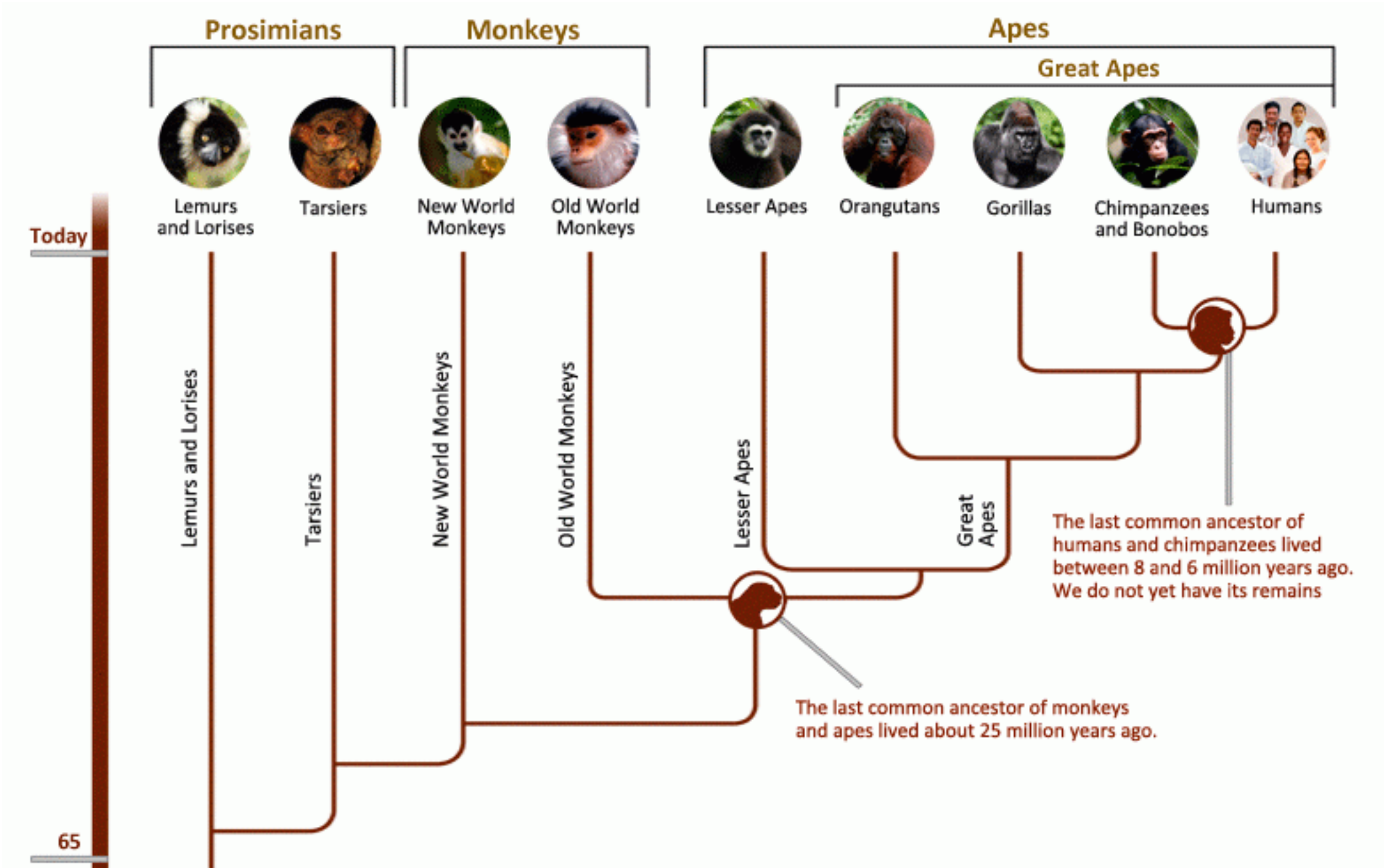
Alex was an African Grey Parrot that was taught an extensive vocabulary of color terms, number terms, shape terms, etc.

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

https://www.youtube.com/watch?v=ldYkFdu5FJk&ab_channel=Professional_Talker

Primates

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.

Lying capuchin monkeys?

Capuchin monkeys have similar alarm calls.

I haven't seen experiments on this, but David Attenborough's BBC series has a clip of a Capuchin monkey using a snake alarm call to create space so he can eat an egg!

https://www.youtube.com/watch?v=8c7NEf6qFlc&ab_channel=BBCEarth

If this finding is robust, it would be further evidence that these alarm calls are intentional productions, closer to words, and not just reflexes.

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

Another lesson - animals are not just test subjects

In the 1970s, nobody was thinking about the welfare of a chimpanzee in the experiment. When the experiment failed, Nim was sold to a medical testing company for several years. And, even after he was rescued from that, he was never able to integrate with other chimpanzees because he was only ever exposed to humans as a child:

Here is a short video about the experiment and Nim's life after the experiment:

https://www.youtube.com/watch?v=YdQaUT5Eqrw&ab_channel=LeonJ.

And in 2011 they made a documentary about it:

https://www.youtube.com/watch?v=IHoviCO7lpE&ab_channel=DocumentaryTrailers

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

https://www.youtube.com/watch?v=wRM7vTrIIis&ab_channel=IowaPrimate.LearningSanctuary

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://www.youtube.com/watch?v=2Dhc2zePJFE&ab_channel=IowaPrimate.LearningSanctuary

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

But, more welfare controversy

In 2012, employees at the research center where Kanzi lives wrote a letter accusing Sue Savage-Rumbaugh of endangering the welfare of the bonobos.

She has since left the center and has been involved in ongoing litigation over the accusations, etc.

This just underscores the biggest issue - primates are primates! They are extremely intelligent, but they require an appropriate environment. Keeping them in an inappropriate environment (particularly as pets) is extremely dangerous both to humans and to the primates themselves.

Here is a national geographic news/opinion article about several primate facilities (including the one with Kanzi) and the issues surrounding keeping primates in human-run facilities.

https://www.nationalgeographic.com/animals/article/wildlife-watch-apes-sanctuary-failing-animals

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