

Psych 56L/ Ling 51: Acquisition of Language

Lecture 5 Biological bases of language acquisition III

Announcements

Be working on review questions for biological bases of language

Be working on HW1 (due: 10/13/15)

- Electronic submission due by the end of class (3:20pm) to receive full credit.
- Remember to include the name of everyone who worked on the assignment (and is therefore receiving the same grade), and to submit only a single copy of the assignment per group.
- If you work together but submit separate assignments, you can acknowledge the people you worked with but make sure to indicate that you will be turning in separate assignments.

A linguist's concluding remarks about chimpanzee communication



I do not believe that there has ever been an example anywhere of a nonhuman expressing an opinion, or asking a question. Not ever...It would be wonderful if animals could say things about the world, as opposed to just signaling a direct emotional state or need. But they just don't."

— Geoff Pullum

<http://www.smithsonianmagazine.com/issues/2006/november/speakingbonobo.php>

So what's the problem?



Not a lack of intelligence - chimpanzees are highly intelligent.

One answer: language is an expression of a domain-specific mental faculty that humans have and other primates do not (nativist: generativist).

A more detailed look at the nativist idea

Hauser, Chomsky, & Fitch 2002:

Faculty of Language – Broad (FLB): biological capacity for acquiring language that humans have and other animals don't. However, much of the biological capacity is assumed to derive from **shared origins with animal communication**.

Ex: Parts of the human conceptual system such as causal, spatial, and social reasoning are shared with other primates (Buttelman et al. 2007)

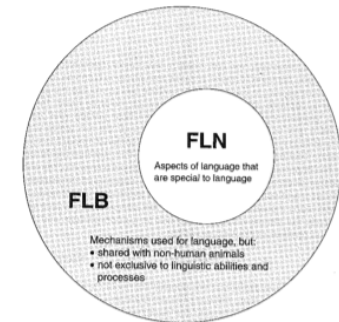
Difference between humans and animals is assumed to be more about **"quantity"** – humans have more power to drive these abilities than other animals, but the fundamental ability is basically the same.

A more detailed look at the nativist idea

Hauser, Chomsky, & Fitch 2002:

Faculty of Language – Narrow (FLN): A subset of **Faculty of Language** abilities that only humans have. Biological underpinnings not shared with other animals. A difference of **"quality"** not just **"quantity"**.

Pinker & Jackendoff (2005) suggest these might be in the FLN: properties of **speech perception, speech production, words** (as referential), **grammar, complex conceptual understanding that requires words** (ex: *week, 10 feet from the blue wall, half past five next Tuesday*)



Qualitative differences

Jane Goodall:

http://www.ted.com/talks/jane_goodall_on_what_separates_us_from_the_apes



“The one thing we have, which makes us so different from chimpanzees and other living creatures is this sophisticated spoken language — a language with which we can tell children about things that aren't here. We can talk about the distant past, plan for the distant future, discuss ideas with each other, so that the ideas can grow from the accumulated wisdom of a group.”

Language and other species



Language and other species

Are we special among the animal species?

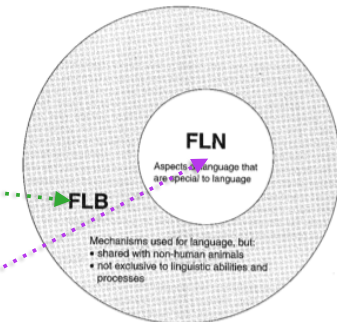
What are other species capable of?

Human language vs. “Animal language”

- Is the difference between an **animal communication system** and **human language** just a matter of degree (a quantitative difference)?

or

- Is there a sense in which human language is qualitatively different from the other communication systems?



Communication systems

Human language does enable communication, but it has several features that separate it from other animal communication systems:

intentionality: speakers use language for the purpose of communicating with others

reference: there are symbols which stand for things (even abstract things) in the world

syntax: productive system for combining symbols to express new meanings

Primate communication

Vervet monkeys



Predator alarm calls:

“leopard” = run to the trees

“eagle” = look up, run into the bushes

“snake” = stand up on hind legs & look around

Seem to have **intentionality** – do this to inform other vervet monkeys.

Primate communication

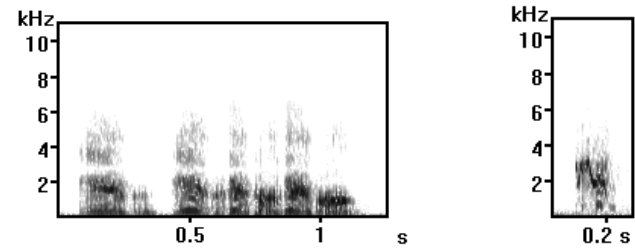
So do chimps — Schel, Townsend, Machanda, Zuberbühler, & Slocombe (2013) have found evidence that chimpanzees produce their alarm calls in a *tactical and goal-directed way*.

<http://www.sciencedaily.com/releases/2013/10/131016212605.htm>



Primate communication

Back to vervet monkeys...



Male (KN)
deep, barking call

Female (LO)
high-pitched chirps

Kaplan 2014

Primate communication

Vervet monkeys



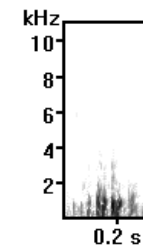
Leopard vervet calls (reacting to pictures of leopards)

<http://www.youtube.com/watch?v=hEzT-85gEdA>

http://www.youtube.com/watch?v=slGvI2y_W2c

Primate communication

Vervet monkeys



Female (BA)

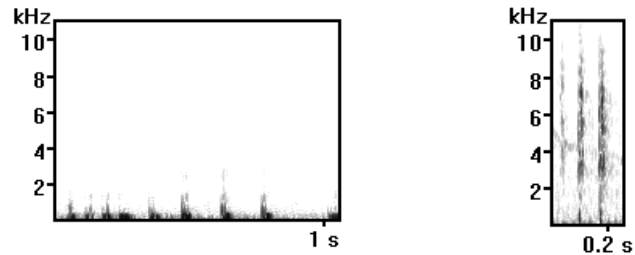
Vervet 'Eagle' Alarm Call

single cough-like call

Kaplan 2014

Primate communication

Vervet monkeys



Male (KN)

Female (LB)

Vervet 'Snake' Alarm Call

chutter-like call
Kaplan 2014

Primate communication

Campbell's monkeys, Tiwai Island in Sierra Leone



Have dialects when it comes to their alarm calls.

<http://www.scientificamerican.com/article/monkey-see-monkey-speak-video/>



Primate communication

Vervet monkeys



However...no evidence for **complex combinatorial system**.

Unclear if system has **reference** – are these calls really symbols for “eagle”, “snake”, and “leopard”? Or are they more like “Ack - go low!” and “Ack - look down!” Or something else?

Primate communication

Vervet monkeys



What they can't say:

“What a large eagle up in the sky over there! We'd better take cover. C'mon!”

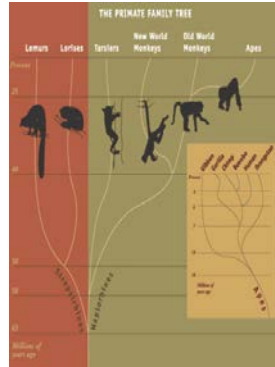
“I doubt there are any leopards around here. The field looks pretty clear.”

Chimpanzees



“Did you see that whopping big snake yesterday? It was super scary!”

Mollusks vs. Primates



Mollusks vs. Primates

Primates likely have:

- More complex bodies and brains
- Better learning and problem solving skills
- More complex social structures
- More complex and flexible behavior
- Longer lives



Mollusks vs. Primates

After 450 million years...



Cephalopods:
15-35 distinct displays



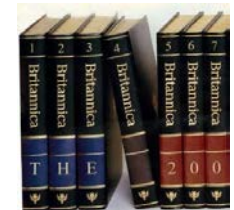
Non-human primates:
15-35 distinct displays

Adapted from Liberman
<http://www.thecephalopodpage.org/cephschool/WhyCephalopodsChangeColor.pdf>

Not just mollusks and non-human primates

“For most relatively social adult fishes, birds and mammals, the range or repertoire size [of communicative displays] for different species varies from 15 to 35 displays.”

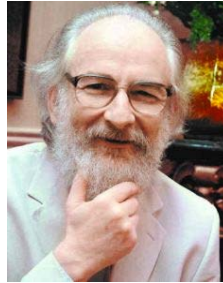
-Encyclopedia Britannica,
“Animal Communication”



Human vocabulary

"Most people know...about 50,000 - easily. A reasonably educated person about 75,000..."

"An ordinary person, one who has not been to university say, would know about 35,000 quite easily."



David Crystal

http://news.bbc.co.uk/2/hi/uk_news/magazine/8013859.stm
"The words in the mental cupboard"

Bee communication

Honey Bees



Dance to **communicate the location of food** (nectar)

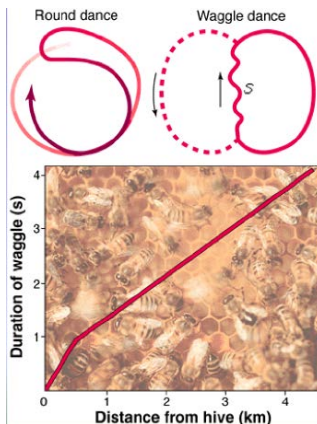
Can indicate: nearby vs. far, direction, richness of the food source (dance harder for the good stuff)

Though bees can create novel messages, they're always about the location of food.

Bee communication

Under 50m away

The angle from the sun indicates direction of food source. The duration of the waggle part of the dance signifies the distance. Approximately 1 second of dance = 1 km distance.



Quantity:

- (1) Ratio of waggle part to round part corresponds to quantity of food.
- (2) More food = more energetic wagging.

Over 50m away:

encodes distance & direction - is encoding of 2D space (a bee's "mental map")

<http://www.youtube.com/watch?v=-7ijl-g4jHg>

'deciphered' by Karl von Frisch, 1919 & onward

Bee communication

Has **intentionality**? Definitely – wagging for other bees.

Has **reference**? Maybe – indicating properties of nectar. (But that's all they ever communicate about with this method – no new symbols are created.)

Has **syntax**? Not really – but has rudimentary combinatorial properties (what direction, how far, how much).

Bee communication

Honey Bees



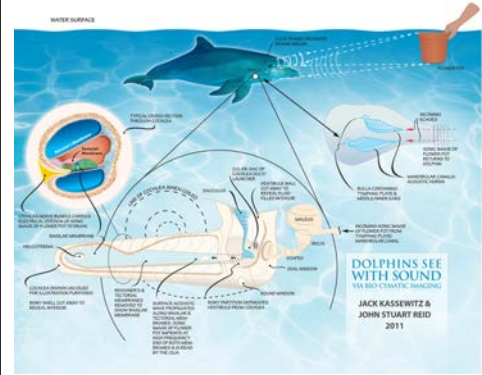
What bees can't communicate:

"Have you seen the flowers in the next field over? They totally rock. I've never seen such brilliant colors."

"I thought the hive was really crowded yesterday."

Dolphin communication

Dolphins



Kasewitz & Stuart Reid (2011): Dolphins use "Sono-Pictorial Exo-holographic Language", (SPEL)

Evidence that dolphins can communicate about novel objects in their environment via the patterns that echolocation makes when pinging off the objects.

Certainly **intentional**, and likely **referential**. Unclear if **syntax** is present.

Dolphin communication

Dolphins Can Call Each Other, Not by Name, But by Whistle

<http://news.sciencemag.org/sciencenow/2013/02/dolphins-can-call-each-other--no.html?ref=hp>

3 samples of dolphin whistles on webpage

Whistlin' Dolphins

In these recordings, you can hear male dolphin A give his signature whistle. Male dolphin B copies A's call in the second recording; B's own signature whistle sounds very different from A's as you can hear in the third recording.



Credit: S. L. King, 2013

Dolphin communication

Herzig (2013), TED Talk: Could we speak the language of the dolphins?

http://www.ted.com/talks/denise_herzing_could_we_speak_the_language_of_dolphins.html

Especially 6:07-6:50 (complexity of dolphin whistles)

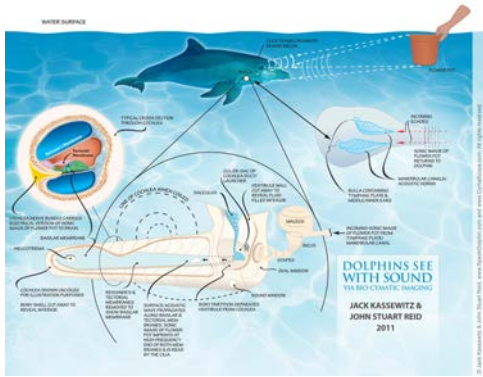
8:36-9:26 (two-way communication & symbolic representation)

10:26-10:52 (dolphin requests)



Dolphin communication

Dolphins



Unclear if they have a complex combinatorial system (syntax)

Can a dolphin communicate this?

“I wish there were some better fish around.”

“Those humans are soooo annoying sometimes.”

Bird communication

Songbirds



Males use songs to attract and acquire mates (fairly clear **intentionality**). In many species, the development of the song requires exposure to adult birds who model the song.

Bird communication

White-crowned sparrows: Stages of learning



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

Bird communication

Songbirds



Note: even though there is a learned part and a genetic part, we still classify birdsong as an instinct.

Bird communication



- Songs are learned
 - Regional dialects
- Learning, however, is innately guided (Marler, 1990)
 - Many species of sparrows prefer to learn the songs of their own species
 - And if they are only exposed to other species' songs, they follow species-specific structure
 - Learning is subjected to a sensitive period (must be learned within a time period)

Bird communication

Variation in song

Bird 1

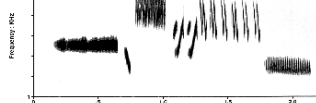
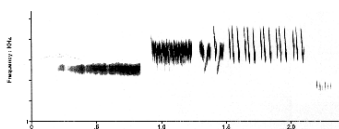
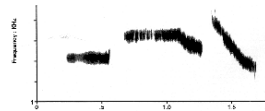


Bird 2

White-crown sparrow song



- White-crown sparrow #1 in isolation
- White-crown sparrow #2 w/ tutor
- White-crown sparrow's tutor



Bird communication

Sparrow song

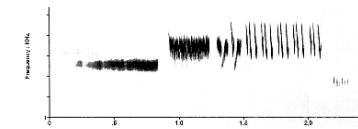


song



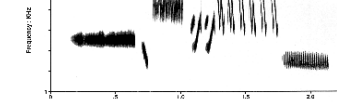
call

student



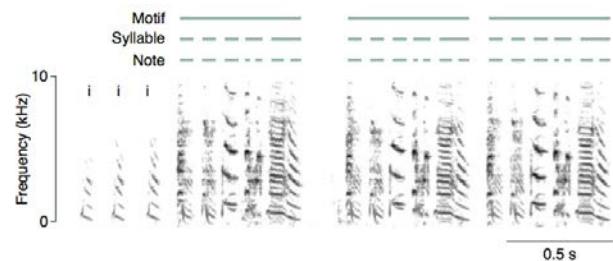
Song is highly structured (combinatorial system) - notes, syllables, phrases

teacher



Bird communication: Hierarchical structure

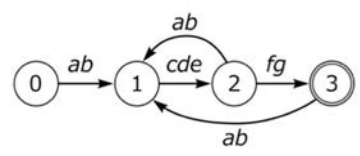
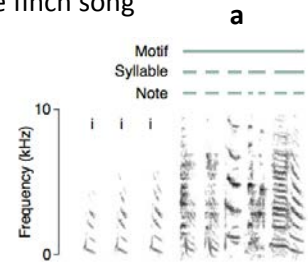
Zebra finch song



“Sound spectrogram of a typical zebra finch song depicting a hierarchical structure. Songs often start with ‘introductory notes’ (denoted by ‘i’) that are followed by one or more ‘motifs’, which are repeated sequences of syllables. A ‘syllable’ is an uninterrupted sound, which consists of one or more coherent time-frequency traces, which are called ‘notes’. A continuous rendition of several motifs is referred to as a ‘song bout.’” – Berwick et al. 2012

Bird communication: Variety of communication

Bengalese finch song



A **state diagram** of the sequence of motifs that can make up a Bengalese finch song.

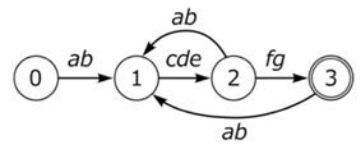
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

A state diagram is a compact way of representing a collection of outputs. It consists of states (0, 1, 2, 3...) and transitions (the arrows between the states).

state diagram



Here, the starting state is 0, and the ending state (indicated by a double circle) is 3.

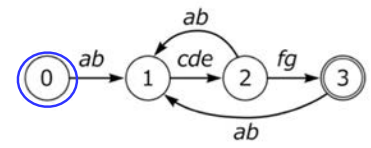
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

To generate an output from a state diagram, begin in the starting state.

state diagram



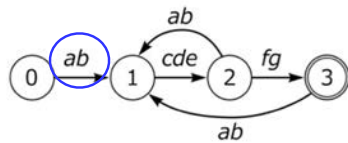
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

Then follow one arrow to the next state, outputting the symbols along the arrow.

state diagram



When going from state 0 to state 1, "ab" is output.

ab

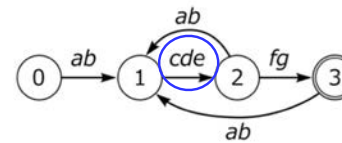
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

Then follow one arrow to the next state, outputting the symbols along the arrow.

state diagram



When going from state 1 to state 2, "cde" is output.

abcde

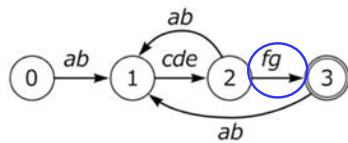
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

If a state has more than one arrow leading out of it, choose any arrow and follow it.

state diagram



If we follow this arrow out of state 2, we go to state 3 and output "fg".

abcdefg

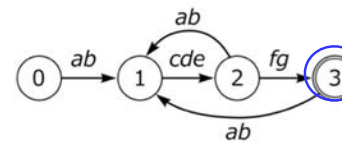
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

When you reach the end state, you are allowed to stop following arrows. The output you have at this point is a valid output captured by the state diagram.

state diagram



If we end here, our output looks like this:

abcdefg

Miyagawa et al. 2014

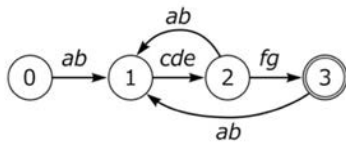
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*

state diagram



Miyagawa et al. 2014

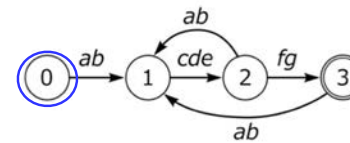
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Miyagawa et al. 2014

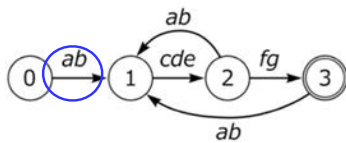
Bird communication: Variety of communication

Bengalese finch song

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state diagram



Our current output:

ab

Miyagawa et al. 2014

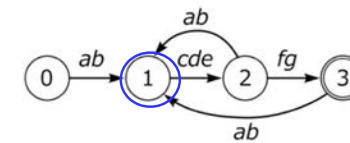
Bird communication: Variety of communication

Bengalese finch song

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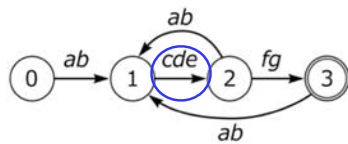
Bird communication: Variety of communication

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Miyagawa et al. 2014

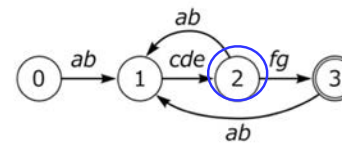
Bird communication: Variety of communication

Bengalese finch song

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state diagram



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Miyagawa et al. 2014

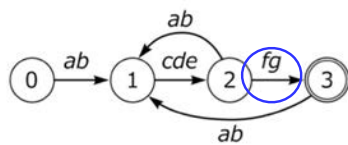
Bird communication: Variety of communication

Bengalese finch song

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Allowed: abcdefg

state diagram



Our current output:

abcdefg

Miyagawa et al. 2014

Bird communication: Variety of communication

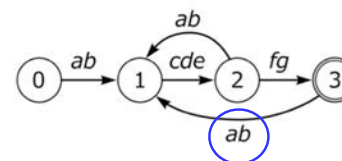
Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: abcdefg

state diagram

But we don't *have* to stop there...



Our current output:

abcdefgab

Miyagawa et al. 2014

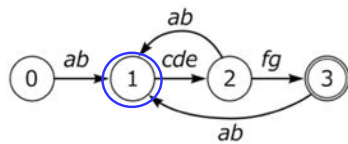
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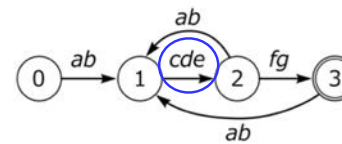
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Bengalese finch song

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state diagram



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Miyagawa et al. 2014

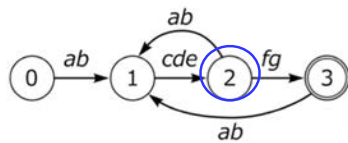
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Miyagawa et al. 2014

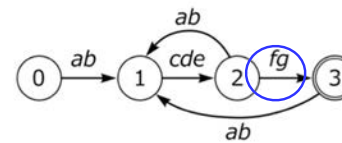
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state diagram



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Miyagawa et al. 2014

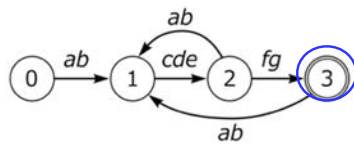
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdefg

Miyagawa et al. 2014

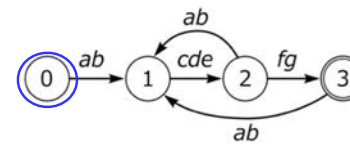
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Miyagawa et al. 2014

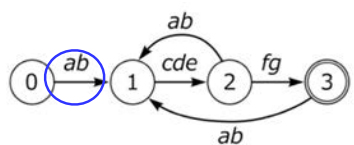
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Allowed: *abcdefg*, *abcdefgabcdefg*

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ab

Miyagawa et al. 2014

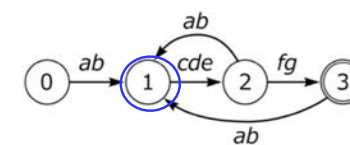
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

ab

Miyagawa et al. 2014

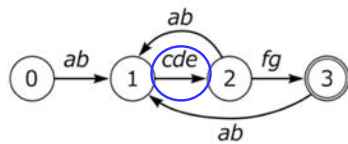
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcde

Miyagawa et al. 2014

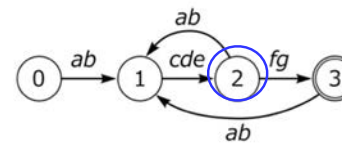
Bird communication: Variety of communication

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state diagram



Our current output:

abcde

Miyagawa et al. 2014

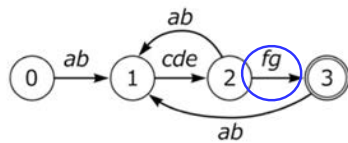
Bird communication: Variety of communication

Bengalese finch song

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefg

Miyagawa et al. 2014

Bird communication: Variety of communication

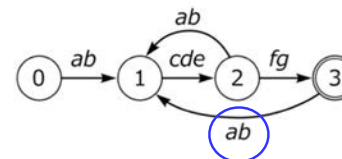
Bengalese finch song

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram

But we don't *have* to stop there...



Our current output:

abcdefgab

Miyagawa et al. 2014

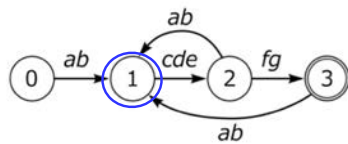
Bird communication: Variety of communication

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgab

Miyagawa et al. 2014

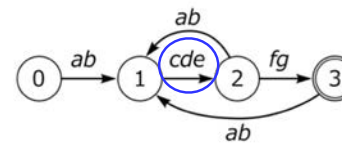
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcde

Miyagawa et al. 2014

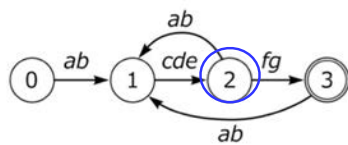
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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcde

Miyagawa et al. 2014

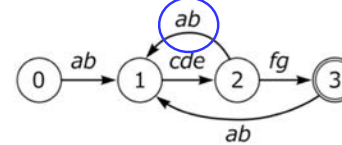
Bird communication: Variety of communication

Bengalese finch song

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdeab

Miyagawa et al. 2014

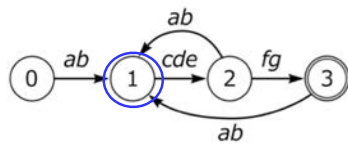
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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdeab

Miyagawa et al. 2014

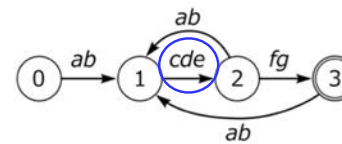
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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdeabcde

Miyagawa et al. 2014

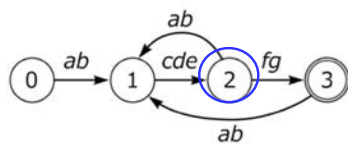
Bird communication: Variety of communication

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdeabcde

Miyagawa et al. 2014

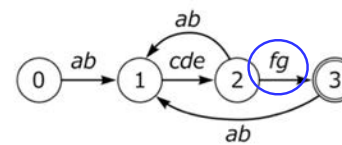
Bird communication: Variety of communication

Bengalese finch song

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Allowed: *abcdefg*, *abcdefgabcdefg*

state diagram



Our current output:

abcdefgabcdeabcdefg

Miyagawa et al. 2014

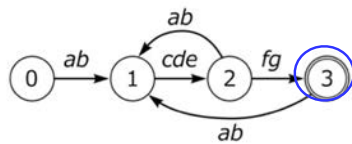
Bird communication: Variety of communication

Bengalese finch song

What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: *abcdefg*, *abcdefgabcdefg*, *abcdefgabcdeabcdefg*

state diagram



Our current output:

abcdefgabcdeabcdefg

Miyagawa et al. 2014

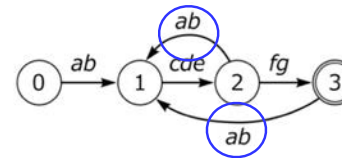
Bird communication: Variety of communication

Bengalese finch song

Important: An *infinite* number of valid sequences can be generated because we have these backward arrows. This aspect of bird song is similar to human language (which has *infinite* sentences).

Allowed: *abcdefg*, *abcdefgabcdefg*, *abcdefgabcdeabcdefg*, ...

state diagram



Miyagawa et al. 2014

Bird communication vs. Human language



There are several similarities between language in humans and birdsong. Both human language and birdsong:

(1) Alarm calls in birdsong and words in human language are referential and stable signals. These signals can incorporate spontaneous gestures like pointing (by either finger or beak) [Kaplan 2014]

(2) Birdsong and human language both have a way to combine units (birdsong: notes make syllables which make motifs; human language: phonemes make syllables which make words) [Kaplan 2014]

Bird communication vs. Human language



There are several similarities between language in humans and birdsong. Both human language and birdsong:

(3) How the units that make up syllables (human language: phonemes, birdsong: notes) are perceived depends on the surrounding context (Lachlan & Nowicki 2015,

<http://www.sciencedaily.com/releases/2015/01/150105170024.htm>)

Bird communication vs. Human language



There are several similarities between language acquisition in humans and song acquisition in songbirds (Okanoya 2013). Both human language and birdsong:

- (1) have early stages prior to the appearance of the adult form (babbling vs. subsong)
- (2) require the babies to be able to hear their own productions

Bird communication vs. Human language



There are several similarities between language acquisition in humans and song acquisition in songbirds (Okanoya 2013). Both human language and birdsong:

- (3) have sensitive periods (between 7 and 60 days old for birds) and can reconstitute itself from impoverished input (human language: pidgin to creole; birdsong (zebra finches): from song produced by isolates to full song over several generalizations)
- (4) are lateralized in the left hemisphere

Bird communication vs. Human language



There are several similarities between language acquisition in humans and song acquisition in songbirds (Okanoya 2013). Both human language and birdsong:

- (5) rely on similar genes for vocalization (Pfenning et al. 2014, Zhang et al. 2014, <http://www.sciencedaily.com/releases/2014/12/141211142429.htm>)
- (6) have smaller and larger units learned simultaneously (human language: sounds and words; birdsong: motifs and song bouts) (Comins & Gentler 2015, <http://www.sciencedaily.com/releases/2015/06/150625130900.htm>)

Bird communication vs. Human language



However, there are also some crucial differences (see Berwick et al. 2012 for a more thorough discussion of this):

- (1) Birdsong seems to lack flexible semantics. (Like the bee dance, birdsong is only ever about one thing. No novel meanings.)
- (2) Birdsong seems to lack individual words. (Is a particular note sequence a **symbol** for something? What does it **refer** to? It's unclear.)

Bird communication vs. Human language



However, there are also some crucial differences (see Berwick et al. 2012 for a more thorough discussion of this):

(3) The **combinatorial system seems less complex** in birdsong. While human language has phonemes that make syllables that make words that make phrases that make sentences, birdsong seems to stop at the “word” level (~motif).

Bird communication vs. Human language



However, there are also some crucial differences (see Berwick et al. 2012 for a more thorough discussion of this):

(4) Also, while birds can reorder elements within their song, this never changes the meaning of the entire song. Thus, their **combinatorial system** does not connect with meaning in the same way that human syntax does. (For example, “Penguins eat fish” does not mean the same thing as “Fish eat penguins”, but a song made of motif order A-B-C conveys the same meaning as a song made of motif order C-B-A.)

Bird communication vs. Human language



However, there are also some crucial differences:

(4) ...*except* chestnut-crowned babblers produce song “AB” when flying and song “BAB” when feeding chicks (Engesser, Savage, & Townsend 2015). Co-author Townsend suggests this is “the first time that the capacity to generate **new meaning from rearranging meaningless elements** has been shown to exist outside of humans”.

(<http://www.sciencedaily.com/releases/2015/06/150629152230.htm>)

But is it really **meaning** (if so, what does each song *mean*)?
Under debate...

The evolution of human language: One idea

How Human Language Could Have Evolved from Birdsong: Researchers Propose New Theory On Deep Roots of Human Speech

<http://www.sciencedaily.com/releases/2013/02/130221141608.htm>

Describing findings in Miyagawa, Berwick, & Okanoya 2013

Human language's deep origins appear to have come directly from birds, primates

<http://www.sciencedaily.com/releases/2014/06/140611102209.htm>

Describing theory in Miyagawa, Ojima, Berwick, & Okanoya 2014

The evolution of human language: One idea

Human language = combination of two communication forms found elsewhere in the animal kingdom

- elaborate songs of birds

- more utilitarian, information-bearing expressions seen in other animals



"When something new evolves, it is often built out of old parts"
- Robert Berwick

The evolution of human language: One idea

Sample utterance: "Did Sarah trick Hoggle?"



Two layers of human language

Lexical layer

= invariant core elements (Sarah, trick, Hoggle)

[animal equivalents: bee dance components, primate calls]

Expression layer

= rearrangement of core pieces to convey different meanings

Sarah tricked Hoggle. Did Sarah trick Hoggle?

How did Sarah trick Hoggle?

[animal sort-of equivalent: bird song melodies, which rearrange pieces, but don't change the overall meaning of the song]

Linking nativist ideas and language evolution

Faculty of the Language Broad (FLB: quantitative difference)

Humans and some animals have the **lexical layer** in their communication systems.

Humans and some animals have something like the **expression layer** in their communication systems.

Faculty of the Language Narrow (FLN: qualitative difference)

Integration Hypothesis of Miyagawa et al. (2013, 2014):

Only humans have the ability to **combine both layers** in their communication systems.

Recap: Animal communication

While animal communication systems may share some properties of human language, none currently seem to be as complex as human language.

One idea for what makes human language special (qualitatively different from other animal communication systems) is that it is a combination of two pieces: a piece that allows humans to refer to things (lexical layer) and a piece that allows humans to put the smaller elements in different orders to change the meaning (expression layer).

Questions?



Remember: HW1 is due 10/13/15, and you should be able to do all of it now.

You should also be able to do all of the review questions for biological bases of language development.