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: 10/21/14)

- 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 to submit only a single copy of the assignment per group.

Language and other species

Language and other species

Are we special among the animal species?

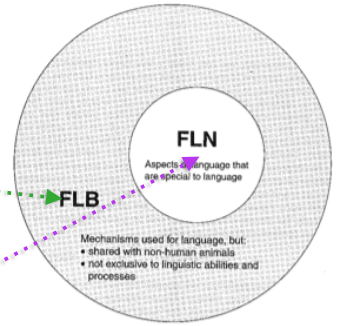
What are other species capable of?

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.

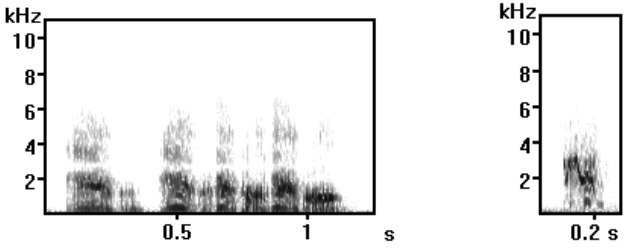
Primate communication

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) **Female (LO)**

Primate communication

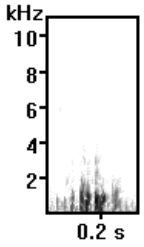
Vervet monkeys

Leopard vervet calls
http://www.youtube.com/watch?v=hEzT-85gEdA

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

Primate communication

Vervet monkeys

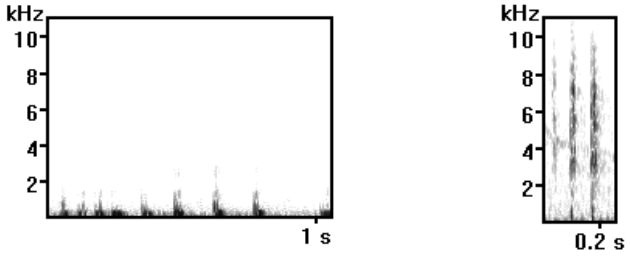


Female (BA)

Vervet 'Eagle' Alarm Call

Primate communication

Vervet monkeys



Male (KN) **Female (LB)**

Vervet 'Snake' Alarm Call

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:

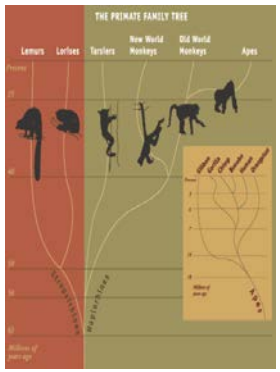
"What a large eagle up in the sky over there! We'd better take cover. C'mon!"

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

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

Chimpanzees

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…

Cephelopods:
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

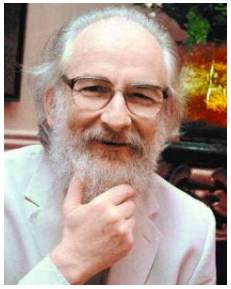
"For most relatively social adult fishes, birds and mammals, the range or repertoire size [of communicative displays] for different species varies from 15 to 35 displays."

-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)

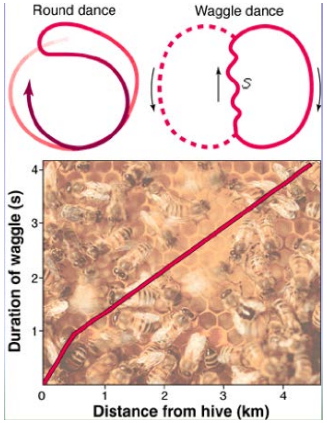
Can indicate: nearby vs. far, direction, richness of the food source (dance harder for the good stuff)

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 waggling.

Over 50m away:

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

http://www.youtube.com/watch?v=-7ijI-g4jHg

'deciphered' by Karl von Frisch, 1919 & onward

Bee communication

Has intentionality? Definitely – waggling 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

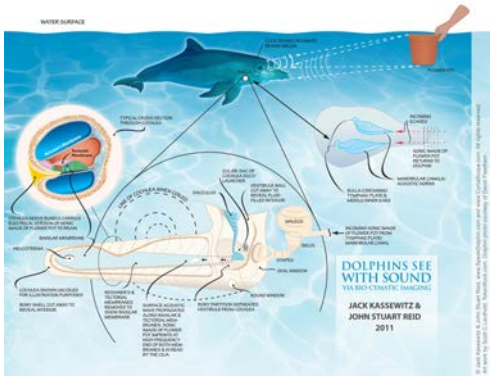
What bees can't communicate:

"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



Kassewitz & 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

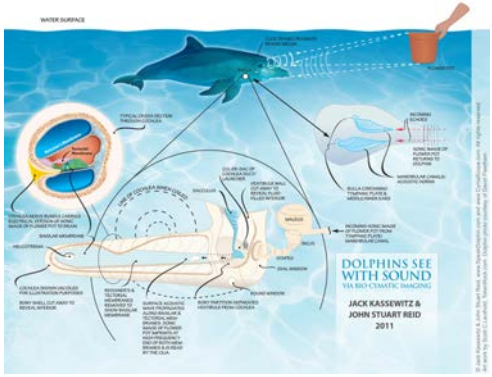
3 samples of dolphin whistles on webpage

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

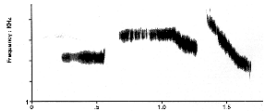
Variation in song

Bird 1

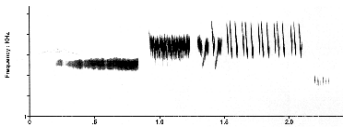
Bird 2

White-crown sparrow song

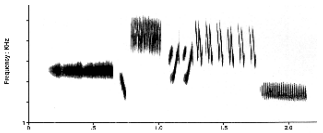
- White-crown sparrow #1 in isolation



- White-crown sparrow #2 w/ tutor



- White-crown sparrow's tutor



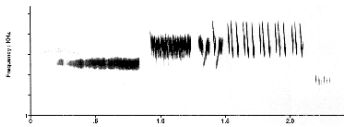
Bird communication

Sparrow song

song

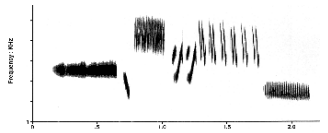
call

student



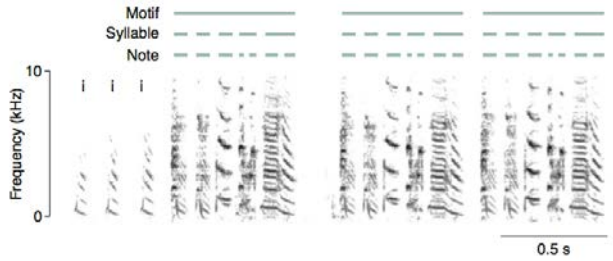
Song is highly structured (combinatorial system) - notes, syllables, phrases

teacher



Bird communication: Hierarchical structure

Zebra finch song

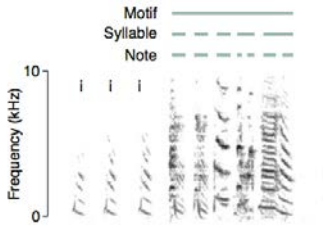


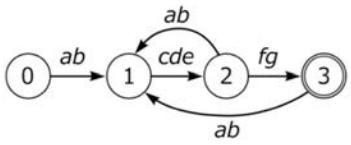
"Sound spectrogram of a typical zebra finch song depicting a hierarchical structure. Songs often start with 'introductory notes' (denoted by 'i') that are followed by one or more 'motifs', which are repeated sequences of syllables. A 'syllable' is an uninterrupted sound, which consists of one or more 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





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

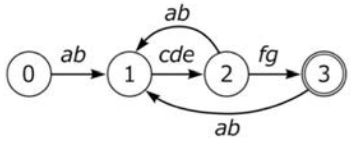
Miyagawa et al. 2014

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.

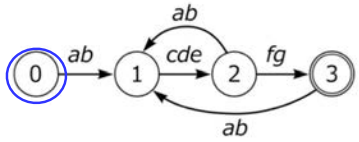
Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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

state diagram



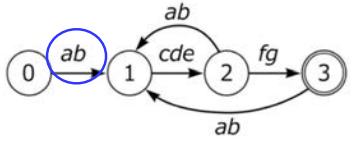
Miyagawa et al. 2014

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

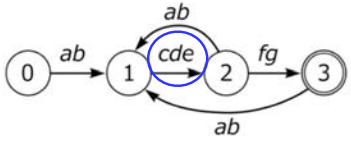
Miyagawa et al. 2014

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

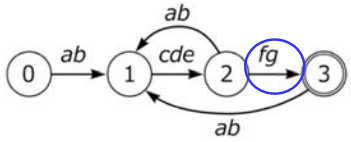
Miyagawa et al. 2014

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

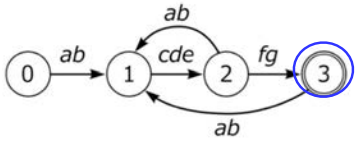
Miyagawa et al. 2014

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

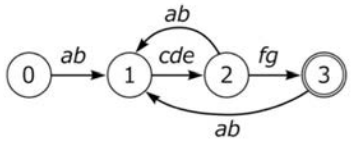
Bird communication: Variety of communication

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

Bird communication: Variety of communication

Bengalese finch song

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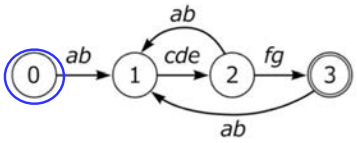

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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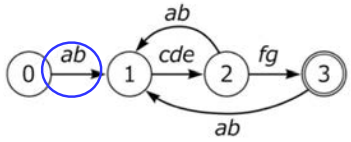
state diagram



Our current output:

ab

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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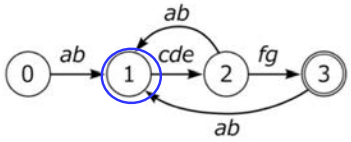

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ab

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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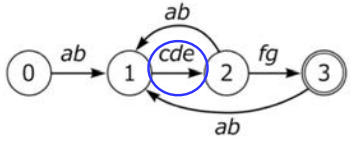
state diagram



Our current output:

abcde

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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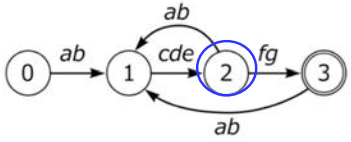
Allowed: abcdefg

state diagram



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Miyagawa et al. 2014

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Bengalese finch song

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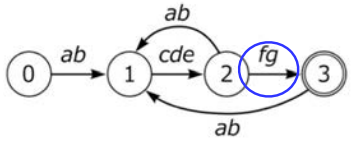


Our current output:

abcdefg

Miyagawa et al. 2014

Bird communication: Variety of communication

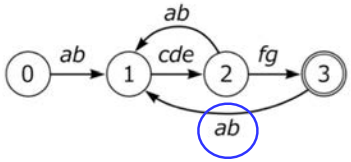
Bengalese finch song

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…



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Miyagawa et al. 2014

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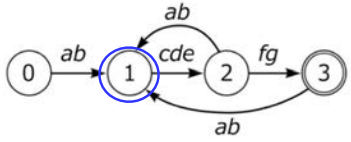

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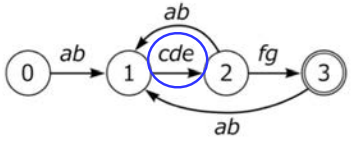

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abcdefgabcde

Miyagawa et al. 2014

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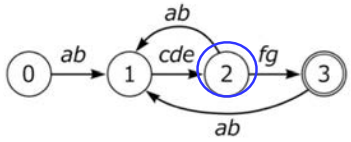

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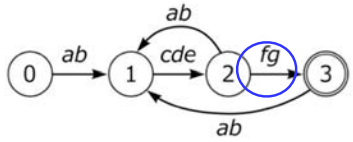
Allowed: abcdefg

state diagram



Our current output:

abcdefgabcdefg

Miyagawa et al. 2014

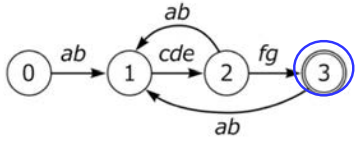
Bird communication: Variety of communication

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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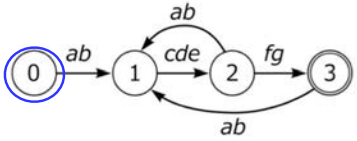

Miyagawa et al. 2014

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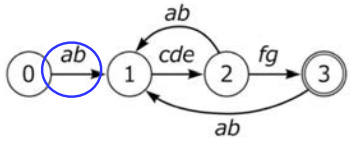

Our current output:

ab

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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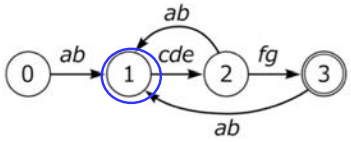
Allowed: abcdefg, abcdefgabcdefg

state diagram



Our current output:

ab

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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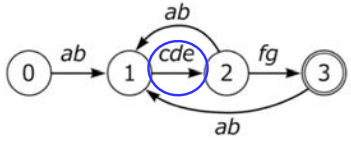
Allowed: abcdefg, abcdefgabcdefg

state diagram



Our current output:

abcde

Miyagawa et al. 2014

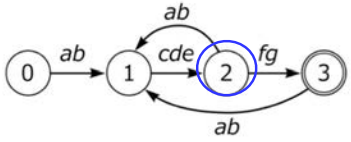
Bird communication: Variety of communication

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



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abcde

Miyagawa et al. 2014

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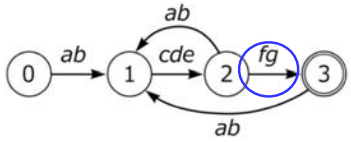
state diagram



Miyagawa et al. 2014

Our current output:

abcdefg

Bird communication: Variety of communication

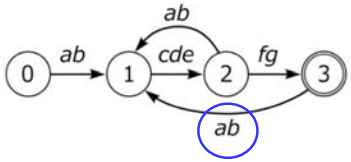
Bengalese finch song

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

Allowed: abcdefg, abcdefgabcdefg

state diagram

But we don't *have* to stop there…



Miyagawa et al. 2014

Our current output:

abcdefgab

Bird communication: Variety of communication

Bengalese finch song

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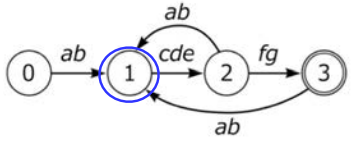
Allowed: abcdefg, abcdefgabcdefg

state diagram



Miyagawa et al. 2014

Our current output:

abcdefgab

Bird communication: Variety of communication

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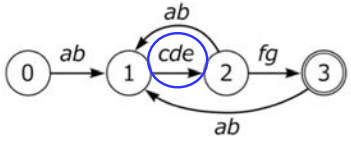
state diagram



Miyagawa et al. 2014

Our current output:

abcdefgabcde

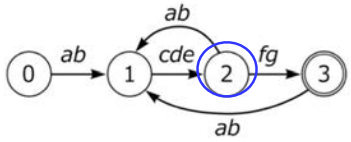
Bird communication: Variety of communication

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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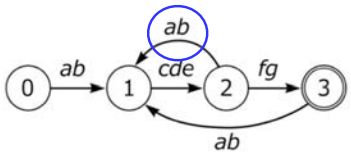
Allowed: abcdefg, abcdefgabcdefg

state diagram



Our current output:

abcdefgabcdeab

Miyagawa et al. 2014

Bird communication: Variety of communication

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Allowed: abcdefg, abcdefgabcdefg

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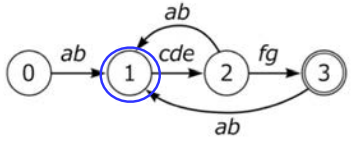


Our current output:

abcdefgabcdeab

Miyagawa et al. 2014

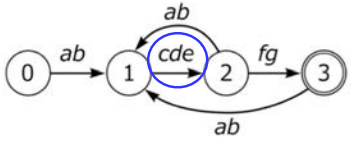
Bird communication: Variety of communication

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:

abcdefgabcdeabcde

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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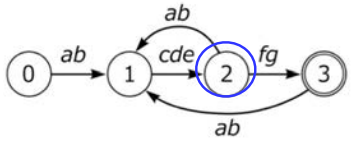
Allowed: abcdefg, abcdefgabcdefg

state diagram



Our current output:

abcdefgabcdeabcde

Miyagawa et al. 2014

Bird communication: Variety of communication

Bengalese finch song

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Allowed: abcdefg, abcdefgabcdefg

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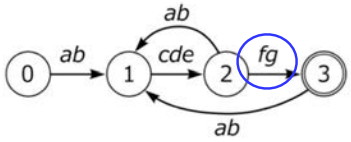

Our current output:

abcdefgabcdeabcdefg

Miyagawa et al. 2014

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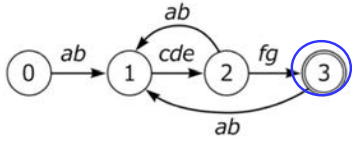
What are some other output sequences (representing valid Bengalese finch motifs sequences) that this state diagram can generate?

Allowed: abcdefg, abcdefgabcdefg, abcdefgabcdeabcdefg

state diagram



Our current output:

abcdefgabcdeabcdefg

Miyagawa et al. 2014

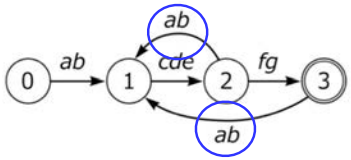
Bird communication: Variety of communication

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 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)

(4) are lateralized in the left hemisphere

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.)

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 10/21/14, 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.