Natural Computation and Self Organization…in Monkey Behavior

KELLY FINN

ANIMAL BEHAVIOR GRADUATE GROUP

Overview

- common methods in animal behavior
- my interests
- rationale
- goals/aims
- preliminary data
- preliminary analysis

Traditional Sampling

Observational methods (Altmann, 1974; Martin & Bateson, 2007)

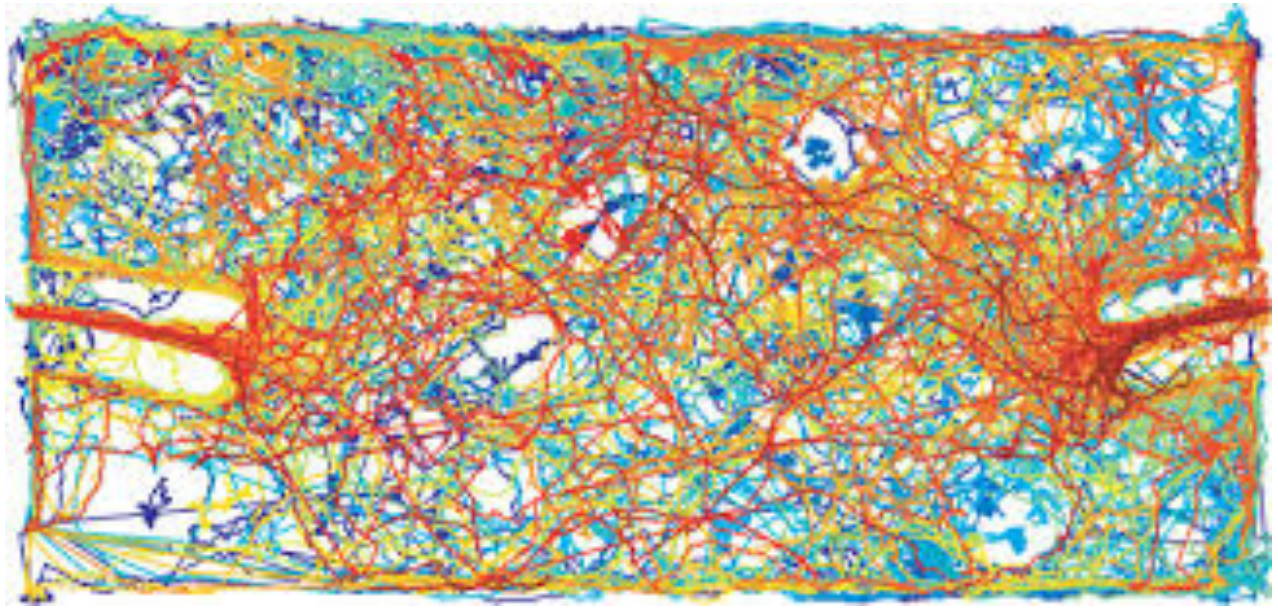
Ethogram – a detailed catalogue of behaviors, usually mutually exclusive and as objective as possible. Ideally, it should be able to instruct two different people to record the same behaviors the same way

Types of sampling:

- All occurrence
- 1/0 sampling
- Instantaneous scan sampling

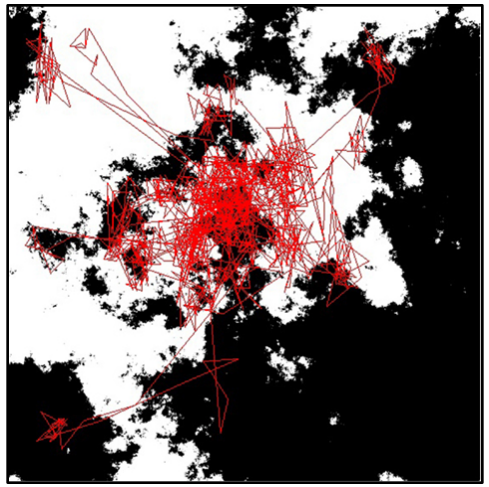
Mostly use intuition to decide upon sampling, time scales, durations.

New tools and technology



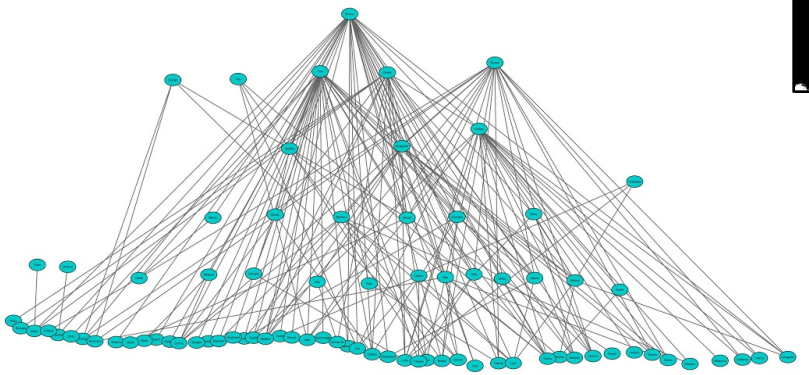
My Interests – pattern and structure

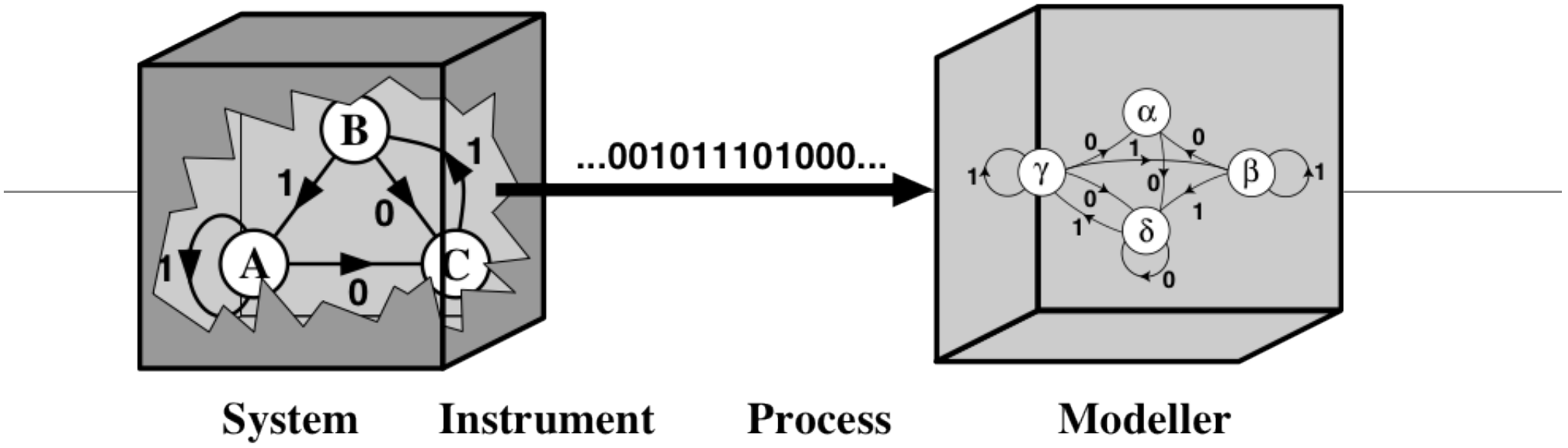
- How to measure behavior
- How patterns relates to function
- How animals perceive and respond to patterns



Dissertation:

1. Pattern perception
2. **Individual behavior patterns**
3. Group level network structure





System is an animal – its behavior is a product of many different things on many different time scales: evolutionary history of the species, genetic composition, rearing influences, interactions with other animals, current environment, past environment, hormones, health state, physiology, etc. etc. etc. (and all of these things also interact with each other).

An animal is basically a black box, with behavioral outputs we can measure.

Complexity in biological systems

'Theory of complexity loss in aging and disease' (Goldberger et al, 2002) - healthy systems output complex multi-scaled variability that allows for adaptive capabilities and breaks down with age or illness.

- the long-range scaling patterns of human heartbeat and gait dynamics have been shown to deteriorate in markedly pathological conditions (Goldberger et al, 2002b).

"A completely ordered universe, however, would be dead. Chaos is necessary for life. Behavioural diversity, to take an example, is fundamental to an organism's survival. No organism can model the environment in its entirety. Approximation becomes essential to any system with finite resources. Chaos, as we now understand it, is the dynamical mechanism by which nature develops constrained and useful randomness. From it follow diversity and the ability to anticipate the uncertain future. There is a tendency, whose laws we are beginning to comprehend, for natural systems to balance order and chaos, to move to the interface between predictability and uncertainty. The result is increased structural complexity." – Crutchfield (2011)

Complexity in behavior patterns

- animal-environment interaction (i.e. resource acquisition)
- self-regulation of behavior in response to a changing environment
- pathological behavioral stereotypy

The measurement of behavioral complexity or structure may be an untapped yet fundamental source of information about an animal's behavioral ecology and health.

Brief review of literature

Previous studies have reported that certain analyses of behavior pattern can detect subtle changes in 'hidden' animal behavioral structure that are missed when using traditional measures such as average durations (Escós et al., 1995; Asher et al., 2009; Seuront & Cribb, 2011).

Variability in behavioral sequence complexity has been linked to many characteristics:

- differences by sex: social behavior of chimpanzees (Alados & Huffman, 2000); foraging and locomotion behavior in Japanese macaques (MacIntosh et al., 2011)

- stress level: boat traffic disturbance in dolphin surface behavior (Seuront & Cribb, 2011); resource deprivation in chickens (María et al., 2009)

- age: young chickens (María et al., 2009); adult macaques (MacIntosh et al., 2011)

- states known to be energetically taxing such as reproduction, clinically impaired health, and parasite infection: Japanese macaques (MacIntosh et al., 2011), Spanish Ibex (Alados et al, 1996), chimpanzees (Alados & Huffman, 2000).

Animal Movement

- fairly objective behavior to score
- fundamental to survival of mobile species, multi-purpose
- already associated with health (self-tracking)
- tons of this type of data is being collected

"Movement data provide a window - often our only window - into the cognitive, social, and biological processes that underlie the behavioral ecology of animals in the wild." - Gurarie et al 2016

Goals:

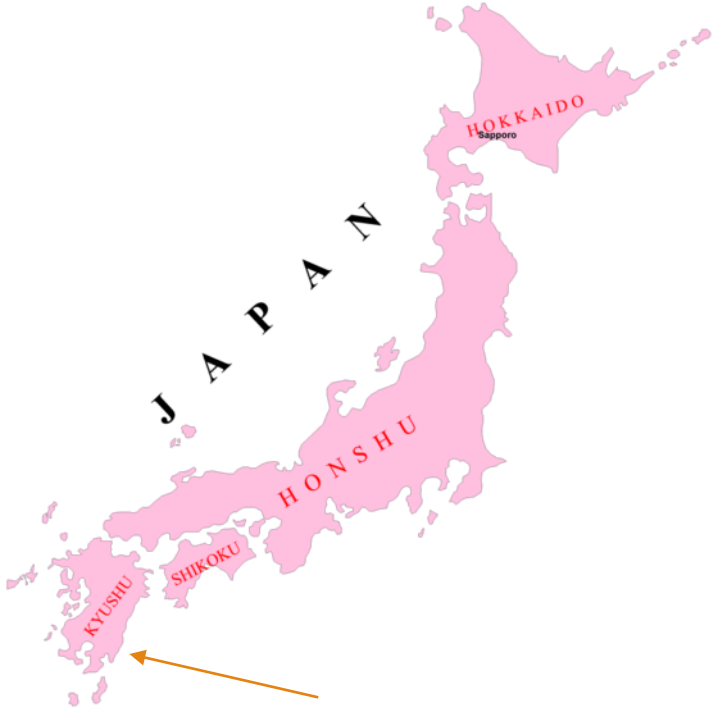
Describe structure in monkey movement

- Relate pattern attributes to function
  - behavioral state, terrain, individual characteristics (age, health, rank, etc.)

- Inform future measurement and sampling

Koshima, Summer 2015

- EAPSI program (NSF/JSPS)
- Pilot data
- collaboration with Dr. Andrew MacIntosh
- behavioral structure ~ parasite load



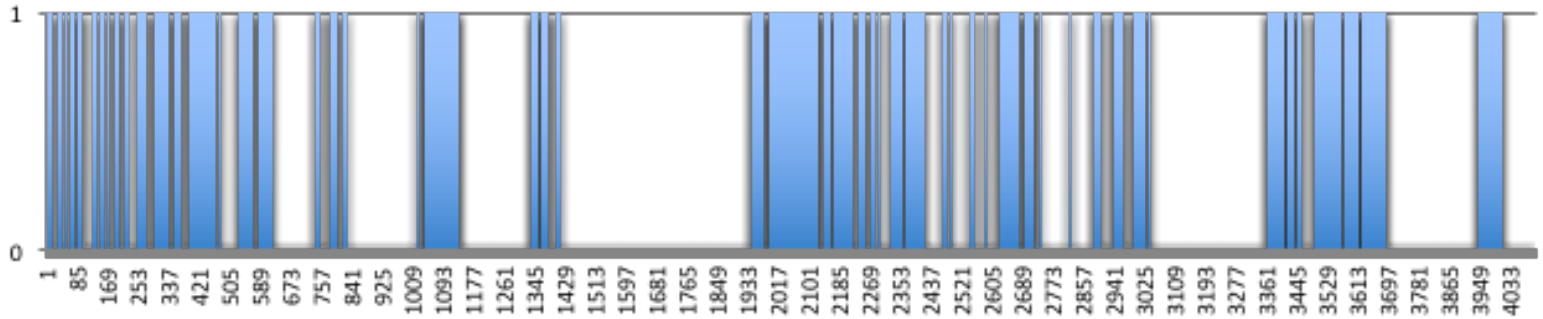
Japanese macaques of Koshima

Life in the field

Data

- 56 sequences (4 sequences from each of 14 monkeys)
  - 1-0 activity down to the second*
  - 1,000-4,000 data points/sequence
  - Activity ranged from .5% to 52% (mean 17.51%)

Sequences


1
0
1
85
169
253
337
421
505
589
673
757
841
925
1009
1093
1177
1261
1345
1429
1513
1597
1681
1765
1849
1933
2017
2101
2185
2269
2353
2437
2521
2605
2689
2773
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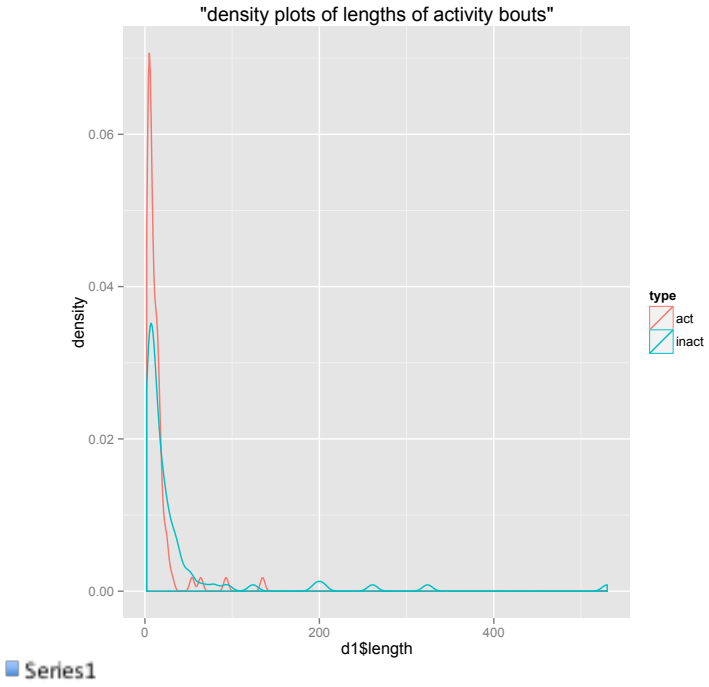
"density plots of lengths of activity bouts"
density
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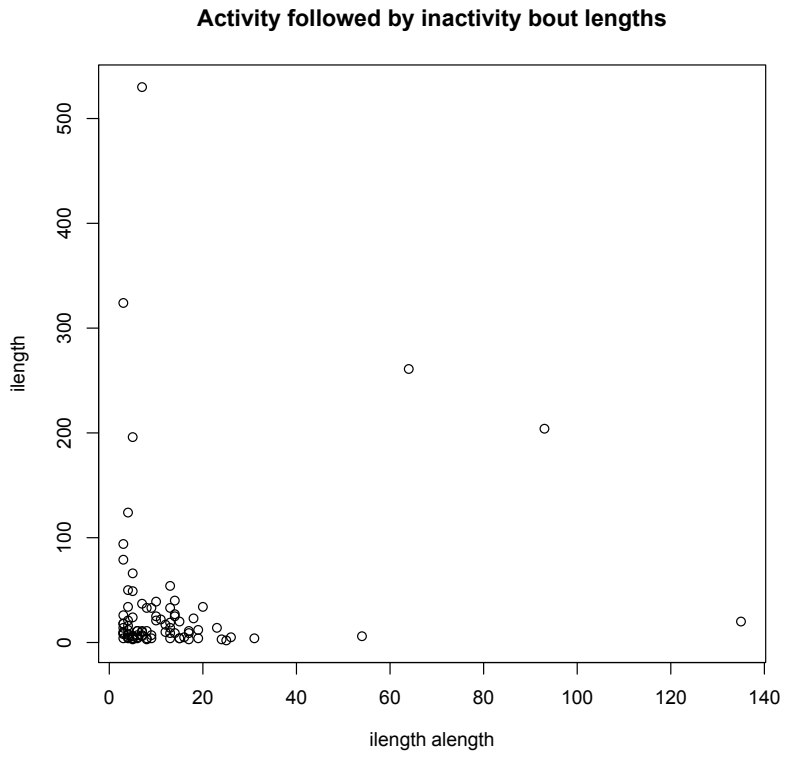
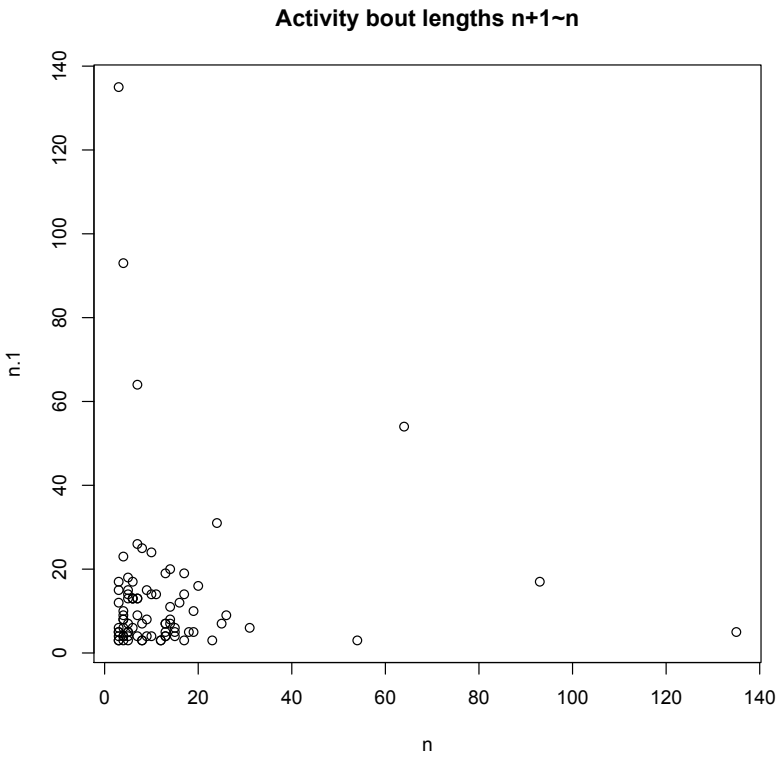
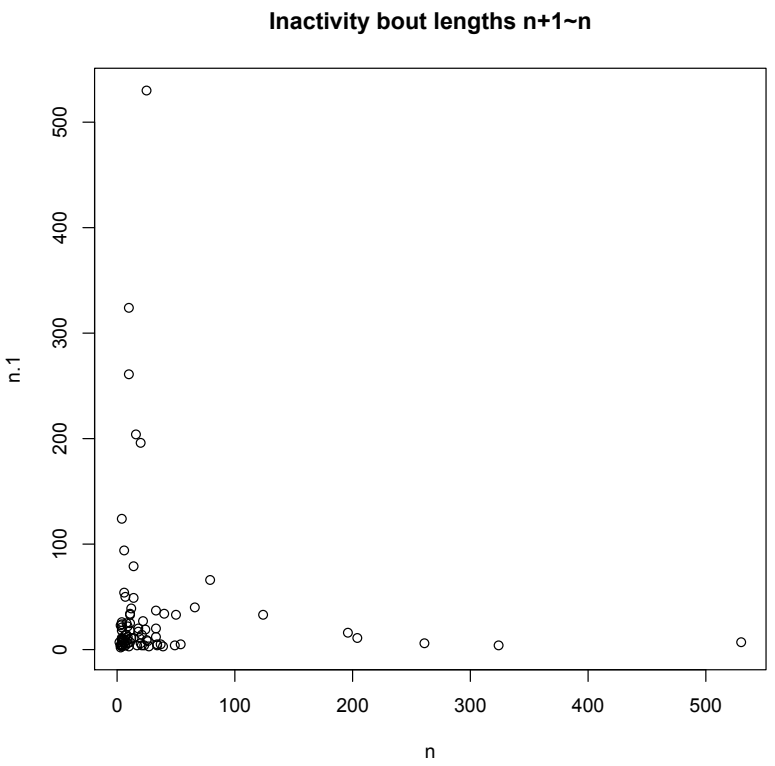
0.04
0.02
0.00
0
200
400
d1$length
type
act
inact
Series1

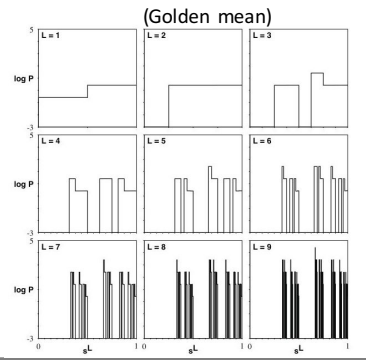
Return Maps

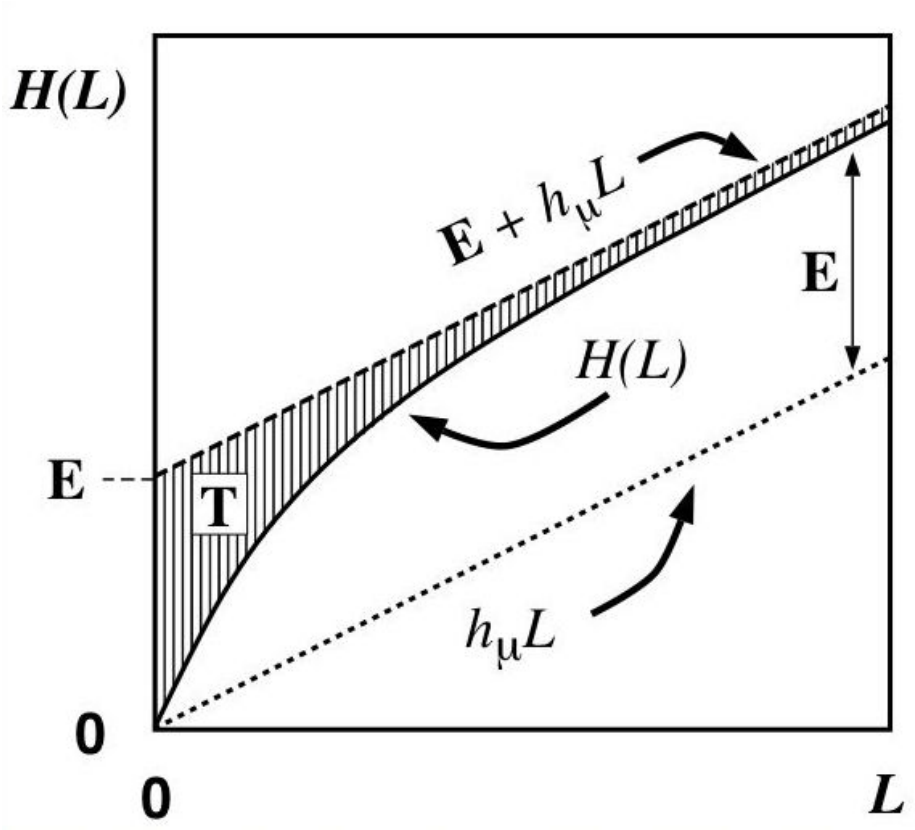

Activity followed by inactivity bout lengths
ilength
ilength alength
0
100
200
300
400
500
0
20
40
60
80
100
120
140

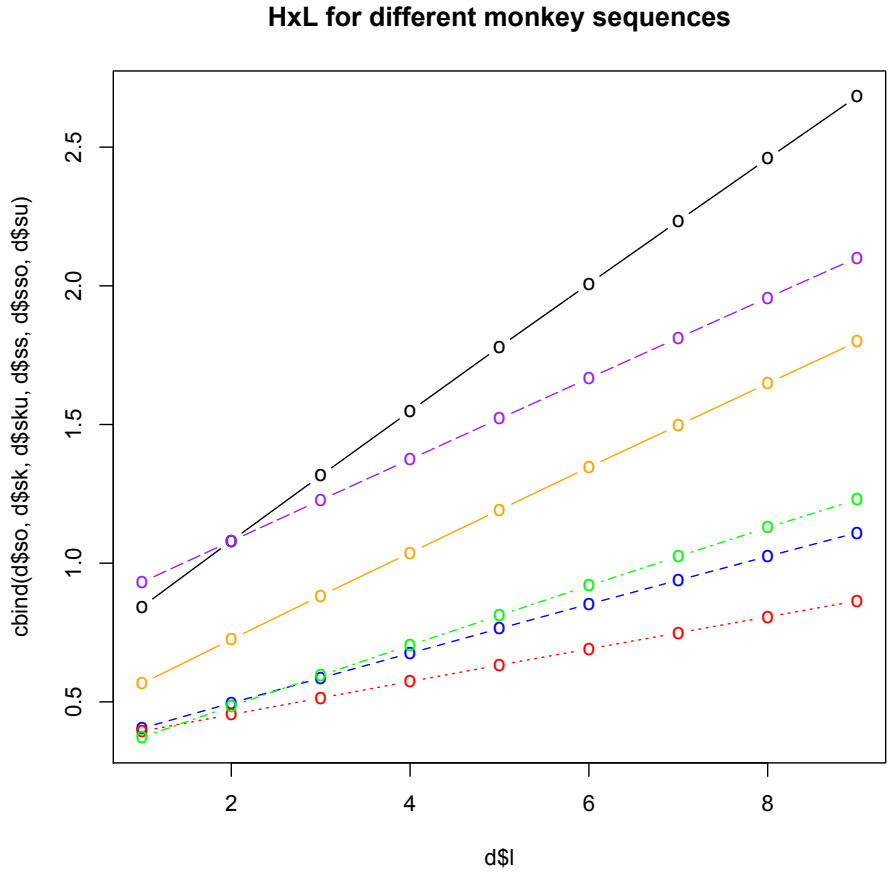

Activity bout lengths n+1~n
n.1
n
0
20
40
60
80
100
120
140

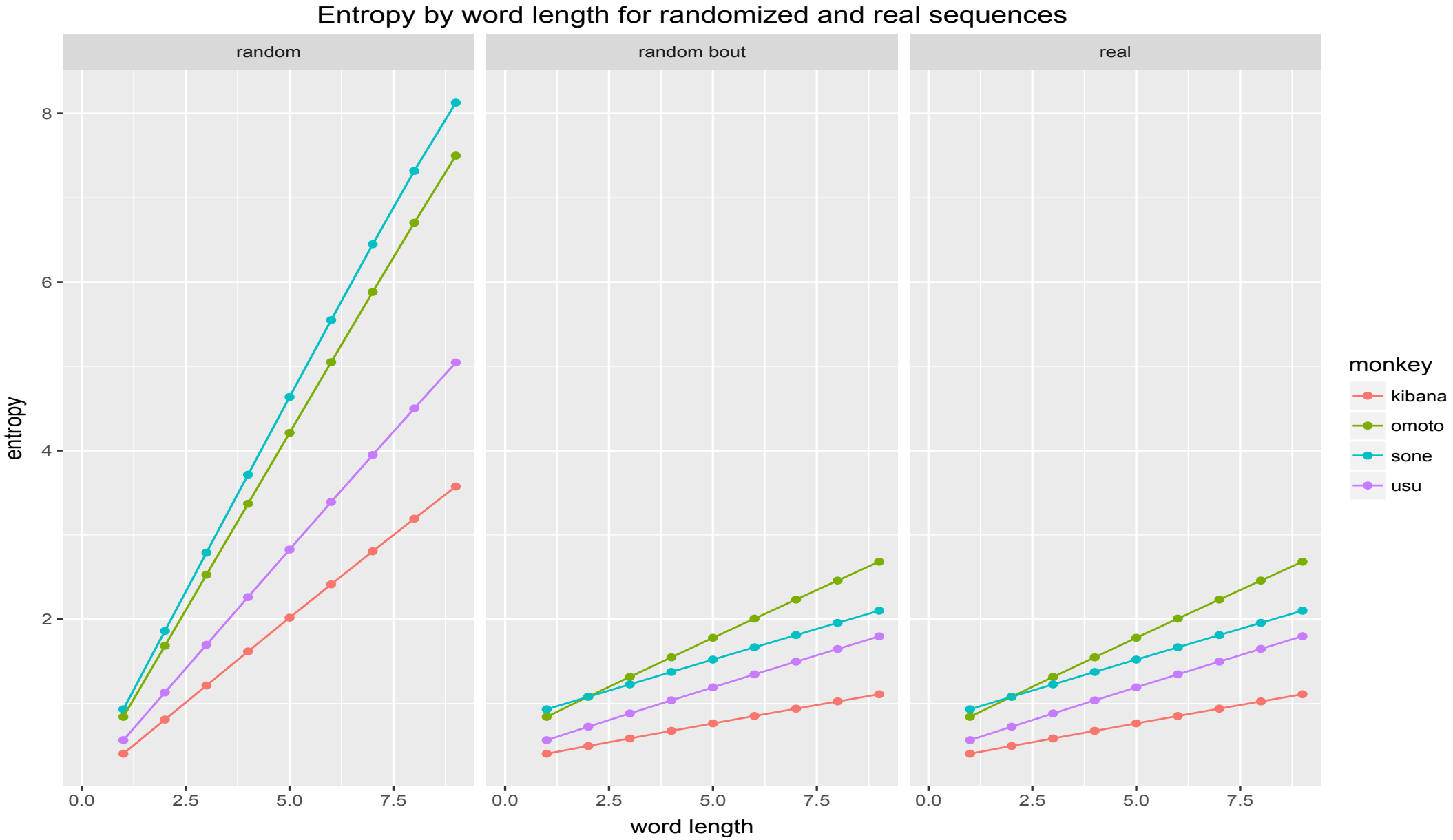

Inactivity bout lengths n+1~n
n.1
n
0
100
200
300
400
500

H(L) for different L, using word frequencies



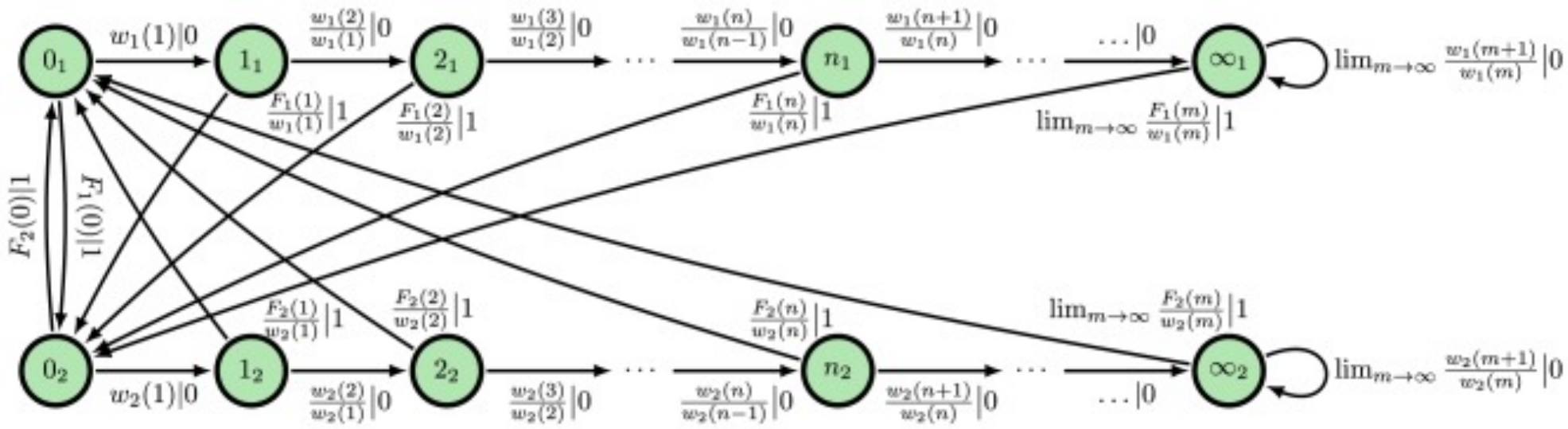





Entropy by word length for randomized and real sequences
random
random bout
real
entropy
8
6
4
2
0.0
2.5
5.0
7.5
word length
monkey
kibana
omoto
sone
usu

Next steps

- E-machines
  - Bayesian Inference to get info calculations
  - Alternating renewal process model type



Marzen et al, 2015

Stay tuned…

- Field season Winter 2017
- Partitioning from accelerometer data
- Simulated data, sampling