Models of Language Evolution ::: Practice Questions

December 7th 2018

General remarks: These questions are for preparation of the mid-term exam. They are *not* necessarily indicative of the *exact* kind of questions that the mid-term might contain. In particular, these practice questions will tend to be more open-ended and more vague than what you would encounter in the exam. They go a certain way in the direction of what you may expect about the final take-home exam. This has a purpose. More open-ended and more vague questions help you think and engage with the material more. Thinking and engaging is what prepares you for the real thing much better than anything else.

1 Design Features of Human Language

Explain what aspects of a natural communication system like human language the following four design features of Hockett (1960) refer to:

a. displacement

b. productivity

c. traditional transmission

d. duality of patterning

2 Meaning Evolution in Cellular Automata

Name two reasons why the model of meaning evolution of Grim, Denis, and Kokalis (2004) (the one with floating predators and food sources and agents arranged on a grid) might not be an ideal model of the evolution of meaning as we find it in human language?

3 The Naming Game

Which of the following statements about the naming game (Loreto, Baronchelli, and Puglisi, 2010) are true?

T F If a finite group of agents plays the naming game repeatedly with completely random and asynchronous pairings, convergence to a single name is certain in the long run.

T F If a (virtually) infinite group of agents plays a minimal naming game with two names repeatedly with completely random and asynchronous pairings, there is a stable state in which some agents use one name, some the other and yet others both. This state is not asymptotically stable, i.e., if small mutations would occur, the system would migrate to another attracting state.

T F Suppose a finite group of agents is arranged on a wrapped-around grid (i.e., a torus (i.e., a donut)), so that every agent plays against its eight nearest neighbors with asynchronous updates, the only stable states are those where all agents use a single name.

4 The Category Game

The category game Loreto, Baronchelli, and Puglisi (2010) had one particularly important parameter: $d_{\min}$.

a. Explain concisely what role the parameter $d_{\min}$ plays in the way contexts are created and/or agents behave during a single encounter?

b. Is it reasonable (with human agents in mind) to assume that $d_{\min}$ should be: (i) strictly positive, (ii) uniform across physical color space?

c. What effect does increasing $d_{\min}$ have on the evolving vocabulary?

d. What effect does increasing $d_{\min}$ have on the agents' evolving color concepts?

5 Signaling Games

Describe concisely the conceptual problem that Lewis (1969) tried to solve by looking at equilibria of signaling games?

6 Evolutionary Stable Strategies

a. Consider the following symmetric population game (an instance of *coordination problem* with pure strategies 'up' (a_{u}) and 'down' (a_{d})):

$$\text{U} = \begin{matrix} \\ a_{\text{u}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{u}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 1 & 0 \\ 0 & 2 \end{pmatrix} \end{matrix}$$

Which, if any, of the two pure strategies are evolutionary stable strategies?

b. Consider the following symmetric population game (an instance of the *Prisoners' dilemma* with strategies 'cooperate' (a_{c}) and 'defect' (a_{d})):

$$\text{U} = \begin{matrix} \\ a_{\text{c}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{c}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 2 & 0 \\ 3 & 1 \end{pmatrix} \end{matrix}$$

Which, if any, of the two pure strategies are evolutionary stable strategies?

c. Consider the following symmetric population game (an instance of no particularly prominent anything) with strategies 'up' (a_{u}), 'middle' (a_{m}) and 'down' (a_{d})):

$$\text{U} = \begin{matrix} \\ a_{\text{c}} \\ a_{\text{m}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{c}} & a_{\text{m}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 1 & 2 & 3 \\ 2 & 2 & 1 \\ 1 & 0 & 3 \end{pmatrix} \end{matrix}$$

Which, if any, of the three pure strategies are evolutionary stable strategies?

7 Replicator Dynamics

Figure 1 shows three predictions of the (continuous-time) replicator dynamic for various initial starting positions, given some two-strategy symmetric population game. Which plot goes with which of the following three games?

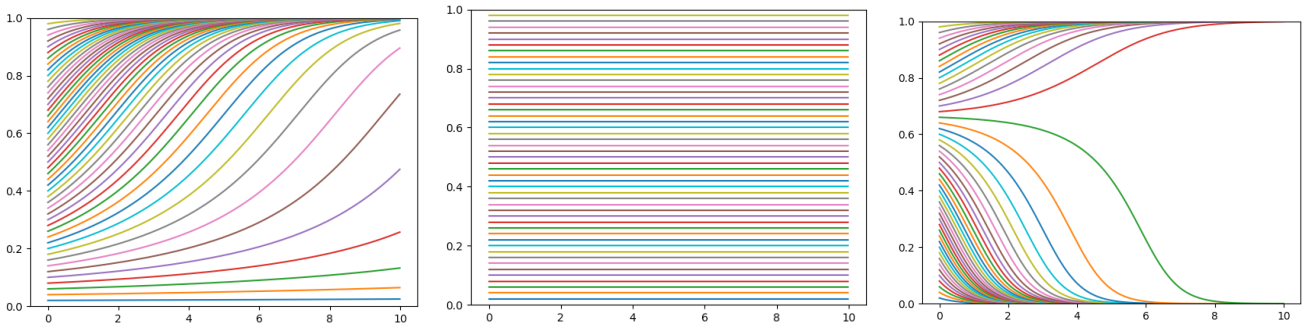
$$\text{U} = \begin{matrix} \\ a_{\text{u}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{u}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 1 & 0 \\ 0 & 2 \end{pmatrix} \end{matrix} \qquad \text{U} = \begin{matrix} \\ a_{\text{u}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{u}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 1 & 0 \\ 1 & 0 \end{pmatrix} \end{matrix} \qquad \text{U} = \begin{matrix} \\ a_{\text{u}} \\ a_{\text{d}} \end{matrix} \begin{matrix} \begin{matrix} a_{\text{u}} & a_{\text{d}} \end{matrix} \\ \begin{pmatrix} 1 & 0 \\ 0 & 0 \end{pmatrix} \end{matrix}$$

8 Different Kinds of Evolutionary Processes

Describe in your own concisely the difference between:

a. horizontal evolution vs. vertical evolution

b. cultural evolution vs. biological evolution



(a) Plot A (b) Plot B (c) Plot C

Figure 1: Predictions of the (continuous-time) replicator dynamic for various initial starting conditions

9 Iterated Learning

Which of the following statements about the iterated learning model of Kirby and Hurford (2002) (the one with simple feed-forward neural networks) are true?

T F A compositional mapping from Boolean input signals to Boolean output interpretations is certain to emerge if the size of the learner's input goes to infinity.

T F A compositional mapping from Boolean input signals to Boolean output interpretations is certain to emerge if the number of generations of repeated learning goes to infinity.

T F The simulation results show that it is possible that iterated acquisition of language can endow structure on a signal-meaning mapping which was not present at the outset.

T F The main difference between an iterated learning model like that of Kirby and Hurford (2002) and the replicator dynamic in signaling games is that the latter looks at evolutionary changes driven by communicative efficiency, whereas the former focuses entirely on changed driven by learnability.

References

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