Evolutionary Game Theory and Linguistics

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Don't talk to strangers:

Spatial EGT

Spatial EGT

- idealized assumption of standard EGT:
    - populations are infinite
    - each pair of individuals is equally likely to interact with each other
- Stochastic EGT gives up the first assumption
- What happens if you give up second assumption as well?

Spatial EGT

- one possible instantiation:
  - individuals are arranged in a spatial structure
  - every individual only interacts with its immediate neighbors

Spatial EGT

Suppose we have

- set of **positions** pos
- irreflexive **neighbourhood** relation n among pos
- **strategy function** st maps positions and time points random variable over strategies
- **density function** d maps positions/time points to positive real number
- **fitness function** f assigns fitness value (positive real) to positions/time points
- $Z(a, t)$: normalization variable; accumulated weighted fitness of the neighborhood of a at time t

Spatial EGT

$$f(a, t+1) = \sum_{b:n(a,b)} u(st(a,t), st(b,t))$$

$$d(a, t+1) = d(a,t) \times f(a, t+1)$$

$$P(st(a, t+1) = i) = \frac{1}{Z(a, t+1)} \times$$

$$\sum_{(b \in \{x:n(a,x)\} \cup \{a\}) \cap \{x:st(x,t)=i\}} d(b, t+1) \times f(b, t+1)$$

$$Z(a, t+1) = \sum_{b \in \{x:n(a,x)\} \cup \{a\}} d(b, t+1) \times f(b, t+1)$$

Spatial structure

- two-dimensional chessboard like structure
- neighborhood: adjacent fields; each field has eight neighbors
- torus shape: upper and lower boundaries are neighbors, and likewise left and right boundaries

Spatial Prisoner's dilemma

- one version of Prisoner's dilemma:

	C	D
C	5,5	1,6
D	6,1	2,2

- standard EGT: one ESS: (D, D)
- spatial EGT:
  - only interaction with neighbors
  - neighbors are likely to be "related" to each other
  - increased likelihood of interactions between individuals with identical strategies
  - favors strategies with high utility against itself, even if not NE

Spatial Prisoner's dilemma

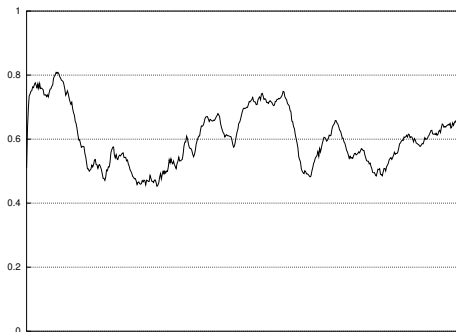- proportion of C-players in a spatial Prisoner's dilemma:
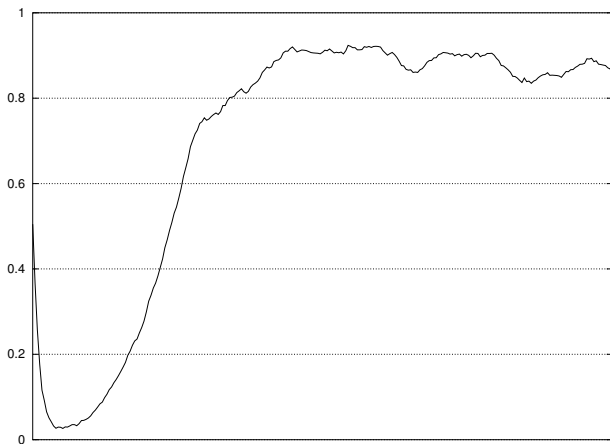
Spatial Hawks and Doves

- spatial evolution generally favors intra-strategy altruism
- should favor Doves over Hawks

	H	D
H	1	7
D	2	3

Spatial Hawks and Doves

- development of
  the proportion of
  hawks in spatial
  HaD
- proportion of
  doves is most of
  the time higher
  than in the ESS
  (20%)

Game of communication

- row strategies:
  - T: talk
  - S: remain silent
- column strategies
  - A: pay attention
  - I: ignore
- only one ESS: (S, I)

	A	I
T	1,2	0,1
S	1,0	1,1

Spatial game of communication

- symmetrized game of communication:

	(T, A)	(T, I)	(S, A)	(S, I)
(T, A)	3	2	1	0
(T, I)	2	1	2	1
(S, A)	3	3	1	1
(S, I)	2	2	2	2

- "cooperative" strategy pair (T, A) forms stable clusters