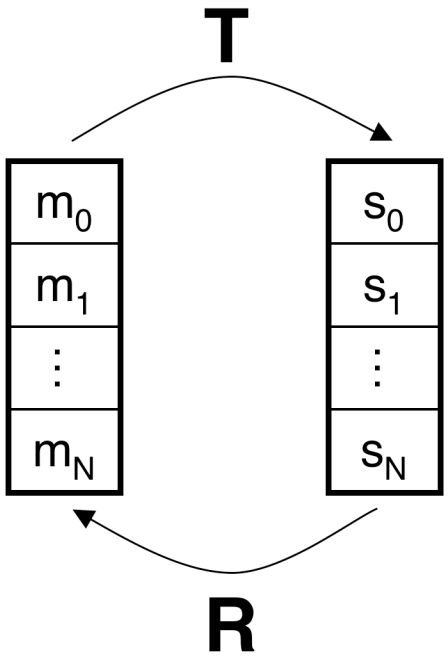
Emergence Evolution and Maintenance of Communication Conventions

The Goal: investigate which selective pressure are necessary for a *Saussurean* communication system to evolve. (Oliphant, 1996)

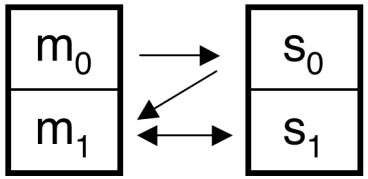
Limit our experiment on a very simple communication system (animal alarm calls).

The Communication System

- N signals **S** = $\langle s_0, s_1, \ldots, s_N \rangle$ used to convey
- N meanings **M** = $\langle m_0, m_1, \ldots, m_N \rangle$
- 400 agents having a Communication System **T/R** composed by a **T**ransmitting and a **R**eceiving system:

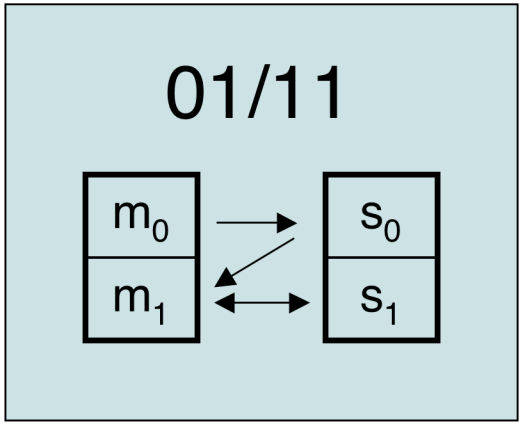


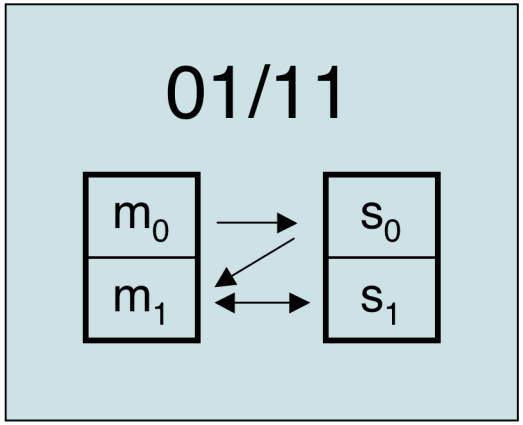
e.g. 01/11



Communication Success

Transmission/Reception success
signals being correctly transmitted/received

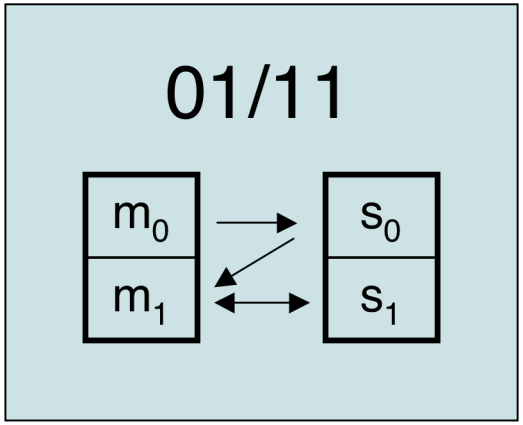


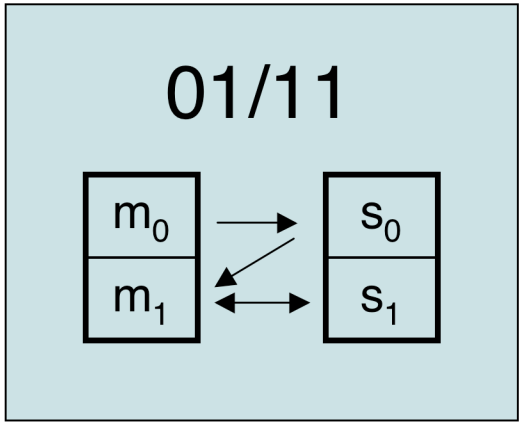


Transmission success
Reception success

Communication Success

Transmission/Reception success
signals being correctly transmitted/received

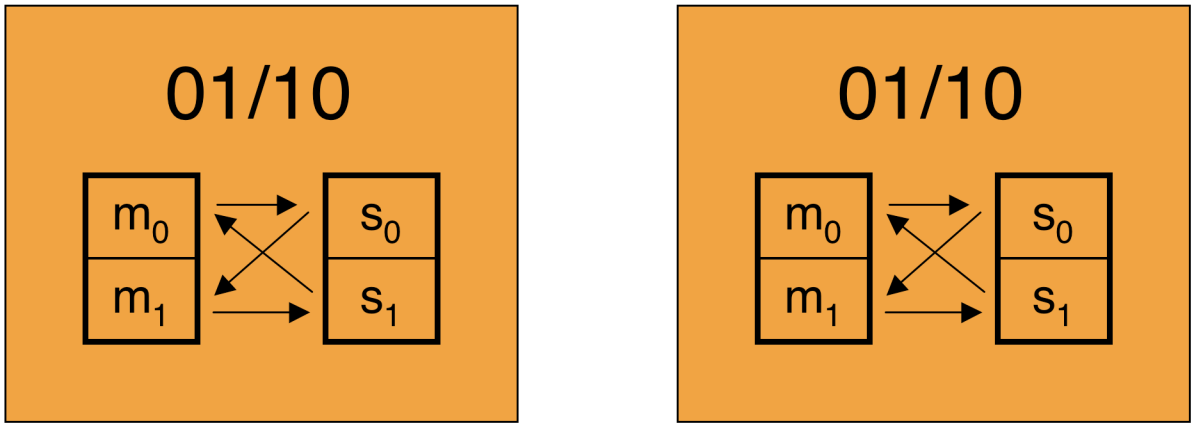




Transmission success	0.5
Reception success	0.5

Communication Success

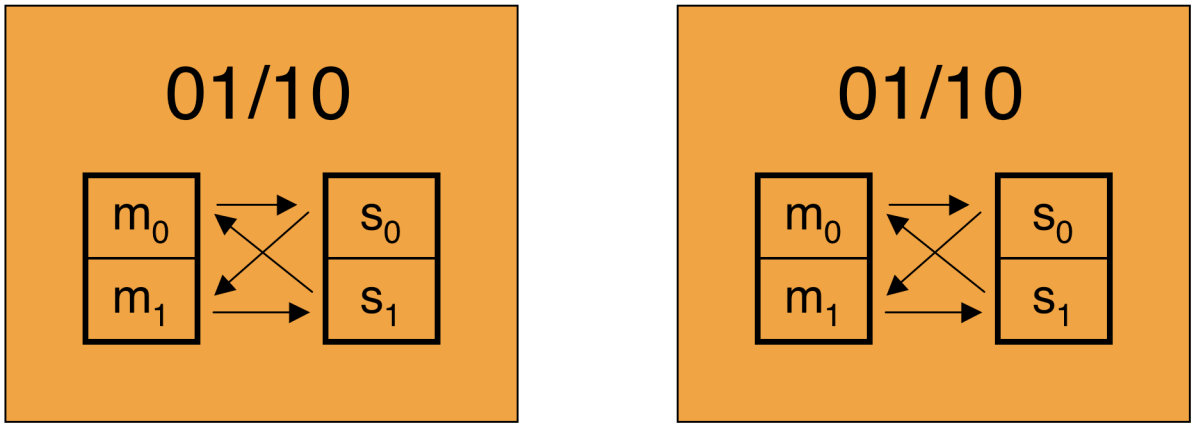
Transmission/Reception success
signals being correctly transmitted/received



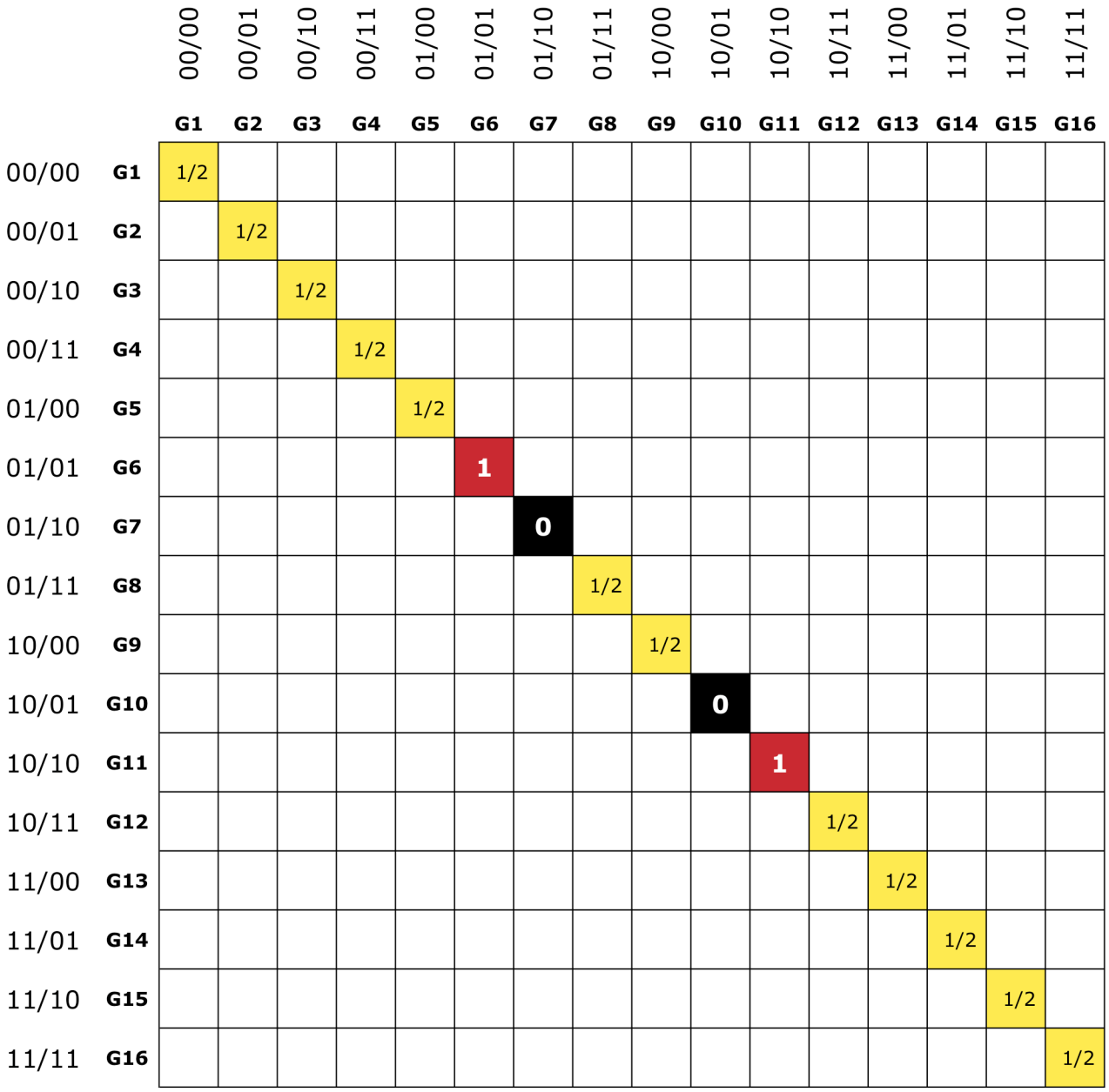
Transmission success
Reception success

Communication Success

Transmission/Reception success
signals being correctly transmitted/received



Transmission success	0
Reception success	0


00/00
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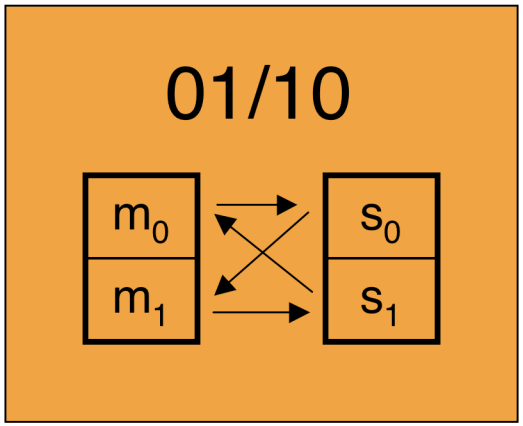
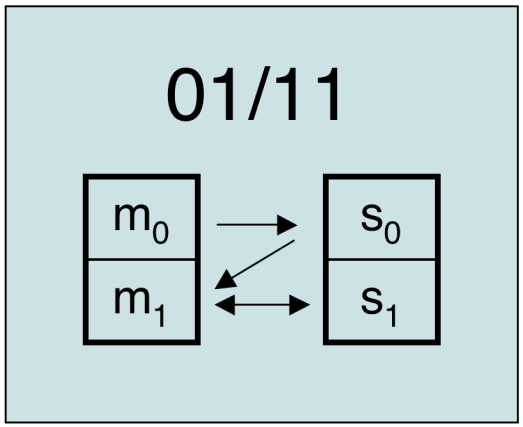
11/11
G1 G2 G3 G4 G5 G6 G7 G8 G9 G10 G11 G12 G13 G14 G15 G16
00/00 G1
00/01 G2
00/10 G3
00/11 G4
01/00 G5
01/01 G6
01/10 G7
01/11 G8
10/00 G9
10/01 G10
10/10 G11
10/11 G12
11/00 G13
11/01 G14
11/10 G15
11/11 G16
1/2
1
0

Communication Success

Transmission/Reception success
signals being correctly transmitted/received



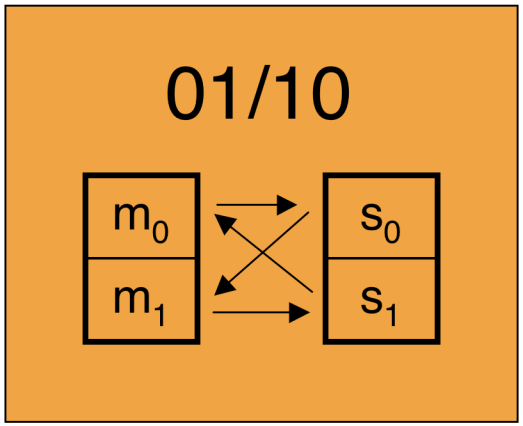


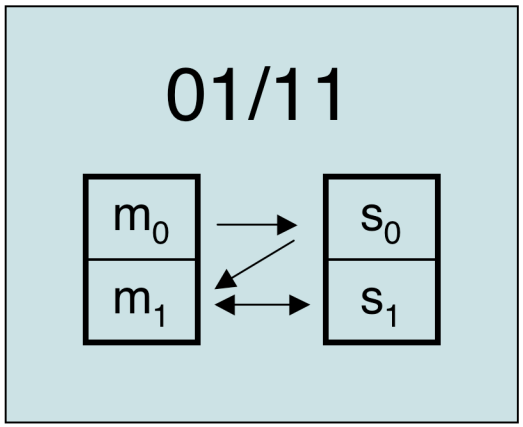
TS
RS

TS
RS

Communication Success

Transmission/Reception success
signals being correctly transmitted/received



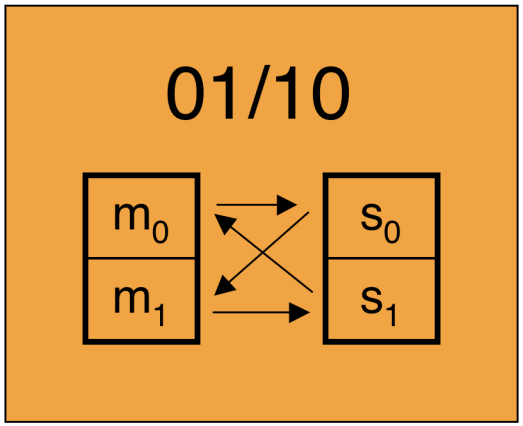


TS 0.5
RS

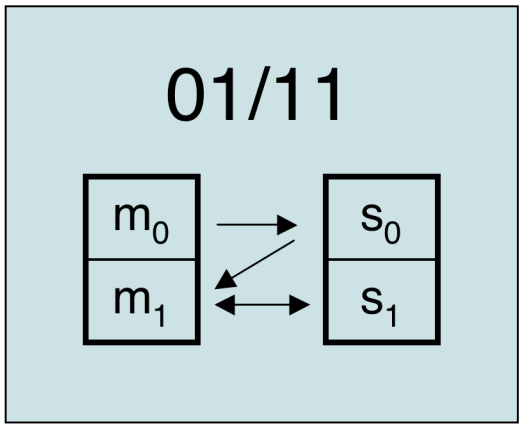
TS
RS 0.5

Communication Success

Transmission/Reception success
signals being correctly transmitted/received



TS 0.5
RS 0



TS 0
RS 0.5

Fitness Function (F)

In NON-altruistic communication

F = (TS + RS) / 2

		00/00	00/01	00/10	00/11	01/00	01/01	01/10	01/11	10/00	10/01	10/10	10/11	11/00	11/01	11/10	11/11
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16
00/00	G1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
00/01	G2	1/2	1/2	1/2	1/2	3/4	3/4	3/4	3/4	1/4	1/4	1/4	1/4	1/2	1/2	1/2	1/2
00/10	G3	1/2	1/2	1/2	1/2	1/4	1/4	1/4	1/4	3/4	3/4	3/4	3/4	1/2	1/2	1/2	1/2
00/11	G4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
01/00	G5	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2
01/01	G6	1/2	3/4	1/4	1/2	3/4	1	1/2	3/4	1/4	1/2	0	1/4	1/2	3/4	1/4	1/2
01/10	G7	1/2	3/4	1/4	1/2	1/4	1/2	0	1/4	3/4	1	1/2	3/4	1/2	3/4	1/4	1/2
01/11	G8	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2	1/2	3/4	1/4	1/2
10/00	G9	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2
10/01	G10	1/2	1/4	3/4	1/2	3/4	1/2	1	3/4	1/4	0	1/2	1/4	1/2	1/4	3/4	1/2
10/10	G11	1/2	1/4	3/4	1/2	1/4	0	1/2	1/4	3/4	1/2	1	3/4	1/2	1/4	3/4	1/2
10/11	G12	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2	1/2	1/4	3/4	1/2
11/00	G13	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11/01	G14	1/2	1/2	1/2	1/2	3/4	3/4	3/4	3/4	1/4	1/4	1/4	1/4	1/2	1/2	1/2	1/2
11/10	G15	1/2	1/2	1/2	1/2	1/4	1/4	1/4	1/4	3/4	3/4	3/4	3/4	1/2	1/2	1/2	1/2
11/11	G16	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2

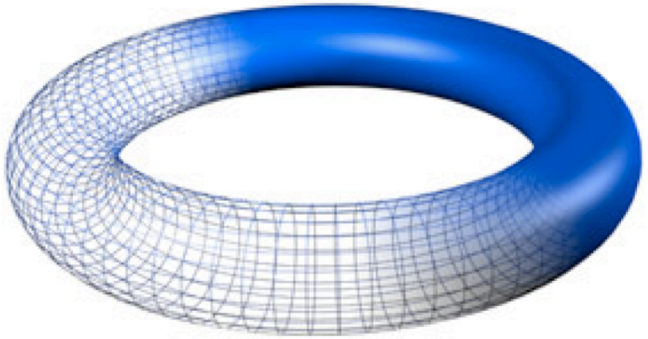
Fitness Function (F)

In altruistic communication

F = RS

		00/00	00/01	00/10	00/11	01/00	01/01	01/10	01/11	10/00	10/01	10/10	10/11	11/00	11/01	11/10	11/11
		G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12	G13	G14	G15	G16
00/00	G1	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
00/01	G2	1/2	1/2	1/2	1/2	1	1	1	1	0	0	0	0	1/2	1/2	1/2	1/2
00/10	G3	1/2	1/2	1/2	1/2	0	0	0	0	1	1	1	1	1/2	1/2	1/2	1/2
00/11	G4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
01/00	G5	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
01/01	G6	1/2	1/2	1/2	1/2	1	1	1	1	0	0	0	0	1/2	1/2	1/2	1/2
01/10	G7	1/2	1/2	1/2	1/2	0	0	0	0	1	1	1	1	1/2	1/2	1/2	1/2
01/11	G8	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
10/00	G9	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
10/01	G10	1/2	1/2	1/2	1/2	1	1	1	1	0	0	0	0	1/2	1/2	1/2	1/2
10/10	G11	1/2	1/2	1/2	1/2	0	0	0	0	1	1	1	1	1/2	1/2	1/2	1/2
10/11	G12	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11/00	G13	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
11/01	G14	1/2	1/2	1/2	1/2	1	1	1	1	0	0	0	0	1/2	1/2	1/2	1/2
11/10	G15	1/2	1/2	1/2	1/2	0	0	0	0	1	1	1	1	1/2	1/2	1/2	1/2
11/11	G16	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2

The Model



- Continuous space (torus)
- Group of agents (400)
  - each with a CS
  - 5 life stages (0-4)

  - 8 bidirectional communication attempts with neighbors
  - success of communication: (transmission/reception)
  - fitness based on the fitness function (altr./non-altr.)

Selective Pressure

- At life stage 4 an agent dies and it is replaced with an agent of stage 0.
- The newborn agent selects a **teacher** from the set of its neighbors according to their fitness.
- The newborn agent then acquires with a certain precision the communication system of its teacher: each mapping in the teacher's communication system is
  - randomly chosen with probability μ (mutation rate)
  - learned with probability 1 - μ

Simulation 1

- Non Altruistic communication

Simulation 1

- **Non Altruistic communication**

Simulation 1

- **Non Altruistic communication**

Simulation 2

- **Altruistic communication**

Simulation 1

- **Non Altruistic communication**

+

Simulation 2

- **Altruistic communication**

-

Altruistic communication is evolutionary unstable (Maynard Smith, 1982)

Simulation 1

- **Non Altruistic communication**

+

Simulation 2

- **Altruistic communication**

-

Altruistic communication is evolutionary unstable (Maynard Smith, 1982)

Simulation 3

- **Altruistic communication**
- **Iterative Mode**

Simulation 1
- **Non Altruistic communication**

+

Simulation 2
- **Altruistic communication**

-

Altruistic communication is evolutionary unstable (Maynard Smith, 1982)

Simulation 3
- **Altruistic communication**
- **Iterative Mode**

+

Simulation 1
- **Non Altruistic communication**

+

Simulation 2
- **Altruistic communication**

-

Altruistic communication is evolutionary unstable (Maynard Smith, 1982)

Simulation 3
- **Altruistic communication**
- **Iterative Mode**

+

Simulation 4
- **Altruistic communication**
- **Spatially Distributed**

Simulation 1
- **Non Altruistic communication**

+

Simulation 2
- **Altruistic communication**

-

Altruistic communication is evolutionary unstable (Maynard Smith, 1982)

Simulation 3
- **Altruistic communication**
- **Iterative Mode**

+

Simulation 4
- **Altruistic communication**
- **Spatially Distributed**

+