Can Memes Drive Genes?

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for

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1 What are memes?

- for my purpose defined as ideas which are transmitted via imitation
- assume “catchiness” of idea not completely dependent on source
- then a meme is a new replicating entity
- *memetic fitness not identical to genetic fitness*
- but memes and genes interact

2 Motivation

- orthodox view (I think) is that culture serves genetics
- but Blackmore (1999) claims memes can have adverse effect on genes

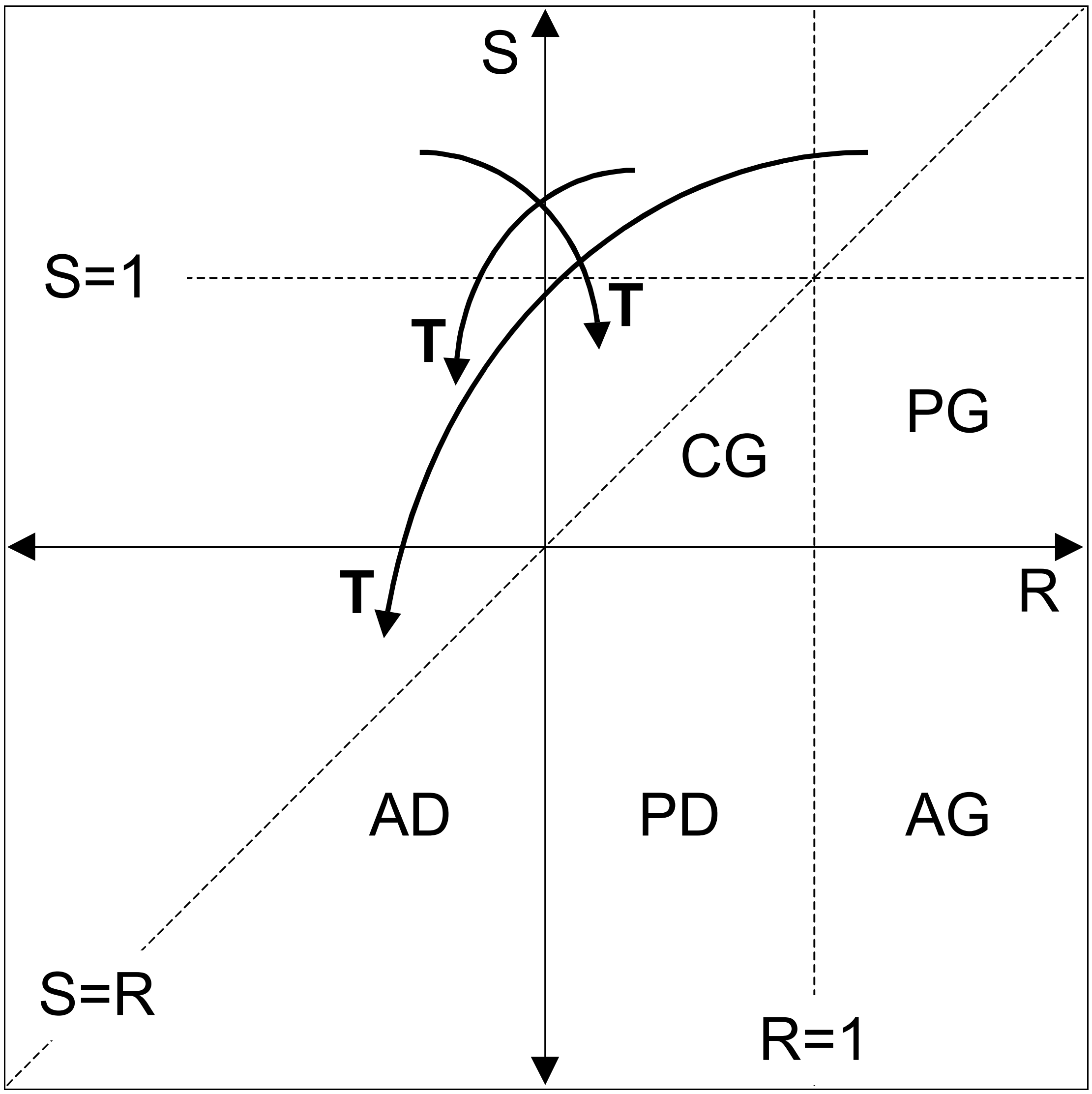
- own intuition was that fast process (memes) must adapt to slow (genes) (adiabatic approximation)
- to test, constructed simple model

3 The Model

- individual-based model
- each individual has single meme/gene pair
- each consists of single bit (‘D’ or ‘C’)
- simplest interaction between memes and genes is a 2-player game
- chose a symmetric game to avoid biasing the results. Described by 4 possible payoffs:

		Gene	
		D	C
Meme	D	P=0 P=0	S T=1
	C	T=1 S	R R

- with P=0, T=1, game space still captures all 5 significant collective action games (Heckathorn, 1996)

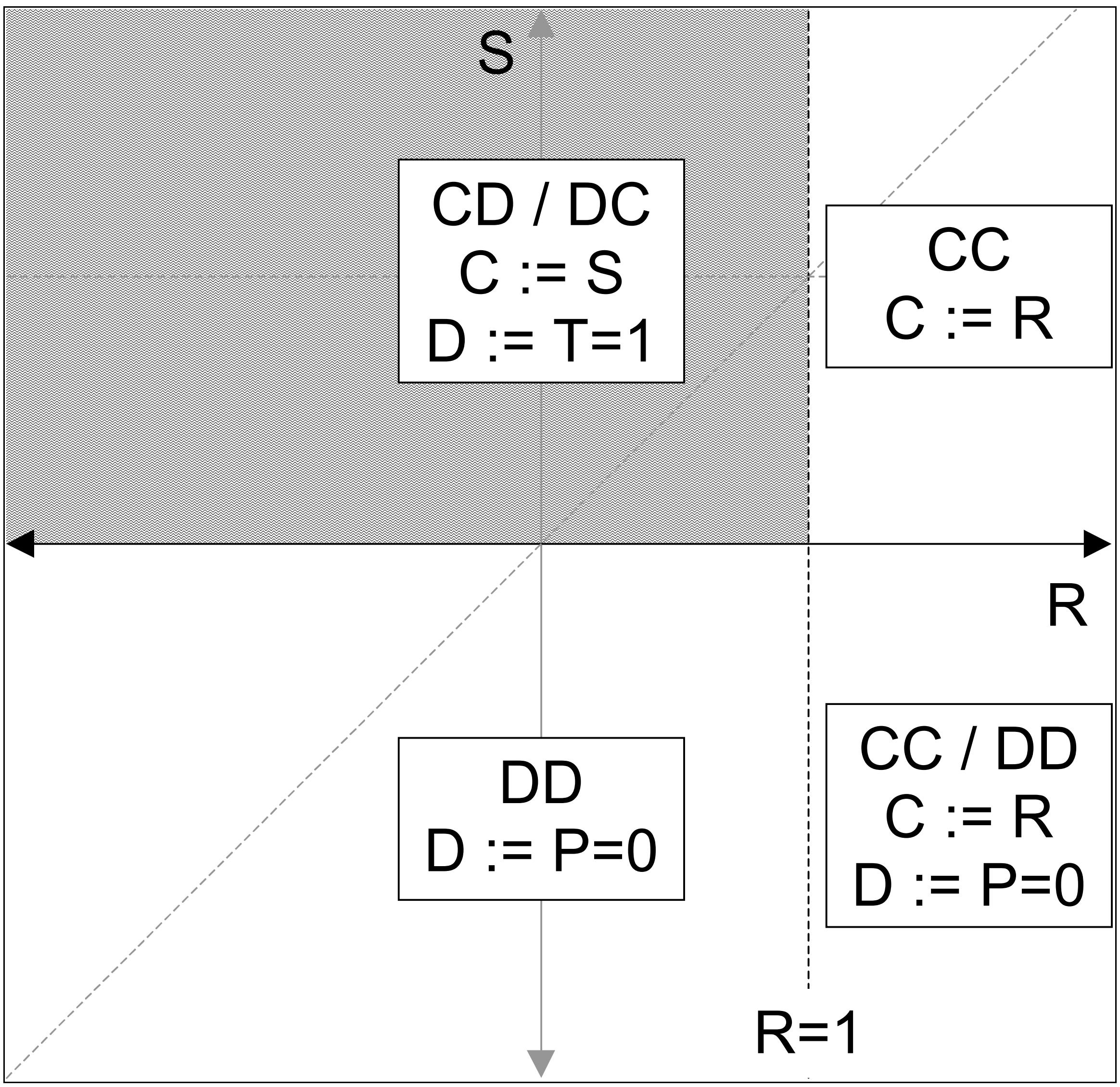


CG= Chicken Game	(T>R>S>P)
PG= Privileged Game	(R>T>S>P)
AG= Assurance Game	(R>T>P>S)
PD= Prisoner's Dilemma	(T>R>P>S)
AD= Altruist's Dilemma	(T>P>R>S)

- **T**=transform (S↔T, R↔P, C↔D) preserves T>S
- 9 distinct games to explore
- 4 of uncertain relevance:
    - T>S>R>P like Chicken except would rather just I swerved, not both (kickback?)
    - T>S>P>R another variation of Chicken
    - T>P>S>R like Altruist's Dilemma (altruists fare poorly, but especially against each other)
    - R>S>T>P like Privileged game (easy to solve, both choose C)

3.1 Nash equilibria

- are configurations such that neither player can improve by changing choice

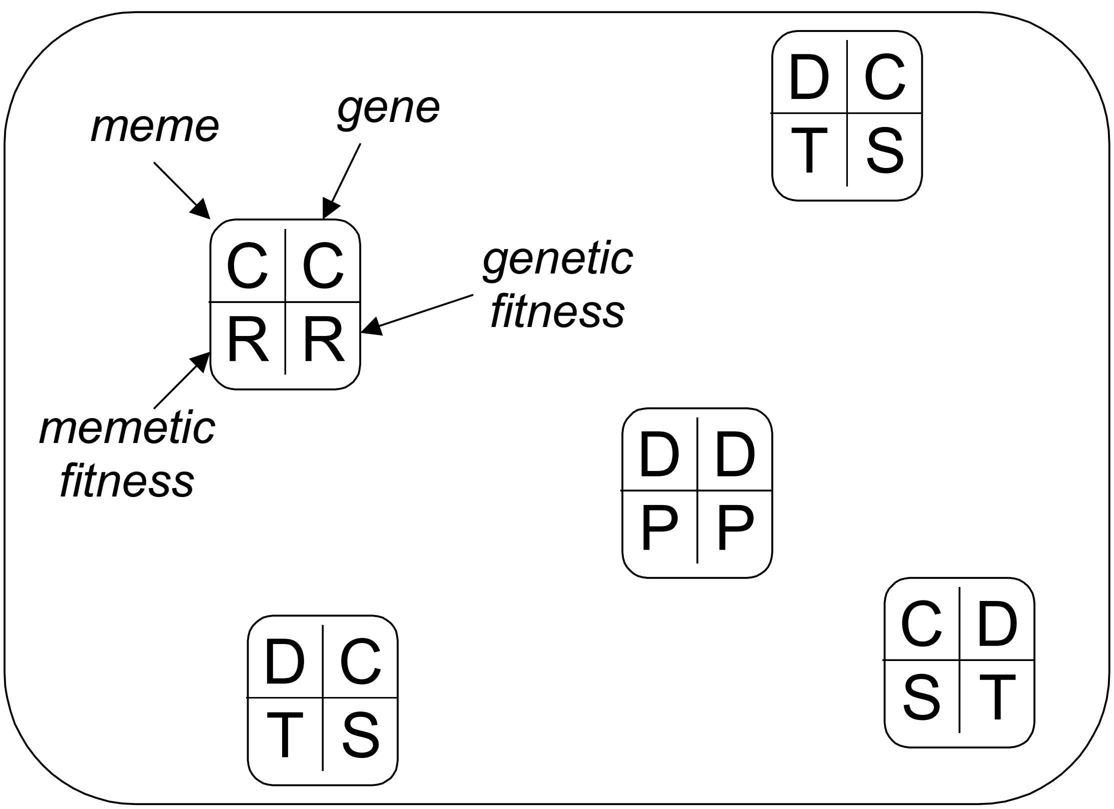


(:= stands for *gets*)

- expect interesting dynamics in upper left region (incl. Chicken)—competition for the best payoff
- in other regions memes and genes can coordinate for mutual benefit

3.2 Replication

- population of individual agents with 4 properties each



- agents interact via replication events (either memetic or genetic)
- asexual reproduction—fitter variant replaces loser (ties decided by coin flip)
- example: genetic interaction between CC (fitness=R) & DD (fitness=P). If R>P then DD→DC, else CC→CD.
- only difference between memes and genes is memetic replication rate ρ faster than genetic ($\rho>1$)
- each replication has chance of mutation, $0<\mu<1/2$ (C↔D). $\mu=1/2$ would be completely random.

4 Aside: Model Justification

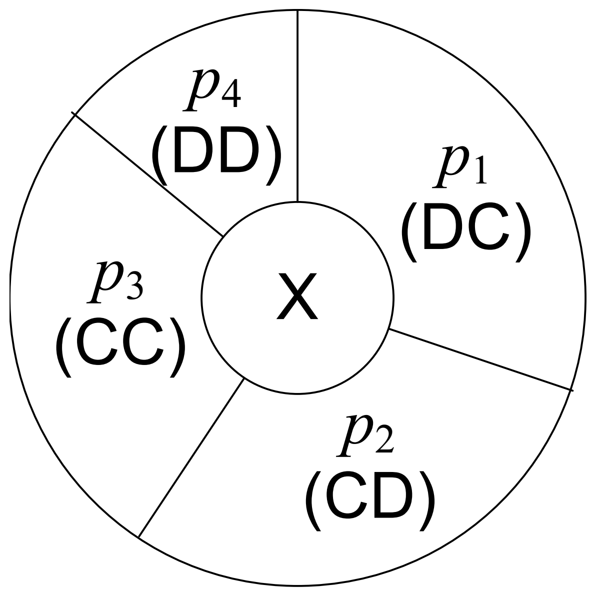
- simplest model I could construct with desired properties:
    - memes and genes are replicators
    - only difference is timescale
    - non-trivial interaction
- simplicity serves two purposes:
    - demonstrates results clearly
    - analytically tractable

5 Mean field analysis

- allows estimation of steady-state proportions neglecting correlations

5.1 Method

- label states: DC=1, CD=2, CC=3, DD=4
- consider single agent X in "sea" (field) with frequencies p_1, p_2, p_3 & p_4



- X has state prob's x_1, x_2, x_3 & x_4
- want to determine prob's after one interaction with field, $x'_{1\ldots4}$

$$x_i' = \sum_{jk} x_j p_k T_{j\to i}^k$$

- $T^{k}_{j \to i}$ is transfer prob., likelihood of $j \to i$ via interaction with k
- self-consistency requires $x_j = p_j$
- steady-state requires $x'_i = x_i$
- so can (theoretically) solve for $p_{1 \ldots 4}$

5.1.1 SERIES EXPANSION

- couldn't solve exactly
- assume mutation rate small μ<<1 so prob can be written as power series

$$p_i = \sum_{j \geq 0} p_i^{(j)} \mu^j$$

- then each side (LHS/RHS) of mean field eqn. can be written as

$$* \mathrm{HS} = \sum_{j \geq 0} (*\mathrm{HS})_j \mu^j$$

- equality must hold for any μ so can solve by requiring equality for each coefficient:

$$(\mathrm{LHS})_j = (\mathrm{RHS})_j$$

- truncate at desired power of μ
- gives approximate solution for stable fixed points

5.2 Results

- 9 regions of R-S parameter space to consider
- in most, dynamics fixate around Nash equilibrium
- in Assurance game (R>1, S<0) DD configuration is unstable, only $p_{CC} \approx 1-\mu$ is stable

- in (quasi-) Chicken ($R<1$, $S>0$) get 2 stable fixed pts.:

Species	*Representation*
CD	$1-\mu$ or $\Theta(\mu^2)$
DC	$\Theta(\mu^2)$ or $1-\mu$
CC	$\mu/2$
DD	$\mu/2$

6 Simulation

- random sequential updating
- 1 unit Time=1 generation

6.1 Non-spatial

- every agent interacts with every other with equal probability
- confirms mean field results in regions with only one fixed pt.

- in Assurance game (R>1, S<0), finds cooperative Nash equil. (CC) even if initialized at defective Nash eq. (DD)

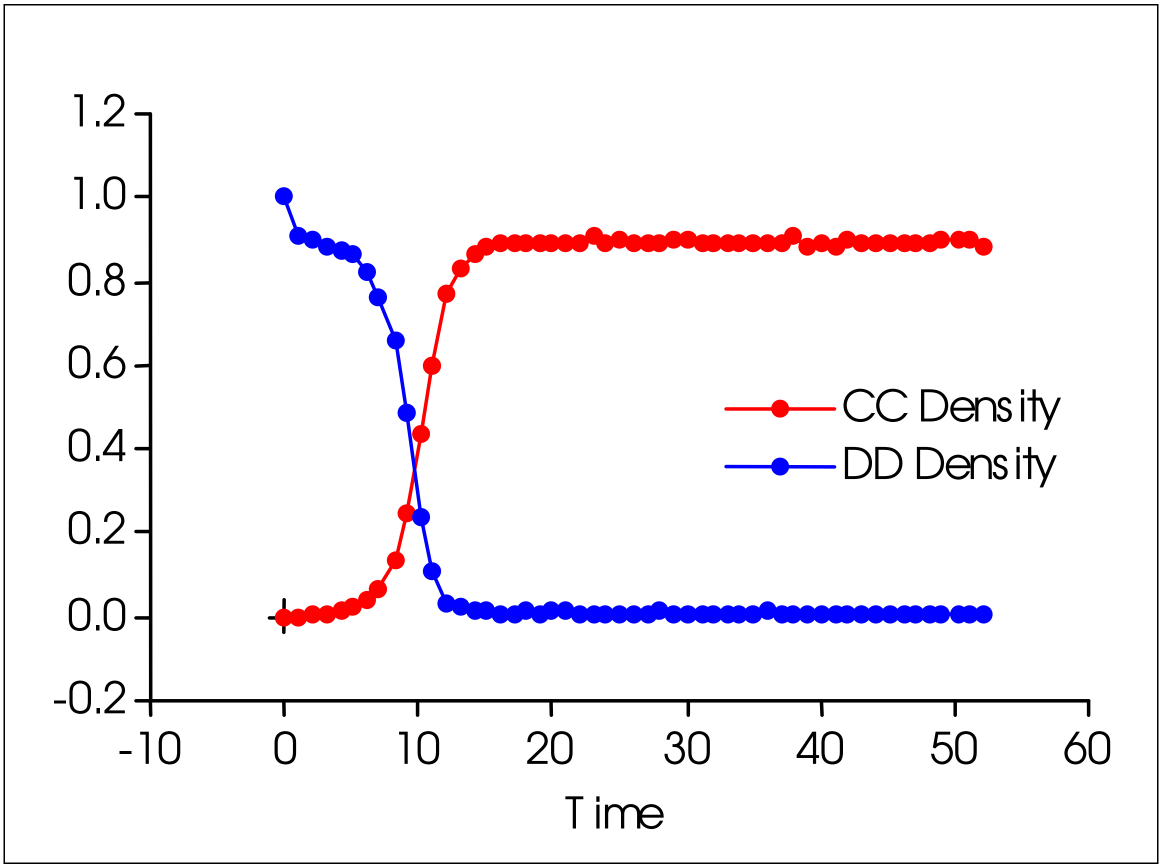


Figure 6.1: Non-spatial, $N=64\times64$, $\mu=0.1$, $\rho=10$, R=3/2, S=–1/2. Initial conditions: all DD.

- in (quasi-) Chicken (R<1, S>0) outcome depends on initial conditions

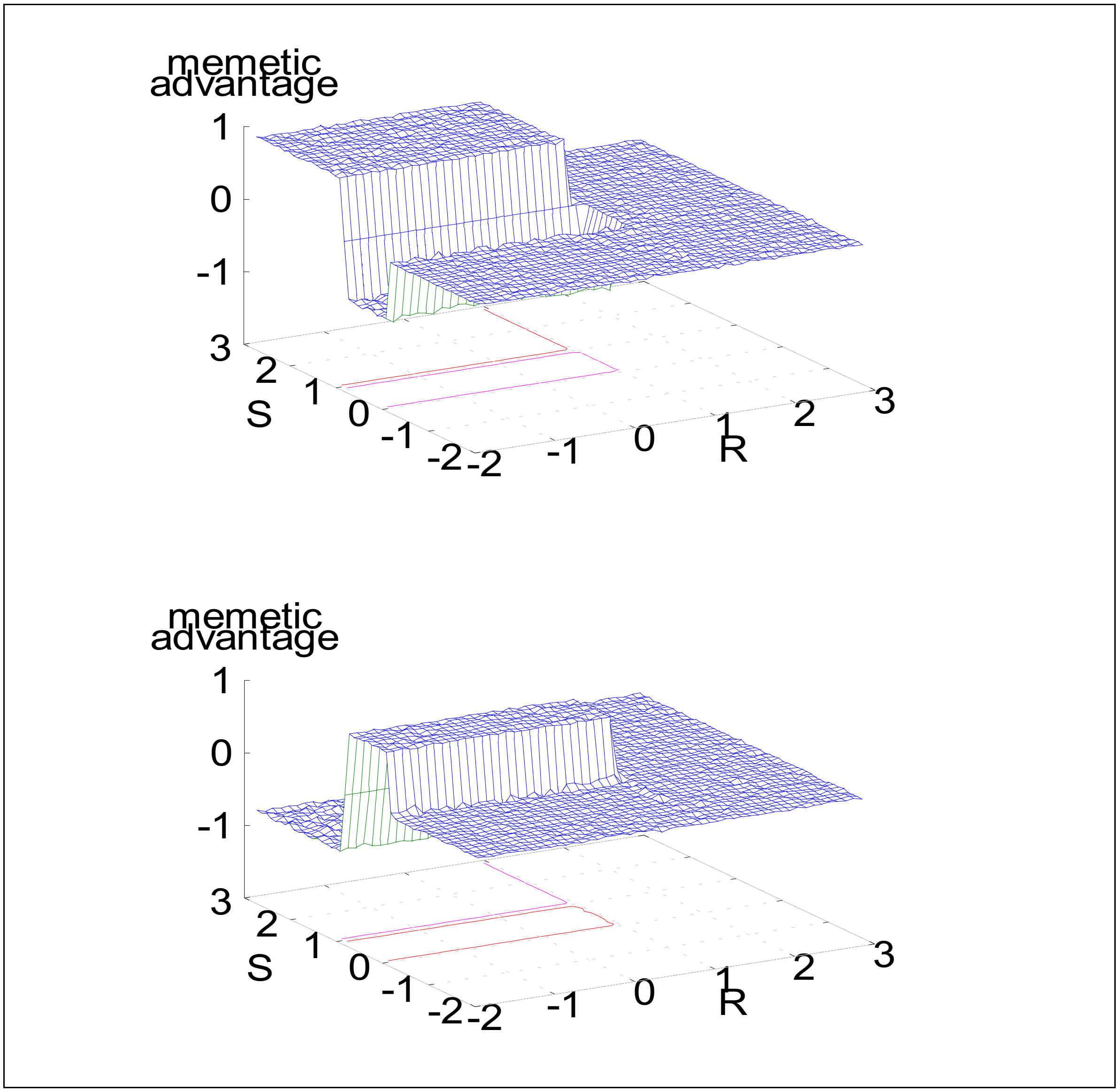


Figure 6.2: Non-spatial, 1,000 generations, N=32×32, μ=0.1, ρ=10. Initial conditions: all D genes (upper), all C genes (lower). [Memetic advantage = (meme fit.–gene fit.)/|T–S|.]

- neither fixed point can be invaded

Conclusion #1: once genetic advantage has been established it cannot be invaded by competitive memes if interactions are global

6.2 Spatial

- agents only interact with neighbours on lattice
- 2-d von Neumann (8 nearest nbrs.). Also looked at 1-d and random networks with same conclusions
- dynamics generally the same except in quasi-Chicken regime
- in quasi-Chicken ($R>0$, $S<1$), initially behaves as mean-field but eventually memes dominate regardless of initial conditions

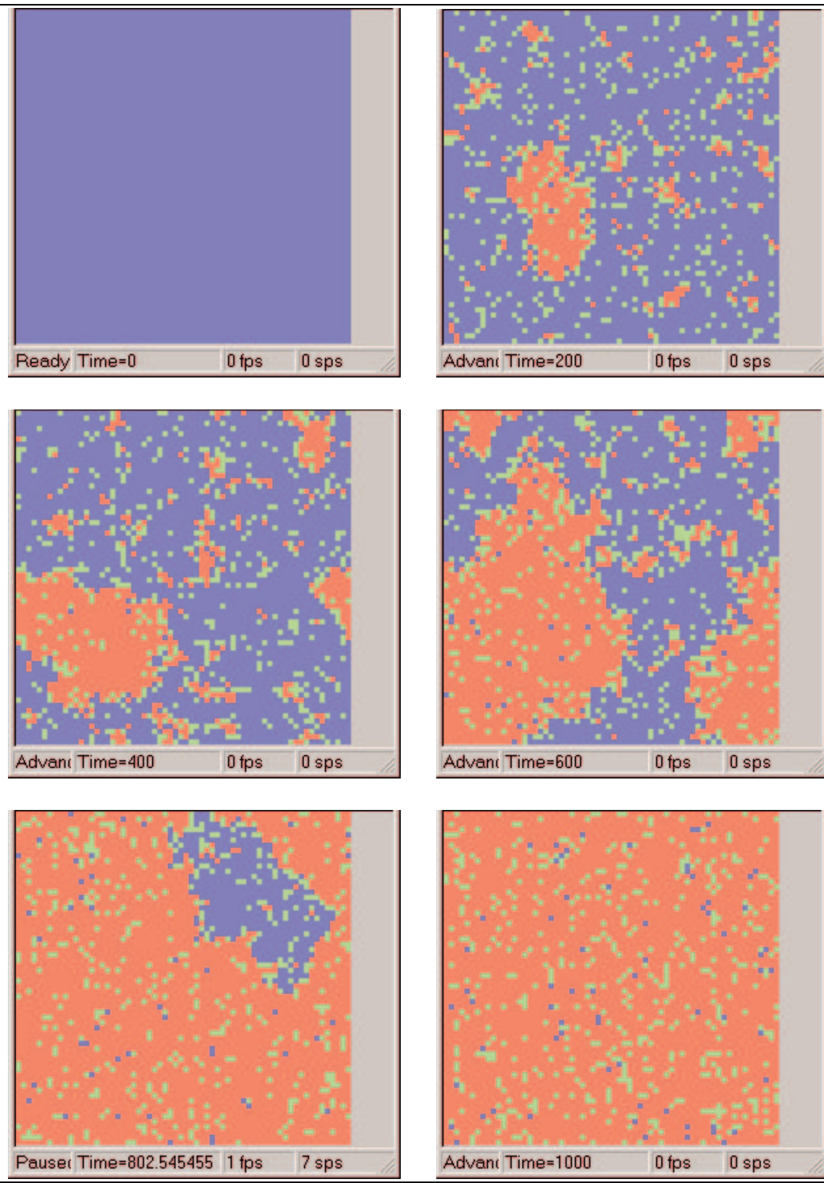


Figure 6.3: Snapshots of 2-d, 8 n.n., N=64×64, μ=0.1, ρ=10, R=0.7, S=0.3, at times 0…1,000. (Blue=CD, Green=CC/DD, Red=DC).

- holds for all R>0, S<1

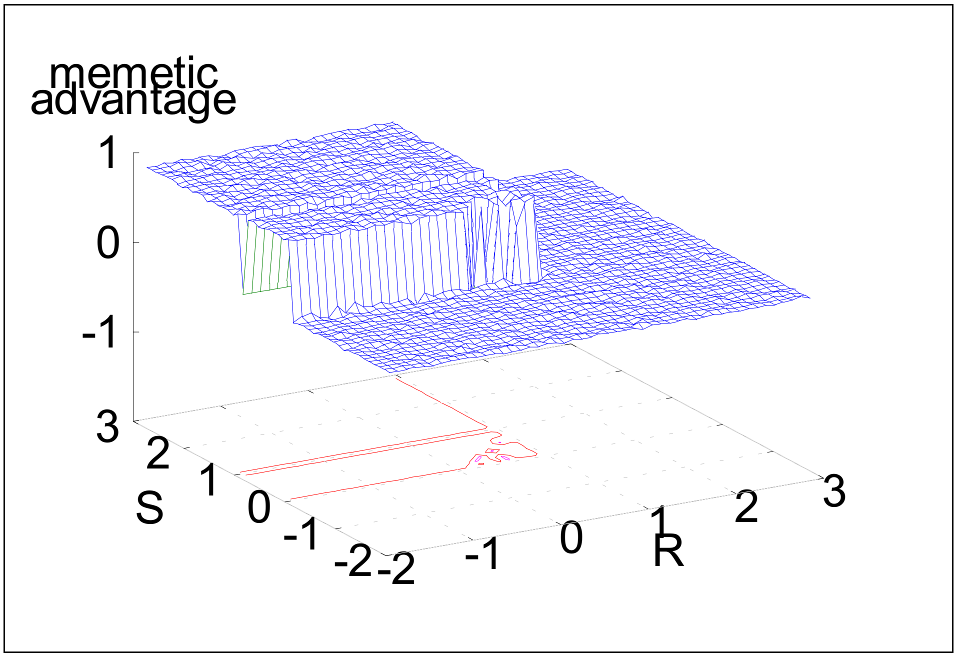


Figure 6.4: 2-d, 8 n.n., 1,000 generations, N=32×32, μ=0.1, ρ=10, largely independent of initial conditions. [Memetic advantage = (meme fit.–gene fit.)/|T–S|.]

Conclusion #2: successful genes can be undermined by competitive memes if interactions are local

- mechanism poorly understood (by me)
- depends on reciprocal links (does not occur in non-reciprocal random networks)

7 Summary

- successful genes (slow replicator) can be undermined by memes (fast replicator) if:
    - replicators are competing
    - interactions are local and reciprocal
- significance open to interpretation, eg. “globalization is bad because it forces us to put aside compassion and discard the less successful in our society” (paraphrasing Michael)

- simulation tool and model (to be) posted on web site (with source code) http://rikblok.cjb.net/software/r2dtoo/models/

References

Blackmore, S. (1999). *The Meme Machine*. Oxford University Press.

Heckathorn, D. (1996) The dynamics and dilemmas of collective action. *Amer. Sociol. Review* 61:250—277.