The Evolution of Specialisation in Groups – Tags (again!)

David Hales
Centre for Policy Modelling,
Manchester Metropolitan University, UK.
http://cfpm.org

What are “tags”

- Holland (1992) discussed tags as powerful “symmetry breaking” mechanism which could be useful for understanding complex “social-like” processes
- Tags are observable labels or social cues
- Agents can observe the tags of others
- Tags evolve in the same way that behavioral traits evolve
- Agents may evolve behavioral traits that discriminate based on tags

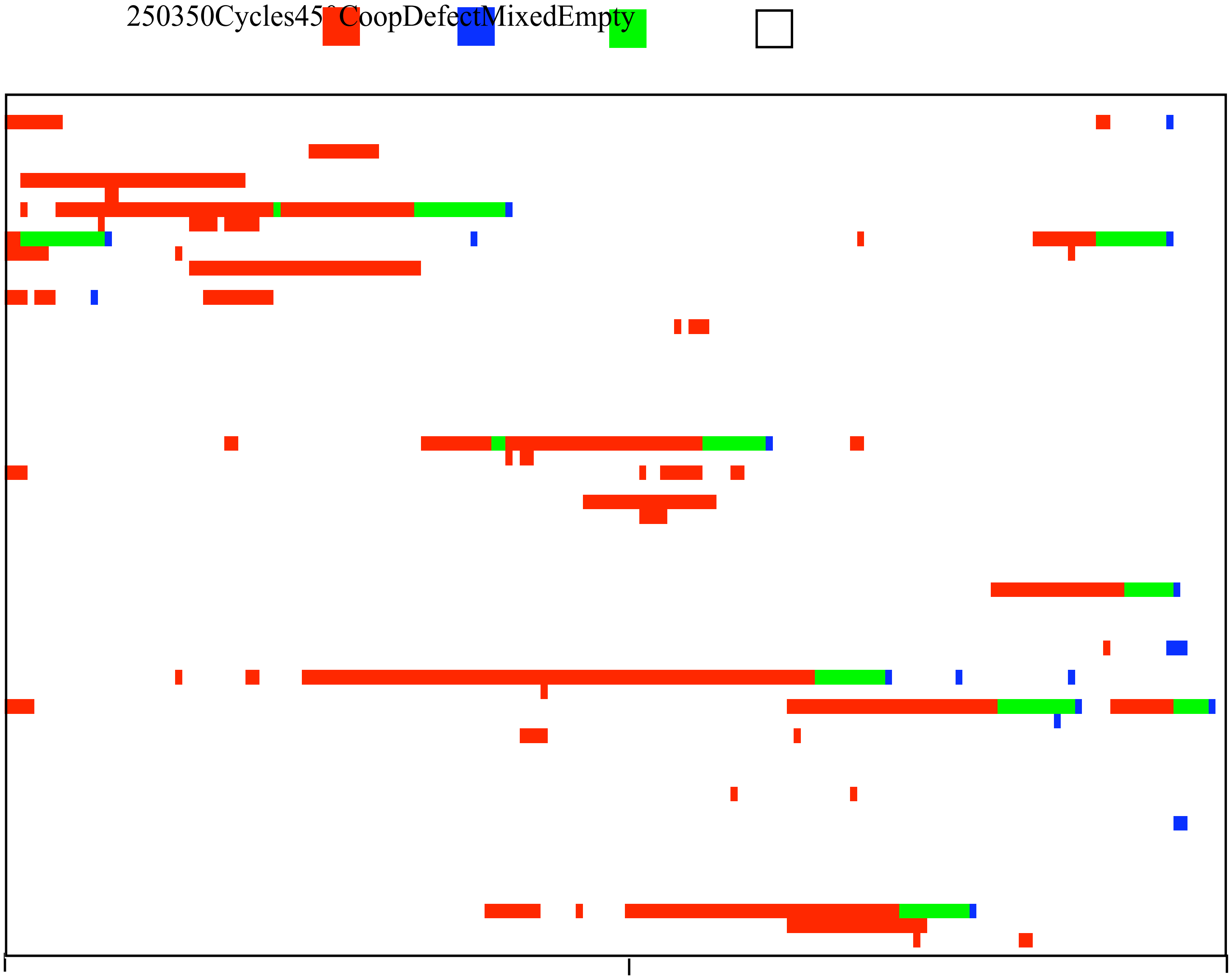
Recent tag models

- Tags may be bit strings signifying some observable cultural cue (Sugarscape model, Hales Mabs2000)
- Tags may be a single real number (Riolo, Cohen, Axelrod Nature2001)
- Earlier work by Riolo showed how tags could improve cooperation between agents playing the IPD.
- More recent work is focusing on how, even without memory of past interactions, tags can cause seemingly altruistic behavior between strangers

Recent tag models

- In Hales (Mabs2000) high levels of cooperation evolved using tag game biasing in the single round PD.
- In Riolo et al (Nature2001) high levels of altruistic donation evolved using a tag toleration mechanism.
- However, in both these models the agents effectively either “cooperate” or “defect”.
- In both, groups of agents sharing the same tag form cooperative groups.
- There is a dynamic formation and dissolution of such groups – groups break down when agents invade them that do not cooperate and exploit them

Visualising the process (mabs2000)



What else can tags do?

- These previous models show that cooperation can evolve in groups with tags – overcoming commons dilemmas
- But, can tags support the formation of groups in which agents perform specialised functions – supporting each other to exploit the environment as a “team” or “productive unit”
- We extended the Riolo et al model to test this

The model

- Agents consist of a tag (real number), a tolerance (real number) and a skill (integer)
- Each agent is awarded some of resources in each cycle.
- Resources associated with randomly selected skill
- An agent can only “harvest” a resource matching it’s own skill
- If it can not harvest the resource, it may donate the resource to another agent (if it can find one) that matches its tag

The model

- An agent is considered to “match” the tags of another if the difference between the tag values is no more than the tolerance value
- So a high tolerance means “donate to any agent” and a low tolerance means “only donate to those with similar tag value”
- When an agent attempts to make a donation it selects another agent from the population compares tags for a match and then passes the resource if the receiving agents has the required skill value

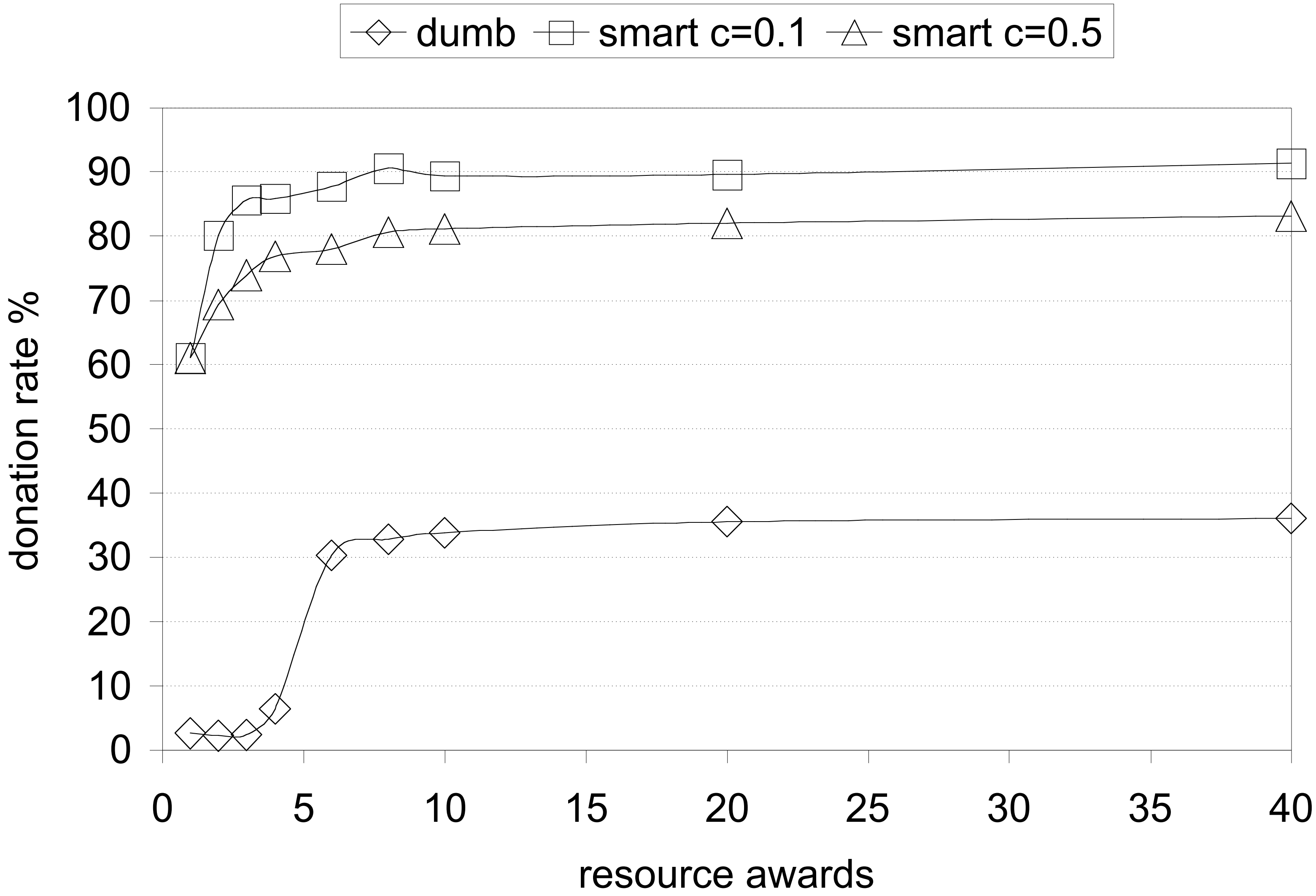
The model

- In the initial model, there are 2-skills, 100 agents, partner selection involves a single random selection from the population
- When agents make a successful donation they incur an energy cost (0.1)
- When an agent successfully harvests a resource it gets a unit of energy (1)
- After each cycle a tournament selection process based on energy, increases the number of successful agents (high energy) over those with low energy
- When successful agents are copied, mutation is applied to both tag, tolerance and skill

What will the results tell us?

- *If* the donation rate (over time) is non-zero, then we can conclude that:
- Agents are forming tag groups with a diversity of skills
- Agents are behaving altruistically, since donation produces immediate costs but does to produce immediate returns
- Therefore agents (from a myopic individual bounded rationality) form internally specialised altruistic teams

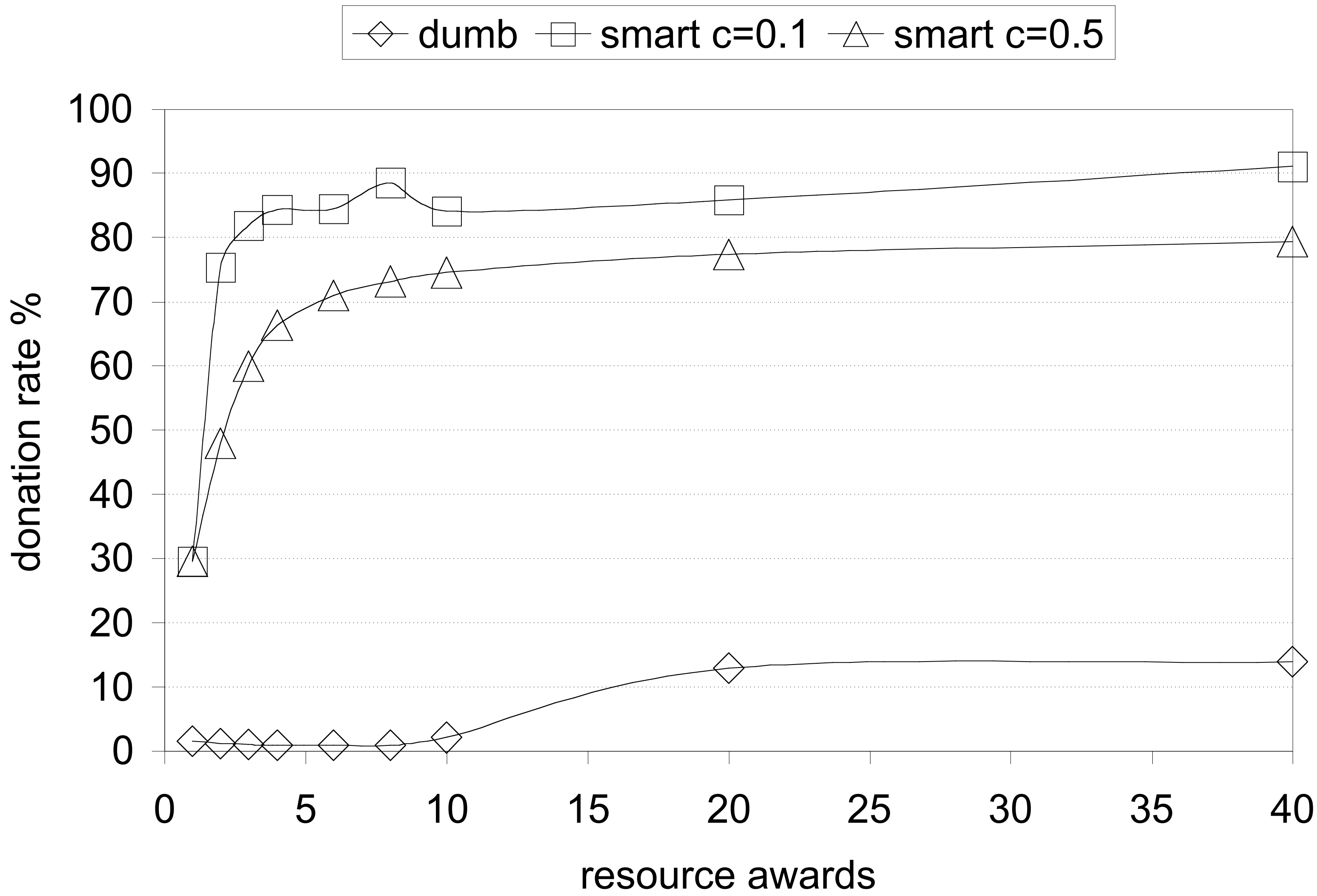
2-skills, averages of 30 runs to 30,000 generations



Results – what does it mean?

- A significant level of donation – confirming specialisation and altruism (of a sort!)
- But not so high, if we instead of selecting potential donation partners at random we use a “smart” matching method then significant increases in the donation rate are seen (previous slide)
- This smart matching can even support higher donor costs

5-skills, **averages of 30 runs to 30,000 generations**



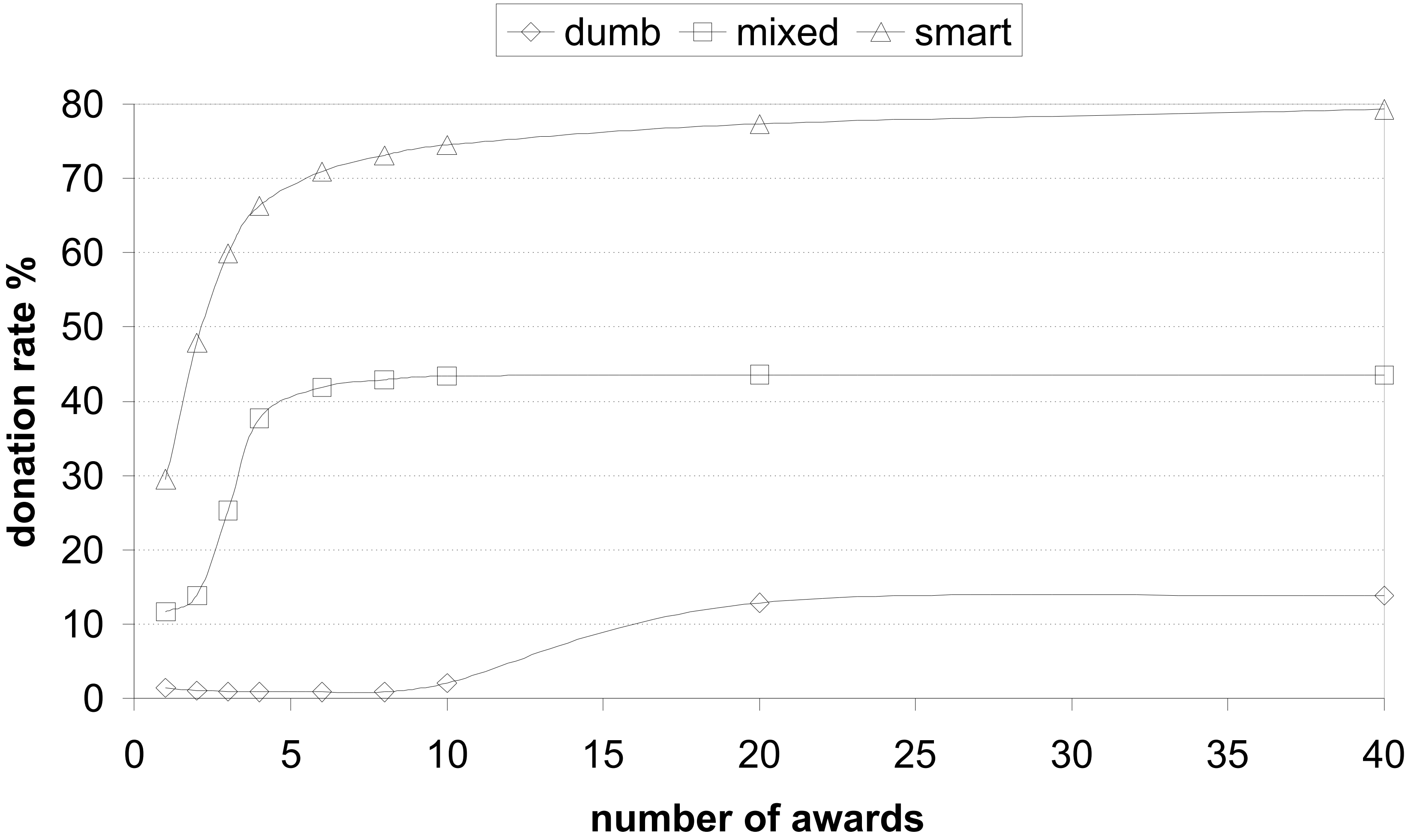
Results – what does it mean?

- The random (or dumb) matching goes lower
- The smart matching goes lower too but still stays high and recovers quickly as the number of resource awards increases
- Hence, it would seem that to support a higher degree of specialisation (more skills) smart matching is required
- However, what happens when the smart/dumb trait is made a binary endogenous trait?

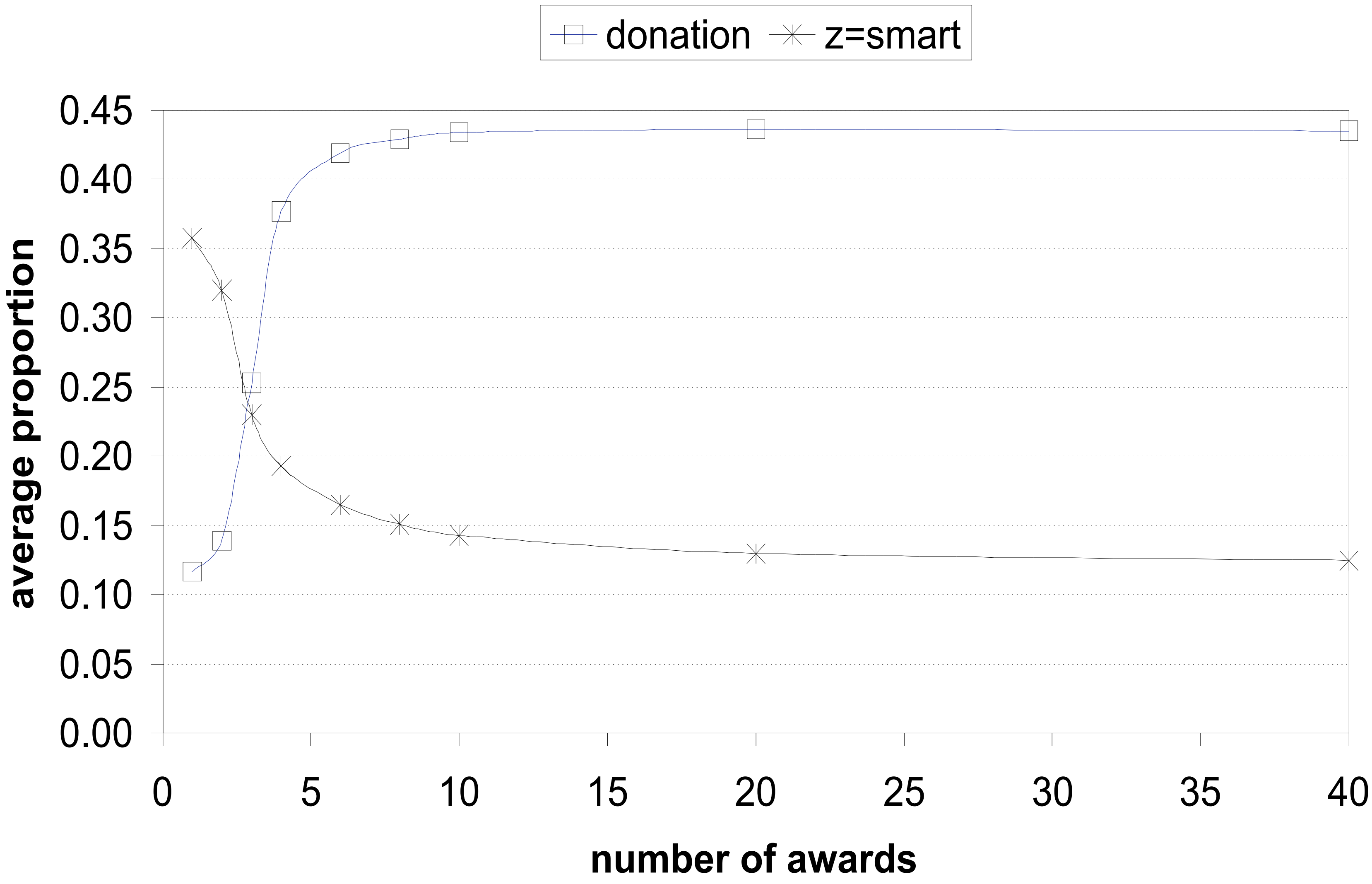
Making smart endogenous

- Agents are extended with another endogenous evolvable binary trait
- The trait represented smart/dumb searching
- This means that populations may now contain a mixed set of smart/dumb agents
- Will all the agents evolve to be smarts?
- Is there evolutionary pressure?
- In all cases smart searching costs 0.5 but dumb only 0.1.

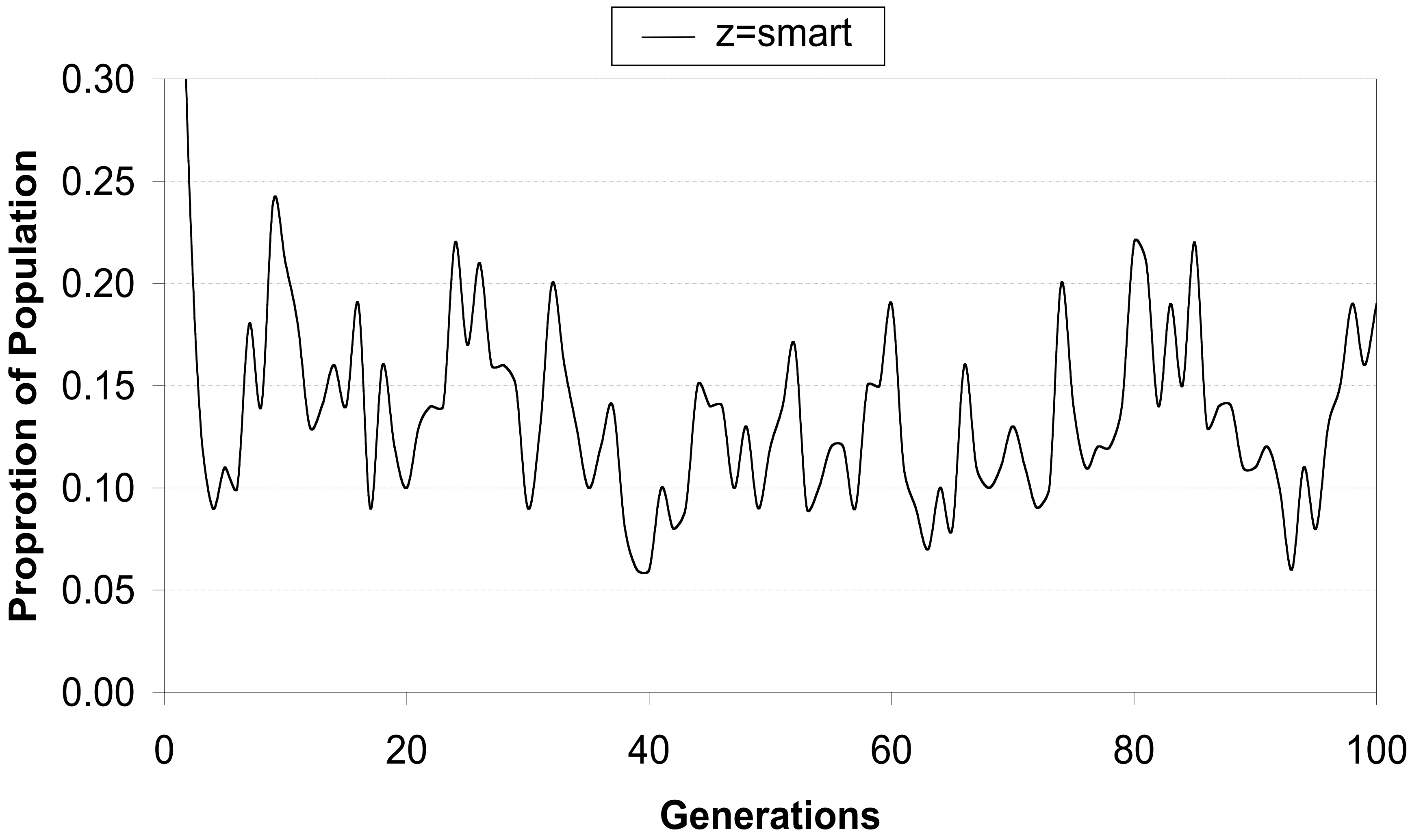
2-skills, dumb/smart/mixed – c=0.5



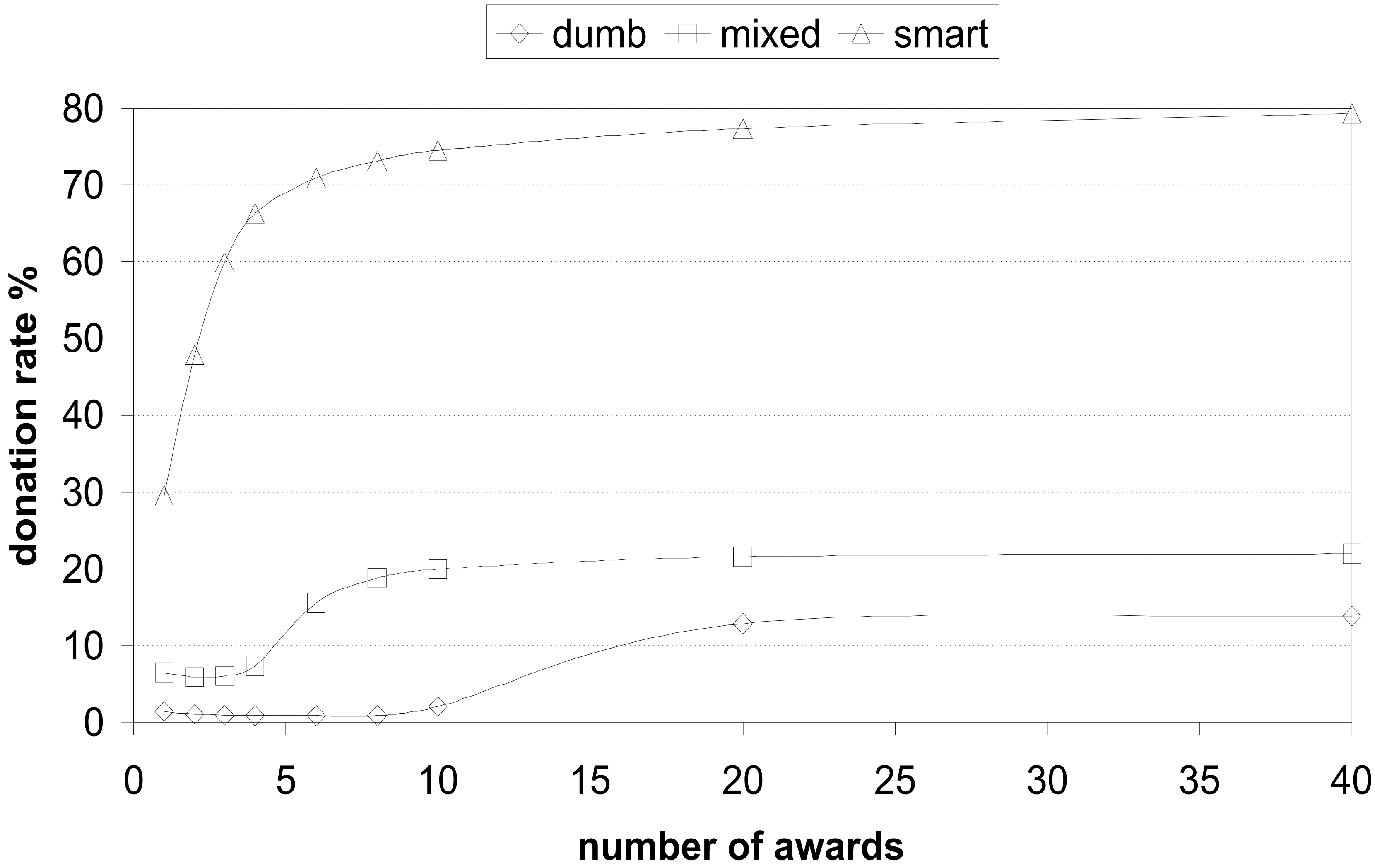
Proportion of smarts



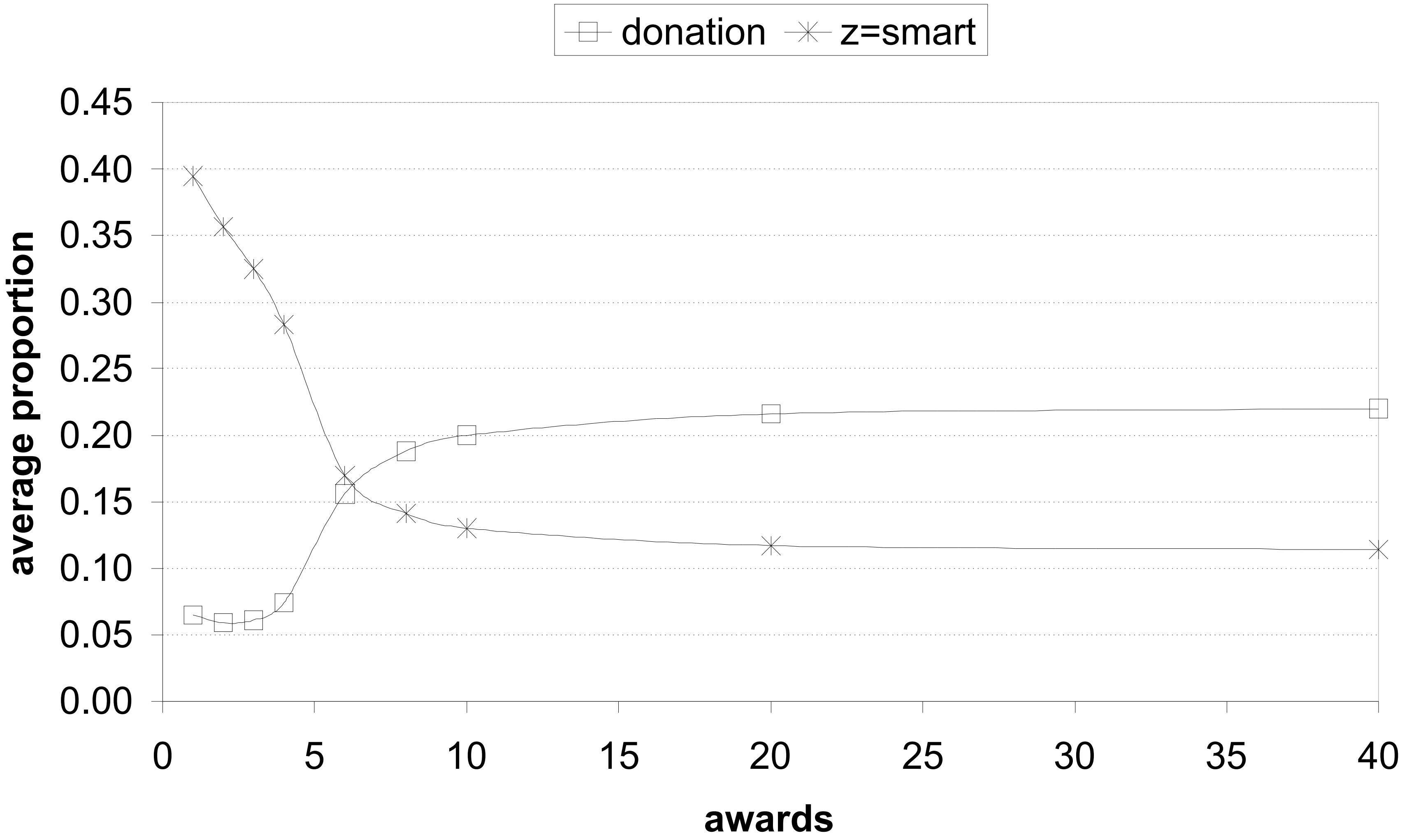
Proportion of smarts – time series



5-skills, dumb/smart/mixed – c=0.5



Proportion of smarts – time series



Conclusions

- Agents form groups based on tag similarity, containing diverse skills, donating resources to between each other, to efficiently exploit the environment – for the good of the group
- This happens even though individuals are selected on the basis of their individual utility
- Non-random interactions between agents can be selected for by a simple evolutionary process
- Group distinguishing and location abilities (smart searching) would appear to be important
- But *HOW* would smart searching be *implemented*. What about putting agents in social networks = smart is cheap?
- The Tag Clone issue! What are we really seeing here?