

# (Autonomous) Normative Agents in Artificial Societies

A Simulative Study  
about social artifacts' emergence

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# Outline

- State of the Art
- (cognitive) MAS Approach
- The Norm Recognition Module at Work:
  - The Model
  - Effects on the Environment
  - Simulative Results

# STATE OF THE ART

## ***GAME-THEORETICAL APPROACH***

(Ullman-Margalit, E. 1977, Axelrod, R. 1986,  
Bicchieri, C. 1990, Young, P.H. 1996)

- o How do norms emerge, spread and change over time?
- o Norms as conventions
- o Norms gradually emerge from interaction among agents, driven by non normative internal mechanisms

***NORMS AS explanandum***

## ***DEONTIC-LOGIC APPROACH***

(Shoham, Y. and Tennenholtz, M. 1992; Conte, R., and Castelfranchi, C. 1995; Jones, A. and Sergot, M. 1996; Dignum, F. 1999; Van der Torre. L. and Tan, Y. 1999)

- o Why do agents comply with norms and how is it possible that norms operate upon autonomous intelligent agents?
- o Investigation of the effects of norms, i.e. a *functional analysis*.

***NORMS AS explanans***

# (cognitive) MAS Approach

- How do norms emerge, spread and change over time?
- ~~Norms as conventions~~
- Norms gradually emerge from interaction among agents, driven by ~~not~~ normative internal mechanisms
- Why do agents comply with norms and how is it possible that norms operate upon autonomous intelligent agents?
- Investigation of the effects of norms, i.e. a *functional analysis*.

**PLUS**

- Cognitively rich agents: agents decide upon norms
- Norms are **not** Conventions
- agents' mind is not necessarily a *tabula rasa*, nor it contains norms from beginning

# NORM EMERGENCE

***Emergence:*** the process by means of which effects are generated by (inter)acting micro(-social) entities, and implemented upon, but *not* incorporated into their rules.

- ✓ An emergent phenomenon is generated ( $\neq$ caused) if it is possible to find out local rules allowing the phenomenon to occur, or using Epstein's words, to grow.
- ✓ An emergent phenomenon is implemented on a micro-social one when, *determining* new properties in the generating system, it selects a specific routine by means of which it is repeatedly executed by the micro levels entities.

- **Hybrid** notion of norm incorporated both in social and mental objects
  - social prescriptions implicitly transmitted from one agent to another, based upon deontics “one must do it”, “people are obliged to...”, etc...
  - beliefs that a given action *a*, in a given context, for a given set of agents, is forbidden, obligatory, permitted, etc.
- **No need** for the agents to *represent* the effects of norms to comply with them
- **Need** for the agents to *recognize* a norm as a norm to exhibit an actual normative behaviour
- **Norms** not only regulate behaviour but also act on different aspects of the mind. Which are the mechanisms that implement them?

- o *Incorporation* (or 2nd order emergence): the process by means of which the emergent effect gets *represented* in the producing system, for examples within its rules, and this representation contributes to replicate the effect.
- o *Immergence*, the process by means of which the emergent effect *modifies* the way of functioning of the generating system, affecting its generating rules or mechanisms in such a way that it is likelier to be reproduced. The most striking example of this phenomenon is *norm immergence*.

# NORMATIVE NOTIONS

- **Norm:** a behaviour that spreads thanks to the spreading of normative commands
- **Normative command:** a command based upon a normative belief,
- **Normative belief:** A belief that a given action  $a$ , in a given context, for a given set of agents, is forbidden, obligatory, permitted, etc.
- **Normative belief of pertinence:** a belief that a given norm  $n_i$  concerns us.
- **Normative Goal:** the goal - relativized to a N-belief - to act in accordance with  $n_i$ . Cognitive mechanisms are needed.
- **Metanorm:** A general obligation, telling agents how to decide upon and apply specific norms.



# Our objective

- bringing together the strength of both traditions
  - high resolution of *both aspects* of norms: inter and intra agent processes
  - *and* the *recursive* impact of inter and intra agent processes on each other emergent features
- ✓ Modelling normative agents not just paying attention to norm compliance but also to norm recognition will help to show how norm emergence and innovation are affected by cognition

Norm emergence is a 2 way dynamics, an inter (*emergence*) and intra agents (*immergence*) process: norms cannot emerge in society unless they simultaneously immerse into the agents' minds

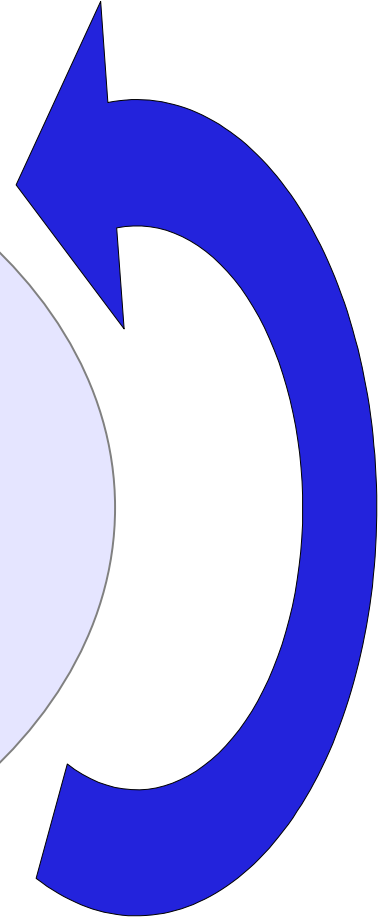
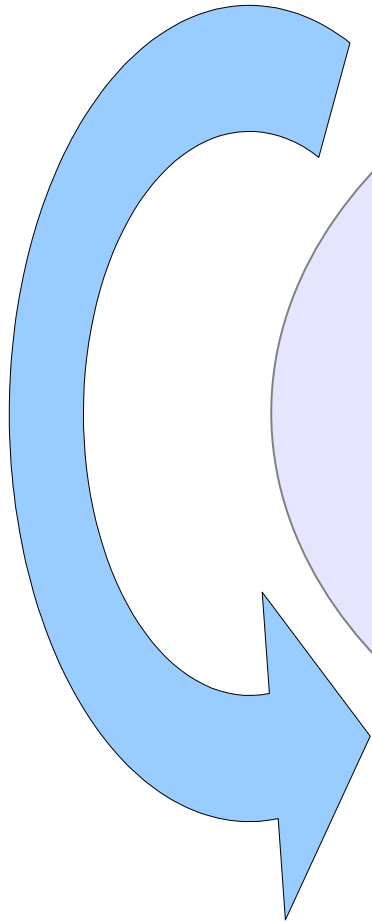
**Emergence**

**COMPLEX SOCIAL SYSTEMS**

**NORM EMERGENCE**

**AUTONOMOUS INTELLIGENT  
AGENTS**

**Immergence**



The Use of Norm Recognition  
Module:  
Effects on the Environment

# Objectives

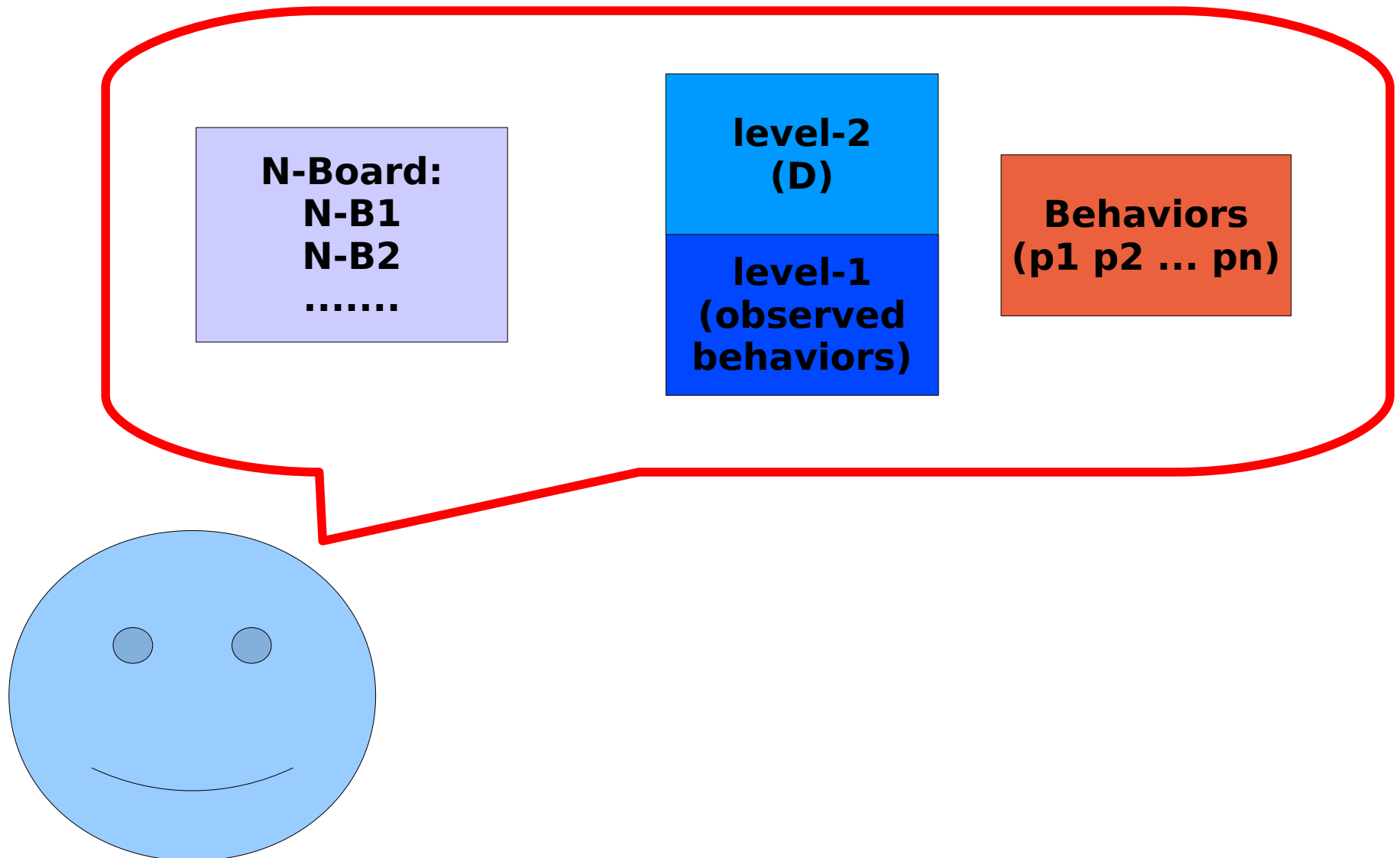
- To Model the traces that agents leave in the environment performing specific actions
- To Model cognitive traces (normative beliefs)
- To Model the dynamics produced by the interference of both
- To Model the complex loops generated by
  - agents' actions and environment
  - agent-agent interactions
  - combination of both

# The Agent (1)

Each Agent is provided with:

- 1) a Normative Board;
- 2) a double-layer architecture;
- 3) a vector of possible behaviors.

# The Agent (2)



# The Model 1/2

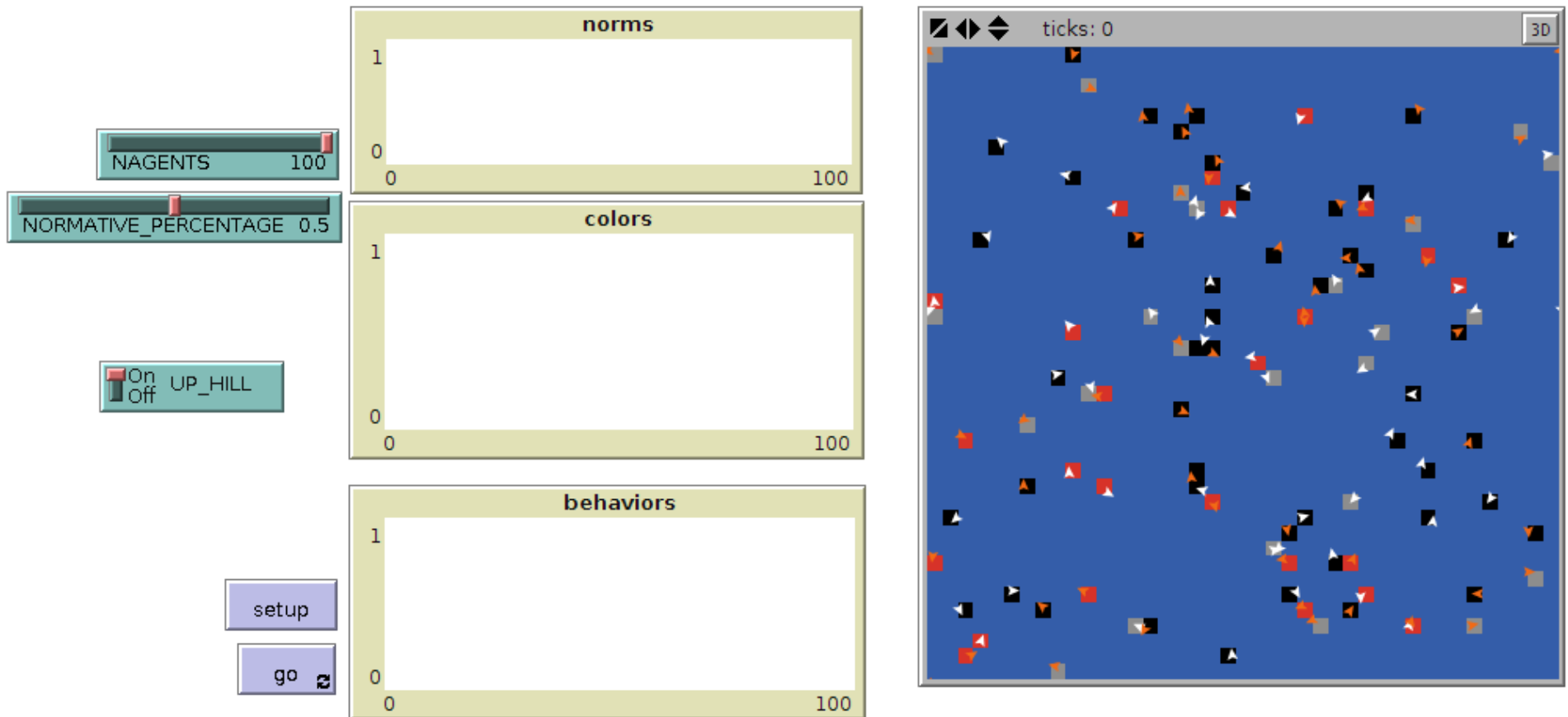
- All Agents have two goal:
  - 1) To be compliant with the surrounding environment;
  - 2) To follow the colors' gradient (if switched on);
- Social Conformers have also a (socio) imitative goal:
  - To imitate others
- Norm Recognizers have also a normative goal:
  - To be compliant with their normative beliefs
- Agents randomly move in the world (if they do not follow the colors' gradient)
- Agents color the patches with one of three possible colors:
  - Red
  - Black
  - Gray



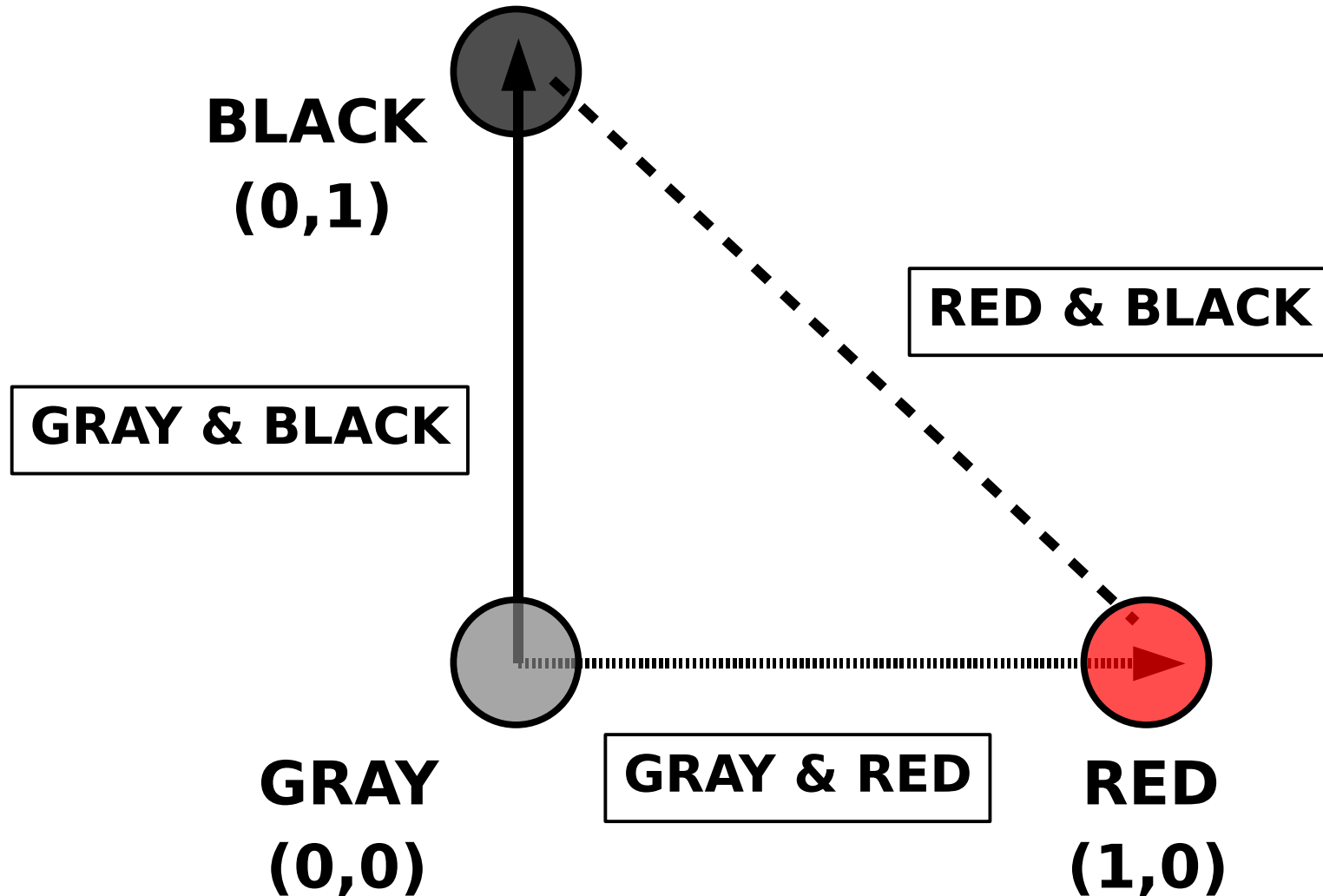
# The Model 2/2

- To each color corresponds a compliance rate:
  - Red and Black = 2
  - Gray = 0.75
- This means that gray is more compliant than black and red because, if agents, in a portion of the world where is a lot of black and red patches, color a patch with gray, they perturb less the environment than if they color with the wrong color (the red if the most patches are black and vice-versa)
- The idea beyond the model is that for a given population, living in a given environment, there is a set of possible actions and between them one could be more compliant (in an environmental sense) than the others
- What is the relationship between social compliance (color of patches) and norm compliance (follow the salience of normative beliefs to chose the action to be performed)?

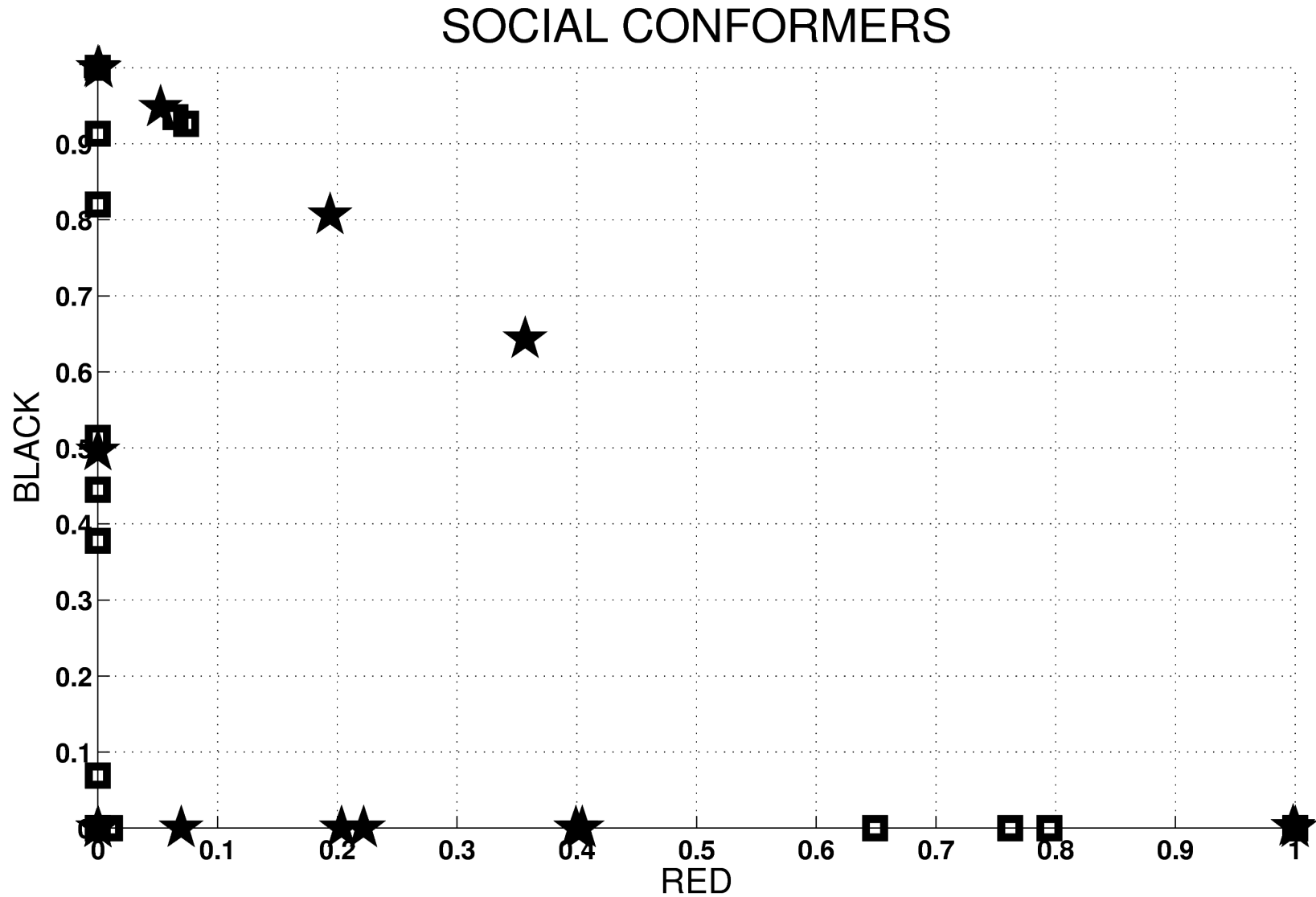
# The Model – The Interface



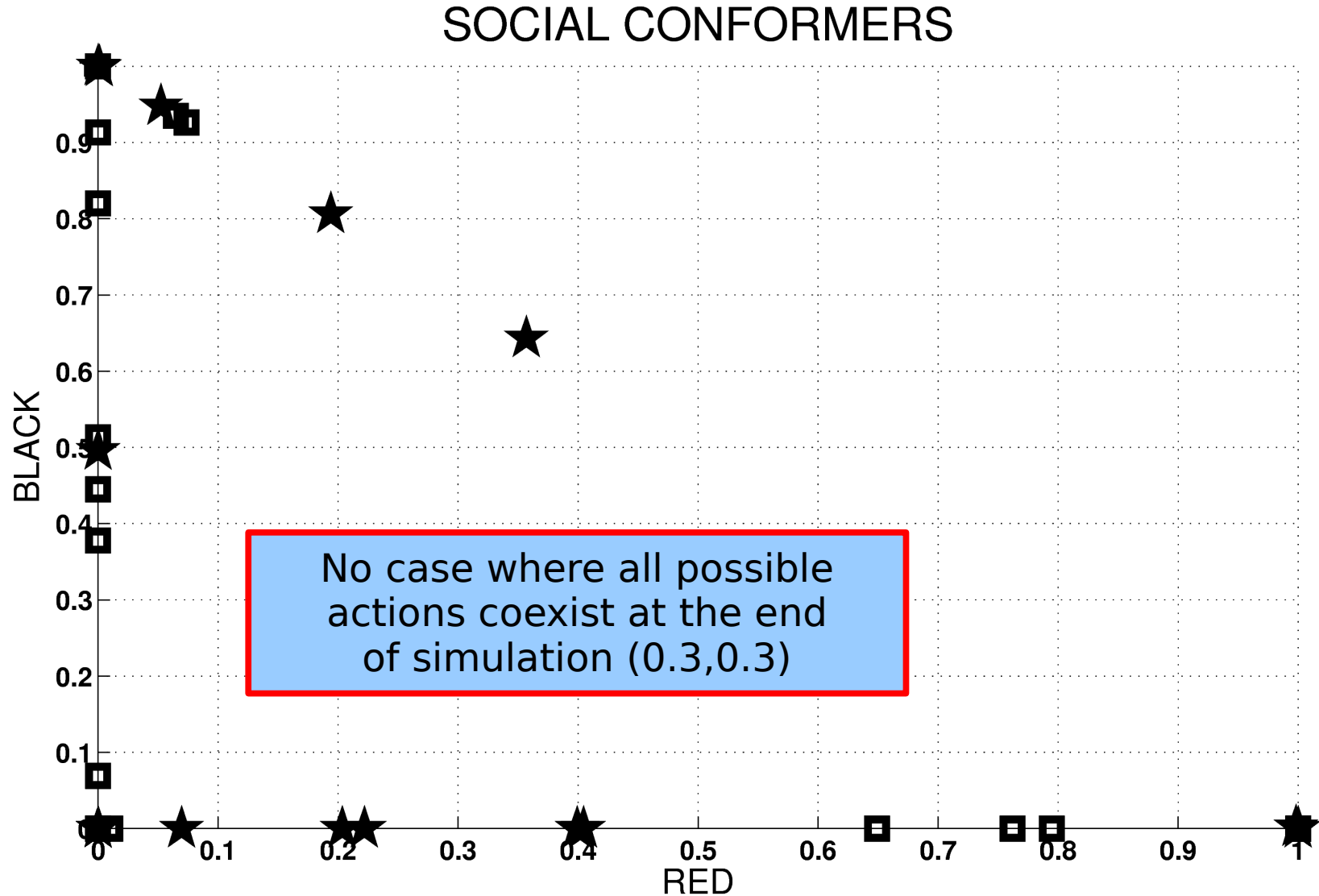
# The Style of Plot



# Preliminary Results

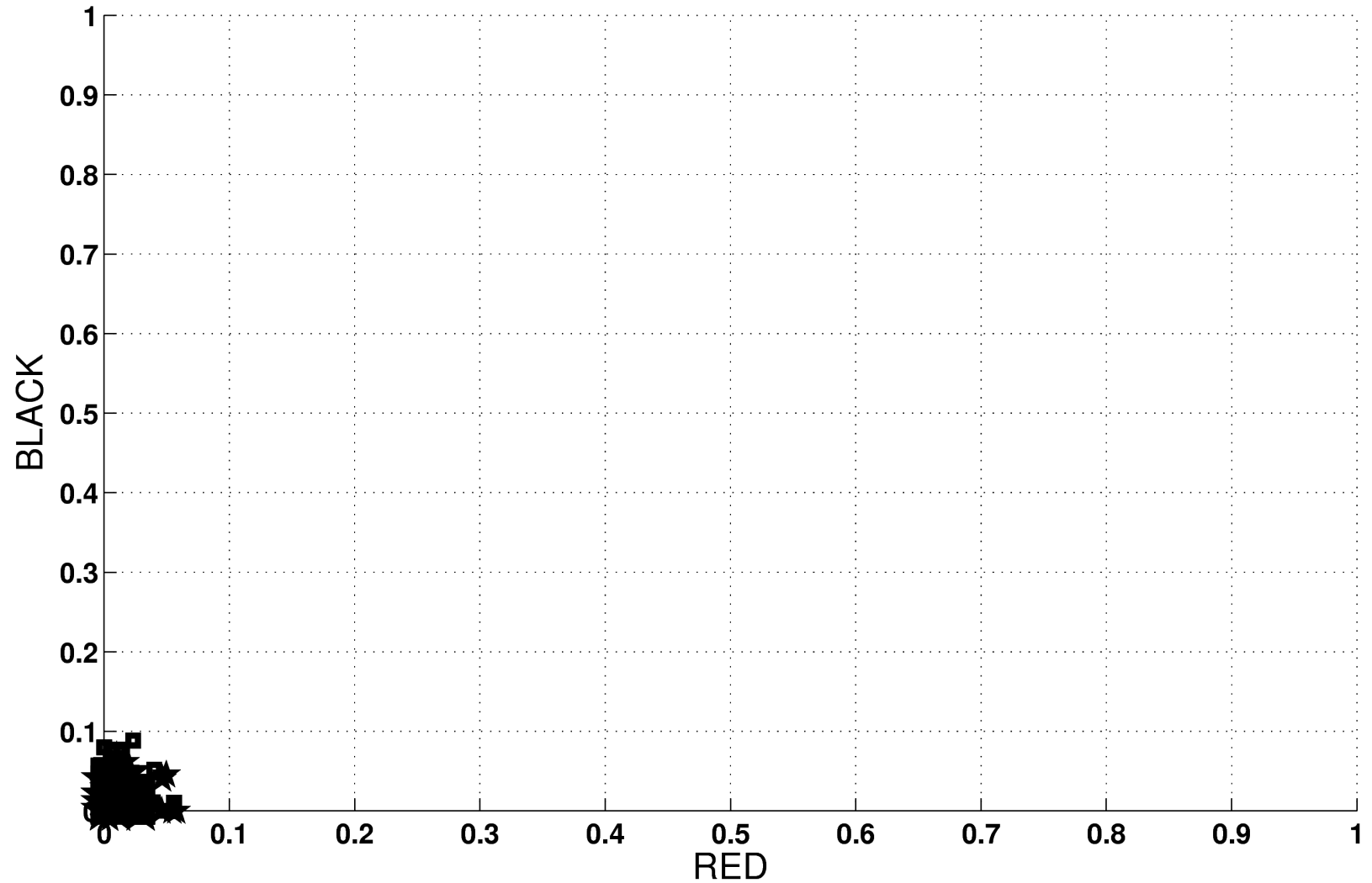


# Preliminary Results



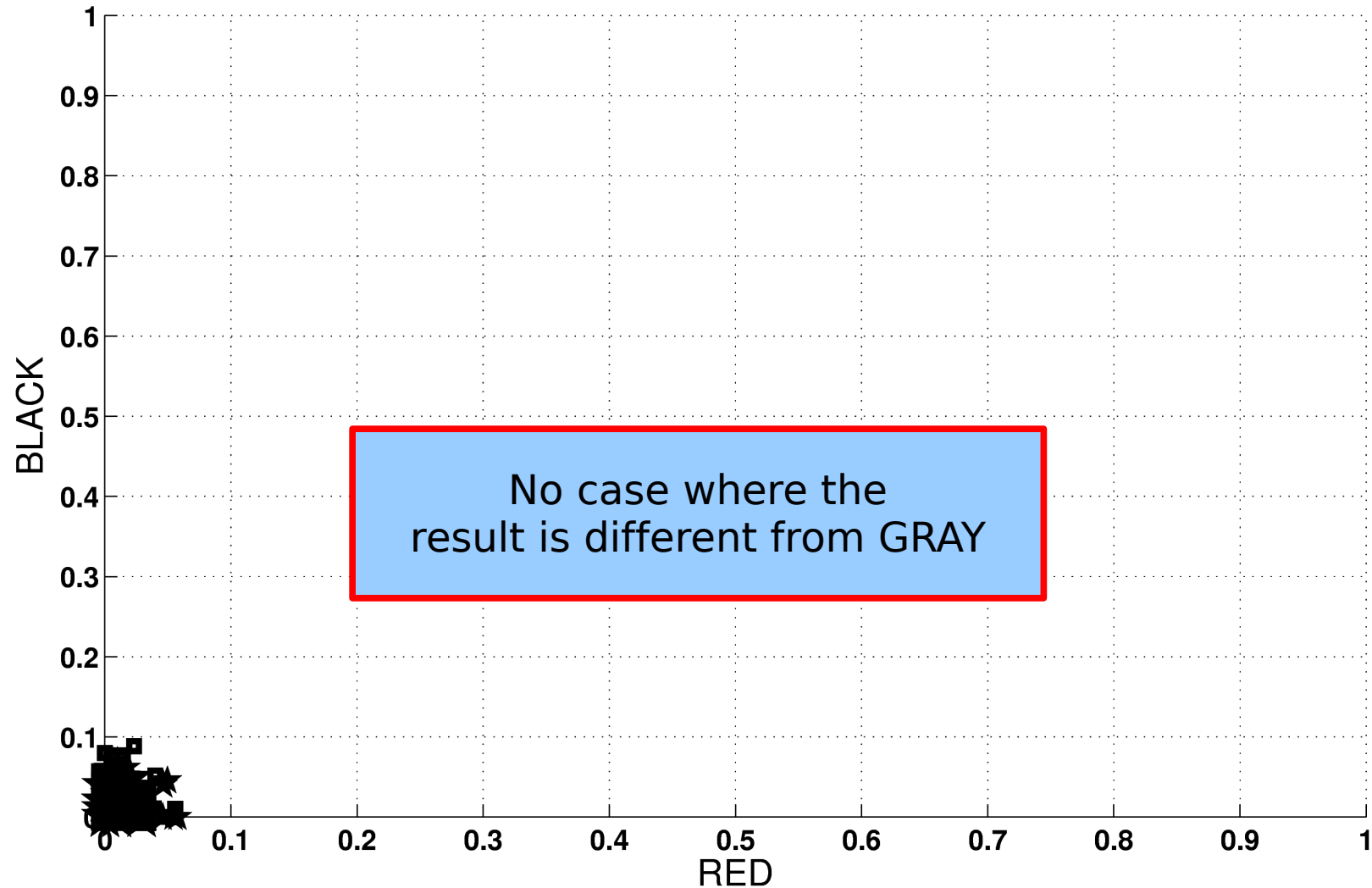
# Preliminary Results

NORM RECOGNIZERS (50% – 100%)



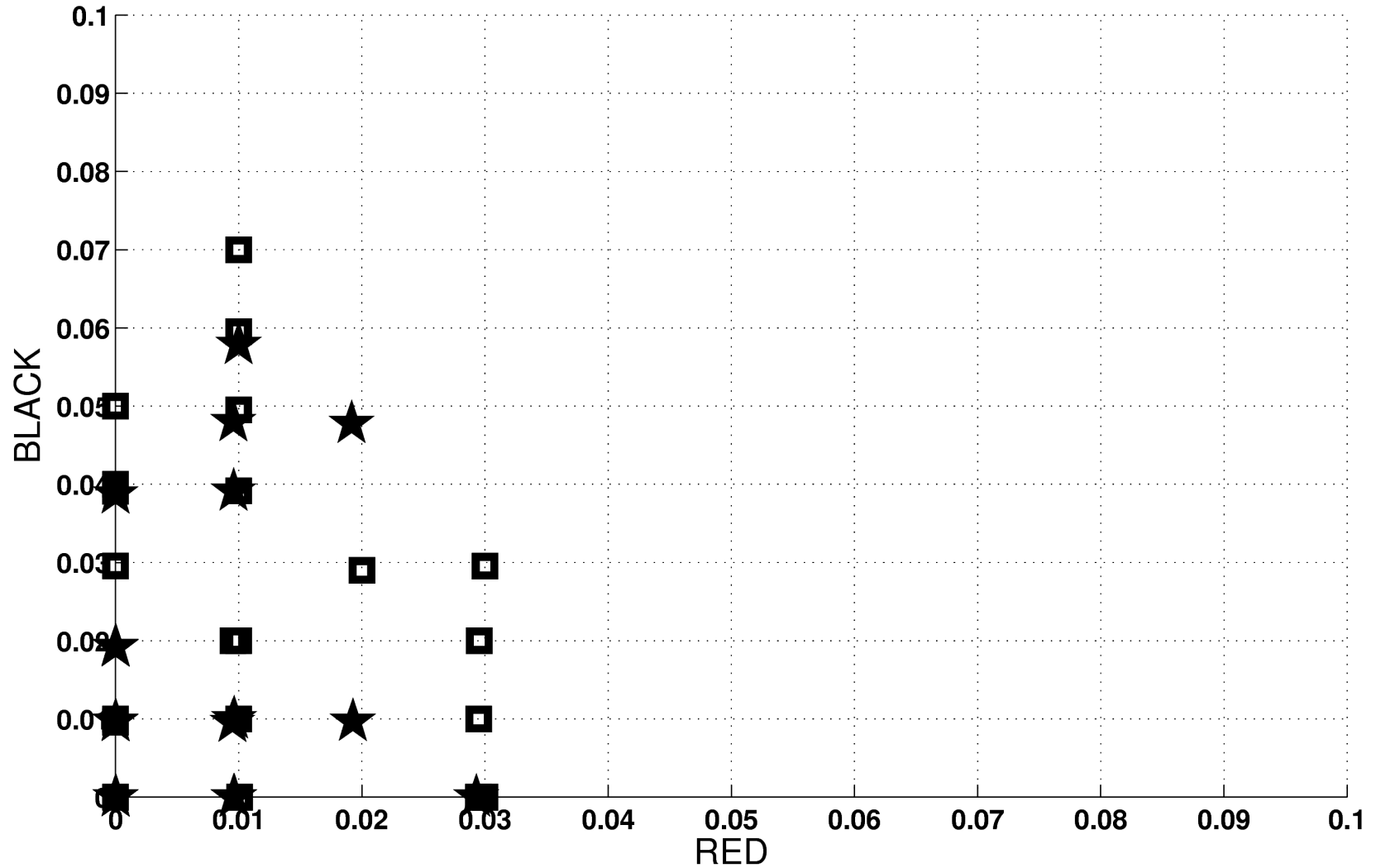
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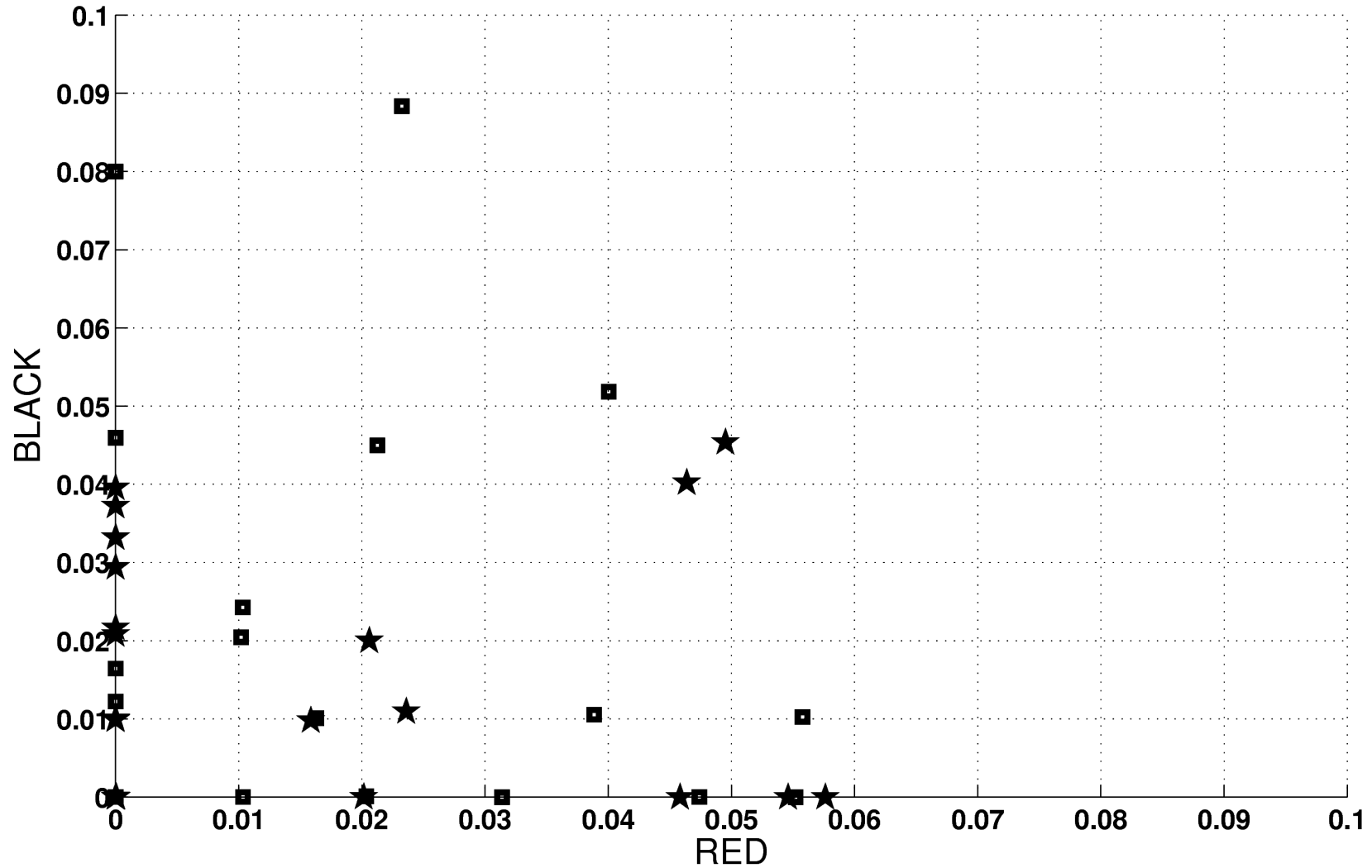
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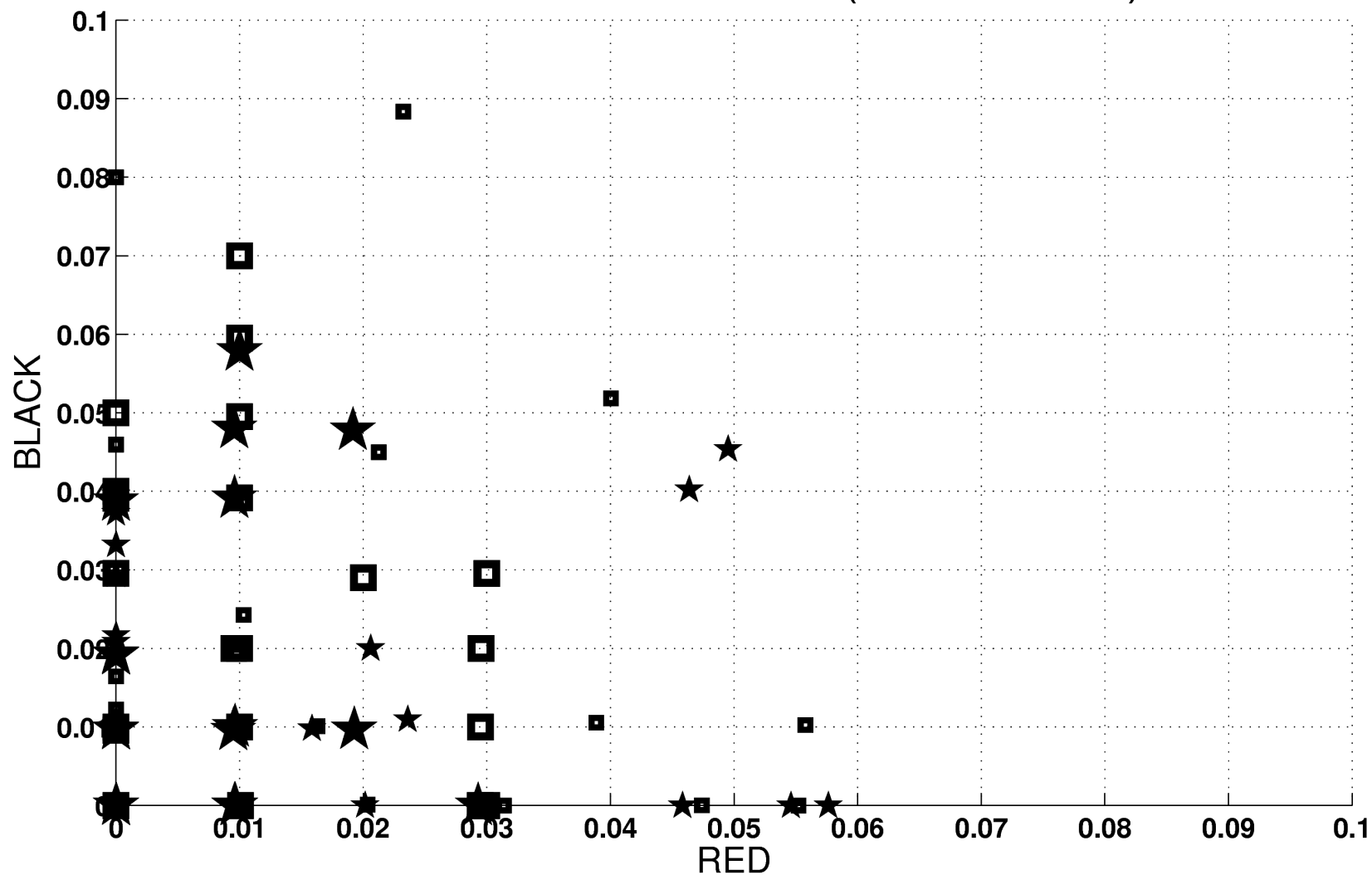
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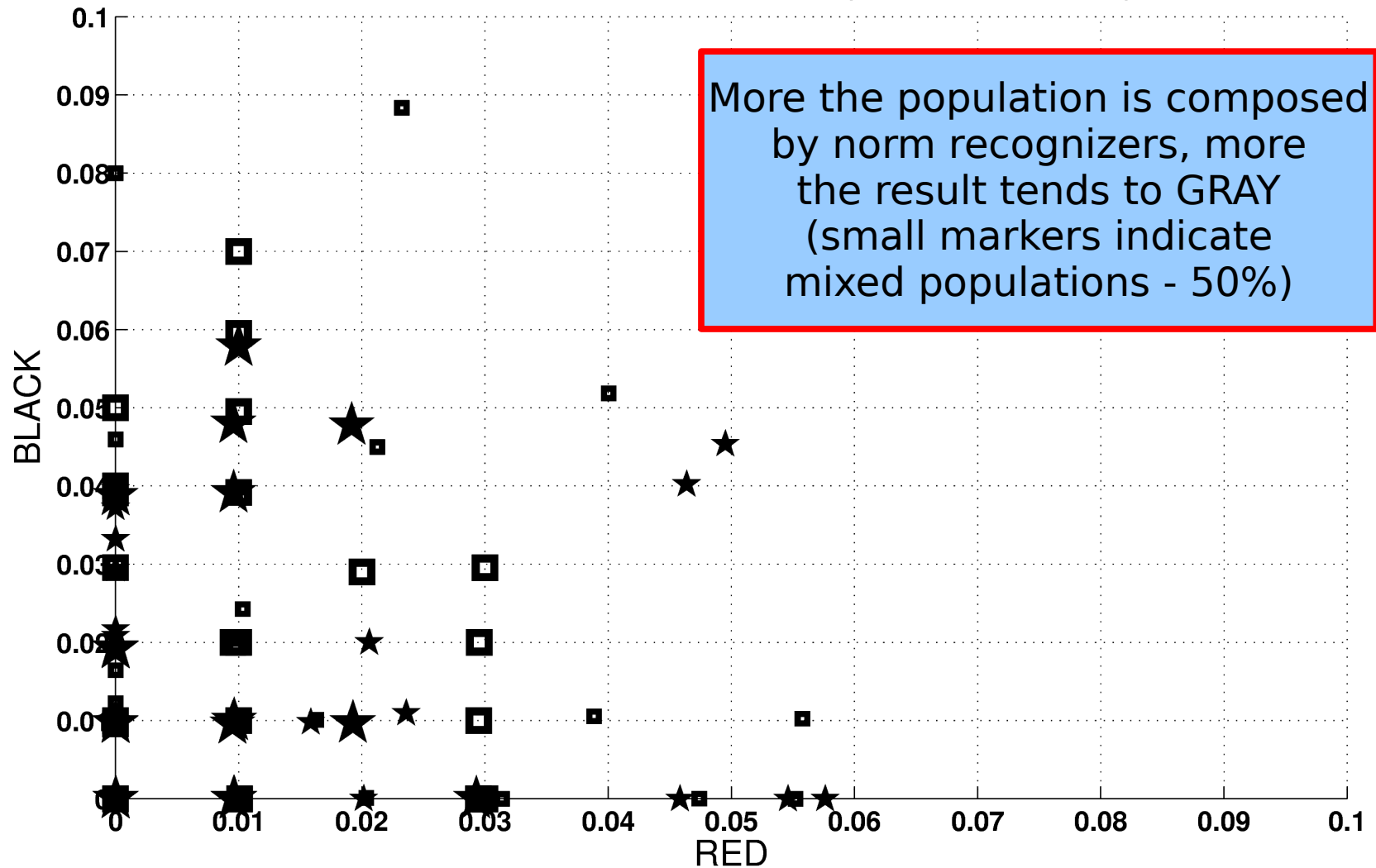
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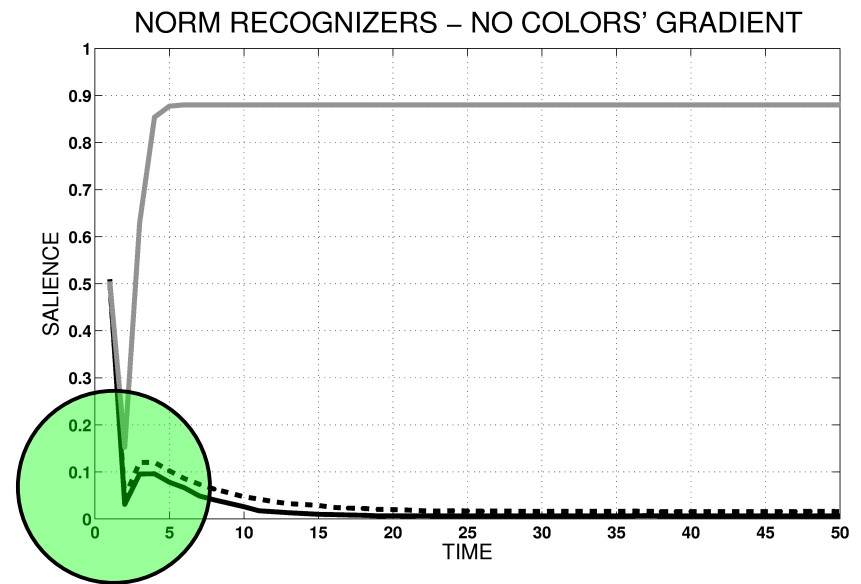
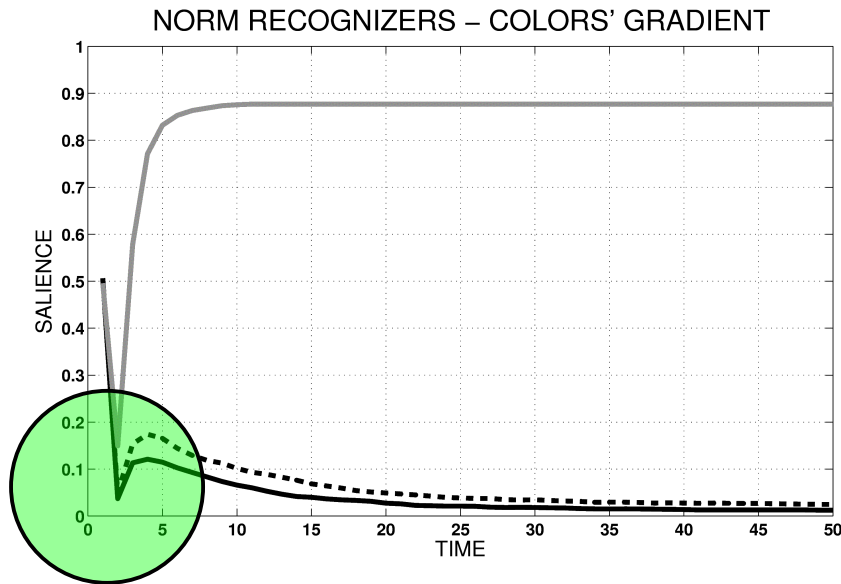


# Preliminary Results

## NORM RECOGNIZERS (50% – 100%)

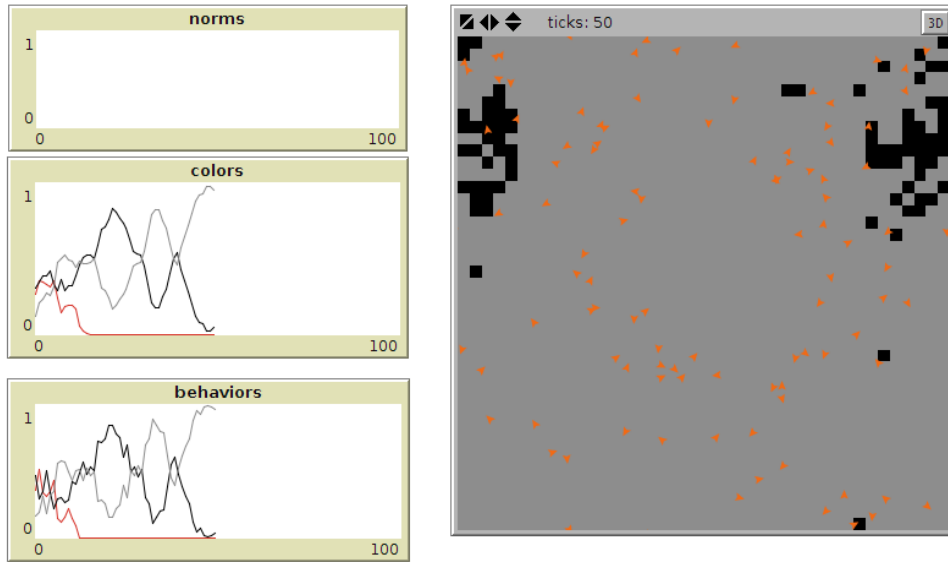


# Norms' Saliience

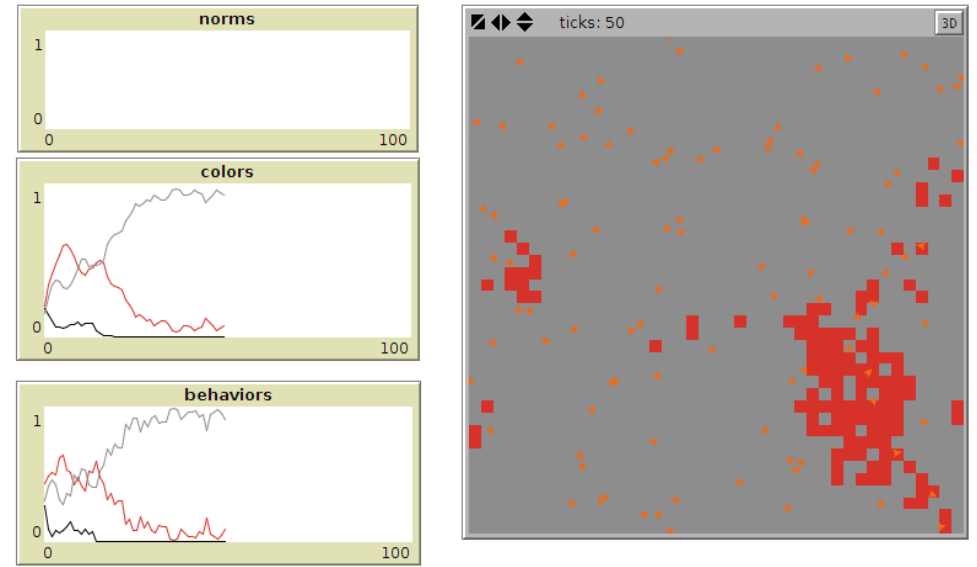


- When agents can follow the colors' gradient, the convergence on the GRAY action seems to be less abrupt

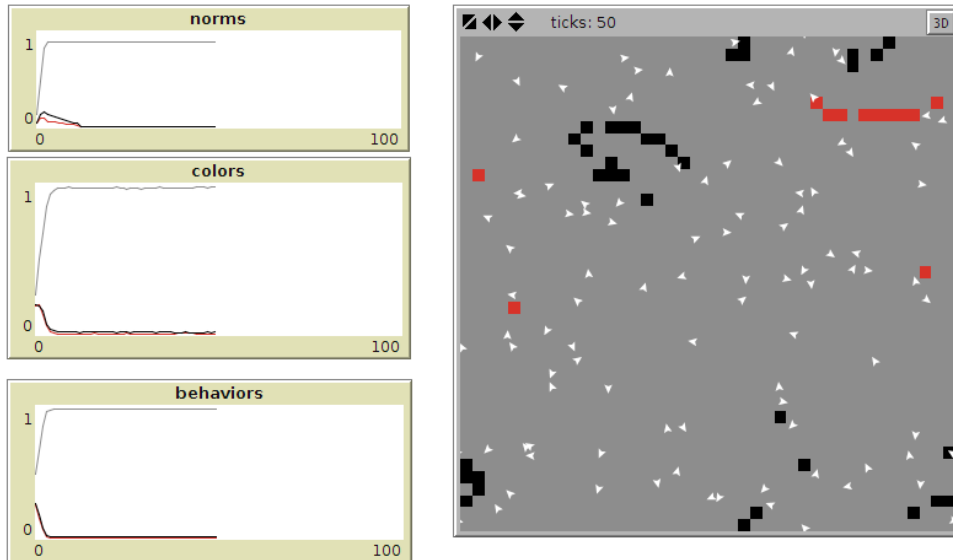
# Social Conformers Vs Norm Recognizers



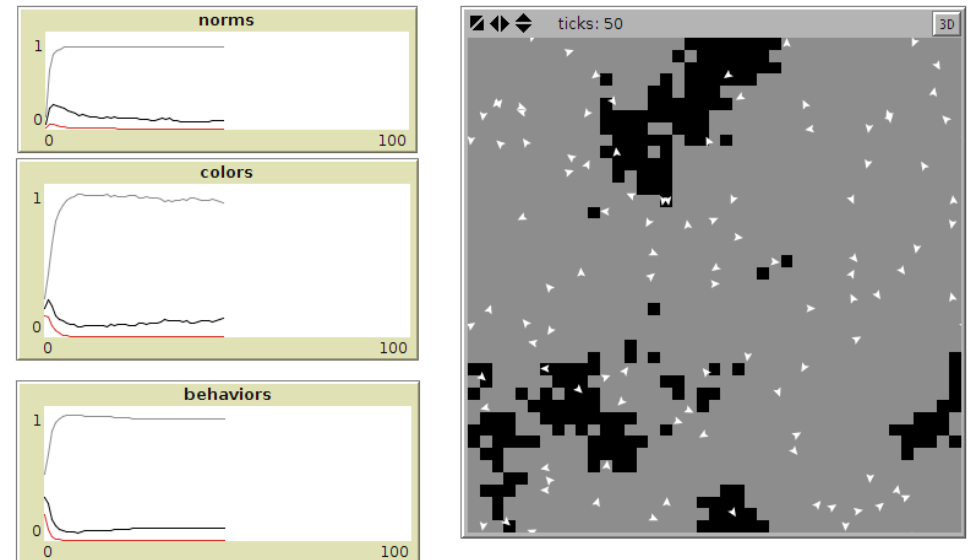
SC - Without UP\_HILL



SC - With UP\_HILL

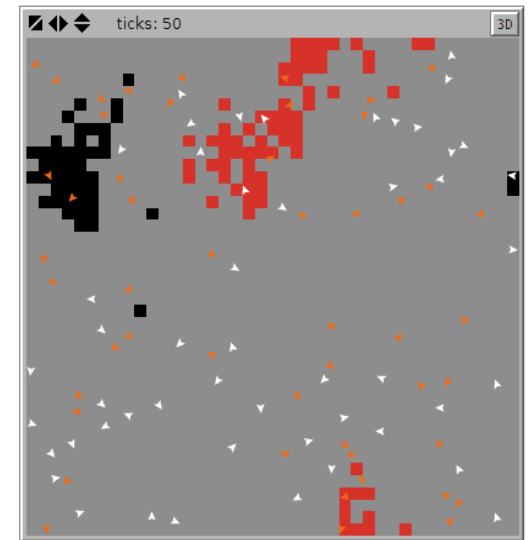
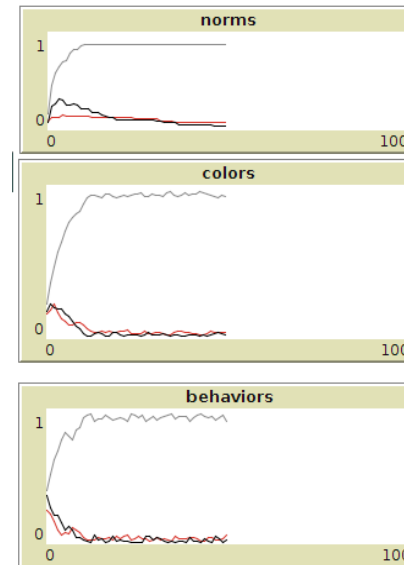
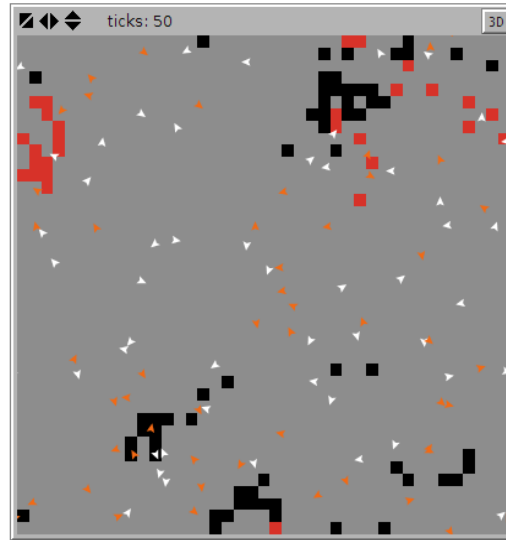


NR - Without UP\_HILL



NR - With UP\_HILL

# Mixed Populations



NR + SC (50%) - Without UP\_HILL

NR + SC (50%) - With UP\_HILL

- When agents can follow the colors' gradient, the survival of different “socio-enclaves” seems to be more easy

# Concluding Remarks

- Social Conformers: No case where all possible actions coexist at the end of simulation (0.3,0.3) – the sum of all must be 1
- Norm Recognizers: No case where the result is different from GRAY (they converge very clearly on gray)
- Mixed Populations: More the population is composed by norm recognizers, more the result tends to GRAY (small markers indicate mixed populations – 50%) – non-linear dynamics beyond the effects of ratio of normative & social conformers

*Thank you very much for your  
attention...*