

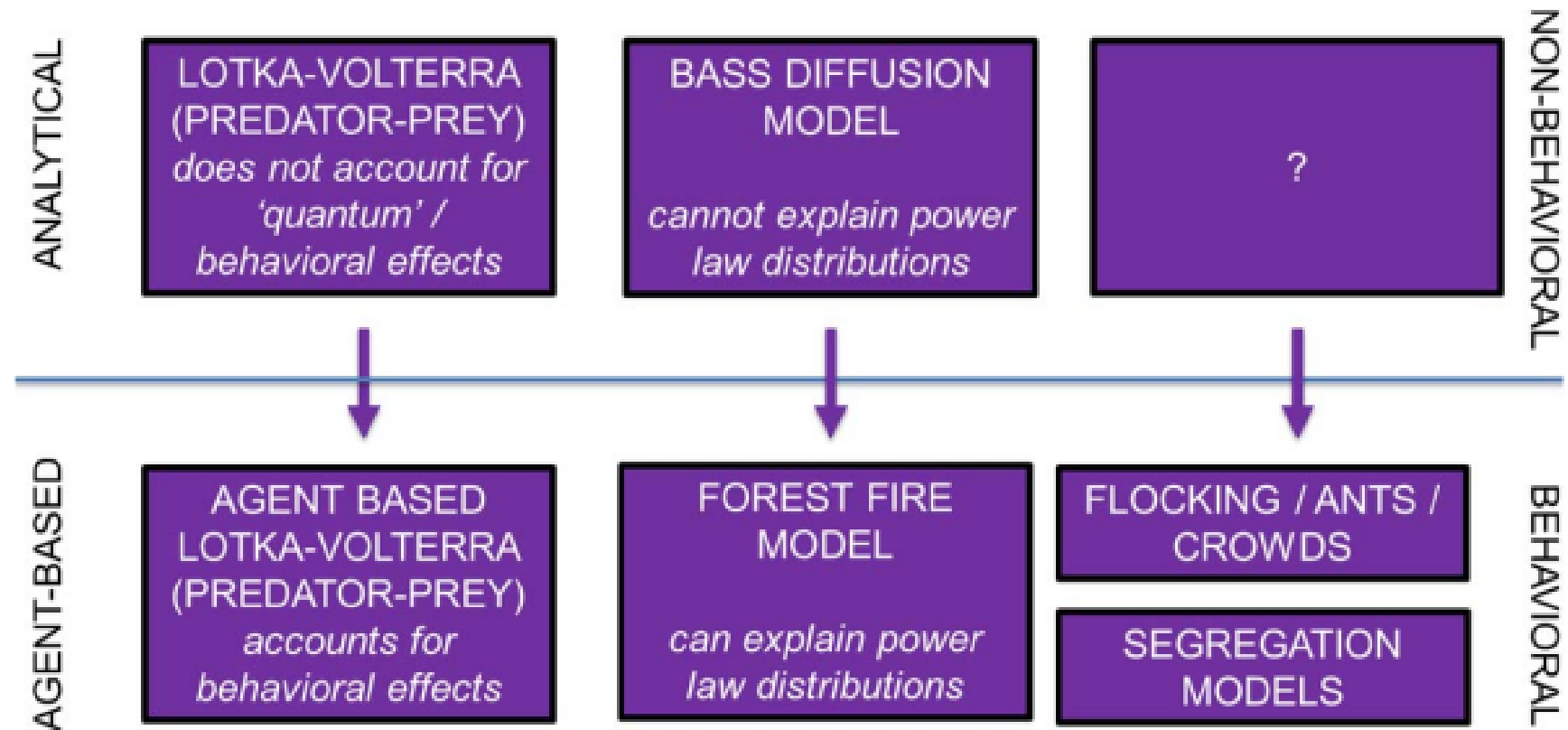
# SIMULATING HUMAN BEHAVIOR: Agent Based Models for Simulating Human Behavior

IFORS 2017 CONFERENCE  
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# INTRODUCTION

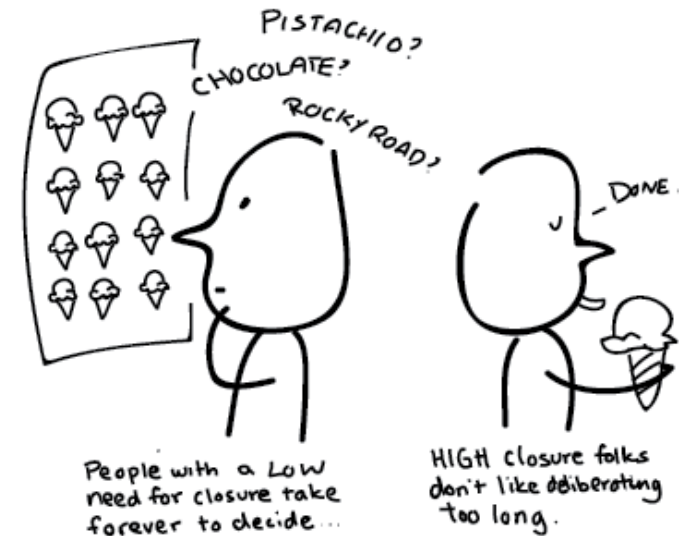
# MODELLING APPROACHES



# EXAMPLE APPLICATION: GROUP DECISION MAKING

# NEED FOR CLOSURE

- A desire for unambiguous information, as opposed to uncertainty or unambiguity. (Webster & Kruglanski 1996)
- Goal oriented
- High **NClos** individuals typically are inclined to (Kruglanski & Fishman 2009):
  - attain closure as quickly as possible, and maintain it for as long as possible;
  - they achieve this by relying on past knowledge and avoiding new information.



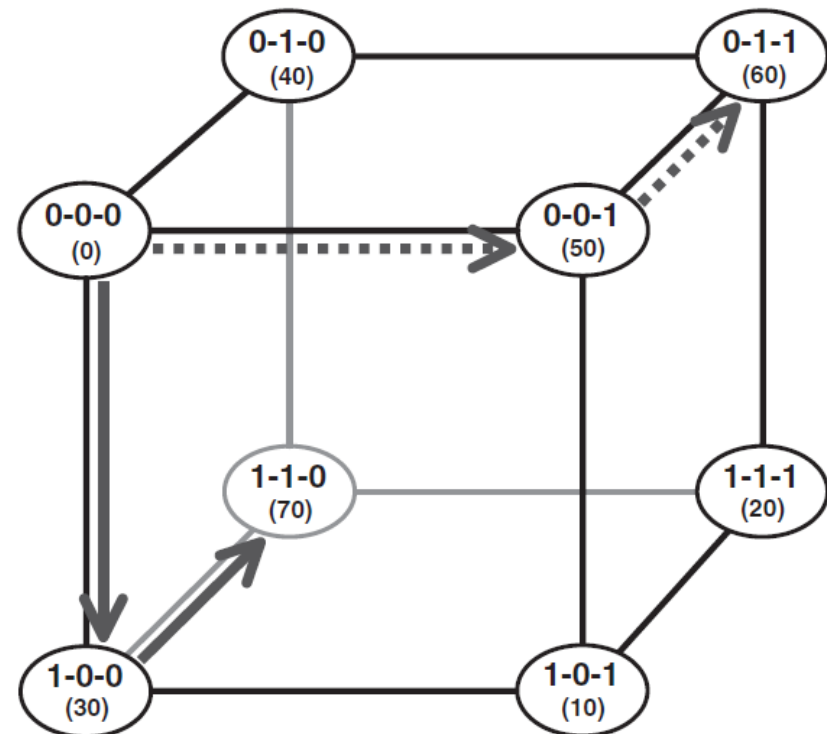
# AGENT-BASED MODELS

- Allow *heterogeneity* of agents (e.g. participants in a group process), moving on from representative individuals or aggregate measures: the state of each agent can be inspected at any time
- Allow study of the *interactions* between agents
- Allow modelling of the temporal: study of the *dynamics* of a system rather than just an equilibrium
- '*bottom up*' rather than 'top down' Modelling
- Previous work:
  - Larson (2007)  $N$  dimensional hill climbing
  - Rousseau and van der Veen (2006) cellular automata
  - Deffuant (2000)

# PREVIOUS SIMULATION STUDIES OF GROUP PROCESSES

Larson (2007)  $N$  dimensional problem space (hill climbing algorithm)

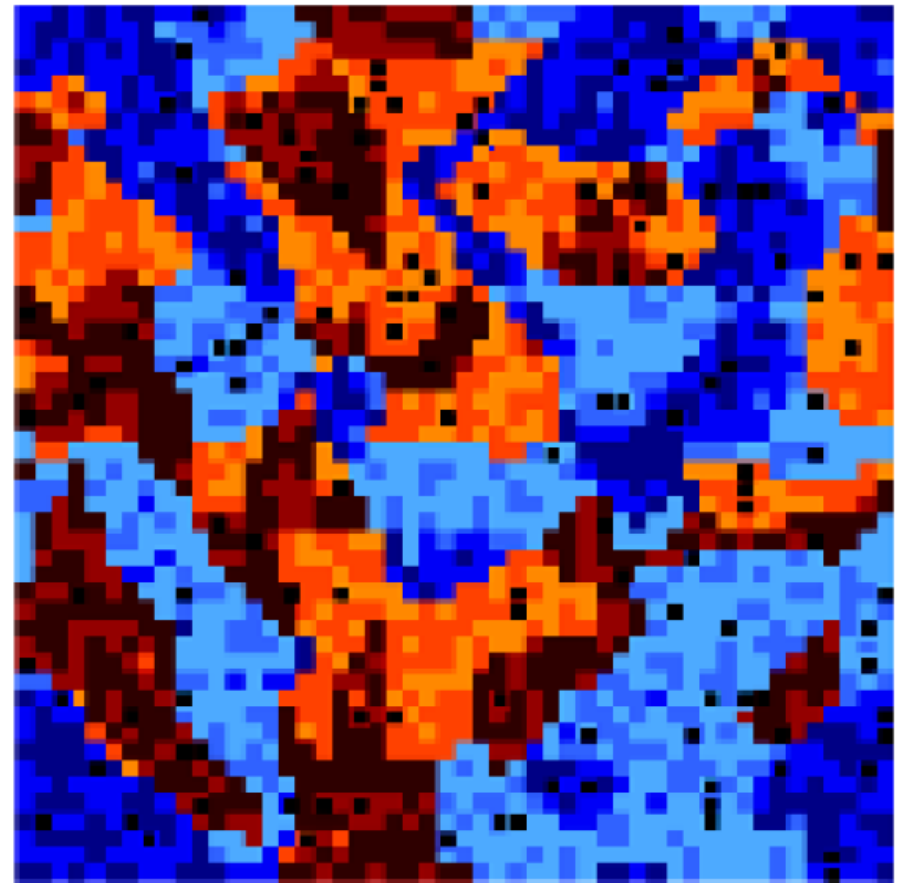
- Results: heterogeneous groups (different searching / 'flipset' heuristics) produce better solutions
- Stylized heuristics – limited to ways that a relatively simple solution space is searched
- Little interaction between group members



# PREVIOUS SIMULATION STUDIES OF GROUP PROCESSES

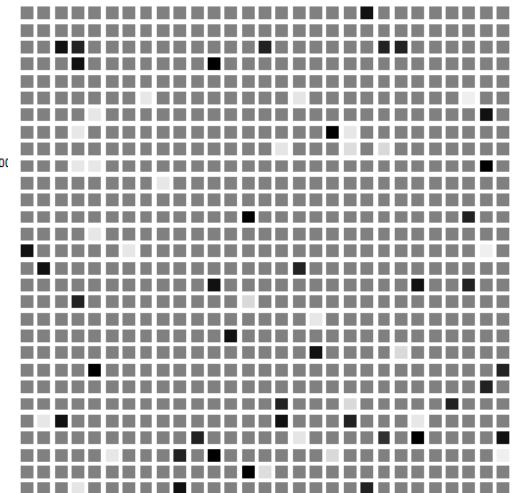
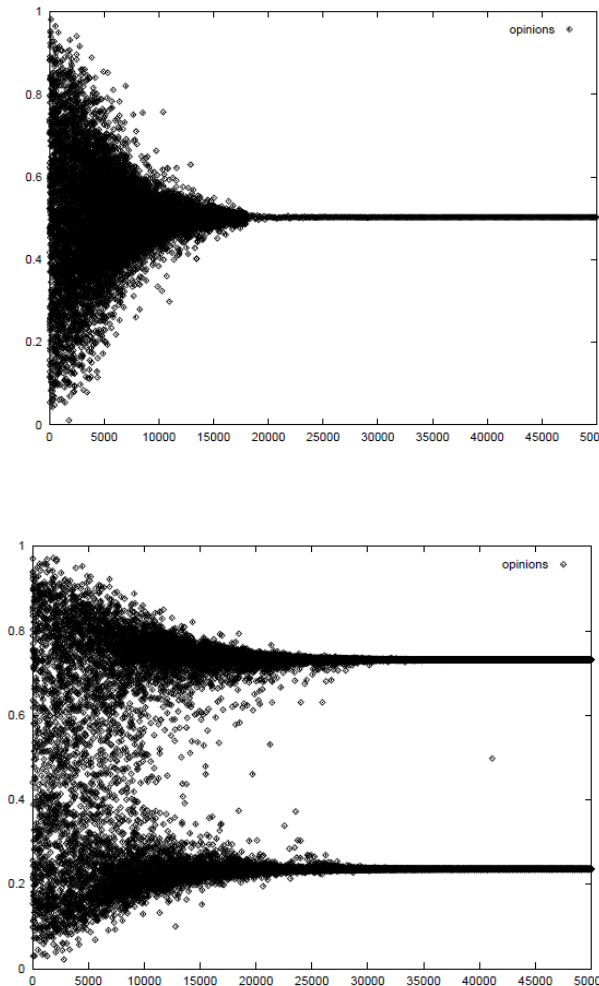
Rousseau and van der Veen (2005)

- Model of the emergence of a shared identity
- Limited repertoire of possible outcomes
- Actually a cellular automata model – agents are confined to grid locations



# PREVIOUS SIMULATION STUDIES OF GROUP PROCESSES

Deffuant et al (2000)  
Continuous beliefs (rather than binary). Adjustment based on random meeting of agents who readjust when opinion difference is lower than a threshold  $d$ . Either random mixing or (percolation) on a grid to reflect a fixed social network (cf Schelling segregation model, Bak et al forest fire model)



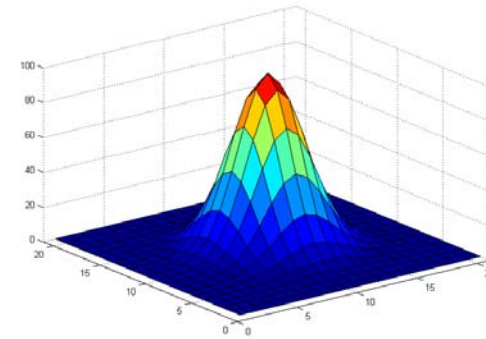
# OUR TWO APPROACHES: EXTERNAL & INTERNAL

# TWO APPROACHES TO THE PROBLEM

Two approaches to the problem of behavioural modelling:

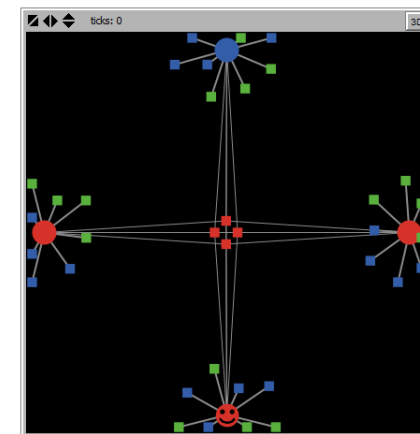
1 Individuals Moving Over Cognitive Landscape

*Decision based on **external** comparison with next best neighbor*



2 Individuals Updating their Information

*Decision based on **internal** comparison with my next best alternative*



## APPROACH 1: INDIVIDUALS MOVING OVER COGNITIVE LANDSCAPE

DECISION BASED ON EXTERNAL COMPARISON WITH  
NEXT BEST NEIGHBOR

# OUR MODEL

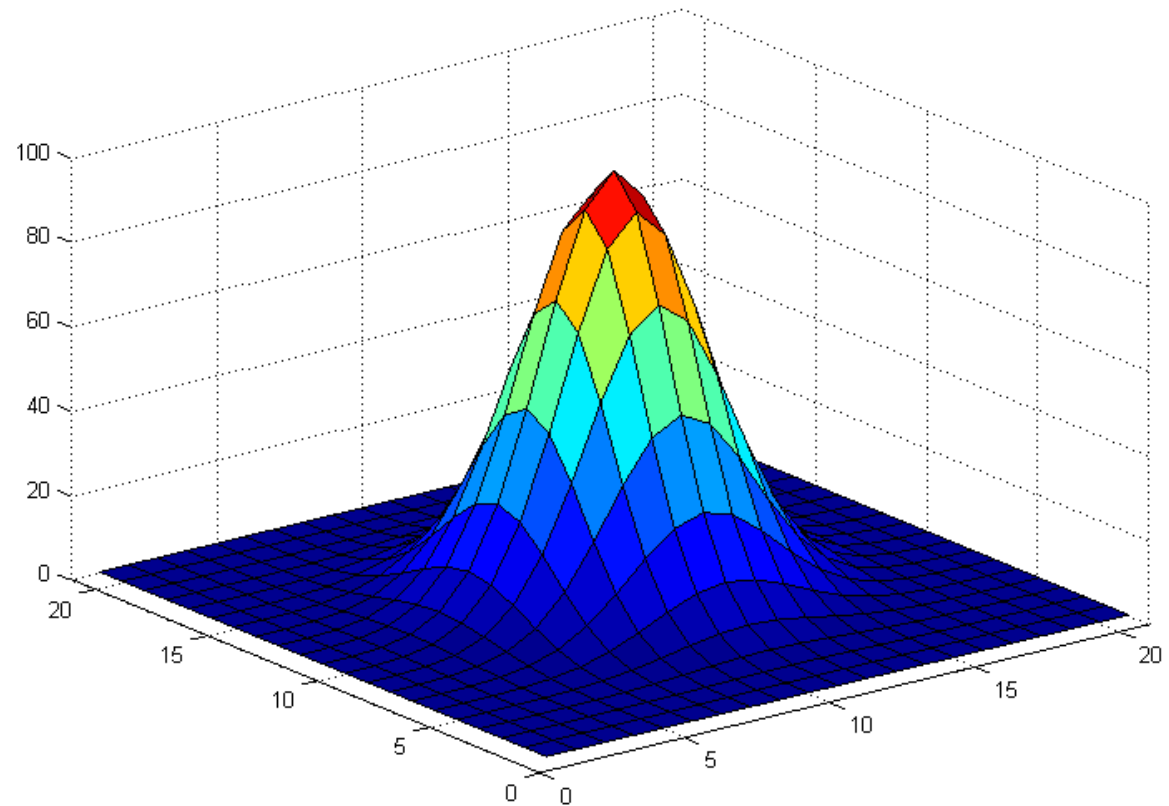
## Combines

- Thresholds of Deffuant et al (2000)
- Hill Climbing of Larson (2007)
- Social network of both Rousseau and van der Veen (2006) and Deffuant et al (2000) (2nd model) but:
  - Makes the social network endogenously constructed rather than cellular automata

# CONSTRUCTION OF THE FITNESS LANDSCAPE

The fitness landscape is created by adding  $M$  Gaussians at random positions

This is a fitness landscape for  $M = 1$  – one central peak, and is the landscape we will use for our experiments



# PARTICIPATOR AGENTS



$N$  participants – agents in our agent-based model – are randomly positioned on a fitness landscape.

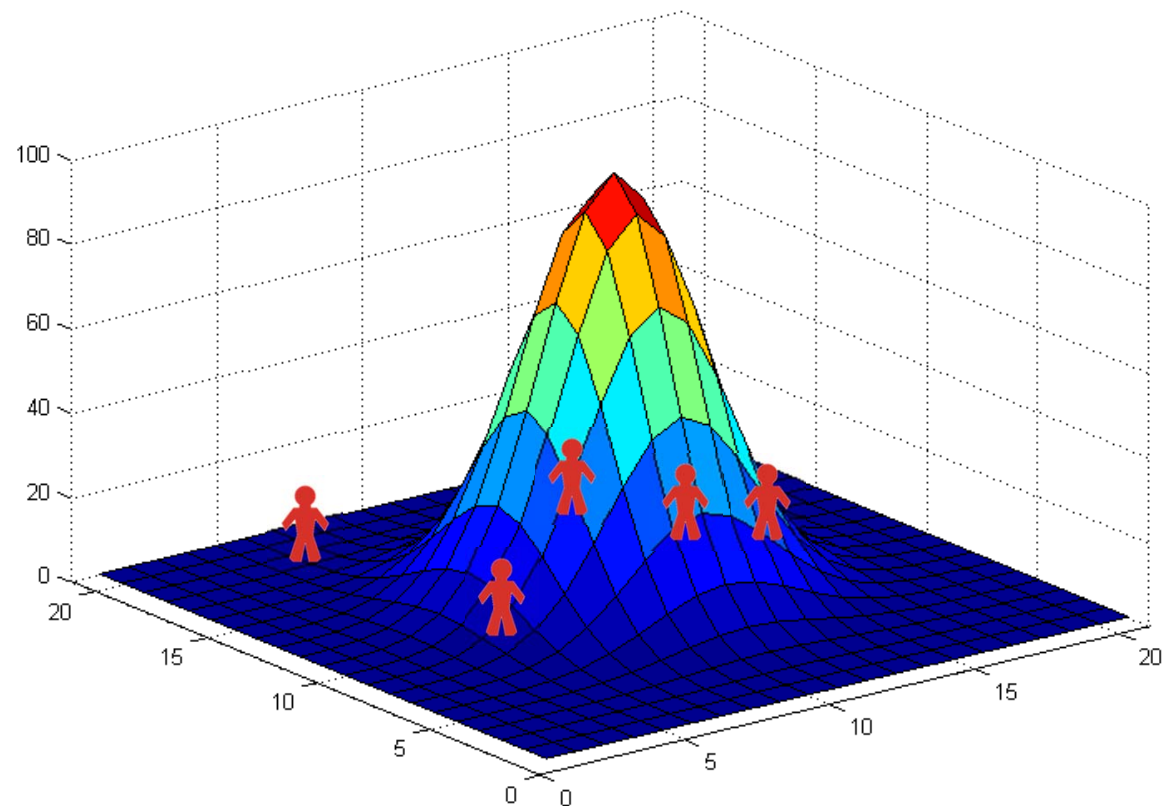
Fitness landscapes (Wright 1932) widely used in the evolutionary biology community. ‘Fitness’ reduces the output into the ‘height’ of the landscape.

Widely used in strategic management (Levinthal 1997 and many more recent publications)

# CONSTRUCTION OF THE FITNESS LANDSCAPE

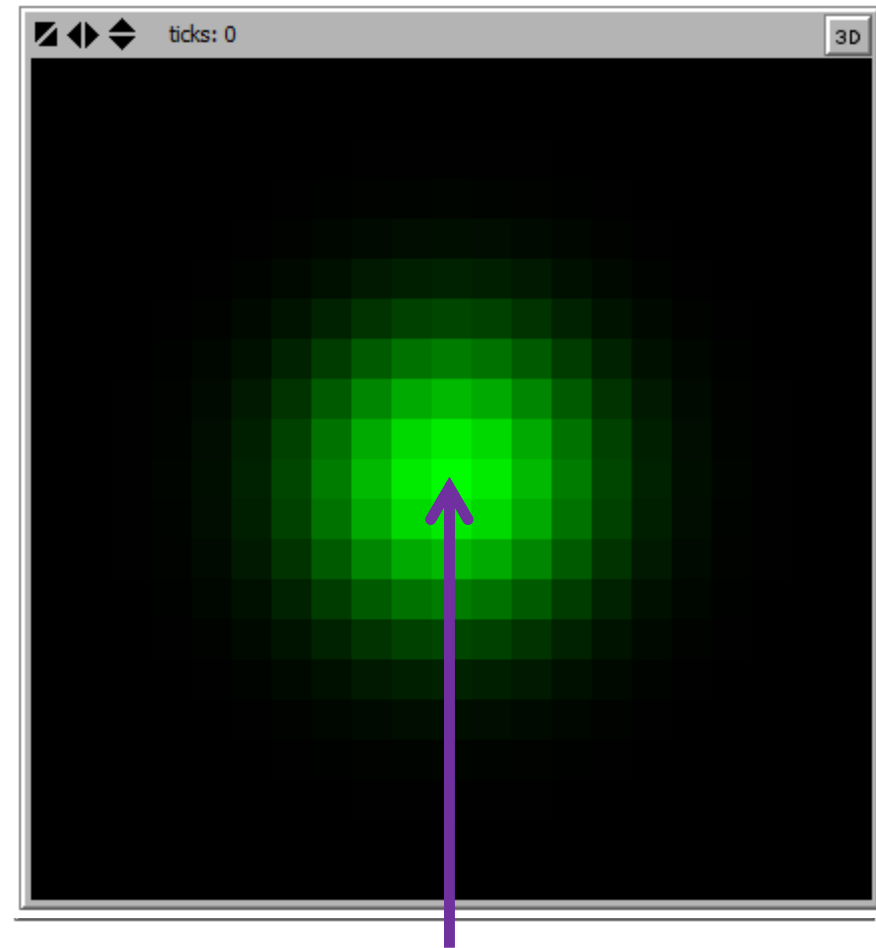
We add  $N$  agents to the landscape

Participant agents can move around a fitness landscape.



# MODEL

The Landscape is  
Constructed

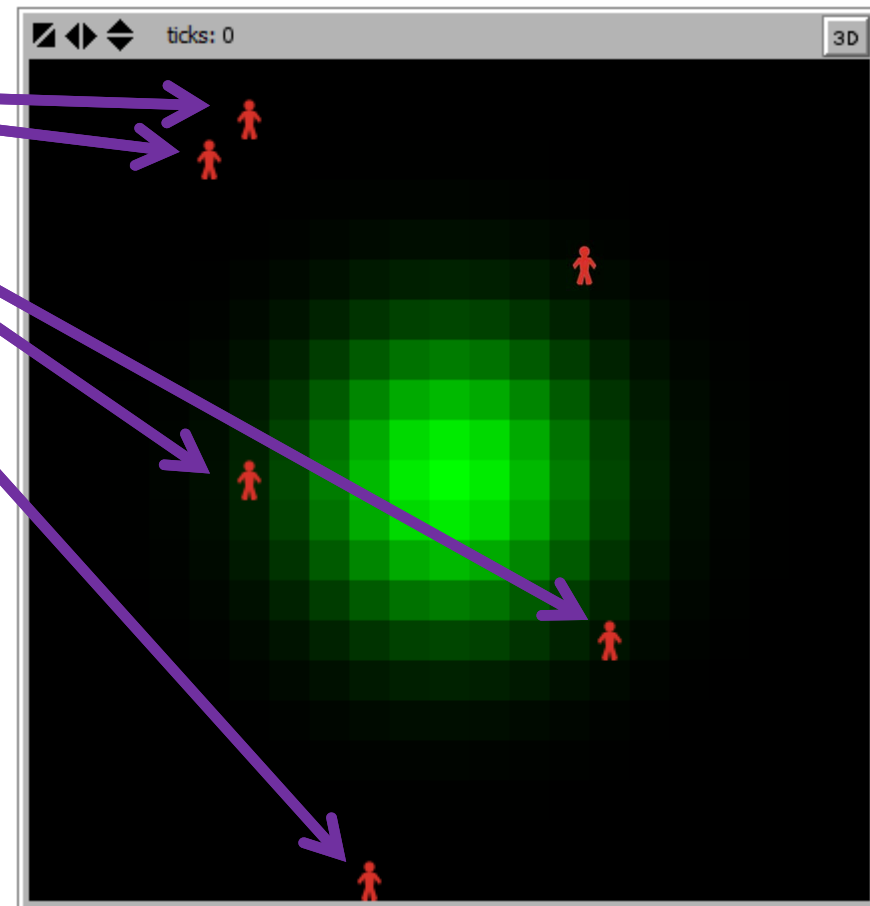


Optimal Solution Point

# MODEL

Participants

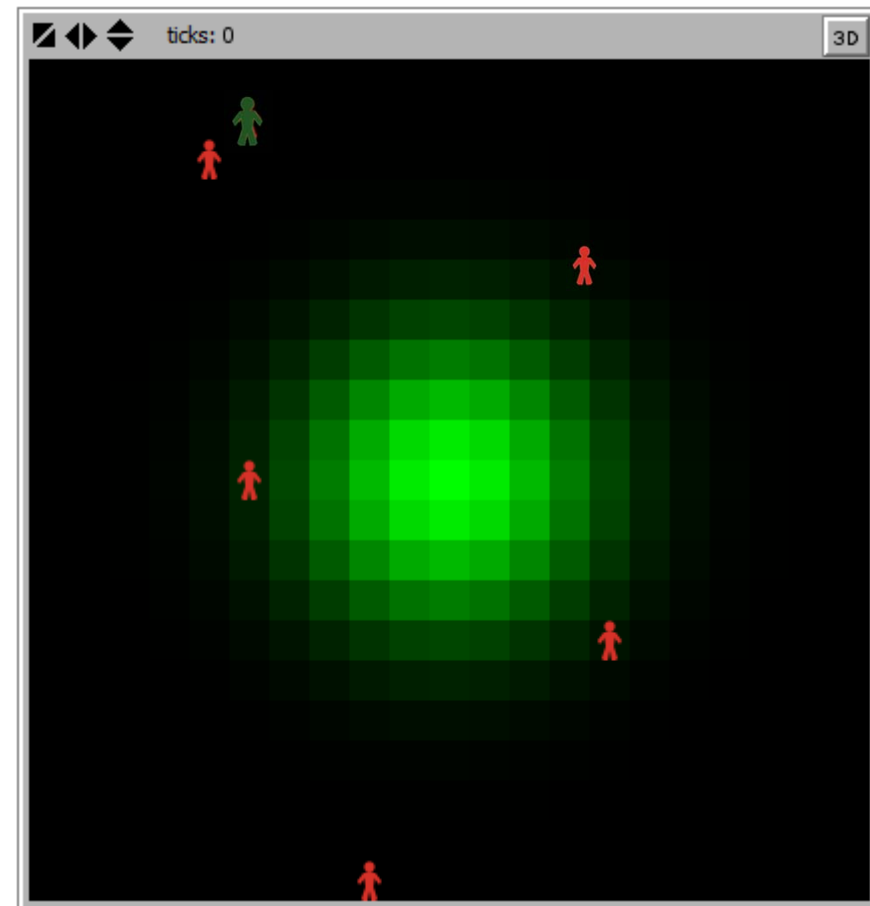
$N$  participants are  
placed randomly on  
the fitness landscape



# MODEL

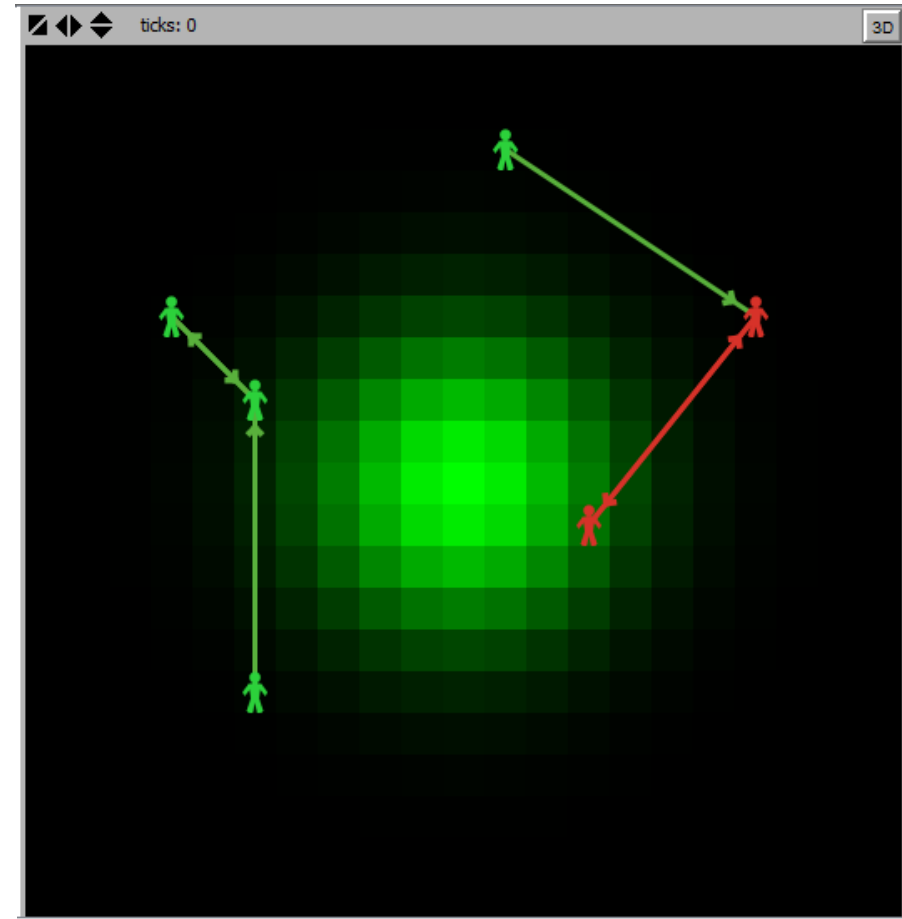
Each participant will compare its height with that of its nearest neighbor. If it is within the *NFClo* threshold, then the participant reaches closure.

If not within this threshold, the participant will search the landscape with a hill climbing random walk (they will take a random walk but will move only if their height increases)



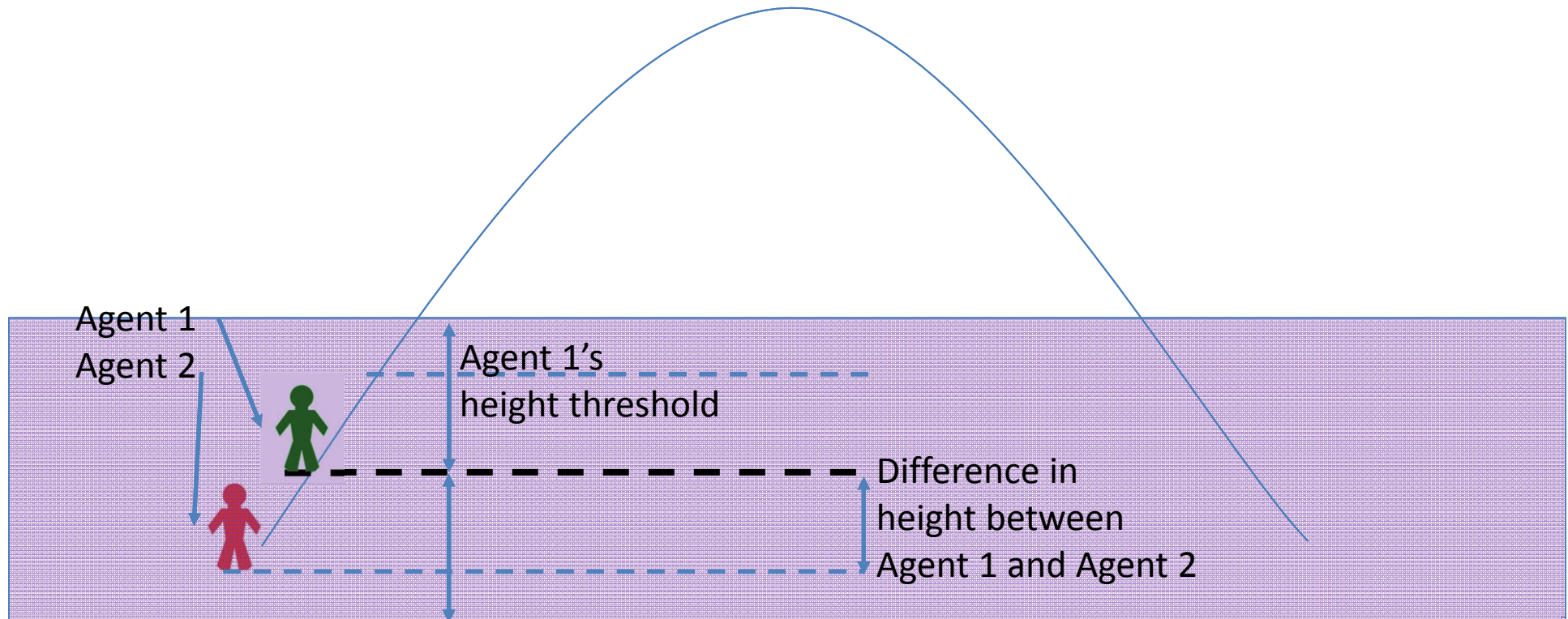
# MODEL: A DYNAMIC SOCIAL NETWORK

In effect we are using an agent-based model to construct a dynamic social network model (arrows show reference participant and whether participants have reached closure).



# HEIGHT THRESHOLDS: $\pm$ THRESHOLDS

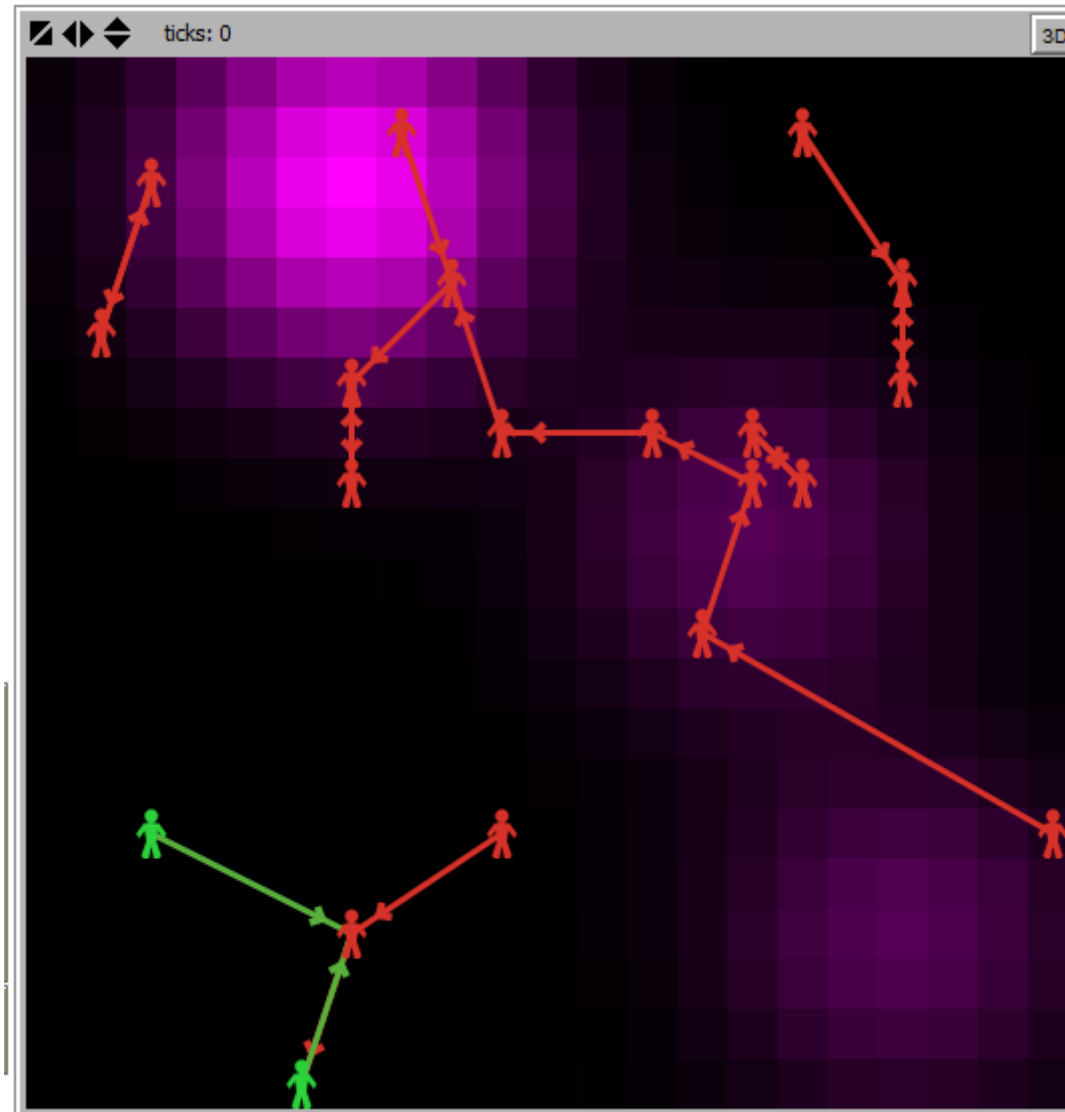
Agent 2 is Agent 1's nearest neighbor



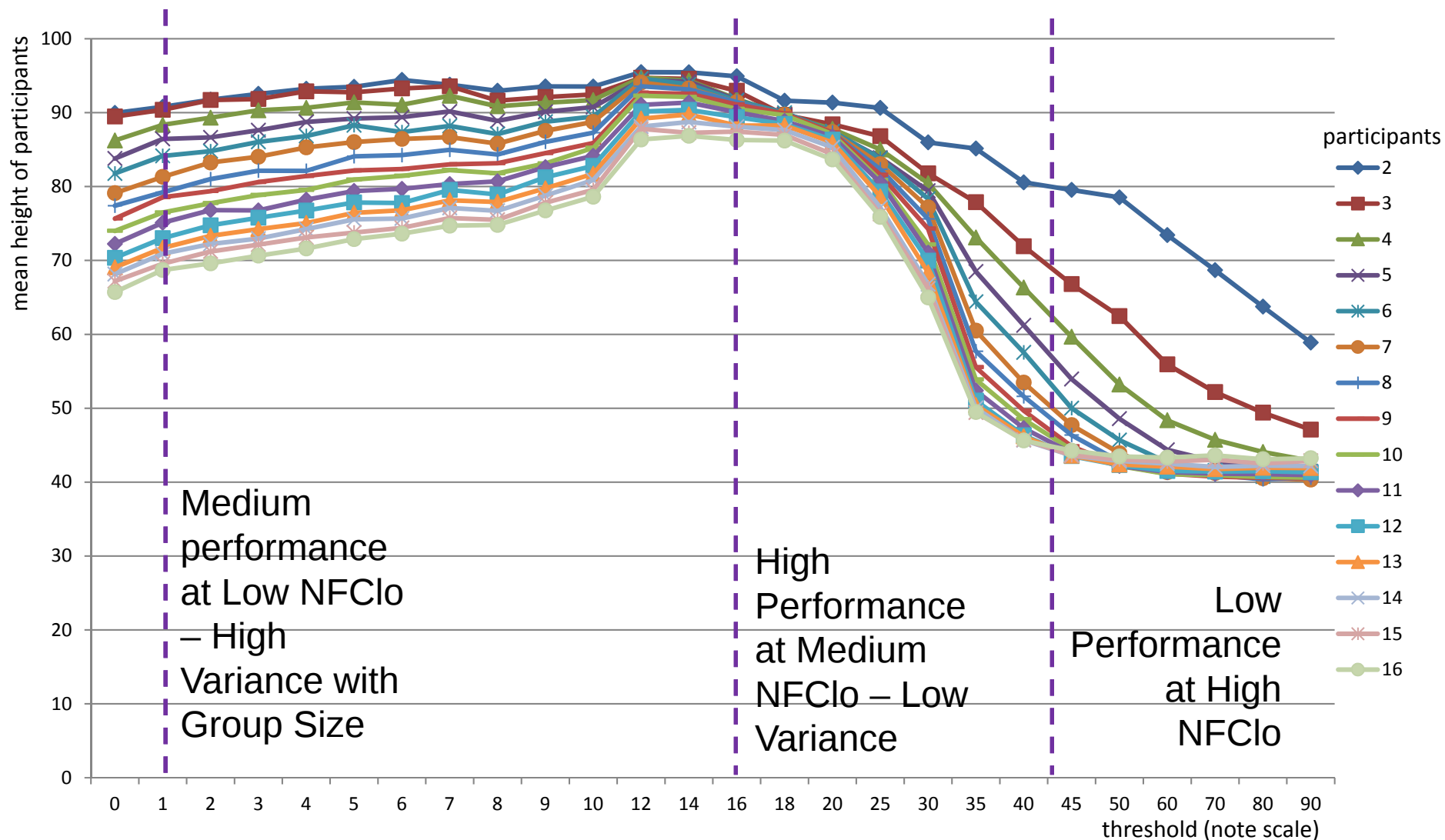
Agent 1's height threshold  $>$  Difference in height between Agent 1 and its nearest neighbor

$\Rightarrow$  Agent 1 **reaches closure** and stops searching

# CONSTRUCTION OF THE DYNAMIC SOCIAL NETWORK



# GROUPS HEIGHT AS A FUNCTION OF NFCLO THRESHOLD



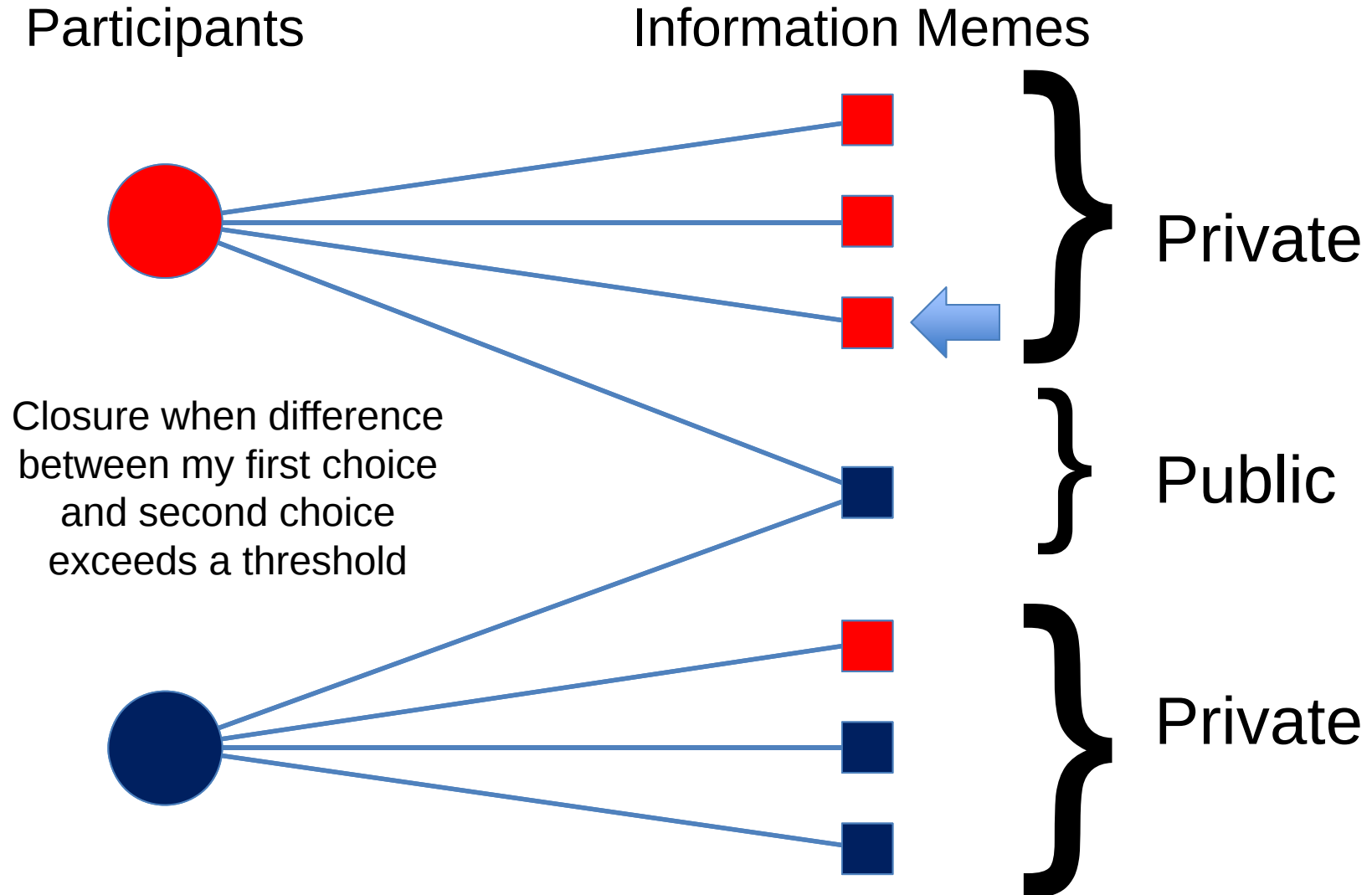
## APPROACH 2: INFORMATION FLOWS IN GROUPS

DECISION BASED ON INTERNAL COMPARISON WITH  
MY NEXT BEST ALTERNATIVE

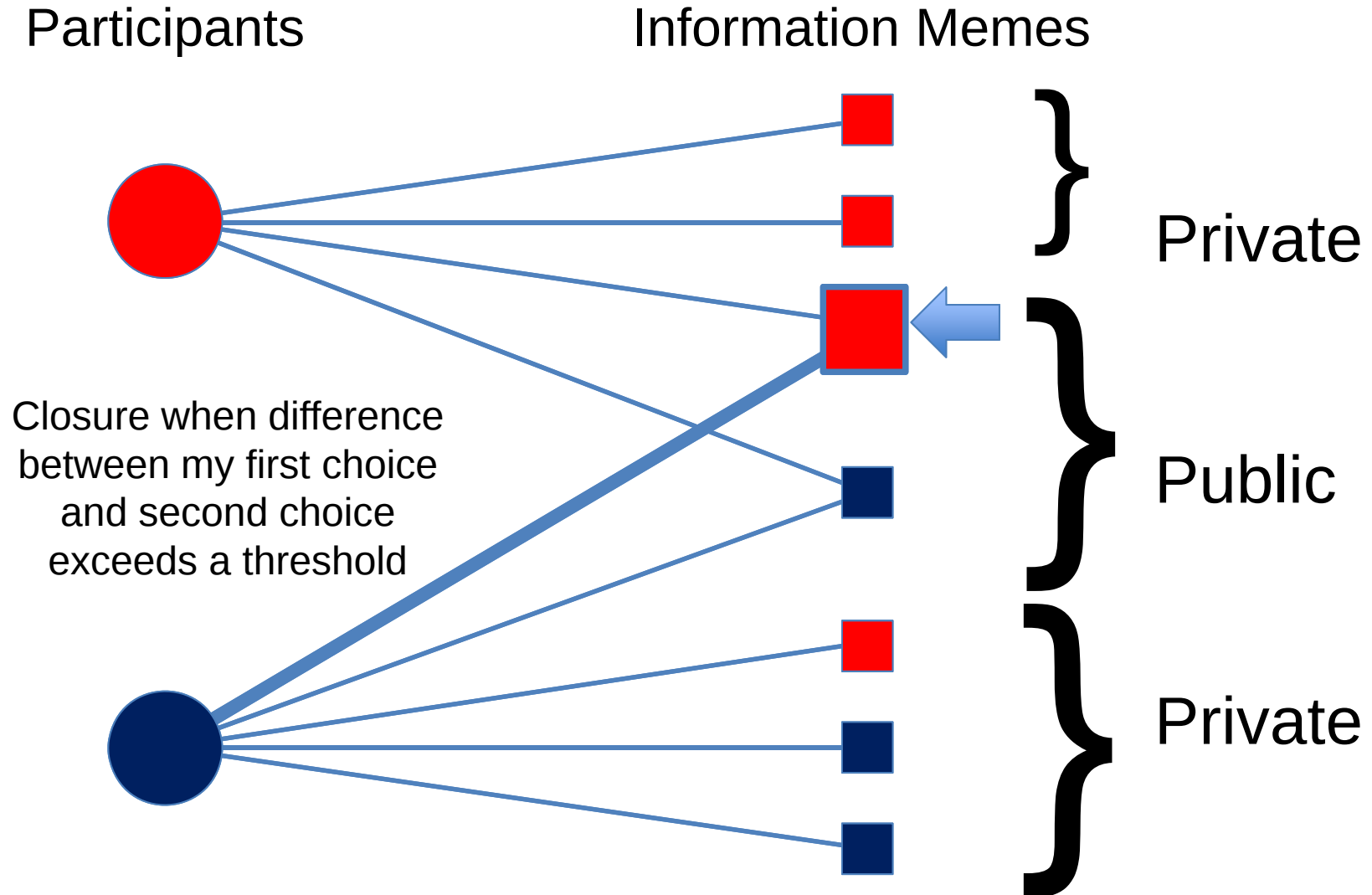
# INDIVIDUAL INFORMATION

- Based on Stasser and Titus (1985) model of Hidden Profiles but adding a Need for Closure parameter for each participant
- Agents (participants) are trying to choose a candidate for a job. They have private information (known only to them) and public information (known to all participants)
- Over the course of discussion, this private information is discussed and becomes public.

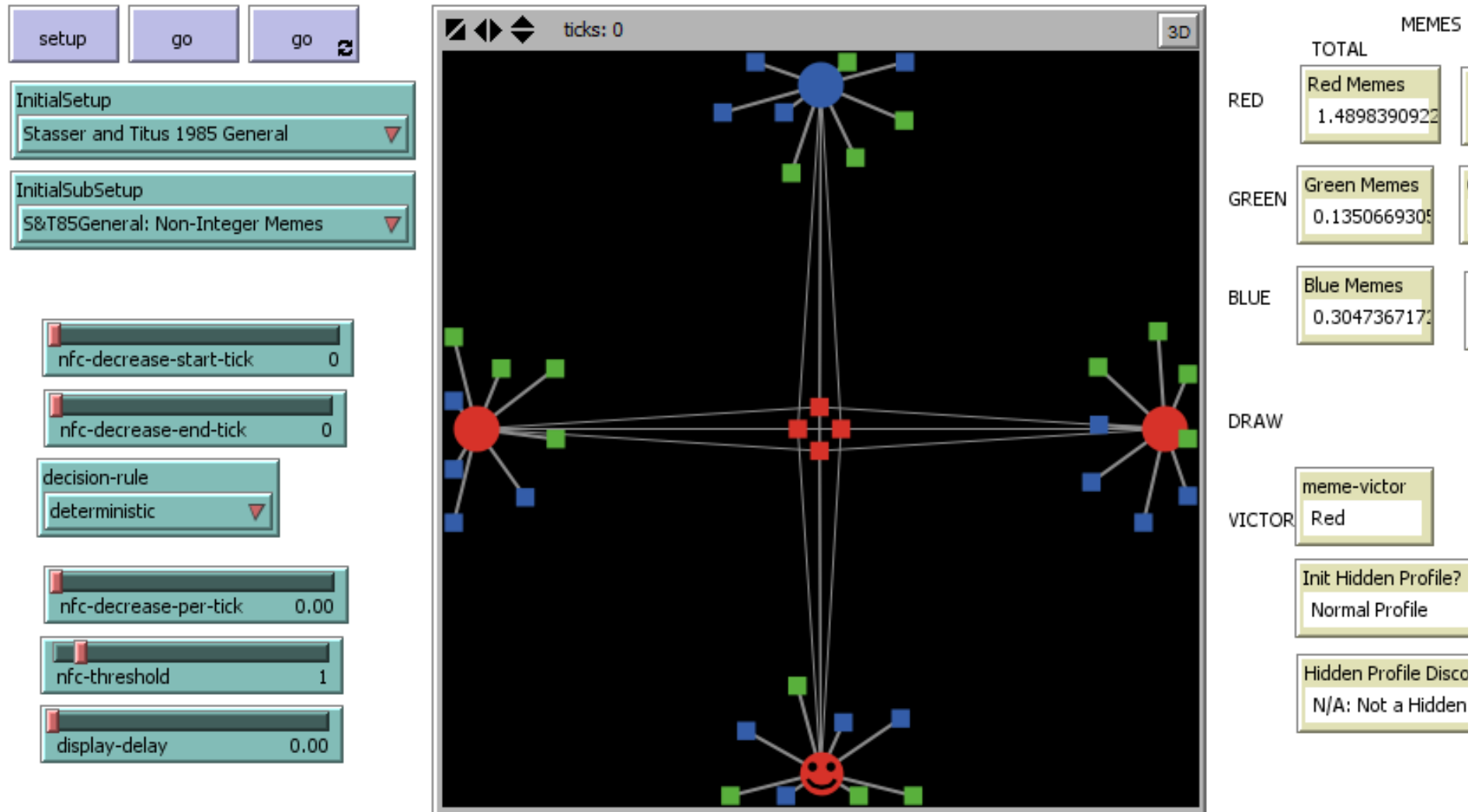
# PARTICIPANTS AND MEMES



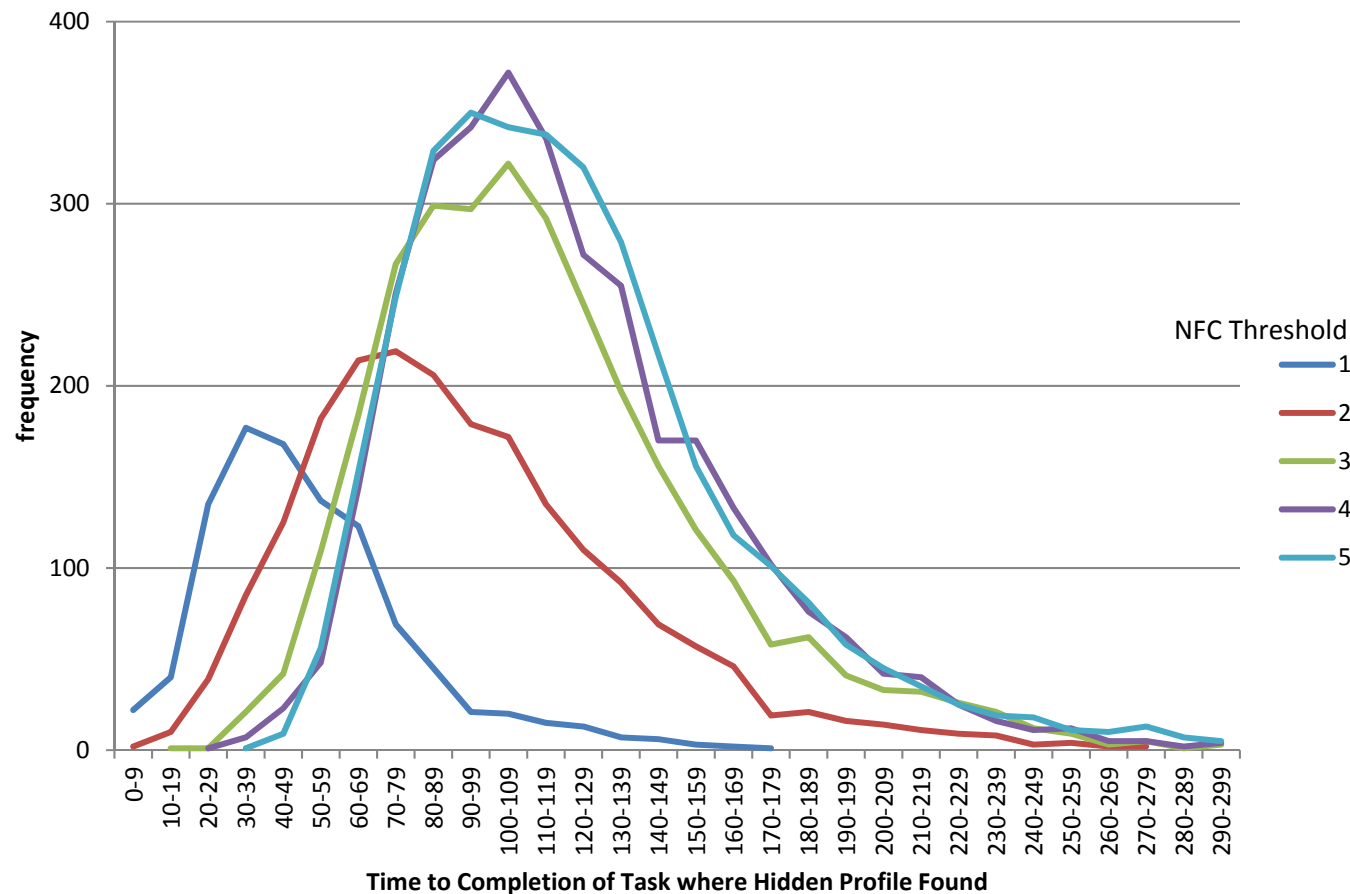
# PARTICIPANTS AND MEMES



# ALTERNATIVE APPROACH: INDIVIDUAL AGENT DECISIONS



# RESULTS: TIME TO COMPLETE TASK



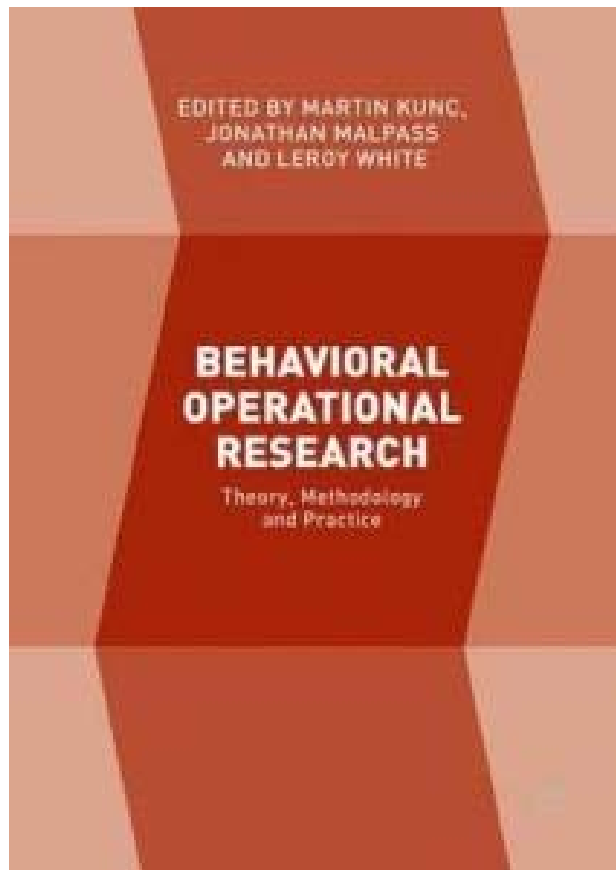
# QUESTION

- At the moment, discussions end when the next best alternative is more than a certain threshold from our current decision.
- But when should the discussion end in our model? At the moment, all information could potentially become public.
- How to model when conversations stop?



# FRAMEWORK FOR ABM & BOR

## Introducing a framework for ABM + BOR



‘Agent-Based Modeling and Behavioral Operational Research’,  
In: Kunc, Malpass, White  
Behavioral Operational Research: Theory, Methodology, and Practice, Palgrave Macmillan  
**[www.duncanrobertson.com](http://www.duncanrobertson.com)**

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