

Agent-Based Modeling: A Bridge Between Games & Social Sciences

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Workshop

**Office of Pre-collegiate Programs
for the Talented and Gifted (OPPTAG)**

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Presentation Outline

- ◆ What is **Agent-Based Modeling (ABM)**?
- ◆ Simple Hands-On Illustration: **Schelling Tipping Game**
- ◆ Schelling Tipping Game: **Demonstration Software**
- ◆ From Games to Practice: **ABM Commercial Applications**

What is ABM?

- ◆ Computational study of processes modeled as **dynamic systems of interacting agents**
- ◆ **Culture-dish approach**

ABM Culture-Dish Analogy

- ◆ Modeler constructs a “virtual world” on a computer populated by various **agent types**
- ◆ Modeler sets **initial world conditions**
- ◆ Modeler then steps back to observe how the **world develops over time**
- ◆ World events are **driven by agent interactions**

ABM Agent Types

Agents = Encapsulated software programs representing individual, social, biological and/or physical entities

* **Cognitive agents** are capable (in various degrees) of

- Behavioral adaptation
- Social communication
- Goal-directed learning
- Endogenous evolution of interaction networks
- “Autonomy” (self-activation and self-determinism based on private internal processes)

So who has seen ABM in action?



Conjecture = Everyone Has!!



Eragon



Charlotte's Web



X-Men: Last Stand



**Harry Potter:
Order of the Phoenix**



**Fellowship of the Ring
(1st Trilogy)**



Flags of Our Fathers



I, Robot



King Kong



**Two Towers
(2nd in Trilogy)**



**Pirates of the
Caribbean: World's End**



Ratatouille



**Night at
the Museum**

Movies, Movies, ...



Happy Feet



Blades of Glory



Ant Bully



Elektra



Return of the King



World Trade Tower



Lion, Witch, & the Wardrobe



Live Free Or Die Hard



One Night with the King



Resident Evil: Extinction



Renaissance



300

And More Movies!!

ABM Hands-On Illustration: Schelling Tipping Game

Basic Motivation

□ An interesting and important puzzle:

- after 1964, housing discrimination was illegal
- since 1950, racial prejudice has declined
- yet, neighborhoods remain highly segregated

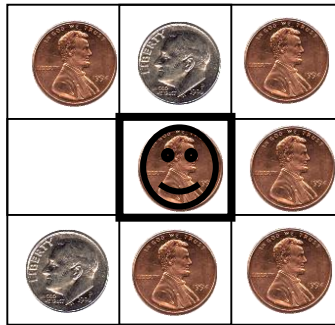
□ T. C. Schelling (1978) hypothesized that segregation:

- does not need to be imposed (top-down)
- does not reflect preferences (bottom-up)
- self-organizes through dynamic interaction

Note: Schelling, a co-recipient of the 2005 Nobel Prize in Economics, is considered a “father” of ABM.

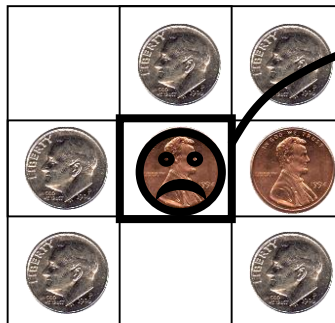
The Schelling Tipping Game

Micro-level rules of the game



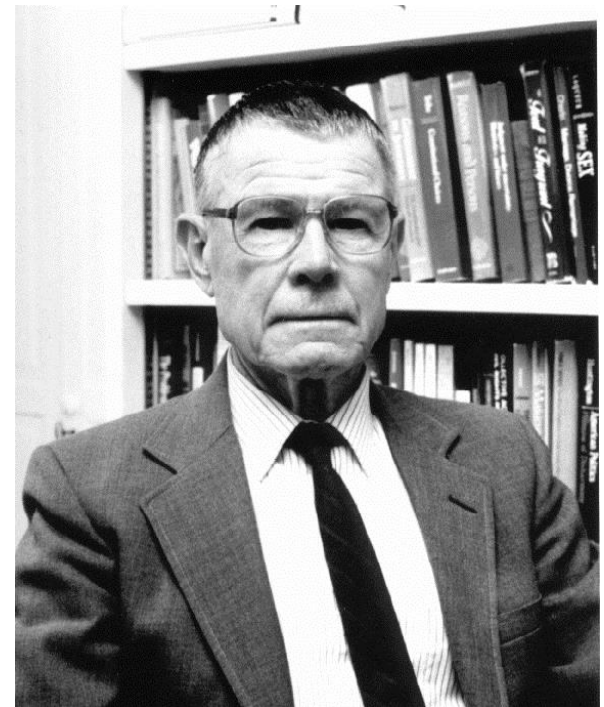
Stay if more than one third of your neighbors are “kin”

$> 1/3$



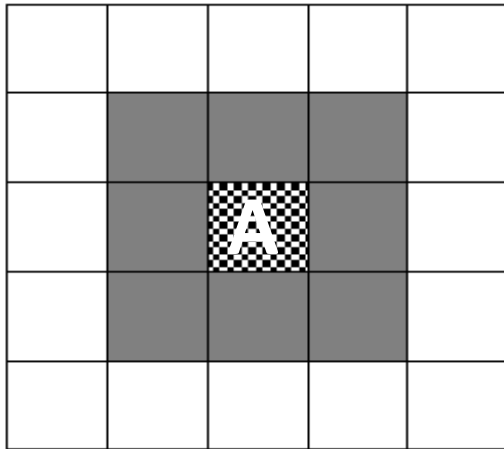
$\leq 1/3$

Otherwise, move to a random “tolerable” vacant location, if possible.

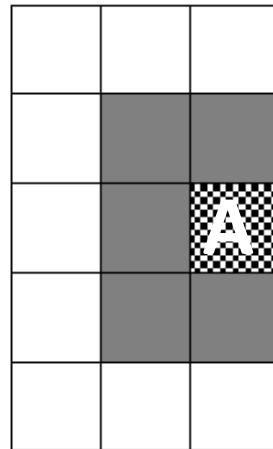


Thomas C. Schelling
*Micromotives and
Macrobavior, 1978*

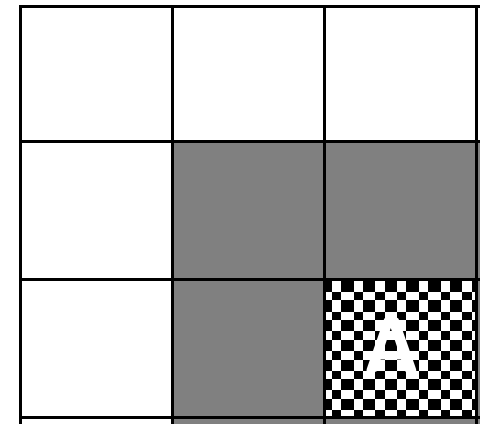
Counting “Neighbors” for an Agent A In the Schelling Tipping Game



**Interior agent A
up to 8 neighbors**



**Border agent A
up to 5 neighbors**



**Corner agent A
up to 3 neighbors**

“Happiness Rule” for the Schelling Tipping Game

- ◆ An agent A is “happy” (no need to move) if **more than 1/3** of A’s neighbors are of same type as A.
- ◆ **Top row of boxes**, below, gives the current total number of A’s neighbors, from 0 to 8.
- ◆ **Bottom row of boxes**, below, gives how many of these neighbors must be the “same type” as A in order for A to be happy.

0	1	2	3	4	5	6	7	8
0	1	1	2	2	2	3	3	3

A’s Total
Neighbors

Starting Pattern for the Schelling Tipping Game

	O	X	O	X	O	X	
O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O
O	X	O	X	O	X	O	X
X	O	X	O	X	O	X	O
	X	O	X	O	X	O	

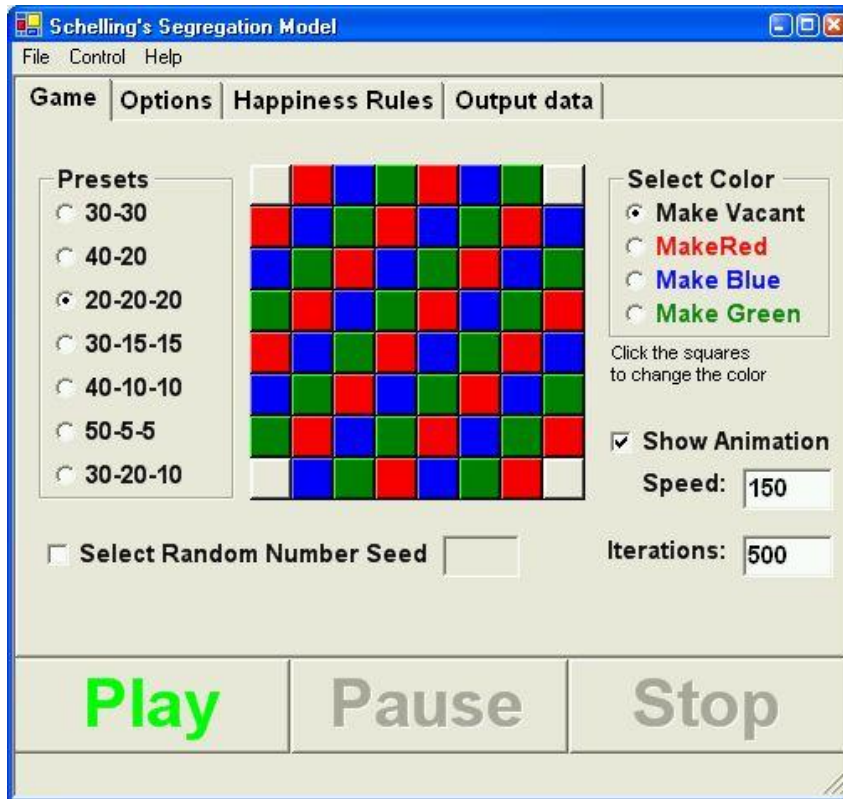
Now “Play the Game” !!

- ◆ Given the pattern on previous slide, everyone is happy and no one moves. Now **remove 10 agents randomly selected from the board.**
- ◆ Next, starting from the top row and moving from left to right, row by row, **check for an unhappy agent.**
- ◆ Every time you encounter an unhappy agent, **if possible move this unhappy agent** to a “tolerable” vacant square where he is happy; **otherwise remove him.**
- ◆ Keep going until there are no unhappy agents left on the board. What degree of segregation is displayed in the **resulting agent location pattern?**

Extended Schelling Tippling Game Demo

Basic Model by T. Schelling; Demo developed by C. Cook

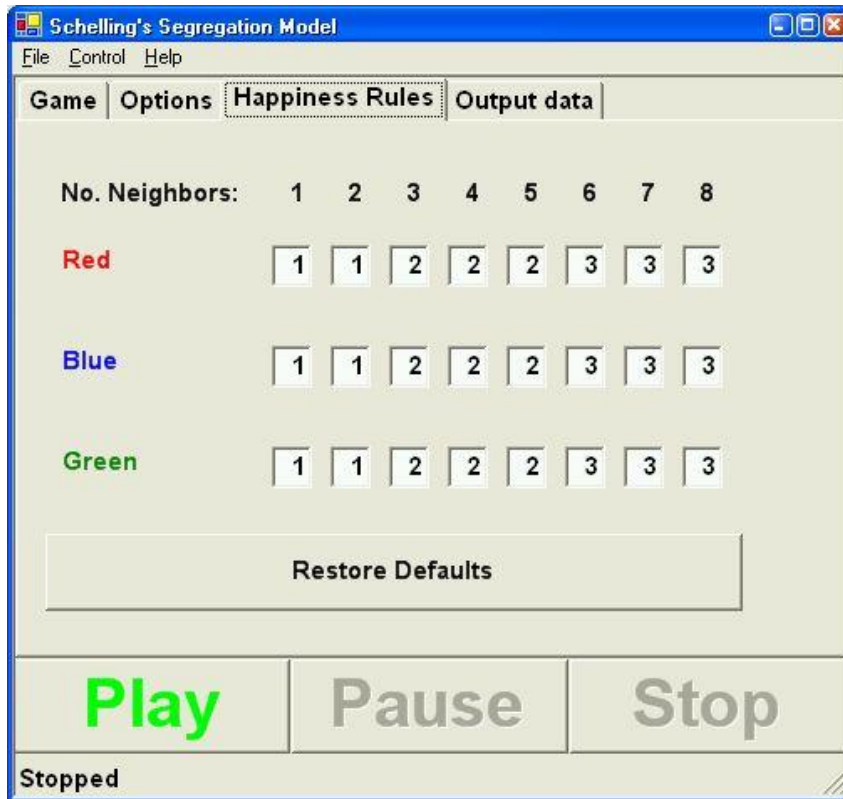
<https://www2.econ.iastate.edu/tesfatsi/acedemos.htm>



- ❑ Checkerboard city model
 - ❑ Three agent types (red, blue, green), plus vacant locations
 - ❑ Agents satisfied with their location if “enough” of their neighbors are of their own type; otherwise, they move.
- **KEY FINDING:** City can “tip” into high segregation even if agents have only mild preferences for living with agents of their own type!

Schelling Tipping Game Demo ... Continued

(Agent Happiness Rules)



- User specifies a happiness rule for each **agent type** (red, blue, or green)
- User specifies a **happiness rule** for each agent type: *Given an agent A with n neighbors (between 1 and 8), how many have to be the same type (color) as A in order for A to be happy at its current location?*
- Unhappy agents attempt to move to vacant spots at which they would be happy.
- Does this cause the city to “tip” into a segregated pattern?

A More Advanced Version of the Schelling Tipping Game

(Mark Fossett, Texas A&M University, sociweb.tamu.edu/vlabresi/sslite3.htm)

The screenshot displays the SimSeg Lite simulation interface. On the left is a grid of agents represented by small colored squares (cyan, yellow, magenta, and black) on a white background. The grid is roughly diamond-shaped, with the widest part in the middle. On the right is a statistics panel titled "SimSeg Lite". Below the title are several sections of data: "Progress" (30 Cycles), "Dissimilarity Scores" (White-Black: 70, White-Hispan: 75, Hispan-Black: 79), "Isolation, Clustering, & Centralization" (W: 79 75 26, B: 58 43 34, H: 61 51 34), "Moves in Cycle" (Attempted: 1143, Completed: 311), and "Households" (White: 2706, Black: 937, Hispan: 930, Vacant: 180). At the bottom of the interface is a control panel with several dropdown menus and buttons. The dropdown menus include "User Defined Scenario", "30 Cycles", "Displaying Ethnicity & SES", "M2-Means Testing -ON", "IS-Inequality V.High", "A5-Area Strat V.High", "S4-Seek SES & HQ", "D1-No Discrimination", "P5-Survey Preferences (per Bobo et al.)", and "N2-Nearby Area -ON". The buttons are "Help", "Reset", "Continue", "Show Settings", and "Legend".

SimSeg Lite

Progress
30 Cycles

Dissimilarity Scores
White-Black 70
White-Hispan ... 75
Hispan-Black ... 79

Isolation, Clustering, & Centralization
W 79 75 26
B 58 43 34
H 61 51 34

Moves in Cycle
Attempted 1143
Completed ... 311

Households
White 2706
Black 937
Hispan 930
Vacant 180

©WLAB-RESI
Texas A&M Univ.

User Defined Scenario | 30 Cycles | Displaying Ethnicity & SES

M2-Means Testing -ON | IS-Inequality V.High | A5-Area Strat V.High | S4-Seek SES & HQ

D1-No Discrimination | P5-Survey Preferences (per Bobo et al.) | N2-Nearby Area -ON

Help | Reset | Continue | Show Settings | Legend

Numerous Commercial ABM Applications

<https://www2.econ.iastate.edu/tesfatsi/AgentLink.50CommercialApplic.MLuck.pdf>

The success of the Internet has changed the way we think about computing. No longer is computing just about numerical calculation, or information processing, it is now about interaction and co-ordination between distinct entities.

Agent systems provide us with the means to design and implement interactive computing, whether between machines, or people, or both.

Professor Michael Luck
AgentLink Roadmap Co-ordinator
School of Electronics and Computer Science
University of Southampton

Examples:

Satellites, primary health care, business management, Internet auctions (eBay), insurance claims processing, large-scale transport, movies, manufacturing, telecommunications, deep-space exploration, product distribution routing, military gaming, autonomic computing, flexible manufacturing, Roomba vacuums, shopbots, pricebots, scheduling, ...

In Summary: Why ABM?

- **a technique for theorizing**
 - designed to address complex real-world issues
- **a practical approach to real-world issues**
 - that permits modeling tools to be adapted to the problem instead of having to adapt the problem to the tools
- **and a fun way to explore real-world issues**
 - that permits creative experimentation with new ideas and
 - encourages “out of control” programming that can surprise and inform

On-Line ABM Resources

- ◆ **On-Line Guide for Newcomers to ABM**

<https://www2.econ.iastate.edu/tesfatsi/abmread.htm>

- ◆ **Chris Cook's Schelling Demo (plus many more)**

<https://www2.econ.iastate.edu/tesfatsi/acedemos.htm>

- ◆ **Self-Study Guide/eBook for ABM (econ stressed)**

<https://www2.econ.iastate.edu/classes/econ308/tesfatsion/>