Schelling Agent-Based Segregation Model with variations

Jon Green

June 12, 2017

I replicated Schelling's segregation model (using David Zimmerman's example at https://www.r-bloggers.com/agent-based-modelling-with-data-table-or-how-to-model-urban-migration-with-r/ as a starting point) using data.table() and ggplot() in order to organize, update, and visualize how agents were interacting in the wrapped universe I specified.

The first function initiates the Schelling universe, taking a specified grid size, number of races, percent of empty cells, and percent of agents of the dominant race, the second function plots the Schelling universe, and the third function determines how the agents interact while iterating through multiple rounds of movement. This third function also stores the percentage of agents who are unsatisfied in each iteration, putting a vector of percentages in the global environment that can be plotted.

The second function plots the grid.

In the first version of the model, each agent looks at their eight surrounding neighbors (agents at the edges and corners look to the other side of the grid such that the universe wraps), and if the percent of like neighbors is below their preference threshold (thresholds vary depending on whether the agent is a member of the majority race – default is for the majority race to prefer a higher percentage of like neighbors) they move to a cell that is either empty or occupied by another unsatisfied agent.

In the second version of the model, everything is the same except unsatisfied agents move to NEAREST AVAILABLE cell. For each iteration, each agent checks whether the percentage of like neighbors is below their preference threshold, and moves to to nearest available cell (empty or occupied by an unsatisfied agent) if they are unsatisfied.

In the third version of the model, unsatisfied agents move to RANDOM AVAILABLE CELL WITHIN A DISTANCE LIMIT. Unsatisfied agents move to a cell sampled from the list of available (empty and occupied by an unsatisfied agent) cells that are less than a specified number of one-unit moves away from the current cell.

We can test out how each of the models performs under different specifications. First, for the initial model (unsatisfied agents move to random available cell with no distance limits), we plot the initial 20x20 wraparound Schelling universe with two races (divided 70/30) and 20 percent empty cells. We then plot the same universe after ten iterations assuming all agents prefer at least half of their neighbors to be of the same race. Finally, we plot the percentage of unsatisfied agents in this universe in each iteration.

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## Loading required package: data.table
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## Loading required package: ggplot2
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## Loading required package: RColorBrewer
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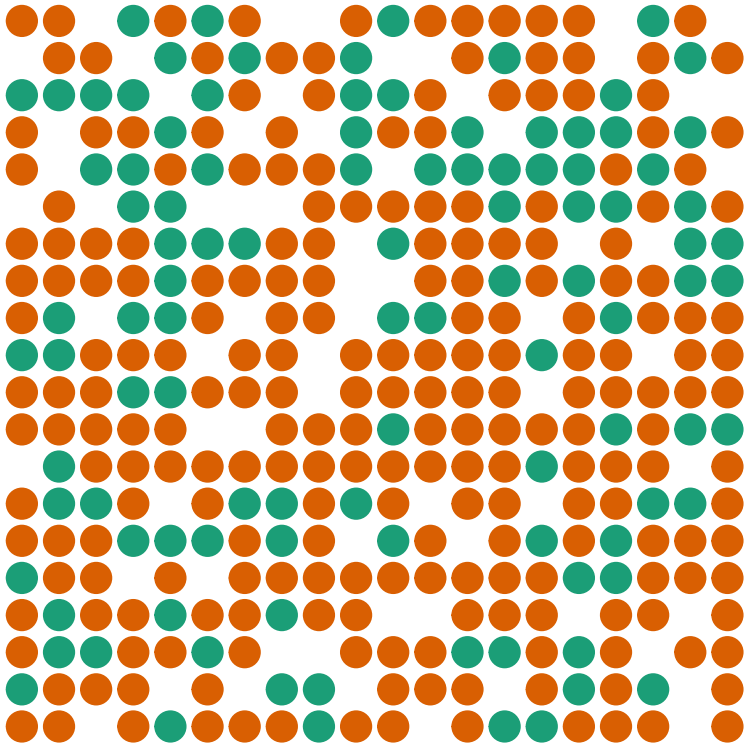
Schelling Segregation Model (Wrapped Environment)



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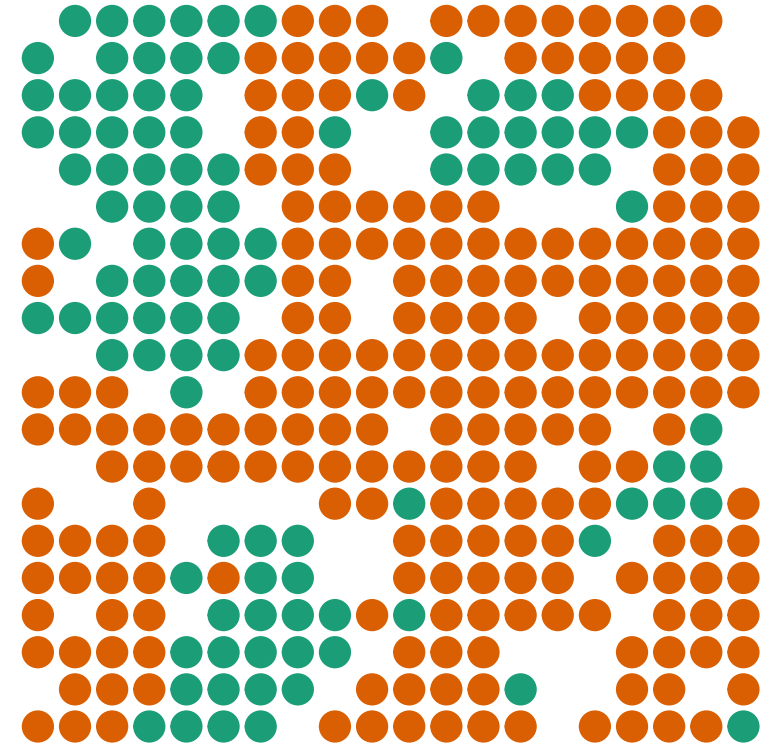
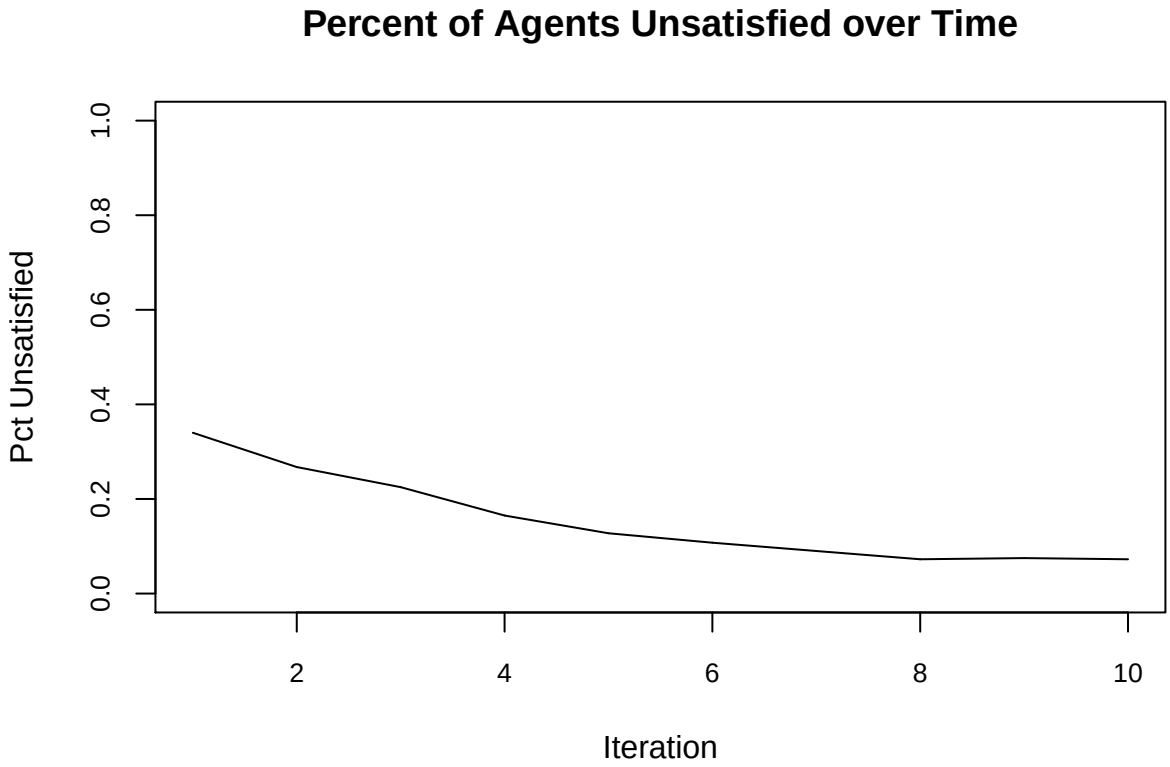


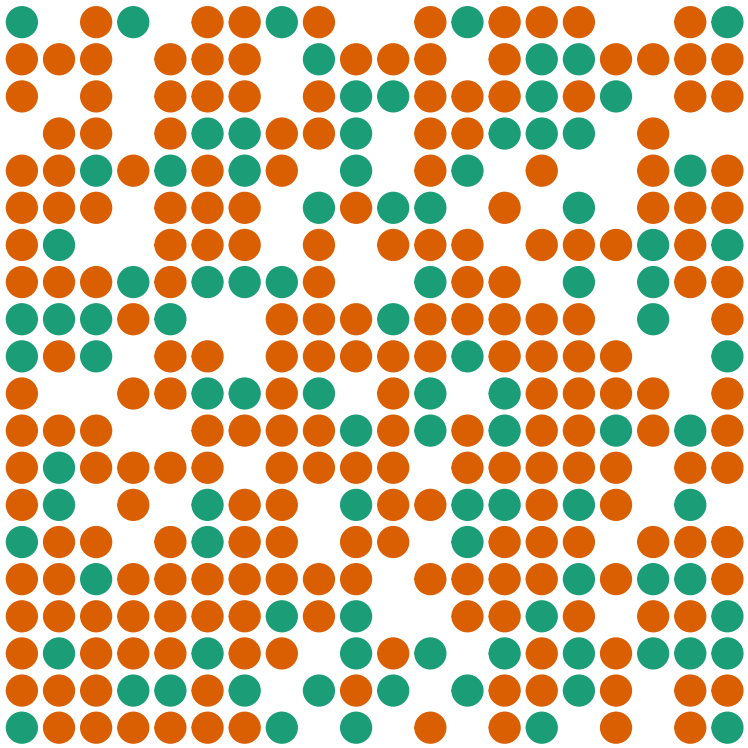


Here we see that the proportion of unsatisfied agents falls from 34 percent to just over 7 percent after ten rounds of movement.

Next, we see how these interactions change when we require that unsatisfied agents move to their nearest

available cell. Again, we specify a 20x20 wraparound universe with two races (70/30 split) that both prefer at least 50 percent like neighbors, with 20 percent empty cells.

Schelling Segregation Model (Wrapped Environment)



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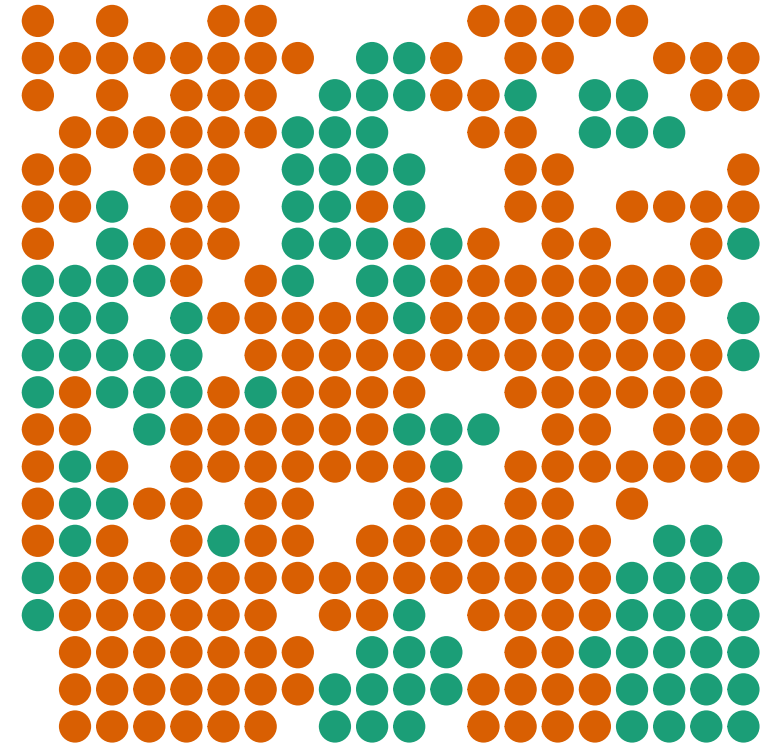
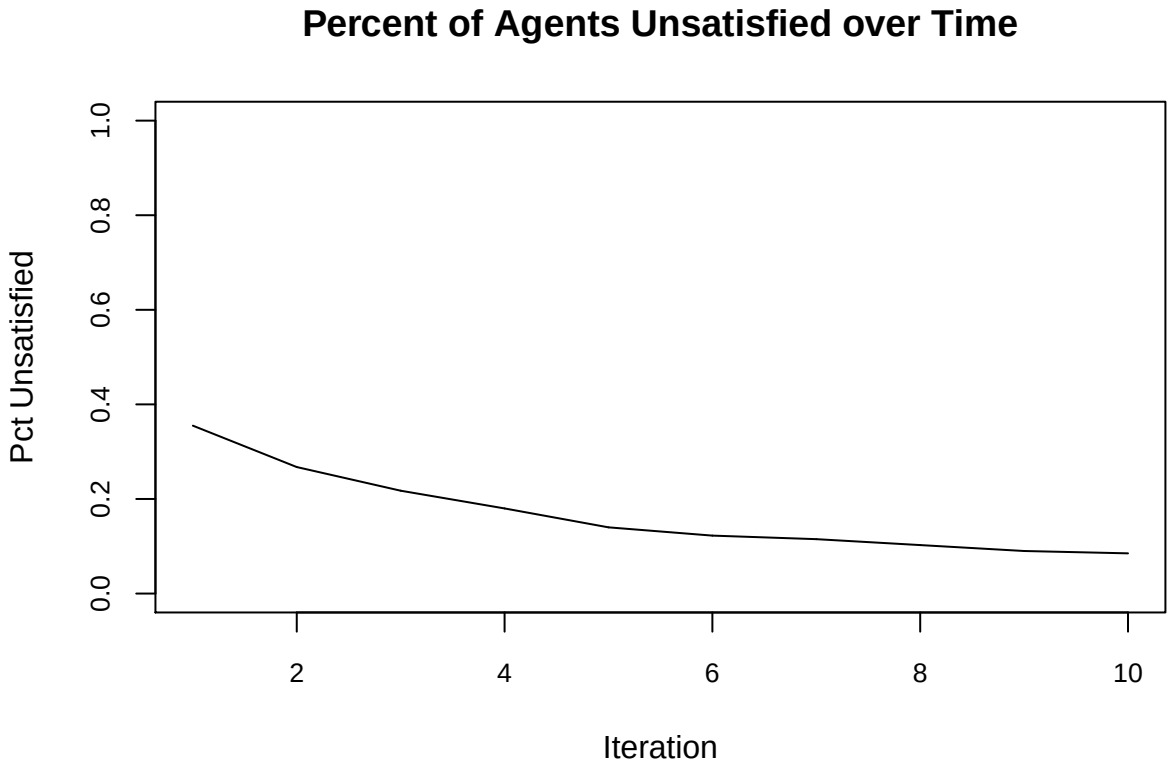


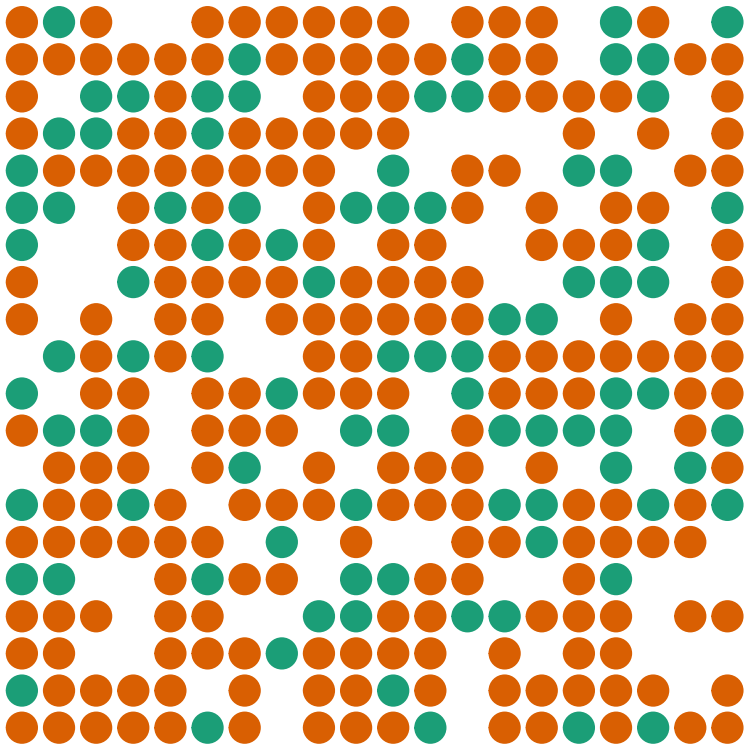


This doesn't change the general pattern. After ten iterations, the percent of unsatisfied agents has fallen similarly from just over 35 percent to just over 8 percent.

Finally, we see how the same Schelling universe and population behaves when they are freed up to move to

any avaialble cell within specified distance limits. In this case, unsatisfied agents in the same population with the same preferences for like neighbors is limited to moving no more than six one-unit steps per round.

Schelling Segregation Model (Wrapped Universe)



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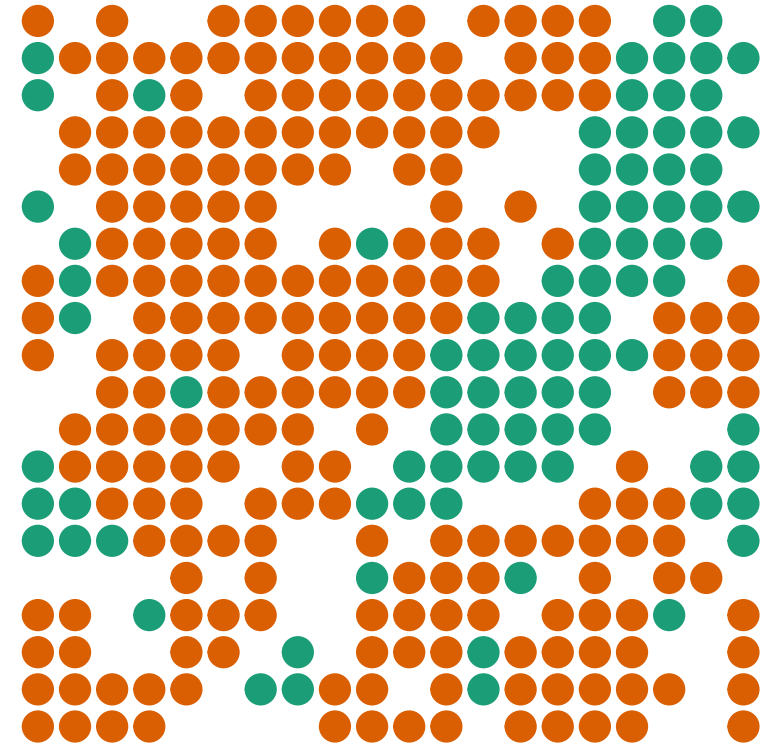
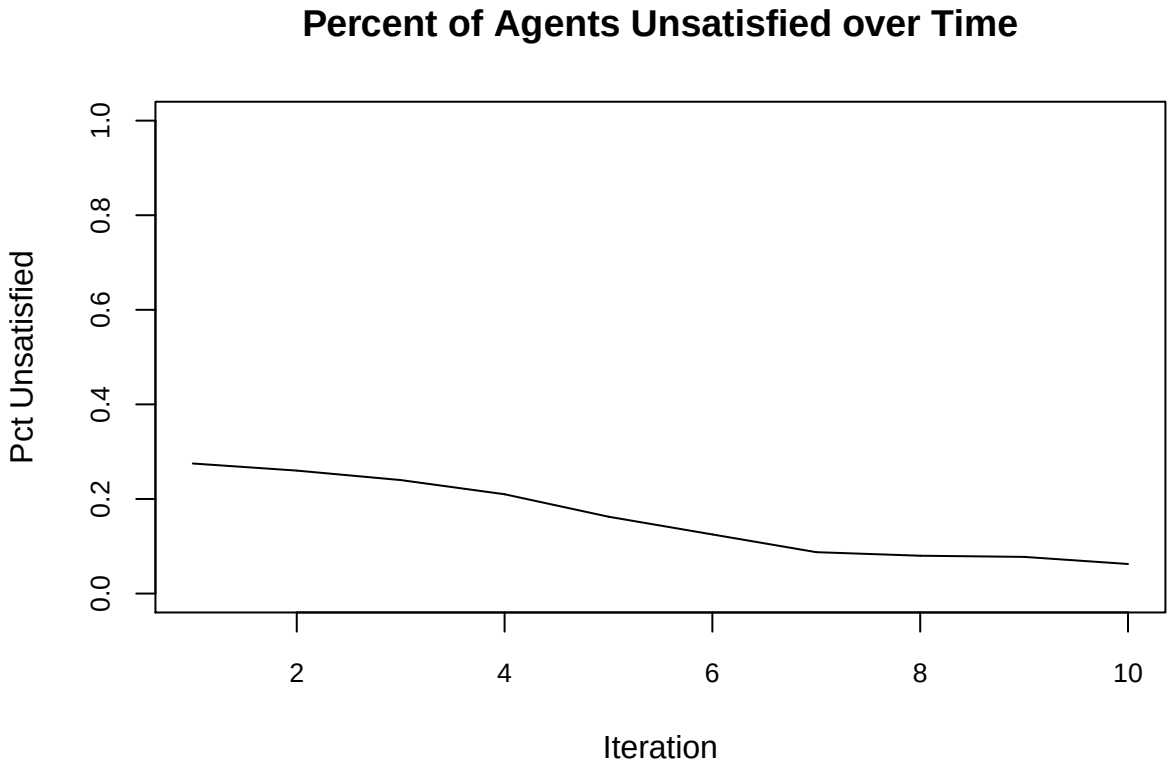


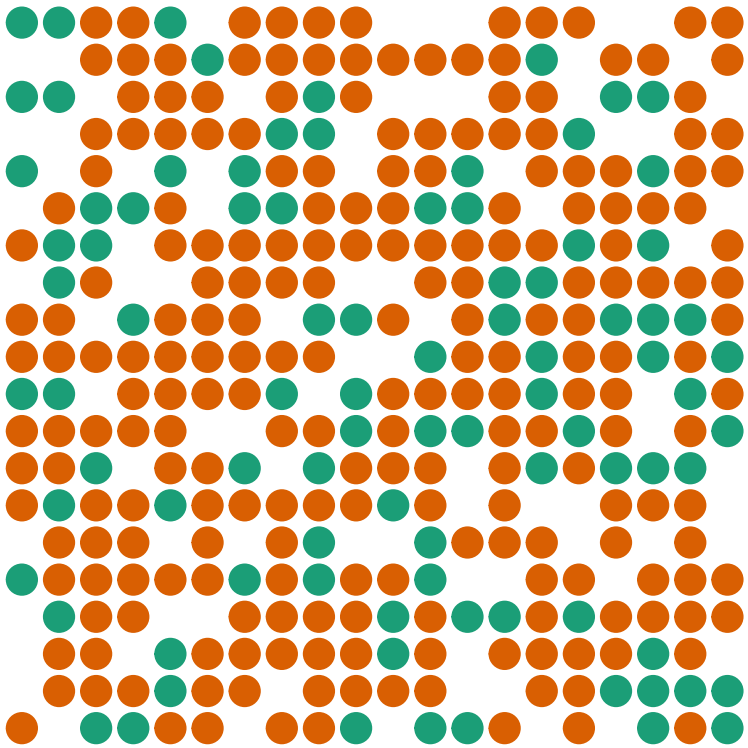


This run started with a lower percent of unsatisfied agents (27.5%) and fell to roughly eight percent unsatisfied within seven moves – not a major deviation from the pattern observed in the previous runs.

But what happens when we change other specifications in our model? Say, for instance, that the different

races have different preferences for the number of like neighbors, given that they represent different shares of the overall population? We re-run the first model with those specifications below – the majority race makes up 70 percent of the population and prefers to have at least 70 percent like neighbors; the minority race makes up 30 percent of the population and will move if less than 30 percent of their neighbors are of the same race:

Schelling Segregation Model (Wrapped Universe)



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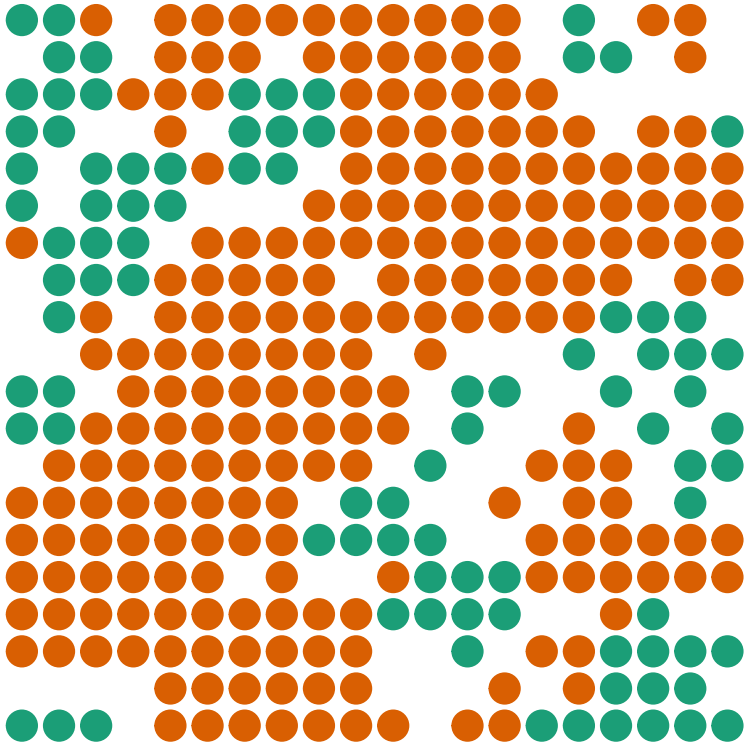
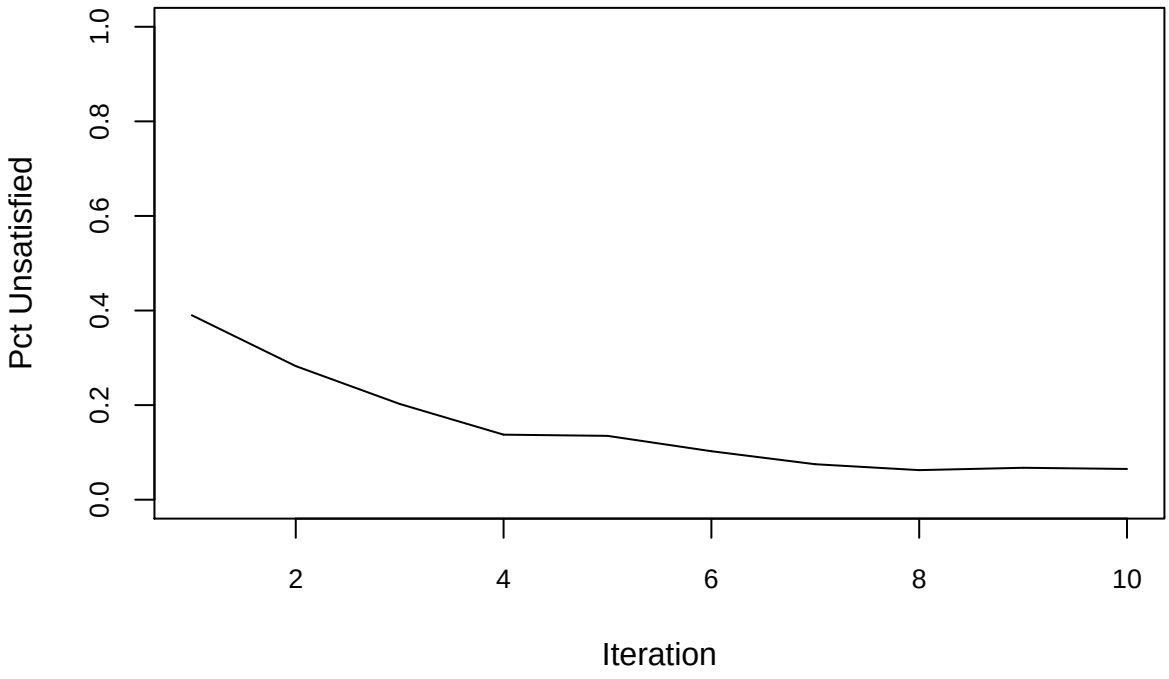
Schelling Segregation Model after 10 Iterations

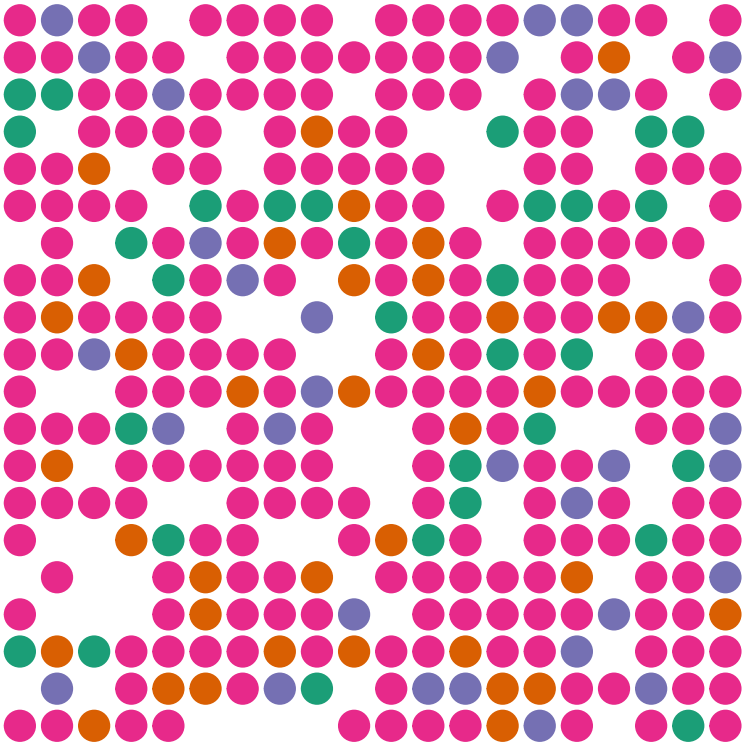


Percent of Agents Unsatisfied over Time



This changes the pattern slightly, with the percent of unsatisfied agents falling from ~40% to ~6% in ten moves. Next, we'll test what happens when we change the number of races present and keep all of the other rules stable. In this case, specifying four races, with the majority race at 70% of the population and preferring at least 70% like neighbors and three minority races that each prefer to live with at least ten percent like neighbors (effectively, minority races only need one like neighbor in order to be satisfied):

Schelling Segregation Model



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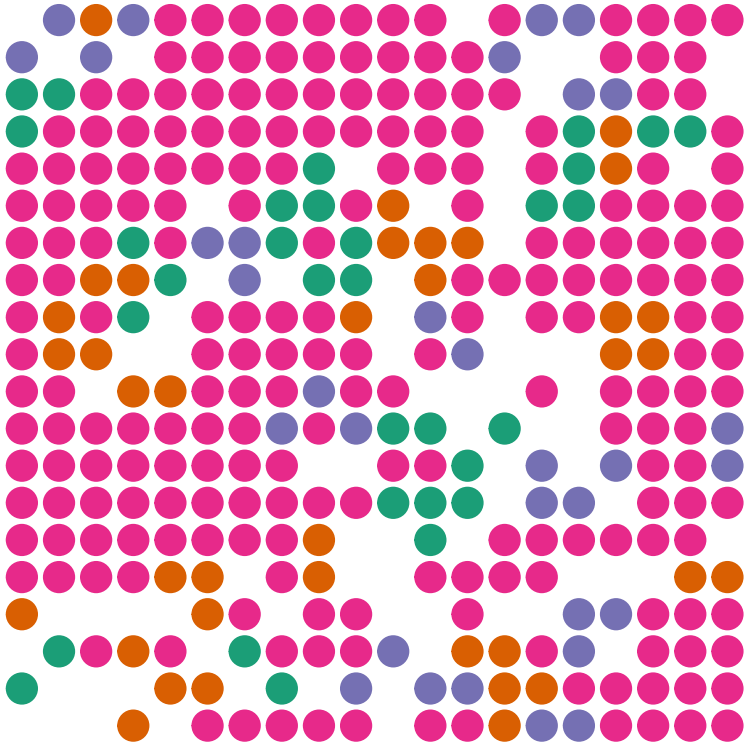
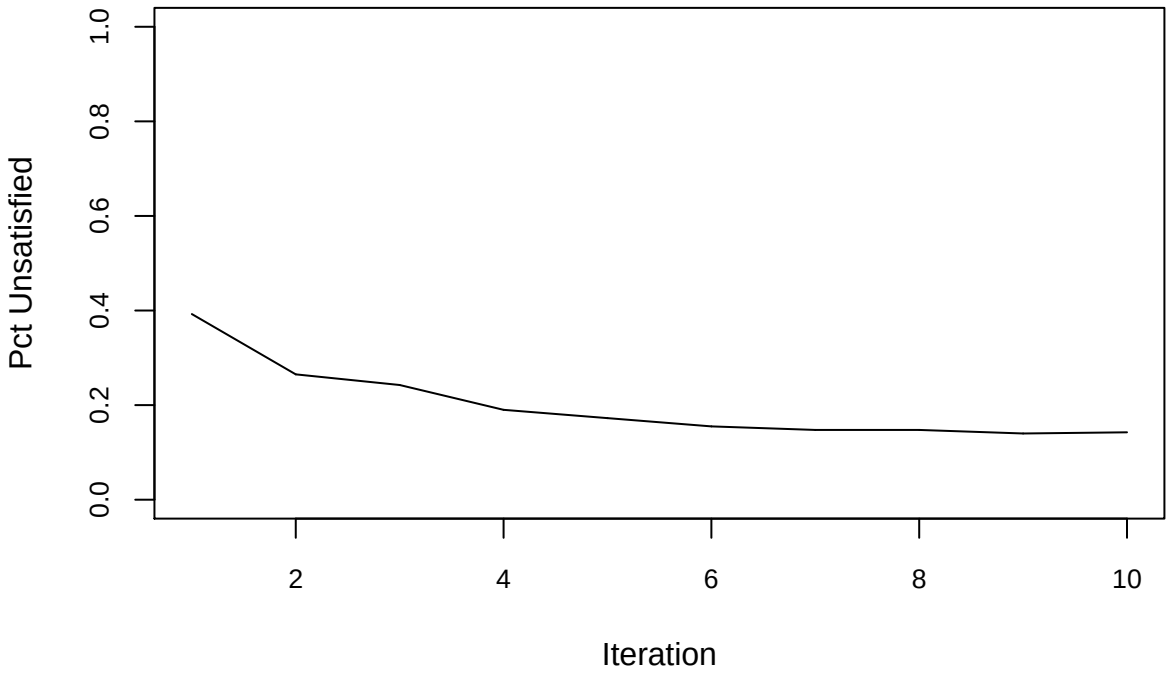
Schelling Segregation Model after 10 Iterations



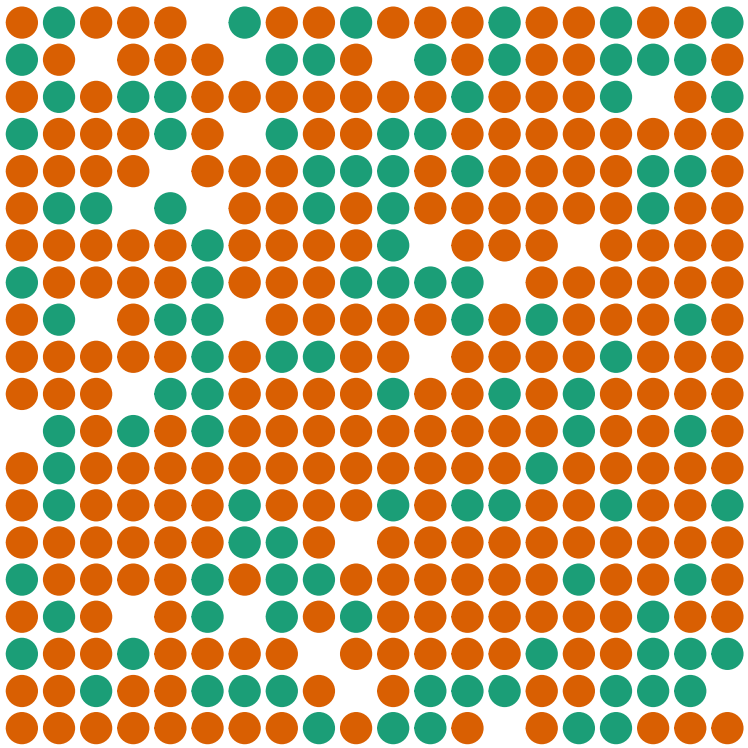
Percent of Agents Unsatisfied over Time



Here we see a slightly different pattern. The percent of unsatisfied agents falls very quickly at first, going from just under 40 percent to just over 15 percent in five iterations. However, in the following five iterations the percent unsatisfied never falls below 14 percent, having seemingly reached an equilibrium more quickly than in previous runs.

Lastly, we look at what happens when the percent of empty cells changes, specifying a run with 5 percent empty cells and a run with 35 percent empty cells:

Schelling



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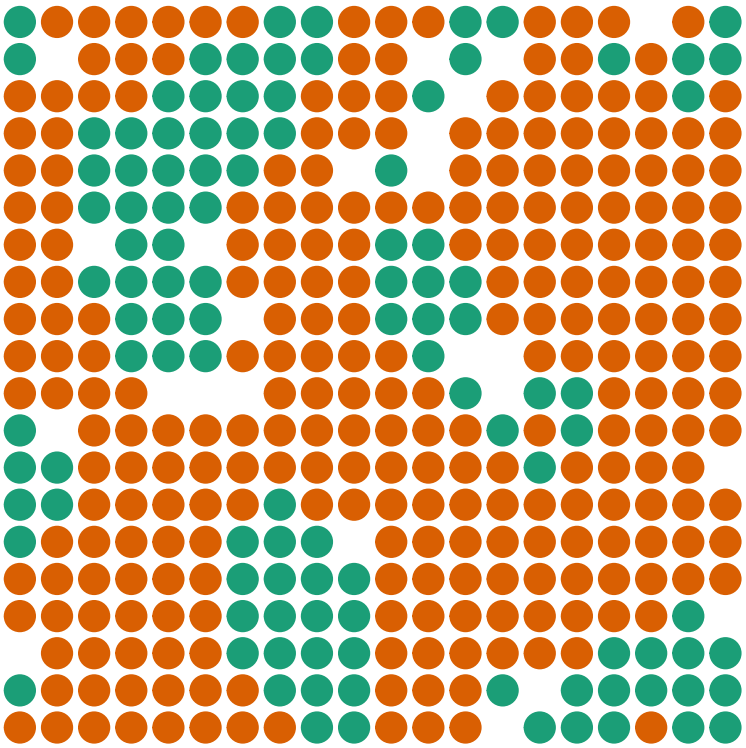
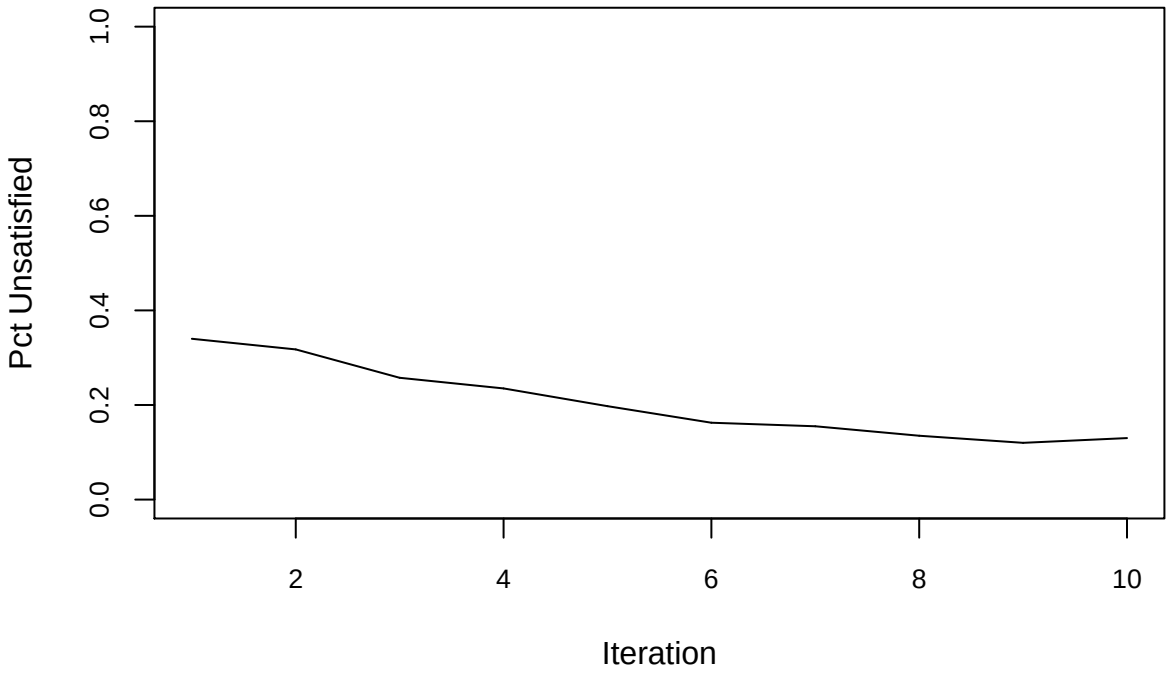
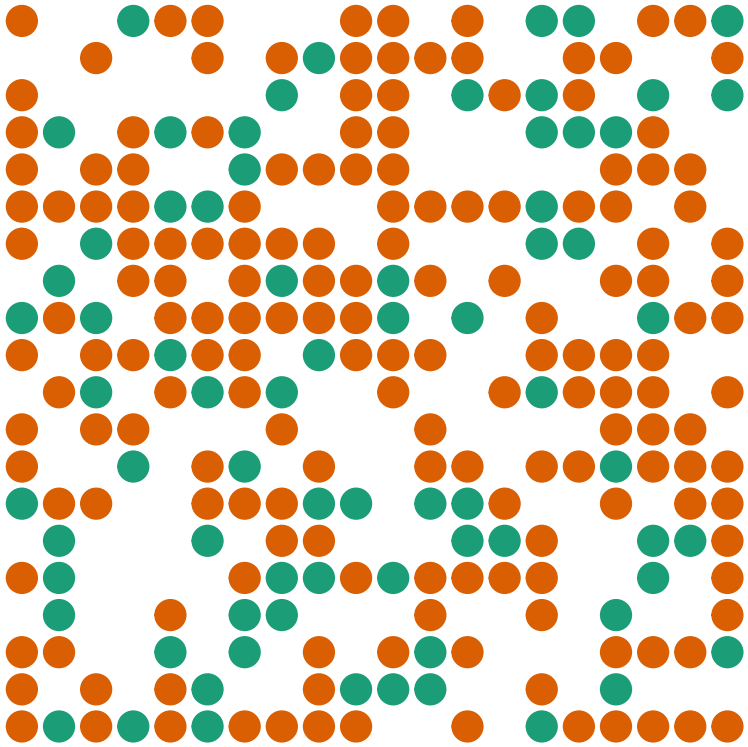
Schelling Segregation Model after 10 Iterations



Percent of Agents Unsatisfied over Time



Schelling Segregation Model



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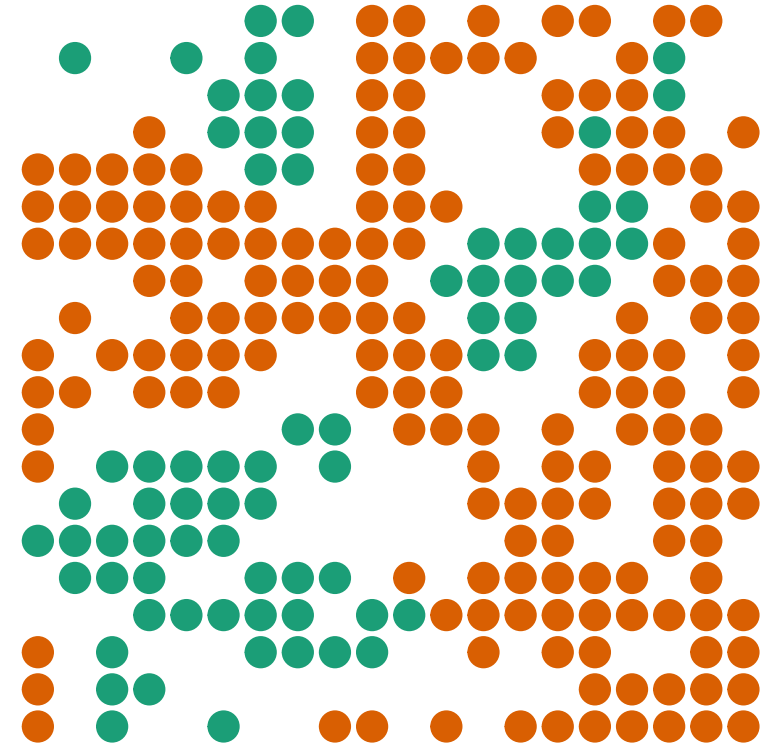

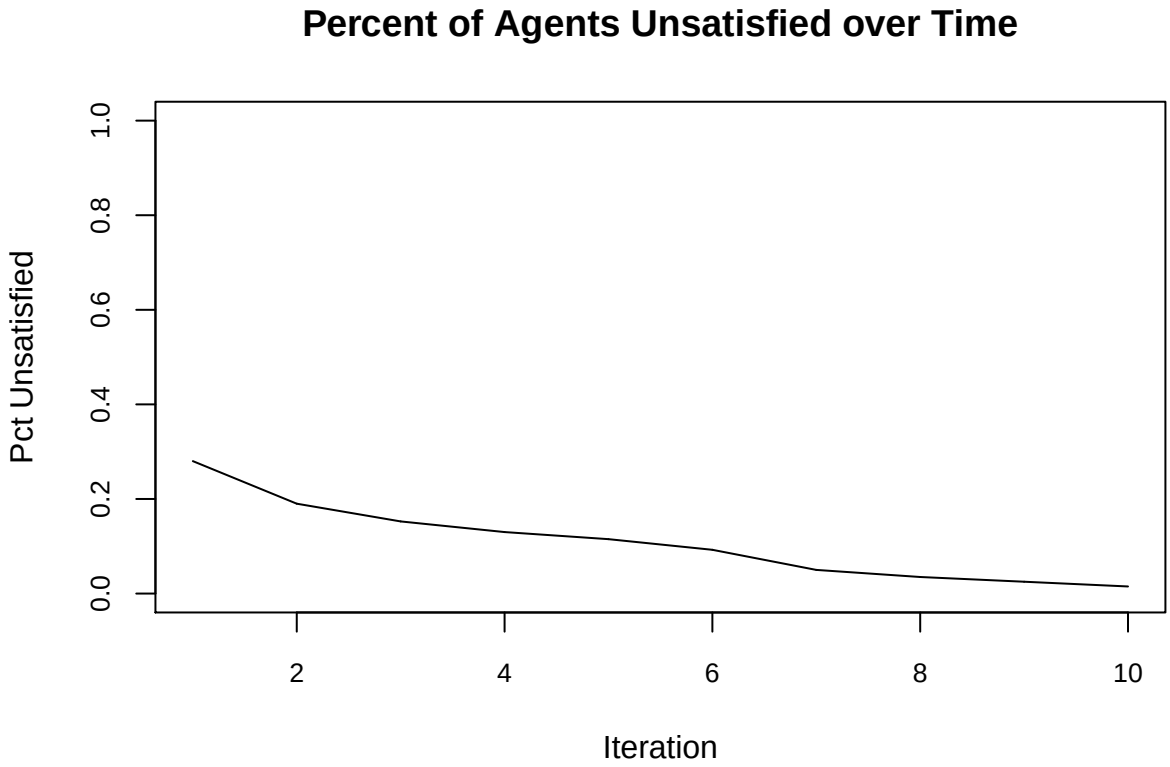

With few empty cells to move to, movement by unsatisfied agents is restricted such that they primarily move to the cells previously occupied by other unsatisfied agents, reducing the likelihood that they will find a new cell with a higher number of like neighbors. As such, the percent of unsatisfied agents in the run with no empty cells does not fall as quickly as before – going from just over 36 percent to just over 16 percent in ten

iterations and having seemingly reached an equilibrium there. On the other hand, with more empty cells, agents are less likely to encounter non-like agents when they move, and as such the percent of unsatisfied agents falls from 28 percent to just under 4 percent in ten iterations.