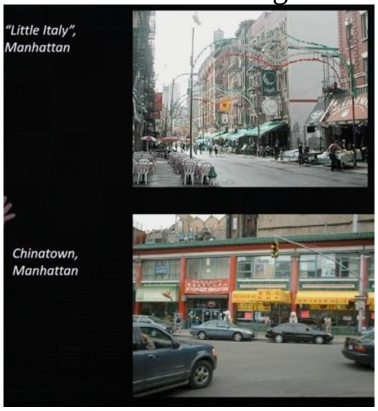
4.1 Multiple Deciding Agents (22:16)

0:00
We’re now going to move onto a different kind of topic and cognitive science, and this is, I think it's an important area of cognitive signs, but it's one that depending on what kind of approach you're hearing it, doesn't always come up in the textbooks. Often, cognitive science is modeled on an individual basis. That is, the idea is you have the lone human mind thinking about solving a problem, making a judgment, or identifying an image. What you're trying to do is get some computational insight into how that process occurs. There are different kinds of cognitive processes that don't involve the operation of a single human mind but the operation of two or more human minds making decisions in the presence of each other. In a later discussion, we're going to be talking about an area of study called Game Theory which explores many ways in which people or thinking agents can make decisions in the presence of other deciding agents. But what I want to show you today is one particular example. This is just; it's a beautiful example of just to get sort of have an object to think with that you starting to think about what happens when thinking agents are making decisions en mass. In this case, in fairly large numbers, not just two or three but fairly large numbers, and how the results of that kind of thinking can be quite interesting and worth modeling computationally in its own right.

02:04
Basically, what I'm just going to do is go through this example and ask you to think about what does example means and him and, how you could, what kind of lessons you can and can't draw from it. The example I'm going to show is one from the game theorist and economist Thomas Schelling who actually won the Nobel prize in economics some years ago, and this is from a terrific book that he wrote called “Micromotives and Macrobehavior” You'll see why a title like that is appropriate to the kinds of things in the example that we're going to be talking about because people have individual motives. The result is a kind of massive multi-person behavior that might not even be reflective of the motives of the individuals involved.

03:04
This is a very famous model Thomas Schelling came up with to illuminate the process of neighborhood formation and how neighborhoods form. And to give you an example of what I'm talking about, I grew up in Manhattan in New York, and when I was growing up downtown in Manhattan, there weren't many neighborhoods, and Manhattan is full of neighborhoods if you look at the sort of you know on a local’s guide to Manhattan you'll see descriptions of all

different kinds of neighborhoods. These two neighborhoods that I'm showing photos of here:


are famous neighborhoods in the history of Manhattan. One is called Little Italy, and it was historically the region of Manhattan where many Italian immigrants came to live.

04:07
It was an Italian primarily Italian neighborhood in, you know, in Manhattan. I think much of the clarity of these kinds of neighborhood definitions has been reduced in the time since I grew up, but you might find this area still being called little Italy. Next to little Italy is Chinatown, an area where Chinese immigrants would come to stay and live in New York. These kinds of neighborhoods served a purpose for the people coming to America. That is, they could live with or near relatives, and their neighborhoods would have restaurants, movies, and services that were reminiscent to or familiar to them from their country of origin. It was easier to get jobs and so forth, so there are many good things about neighborhoods. There are also more difficult sides of neighborhoods in a place like Manhattan. The boundaries between neighborhoods can be sources of friction where people interact and out as well as being inclusive places; they can also sometimes feel like exclusive places when somebody feels there and not welcome in this neighborhood. So a neighborhood is a complex phenomenon, it's neither a good thing nor a bad thing, but it is a human phenomenon in city formation. How do these places form? It was a weird thing when I was growing up; I don't know if this location is still there, but in between Little Italy and Chinatown, there was one block in particular I remember vividly remember; it seems where the little Italy neighborhood ended midway down this block, part of the way down the block, and Chinatown began. And when I looked at this block, it almost seems as if somebody had drawn the line like down the middle of the street where all the Italian restaurants and shops are going to be on this side, and all the Chinese restaurants and shops are going to be on this side.

06:29
And it almost looked as though an artificial boundary had and have been set up; of course, no such boundary had ever been drawn nobody. I mean, nobody ordered people to live on one side of the line or the other. The line seems to spontaneously form that's the kind of phenomenon that Schelling was interested in is how do people aggregate themselves into neighborhoods. And in the case of this particular block that I'm referring to is very vividly marked by the distinction between one neighborhood and another.

07:06

As I said, no city ordinance or anything determining that people have to live on one side of the line or the other. It seems to be something that people, in general, decided to do and live with. Schelling decided to model this computationally and true to form; when you're going to model a situation like this, you try to get insight from, if possible, the very simplest kind of model. So I'm going to show you the kind of simple model that Schelling had in mind. We begin with a model of a, let's call it a town; OK, the town is. I've drawn it as a 10 x 10 array. Think of each of the squares as a family home, OK, so I've drawn it as dark gray and light gray, but for the purposes of discussion, you can think of them as red and blue. So each cell in the grid can be red or blue or, in this case, white or unoccupied.

08:24
So looking at the 10 x 10 neighborhood town, there are 100 families in here that top row if you're looking across that top row there is a light gray family, this house is empty the second one the third one is a dark gray family the next is light gray family, and again you can think of them as red and blue. What are these red and blue standings for? Could be many things could be ethnicity could be religion could be politics could be, language. So you know, in different cities and under different situations, there are boundaries between neighborhoods that are based on those kinds of classifications. The people over here speak this language, and the people over there speak that language people over here are, you know, adherents of one religion people over here are adherents of another religion.

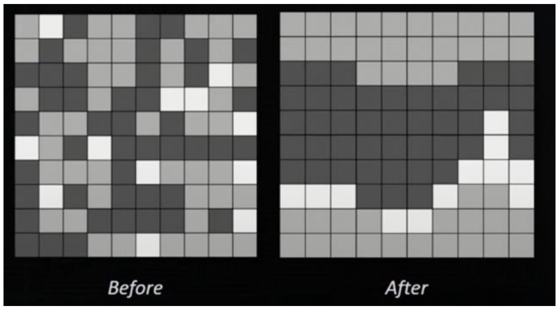
09:21
So red and blue are, in this case, just standings much as with little Italy in Chinatown they are stand-ins for some kind of marker that people used to distinguish themselves and that presumably they care about for whatever reason. OK, so that the model here is going to be the 10 x 10 city with fewer, in fact, fewer than 100 families because in this case, what I've done is I want to 3 4 5- 6- 7 8 9- 10 11 12 empty sites here, so they're 12 occupied homes and then there are 44 red families and 44 blue families. They've been arranged at random at the beginning of the little experiment. So we have a town which in principle could fit 100 families, 88 families are living there, 44 of them are red families, 44 of them are blue families, and their 12 unoccupied size 12 homes that don't have families living in them right now OK.

10:38
Now here's what we're going to say, suppose that each house, each occupant or family, if you like, has this particular preference; they're either going to be happy or unhappy in the place that they were living. And without loss of generality, let's say we're dealing with a red family, OK, so the red family will be content they'll be OK if in the eight neighbors around them, of the three at the top three at the bottom and then one on either side right. In the eight surrounding neighbors in the cardinal directions and diagonally, each red family wants to have at least four red neighbors, OK. If the red family does not have at least four red neighbors, they'll be unsatisfied. Similarly, each blue family wants to have at least four blue neighbors among the eight surrounding it; if they don't have four blue neighbors among their surroundings, they'll be unhappy.

11:54

Now one thing to know before we even go any further is that think about this now just sort of push a little bit to think about the human case of this. Neither the Reds nor the blues think of themselves as particularly bigoted here. The reds and blues are basically saying hey, look, you know I'm happy if I have four red neighbors and four blue neighbors. I'm OK with that. I just want to live in a place where there are at least four neighbors that are, you know, familiar to me, so they were not saying of themselves, “I’m bigoted,” they would just say I have this preference that at least half of my immediate neighbors are like me both reds and blues feel this way.

12:45



Now here’s the way we’re going to do this. Repeat the following procedure. Just look through that current grid and find a dissatisfied cell, a family currently unhappy with the surroundings. A red family with fewer than four red neighbors or a blue family with fewer than four blue neighbors. Find such an unhappy family and move them at random to one empty cell. Just pick an empty cell at random and pick up and move to an empty home.

13:33

That's basically it. You keep doing that – you move the dissatisfied cell to a randomly chosen empty cell, and you keep doing that until there are no more dissatisfied cells. Conceivably in some versions of this simulation, it could go on forever. In practice, in many experiments, it does not go on forever; it actually stabilizes within a relatively small number of moves. So remember, we're choosing a dissatisfied cell and moving it to a random unoccupied cell, and we just do this until, hopefully, we find there are no more dissatisfied cells. In the case of this is a simulation I ran OK - look at the left ear that's the initial situation is where people are pretty much scattered around at random, each cell wants to have four neighbors like at least four neighbors like it’ It’wouldn't be unhappy with eight neighbors like it or seven or six or five.

14:53

But it needs at least four. Both reds and blues feel this way. After a surprisingly small number of random moves to empty cells, you end up with very well-defined neighborhoods, almost like a little Italy and Chinatown. I don't know how many iterations I need to get from the left situation to the right situation, but it was in the low hundreds, maybe.

15:20

In other words, after a few hundred moves, we went from the left to the right. I should also mention that the way I set up the simulation is that we're not on a flat grid we're on a torus. So the right column is actually adjacent to the left; in other words, houses in the rightmost column are just to the left of houses in the left column. It is wrapped around this way. And houses in the top row are adjacent to homes in the bottom row.

15:57

So you can think of it as wrapped around this way too, so actually, this is a town on a torus. But if you made the situation very large, there might be other ways of dealing with the little complications that occur at the edges. In any event, you see what happens within a relatively small number of iterations - we went from a pretty randomly distributed city to a city with homogeneous and very marked neighborhoods, almost like the boundaries between the boundary between Little Italy and Chinatown.

16:33

Schelling makes the argument that these are very simple decisions that individuals are making, and if you ask them beforehand if you were to say to them beforehand, do you want to live in a city with such a homogeneous neighborhood? Wouldn't it be nice to have a little more sort of mixing between the neighborhoods? All the individuals might say yes - I want that; I'm not happy with the pure neighborhood situation on the right here. I just wanted something locally comfortable for me, but I'm not happy with the way the city turned out.

17:08

And this is the crucial point, is that there's decision making and there's decision making. We individuals here, individual families, make decisions about where they wanted to live. In the process of doing that collectively they were contributing to a kind of large-scale massive decision about the organization of the city, and it may run counter to their desires. Their local decisions made one counter to their global desires.

17:41

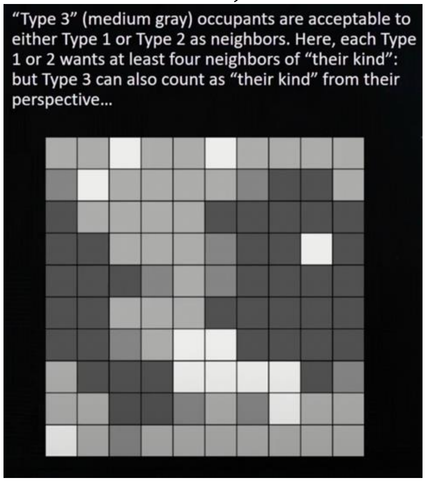
This is not the only version of the simulation you could run. For example, I took a similar random setting at the beginning and ran a bunch of steps in which each occupant wants a lot of diversity. So each occupant does not want more than four, or fewer than one occupied self sites like itself. So, in other words, reds are happy they're content if they have one, two, three, or four red neighbors, but they don't want 5, 6, or seven, and similarly with blues.

18:22

What you end up with here with our things, well, they don't get the good side of neighborhoods anymore. It just looks like a pretty spread-out sort of arrangement. So unlike the situation with little Italy and Chinatown, I don't really see any marked neighborhoods here that you know the mark of the reds from the blues, so maybe that's not the best situation either.

18:51

On the other hand, there’s still another kind of very interested we could try.



Here we have medium gray, OK. The medium gray, think of this as bilinguals if you want to think of the reds and blues is different languages, medium grays speak abut the red language and the blue language, and they count as neighbors for either red or blue an account with either red or blue is acceptable neighbors for them. Then you end up with with a modest number of bilingual or medium gray occupants; you end up with things, a city that looks like it does have neighborhoods in it, but their neighborhoods that are not quite as clearly marked as in the first case.

19:48
As I say, there may be many more variations of this. This is a simple computational model. Does it get out all the complexity of actual human decision-making? Obviously not; I mean, they're all kinds of holes in the poke in this; when people move, they don't just pick up and move it randomly move to someplace where they think they're going to be happier.

20:12
People might have conflicting desires. People might have desires to change over time. So maybe they're there you know early on when they move their content to be in a neighborhood with lots of folks like themselves but over time to get bored with that and would like to be in a neighborhood with more types of neighbors than just themselves. All kinds of variations could be played with this.

20:44
But still there are large themes to take from Schelling’s experiment which are what I want to focus on now. First again the idea of modeling cognition beyond the individual, looking at decisions to get made in the presence of other decision-makers and what happens when a group, either two people or three people or in a case like Schelling’s simulation, many people are making decisions, and they're all making decisions simultaneously and what can result from a situation like that.

21:23
Second, the idea of emergent collective behavior is a very important idea in computer science in general, where the neighborhoods, the formation of neighborhoods could be seen as what's called

an emergent phenomenon. It's a phenomenon that wasn't programmed into the situation directly; nobody had the idea of programming the simulation in order to form neighborhoods—the neighborhoods formed by virtue of the individual decision-making of the occupants of the various houses. So neighborhood formation, in this case, is what you call an emergent phenomenon. There's no place to immediately spot it in the design of the program by the design of the simulation itself. You have to run the simulation and see what kind of behavior emerges.

22:16
Finally, I'll just use this as a prelude to talking about other sorts of topics in multiple decision making, focusing on game theory.