



ACTISS

ACTION FOR COMPUTATIONAL THINKING
IN SOCIAL SCIENCES

THEMATIC COURSE

Why do ghettos form in a tolerant society?
Schelling's model and the introduction of
cellular automata

MATERIALS FOR WEEK 1

Spatial segregation and Schelling's model

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Why do ghettos form in a tolerant society? Schelling's model and the introduction of cellular automata

MATERIALS FOR WEEK 1

Authors:

Anna Baczko-Dombi, University of Warsaw

In cooperation with:

Agata Komendant-Brodowska (project leader), University of Warsaw,

Nataliia Sokolovska, The Alexander von Humboldt Institute of Internet and Society

Gabriela Grzelak, University of Warsaw

Educational expert:

Esther Arrindell, University of Groningen

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OVERVIEW OF THIS WEEK'S MATERIALS

This week we will deal with the topic of spatial segregation and learn about Thomas Schelling's segregation model.

Keywords:

Schelling's segregation model, neighbourhood, rules of change the state, dynamics, iteration, census data, segregations maps

STRUCTURE OF THIS WEEK'S MATERIALS

Welcome to Why do ghettos form in a tolerant society? Schelling's model and the introduction of cellular automata!

Get to know the educator team, introduce yourself, and learn a bit about what to expect in the course.



STEPS:

Welcome to the course! – ARTICLE

Social phenomena in spatial world

We will start by introducing some social phenomena in which space is important. It's happening with residential - or wider - spatial segregation.



STEPS:

Spatial segregation- ARTICLE

Good or bad segregation? Ghettoisation only? - ARTICLE

More about residential segregation - VIDEO

What influences spatial segregation? - DISCUSSION

Segregation maps - ARTICLE

I prefer to... ARTICLE/EXERCISE



Thomas Schelling - the father of dynamic approach to spatial segregation - ARTICLE

Lineville and linear Schelling's model introduction

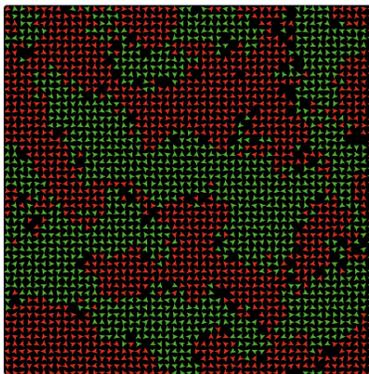
Lineville - QUIZ

Let's move - VIDEO

Let's move - QUIZ

Another starting point - VIDEO and EXERCISES

Possible modifications of the model - VIDEO



Let's make it more realistic - two-dimensional model - SET of EXERCISES

Where to go next? DISCUSSION



Wrap up of Week 1 - ARTICLE

EDUCATIONAL MATERIALS

1. Welcome to the course! – ARTICLE



Welcome to the course Why do ghettos form in a tolerant society? Schelling's model and the introduction of cellular automata.

Let's have a look on ethnic segregation maps of New York, Chicago, London or Copenhagen, or actually - most of the other big European cities. All of them are spatially segregated. We can ask ourselves several questions. Is segregation inevitable? Does it mean that people are fundamentally intolerant? How does segregation occur?

For many years the phenomenon of segregation was linked up mostly with urban studies and problems of ghettoisation, racial segregation and has rather negative connotations. However, this field is much wider and more complex and different variables can be taken into account, e.g. income, type of neighbourhood, available institutions, real estate prices etc. Currently the subject of spatial segregation is a more and more important part of the public debate.

The problem of spatial segregation with its specific mechanisms is a fascinating example of a macroscale social phenomena which is not only a simple sum of individual actions - if we compare it with answers for survey questions about level of tolerance (which base on individual declarations), they cannot be translated in an easy way into results on maps. It shows that there is a need for a tool which could help us understand the underlying

mechanisms of spatial segregation. In this module we would like to introduce a kind of agent based models that focus on dynamics of agents in a certain physical space - called spatial models, namely cellular automata. You will learn also about models from a historical perspective, and hear about Nobel Prize laureate - Thomas C. Schelling and his works. You will also see what life in the savannah, fires, gossip and segregation may have in common, and can be described by similar tools.

For that we will use examples, animations and game-like tools, but you do not require any mathematical and programming skills!

Each week of the course has a specific focus:

- **Week 1: Spatial segregation and Schelling's model**

We will start by introducing some social phenomenons in which space is important. It's happening with residential - or wider - spatial segregation. Then we will talk about one of the best known models - Thomas Schelling's model of spatial segregation and you will have a possibility to experiment a bit with it.

- **Week 2: Cellular automata**

In the second part of the materials we will look at the models in this group in more detail from the "technical and structural" point of view, you will learn what Cellular Automata is and what it has in common with forest fire and simulation of life. Then - at the end we will keep coming back to spatial segregation and we will see what the model approach can contribute to its understanding.

Each week you will learn by engaging in different activities, such as watching videos, undertaking quizzes, reading articles, doing exercises and discussing topics related to social dynamics with other learners.

What will you learn?

At the end of the course you should be able to:

- Understand a basic concept of spatial segregation
- Discuss the problem of inevitability of ghettoisation on the base of Thomas Schelling model
- Experiment with a simple spatial agent-based models by changing the properties of the existing components and propose possible expansion of the model
- Recall and understand the main terms associated Cellular Automata models and their benefits and limitations

Share with others

We are looking forward to your contributions in the comment sections. Also, consider joining us on social media to build the debate. For those of you who use Twitter, the hashtag [#FLsharedresources](#) will help you to share

ideas and experiences of the course. Don't forget to check your privacy settings before posting anything to the course hashtag, to ensure you are happy.

More on social dynamics, modelling and simulations

This course is a part of ACTiSS - an educational initiative Action for Computational Thinking in Social Sciences - if you're interested in the project, please check out our [website](#).

2. Introductions



In this step the course team is introduced and we invite you to introduce yourselves as well.

[Anna Baczko-Dombi](#), **educator**

Hi, my name is Anna Baczko-Dombi and I'm a social researcher from the University of Warsaw. I'm leading the Digital Sociology masters programme and I love translating difficult things into easy and understandable ones. In this course we designed the materials in such a way that they are accessible and understandable. I hope you will experience that modelling and simulations are fun and much easier than they might sound.

[Agata Komendant-Brodowska](#), **sociologist, ACTISS project leader**

Hi, my name is Agata Komendant-Brodowska, I'm a sociologist at the University of Warsaw and I'm passionate about using models and simulations in order to understand social processes. I love the way even simple models can help illuminate some important issues related to what happens in our society. I'm leading the project "[Action for Computational Thinking in Social Sciences](#)" and we created this course as a part of this project.

ACTISS team

[Katarzyna Abramczuk](#), **educator**

Hi, I'm a social scientist working at the University of Warsaw. I enjoy understanding what is happening and how. Hence my interest in formal modelling. Also, I do research on Human-Technology Interaction.

[Wander Jager](#), **educator**

Wander Jager (1962) is a social scientist with a broad interdisciplinary interest in social complex phenomena and transition to a sustainable society. Over the last 25 years he has been working on social simulation projects addressing the dynamics of opinions, the societal processes of acculturation related to migration, the diffusion of sustainable products and practices, on littering and cleaning strategies, crowd behaviour, team performance, and social innovation in communities, to mention a few examples.

[Tom Spits](#), **online learning designer**

Tom Spits is online learning design specialist and video-in-education expert at University of Groningen. He specialises in designing Massive Open Online Courses and has co-created all of [University of Groningen's FutureLearn courses](#) since 2014.

[Esther Arindell](#), **online learning designer**

Esther Arindell is online learning design specialist at University of Groningen. She supports designing Massive Open Online Courses.

[Nataliia Sokolovska](#), **technical project manager.**

Hi, my name is Nataliia and I'm a researcher and project manager at the Alexander von Humboldt Institute for Internet and Society in Berlin, where we study digitalisation of society. I'm passionate about finding ways how to connect the world of academic research with societal needs with the help of using digital tools. In the project **Action for Computational Thinking in Social Sciences**, I developed and implemented strategies for transforming analog study materials into an online course.

ACTISS

This course is a part of ACTiSS - an educational initiative Action for Computational Thinking in Social Sciences, co-funded by Erasmus+. It's aim is to develop engaging and accessible online courses introducing the basics of computational social sciences. The project is carried out by a team of simulation, modelling and open education enthusiasts from three partner institutions: University of Warsaw (leader), University of Groningen and The Alexander von Humboldt Institute for Internet and Society. The project is funded by Erasmus+ KA2: Strategic Partnership in the Field of Higher Education. If you'd like to know more, please check out our [website](#). We also

encourage you to check out our other courses: [Introductory course on modelling and simulations](#), [Social Network Analysis course](#) and an upcoming course on decision-making.

University of Warsaw

University of Warsaw is the leading research university and the largest higher education institution in Poland, with a comprehensive portfolio of research and teaching activities.

University of Groningen

The University of Groningen is a research university with a global outlook, deeply rooted in Groningen, in the north of the Netherlands.

HIIG

The Alexander von Humboldt Institute for Internet and Society from Berlin is exploring digitalisation together with economic, political and civil society stakeholders.

Over to you

So, now you know who we are and what you can expect from us. Maybe you would want to introduce yourself in the discussion section on this page. Please use a few sentences on who you are and why you have joined this course. Also have a look at what other learners posted and start learning together.

3. Spatial segregation- ARTICLE



source: <https://sheribyrnehaber.medium.com/accessibility-separate-but-equal-is-never-ok-e6e97d893d11>

When discussing the issue of segregation, it is worth taking some definitions as a starting point. First, let us start with the very notion of segregation.

We can talk about spatial segregation when we have to do with heterogeneous segregation due to some feature or features of a group occupying a certain limited designated area. Segregation is understood here as actual spatial separation of subgroups distinguished due to these features.

Think about two terms - space and segregation. If we combine them we will get SPATIAL SEGREGATION - segregation of some elements which are divided on the basis of some features in space. It can happen with different objects - alive or not. We segregate our clothes in a wardrobe (dresses on the left, trousers on the right, multi-colored socks in the lower drawer, dark ones in the higher one). Chess are segregated on the chessboard.

In early spring the ducks swim in pairs on the pond. Some time later, all drakes are sitting together on the shore and their mates - ducks are swimming separately with the ducklings. Kids in schools are segregated by

age - younger usually occupy rooms on the lower floors of the school building, older on the higher floors). They can be segregated also by gender - do you remember those times when girls wanted to sit with girls only? Or maybe in your school - due to the teacher's decision - those more disturbing pupils were sitting in the front desks so that he could keep an eye on them?

All those situations have in common space, objects that can be divided in some group and the fact of segregation in space. Of course they are different in many ways - apart from obvious types of objects or being above or not, very important is a source of segregation - in some cases it happens top-down, and in some bottom-up.

From the point of view of sociologists, very important and quite well investigated is **residential segregation**. In the next steps you will learn more about it.

4. Good or bad segregation? Ghettoisation only? - ARTICLE

In some cases we can say that segregation is in some way beneficial to segregated objects, in others it is indifferent, in others it definitely raises problems

There are key features of segregation, including its spatial dimension. In sociology, this definition is, on the one hand, narrower (concerns only people) and, on the other hand, broader (not limited only to the spatial dimension). We are concerned with the typically social character of the concept. However, it is necessary to take into account the spatial aspect. The word "segregation" has generally negative connotations. As Ceri Peach writes, "segregation has a bad name" (Peach 1996, p. 379). It is associated (negatively) with past or current policies of separation and discrimination of certain ethnic groups in some countries. The examples are the apartheid policy in South Africa or racial discrimination in the United States. As a result, very often the problem of spatial segregation is reduced to racial segregation in urban areas. This is a certain simplification or even misuse. It is related, it seems, to the history of interest in this topic in sociology - indeed, many analyses of spatial segregation have been concerned with American cities and the current problem of racism existing in them. In addition to such "bad segregation" associated with ghettos and negative social consequences, there is also "good segregation," which allows for the development of solidarity, strengthening bonds by creating, for example, ethnic villages. For these reasons the term segregation is sometimes replaced by separation. On the one hand it is devoid of negative connotations, on the other hand it seems to be less precise. It assumes a complete division, demarcation, without the possibility of a certain degree of mixing. In the literature these terms are actually used interchangeably.

According to this definition, spatial segregation takes place not only in cities, where white and black districts are created, but also in classrooms, where students form subgroups "sticking together" based on gender (do

you remember that time when girls wanted to sit with girls only?) You can come up with any number of such examples.

It is worth taking an interest in the reasons why segregation occurs. First of all, we should distinguish "top-down" cases in which, due to conscious actions of superior forces (e.g. city authorities), certain groups of people are assigned to certain living areas. An example can be the policy of apartheid in South Africa, where in accordance with the Collective Space Act of 1950, individual races were assigned separate residential zones. Such cases will not be dealt with in detail here because we are interested primarily in the process that is the phenomena of segregation. However, institutional factors may play a significant role in inducing segregation. Another issue is the negative exclusion of a group of individuals associated with segregation. This seems to be another myth worth debunking. Segregation does not need to be the concept opposite to integration. These processes can coexist or even be complementary.

In a word, by "segregating themselves", individuals do not have to lose. It is worth looking at another pair of seemingly contradictory concepts - segregation and aggregation. In order to achieve the result of segregation, aggregation of individuals is necessary. It is necessary to replace dispersion with concentration. So, again: segregation and aggregation are inseparable.

Spatial differentiation of society is the result of many complex processes. They are influenced by economic, political, social as well as cultural situations. Good example is relation about place about place of residence, work and family situation - when a family is looking for a new flat, they will think about schools and kindergartens in the surrounding, distance from work, shops, price of the flat, how close the rest of family lives and - also - kind of willingness to be "among your own".

5. More about residential segregation - VIDEO



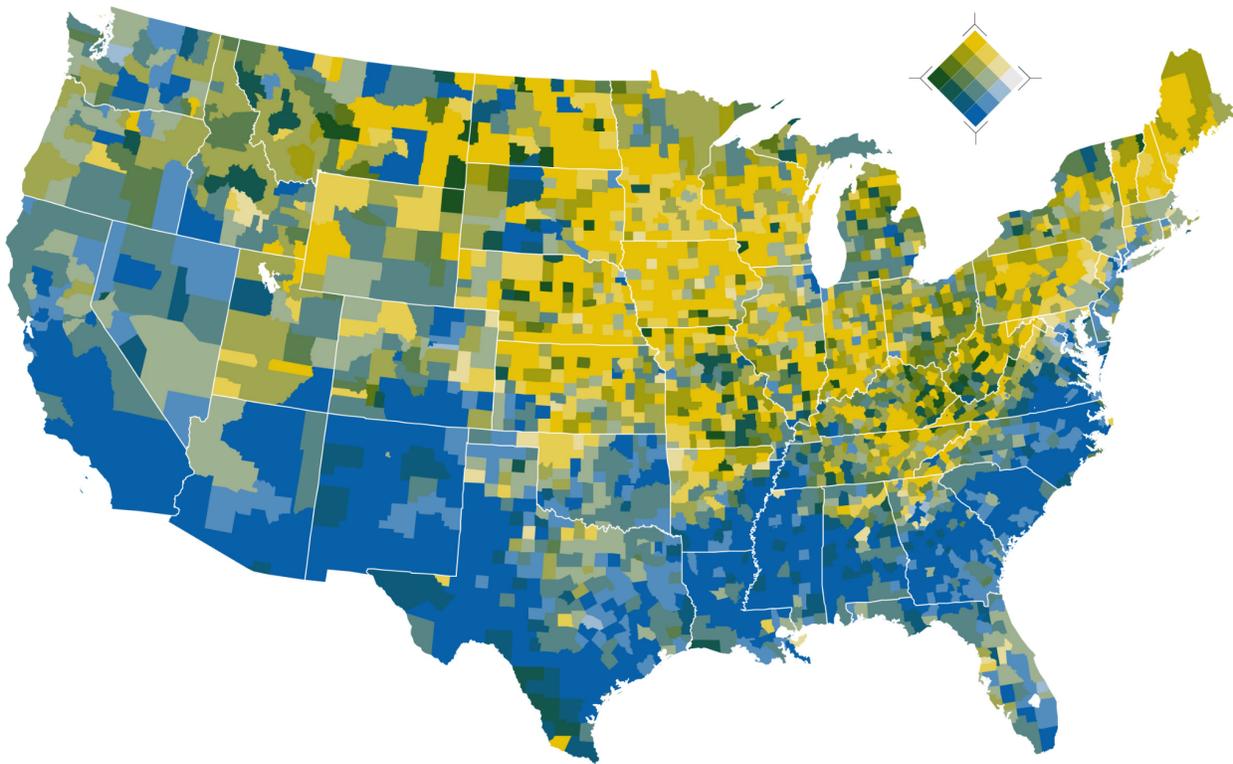
To organize the main concepts of segregation, watch the movie, watch a short lecture on residential segregation.

6. What influences spatial segregation? - DISCUSSION



In the video you heard about two variables which are important in the case of residential segregation: race and income. Think about your place of leaving. Are there other variables which could work here?

7. Segregation maps - ARTICLE



source: www.washingtonpost.com

One of the ways to study spatial segregation is through the so-called studies of existing state, where maps are created from data collected during e.g. censuses, and marked on maps. Read an article and make a short exercise (STEP 8)



8. Segregation maps - EXERCISE/INVESTIGATE

Take a look at the entire map of the United States and the three cities (you can select in "your city")

- Chicago
- New York
- Detroit (type in: 8 Mile Road, Detroit)

What type of segregation can you observe? Are those cities diversified?

9. I prefer to... ARTICLE/EXERCISE



source: <https://unsplash.com/photos/BEyAo16QOAo>

Even in the early days of interest in segregation, studies were conducted on the subject. Here it is difficult to point to one particular method recommended for studying segregation. On the other hand, it is possible to study the effects of segregation processes - let's call this stream "studies of existing state" - you could see results of such studies during the exercise with segregation maps of USA cities.

There are also some studies in which people are asked about their opinions about preferred neighborhoods and places of residence. Another way to study phenomena related to segregation is to ask people about their so-called neighborhood preferences. Such questions are asked, among others, in the World Value Study.

DATA

<http://www.worldvaluessurvey.org/WVSONline.jsp>

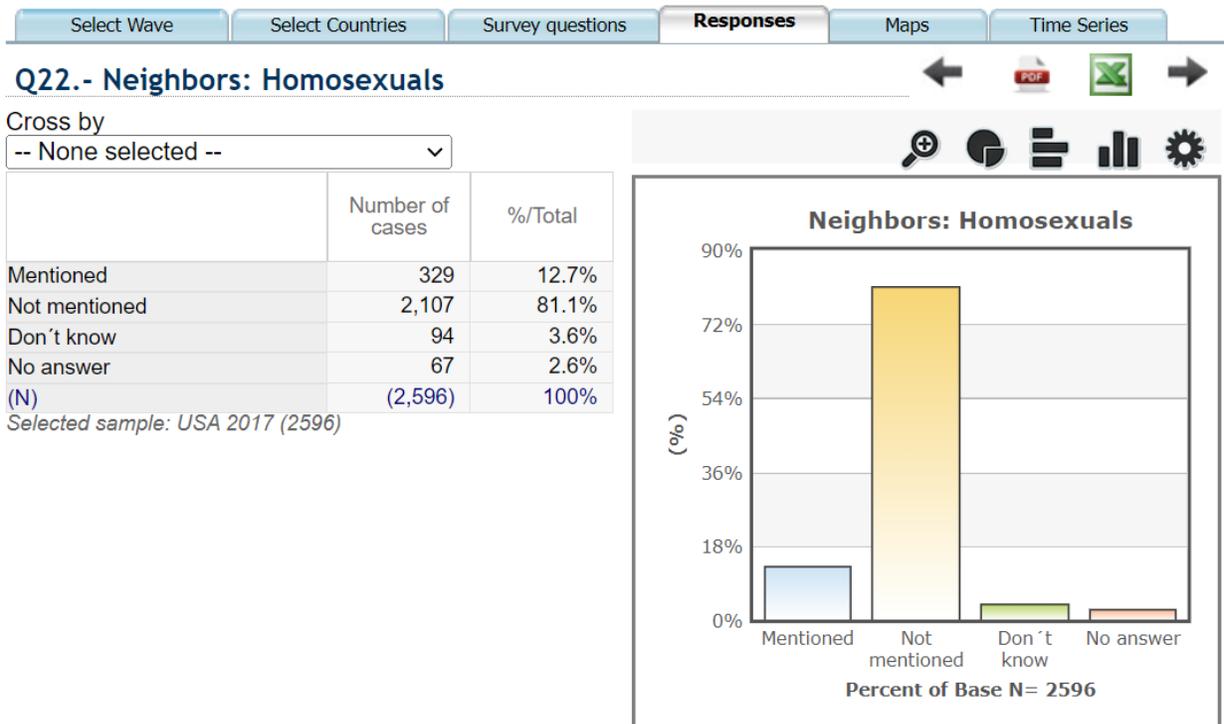
One is asked there the following: "On this list are various groups of people. Could you please mention any that you would not like to have as neighbors?" For the USA, 5.6% of respondents answered "people of different race".

How does this relate to the segregation map effect?

An optional task - take a closer look at this data (maybe not only for the USA?), using a search engine --

<http://www.worldvaluessurvey.org/WVSOnline.jsp>. Look for the variables V36-V44.

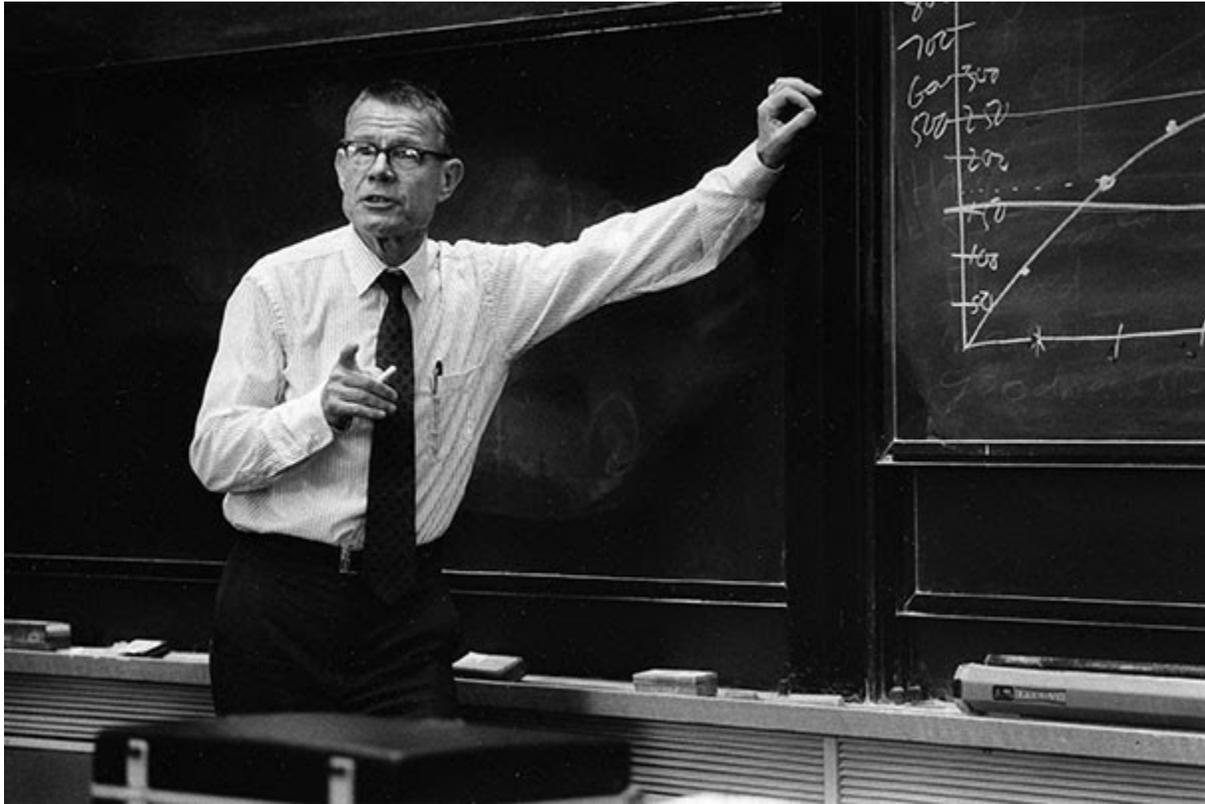
World Values Survey Wave 7: 2017-2020



Source: World Values Survey, Data for USA, 2017, Question: On this list are various groups of people. Could you please mention any that you would not like to have as neighbors? - Homosexuals

These two approaches touch on two different sides of the segregation process. In the first case, we look for motives in people's views that may lead to later or already existing separation. The second is to study the effects of segregation and, based on these, to look for its causes. The basic weakness of these classical methodological approaches is the inability to show the dynamics of the phenomenon. Therefore here we will propose a solution that allows for description of the process of segregation itself - a dynamic approach.

10. Thomas Schelling - the father of dynamic approach to spatial segregation - ARTICLE



Thomas Schelling in Harvard

Source: <https://ichi.pro/>, author: Martha Steward

Thomas Schelling was an economist; he was awarded the Nobel Prize in Economics in 2005, but his interests and achievements go far beyond that field. He should rather be counted among the representatives of the broadly understood social sciences. In the 1970's Schelling became interested in how the behaviour of individuals translates

in an unintended and non-obvious way into outcomes at the social level and what the possibilities of modelling such phenomena are. He is the author of a model commonly known as "Schelling's model of spatial segregation", which in its first version Schelling called "Self-Forming Neighborhood Model" (Schelling, 1969). For Thomas Schelling, the model was based on his observations of processes of separation of human populations. In constructing his model, Schelling chose one dimension of segregation: spatial segregation due to a dichotomous variable corresponding to race. This choice seems quite obvious given the time and place in which the model was constructed. In the United States of America in the 1960's and early 1970's, the issue of race was an important one. The problem of racism was very clear and present in the public discourse. It is enough to recall that in 1968 Martin Luther King was assassinated for his activities. Thus, Schelling's model illustrated the problems that were current at the time. The author explained the need to create such a model by observing that after looking at the demographic map of any American metropolis, it will turn out that it is very easy to find neighbourhoods or smaller areas inhabited almost exclusively by blacks or whites. At the same time, it is very difficult to find neighbourhoods that are clearly "mixed," such as those where African-Americans make up 75% of the population. Even when such integration does occur, it is very short-lived (Schelling, 1969, p. 488). The relationships observed are not only in residential areas, but also in churches, sports teams or schools. Thus, the trends mentioned above apply also on a smaller scale.

The first, one-dimensional version of Schelling's model was presented in the article "Models of segregation" published in 1969 in The American Economic Review. Then the model was further developed in a 1971 publication entitled "Dynamic Models of Segregation" in the Journal of Mathematical Sociology. The conclusions of these articles were summarised in the 1978 book "Micromotives and Macrobehavior". Schelling's most important message is the inevitability of segregation - even with high levels of tolerance, a system tends to form homogeneous clusters.

What is remarkable about Schelling's study of spatial segregation? Well, as he himself writes, he unwittingly became a precursor to the application of multi-agent dynamic models for analysing social processes. Although in his works he does not mention terms typical for this approach at all, such as cellular automaton, attractors or emergence, and the first simulations (for a one-dimensional model) were conducted by Schelling on coins placed on a piece of paper, at the same time, his works fit well with contemporary papers describing the results of computer simulations. Schelling's model has been analysed and developed many times since the 1970s.

CONCLUSIONS:

- **Pioneer use of agent models for description of social phenomena**
- **Impact of micro-level behavior on patterns emerging at the macro level. This relationship does not have to be explicit or direct.**
- **Even a relatively high level of tolerance results in segregation**

11. Lineville and linear Schelling's model introduction



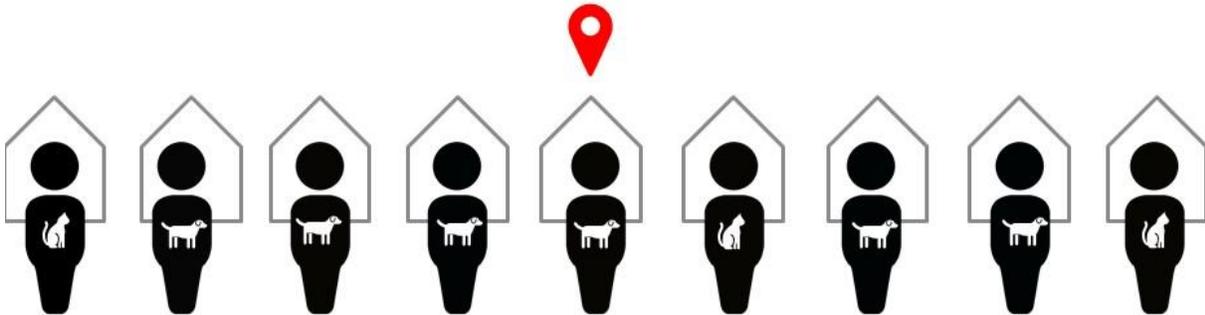
In the next steps I want to introduce you to the basic concept of Schelling's most famous model - spatial segregation model. We will start from a very simple situation - Lineville village, which has a linear shape. In the next three videos we will go through the whole process of spatial segregation and in the fourth video you will be introduced with possible modifications of the model.

12. Welcome to Lineville - VIDEO



13. Lineville - QUIZ

a)



There is also one more important division between Linevillers, so strong that they can even forget about their favorite volleyball team. Some of Libevillers prefer cats, the other ones - dogs. The definition of the neighbourhood will be the same as in the video. Tolerance level is 50 %. What can we say about dog-person sign on the picture?

1. He will be unhappy, because he needs minimum 3 cat-people in his neighborhood
2. **He will be happy, because he needs minimum 2 dog-people ($\frac{1}{2}$ of his neighbours)**
3. **He will be happy, because he can stand maximum two cat-person ($\frac{1}{2}$ of his neighbours)**
4. He will be unhappy, because he needs exactly 2 dog-people and 2 cat-people in his neighbourhood.

b)



There is also one more important division between Linevillers, so strong that they can even forget about their favorite volleyball team. Some of Libevillers prefer cats, the other ones - dogs. The definition of the neighbourhood will be the same as in the video. Tolerance level is 25 %. What can we say about dog-person sign on the picture?

1. He will be unhappy, because he needs minimum 2 dog-people in his neighborhood
2. He will be happy, because he needs minimum one cat-person to make him happy
3. **He will be happy, because he can stand maximum one cat-person (1/4 of his neighbours)**
4. He will be unhappy, because he can stand maximum one dog-person (1/4 of his neighbours)

c)



There is also one more important division between Linevillers, so strong that they can even forget about their favorite volleyball team. Some of Libevillers prefer cats, the other ones - dogs. The neighbourhood is thinner - 1 neighbour on the left and 1 on the right. Tolerance level is 0 %. What can we say about dog-person sign on the picture?

5. **He will be unhappy, because he cannot stand any cat-person in his neighbourhood**
6. He will be unhappy, because he needs 2 cat-people in his neighbourhood
7. **He will be unhappy, because he needs 100% dog-people in his neighbourhood**
8. He will be unhappy, because he need exactly 4 dogs in his neighbourhood.

14. Let's move - VIDEO



15. Let's move - QUIZ

There is also one more important division between Linevillers, so strong that they can even forget about their favorite volleyball team. Some of Linevillers prefer cats, the other ones - dogs. The definition of the neighborhood will be the same as in the video. Tolerance level is 50 %. Unhappy ones will be looking for a new location in XX way: looking for the first happy place, counting from the left to the right (like in the video). Where the cat-person signed on the picture should move?

a) **To place a)**

- b) To place b)
- c) To place c)
- d) Nowhere, she is happy now.

16. Another starting point - VIDEO and EXERCISES



Please watch a video. Try to answer questions asked during the video. If you need more time you can stop a video for a moment and then watch further and see if you were right.

17. Possible modifications of the model - VIDEO



18. Possible modifications of the model - DISCUSSION

If you were developing the model, what would you add first?

19. Let's make it more realistic - two-dimensional model - EXERCISE

In this exercise, you will experiment with the number and preferences of neighbors-turtles, and observe the impact on the neighborhood.

This basic model allows users to play around with two parameters: The NUMBER slider controls the total number of turtles. (It takes effect the next time you click SETUP.) The %-SIMILAR-WANTED slider controls the percentage of same-color turtles that each turtle wants among its neighbors. For example, if the slider is set at 30, each green turtle wants at least 30% of its neighbors to be green turtles. Turtles are “moving” (changing location every time they are unhappy).

At each timestep or tick, you can experiment with how the number of turtles affects the neighborhood.

Setting up

To start the experiment click on [LINK](#).

Mode: Interactive Commands and Code: Bottom

model speed
ticks: 17

number 2500

%-similar-wanted 64 %

Percent Similar

Percent Unhappy

Percent Similar

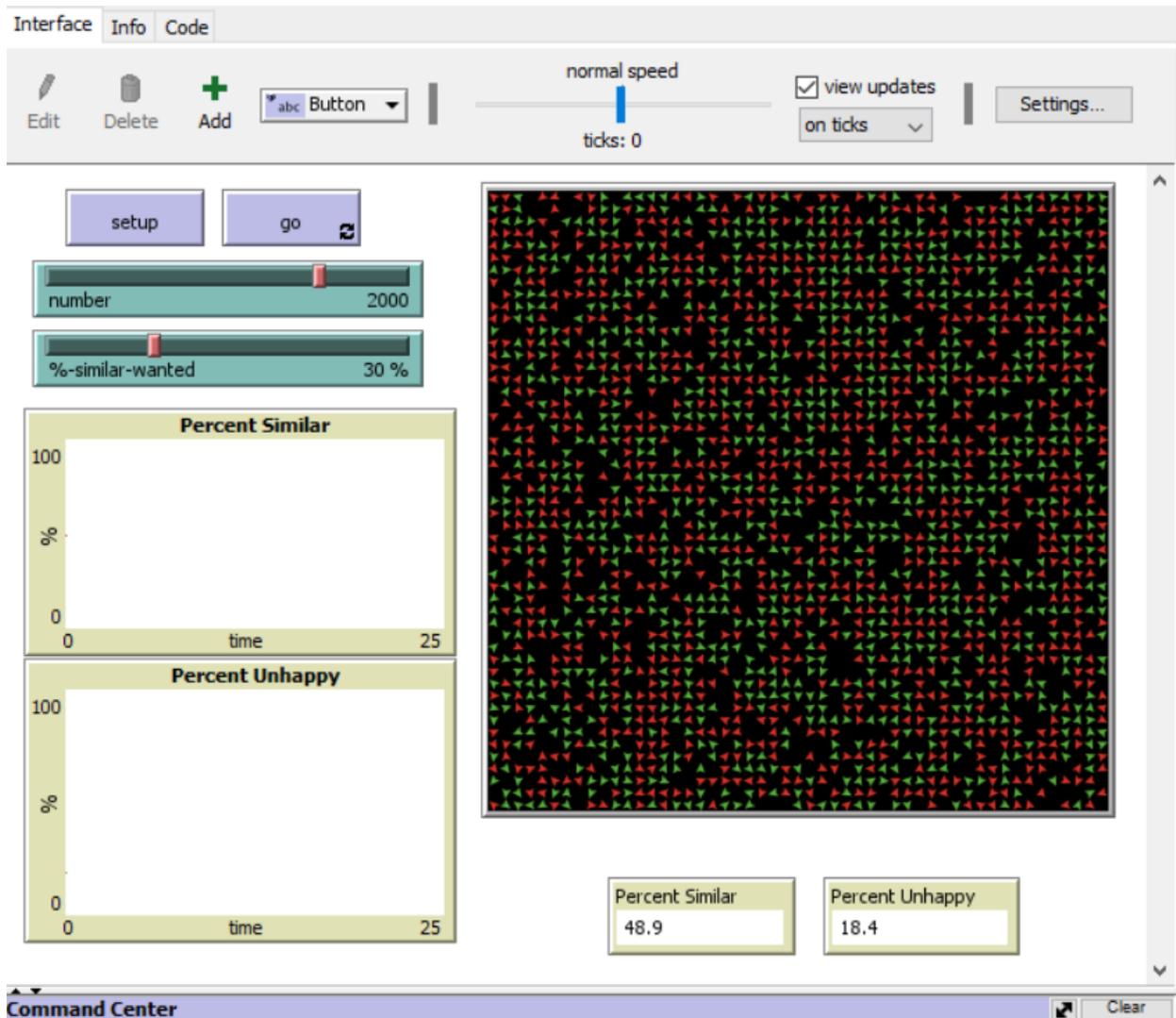
81.8

Percent Unhappy

23.3

The layout of the online version of the Segregation Simple model

Alternatively, you can also download the [Segregation Simple model](#). For this, go to the online model, click on **export netlogo**, and store the file **Segregation Simple.nlogo**. If you have not done so, you can download [Netlogo](#). Next, open your netlogo, go to “file”, “open” and find the “Segregation Simple.nlogo” in the folder where you saved it.



The layout of the download version of the Segregation Simple model

What do you see?

Launching the model shows you an empty model that needs filling first. Press 'Setup' to do that.

The model shows you the virtual population of 2000 turtles. This number can be changed by using the slider on the left side of the model. The number of **turtles** can be anything from 500 to 2500.

Clicking on **go** will show a one-time step, clicking on **go** with a mouse wheel will run the model continuously. (to stop the run, click this button twice) You can observe how the position of turtles changes. As an overall measure, the graph shows the happiness and unhappiness of population over time. The simulation stops once all the turtles are happy and have no reason to move (or doesn't stop at all if even one turtle is unhappy).

Things to explore

Starting with the basic setup, the model shows you how the turtle population moves and stabilizes under the default condition. Run this default setting of the simulation model multiple times by clicking on **go** repeatedly, and observe the stability of the outcomes. **What do you see happening with the turtle neighborhood?**

We encourage you to experiment with different settings of turtle and their % of similar wanted turtles around. What do you observe when you add or remove turtles? What happens when you change %-similar-wanted? What are the implications in terms of settling, do you think? Can you make a rough estimate when it the turtles cannot stabilize? Please share with other learners.

If you want to practice a little more, [here](#) is an additional model, that we recommend!

Can you help neighbours? :)

Go through the material under the [link](#).

20. Where to go next? *DISCUSSION*

What are your thoughts about the model? What is constructive criticism? What - in your opinion - Schelling missed? What would you add to the model?

21. Wrap up of Week 1 - ARTICLE



Spatial segregation and chess-like models

© Flicker

Well done, you have completed the first week of the course. We hope you enjoyed learning with us so far.

We started from the problem of spatial segregation. You learned that we can observe it on segregation maps, but also ask some questions about people's preferences. We took note of the preferences and the actually observed phenomena tend to be divergent. One way to deal with this is to observe dynamics with models. Then we met the main character of this course - Nobel Prize winner Thomas Schelling, the author of the famous model of segregation. Then, with him, we moved to Lineville and watched step by step how - with a relatively high level of tolerance - segregation occurs. The next step was your own play with a slightly more advanced model and thinking about bringing it closer to reality. In the next week, you'll learn more about models in the same genre as the Schelling model - an entire branch of models called cellular automata and what segregation might have to do with forest fires and gossip.