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Agent-Based Modelling

Computational Social Science
Workshop 9

Outline

Work with a simple NetLogo model

- Conformity with majority vote

Exercises

- Understand the existing model
- Experiment with the model
- Extend the model

Understand the model

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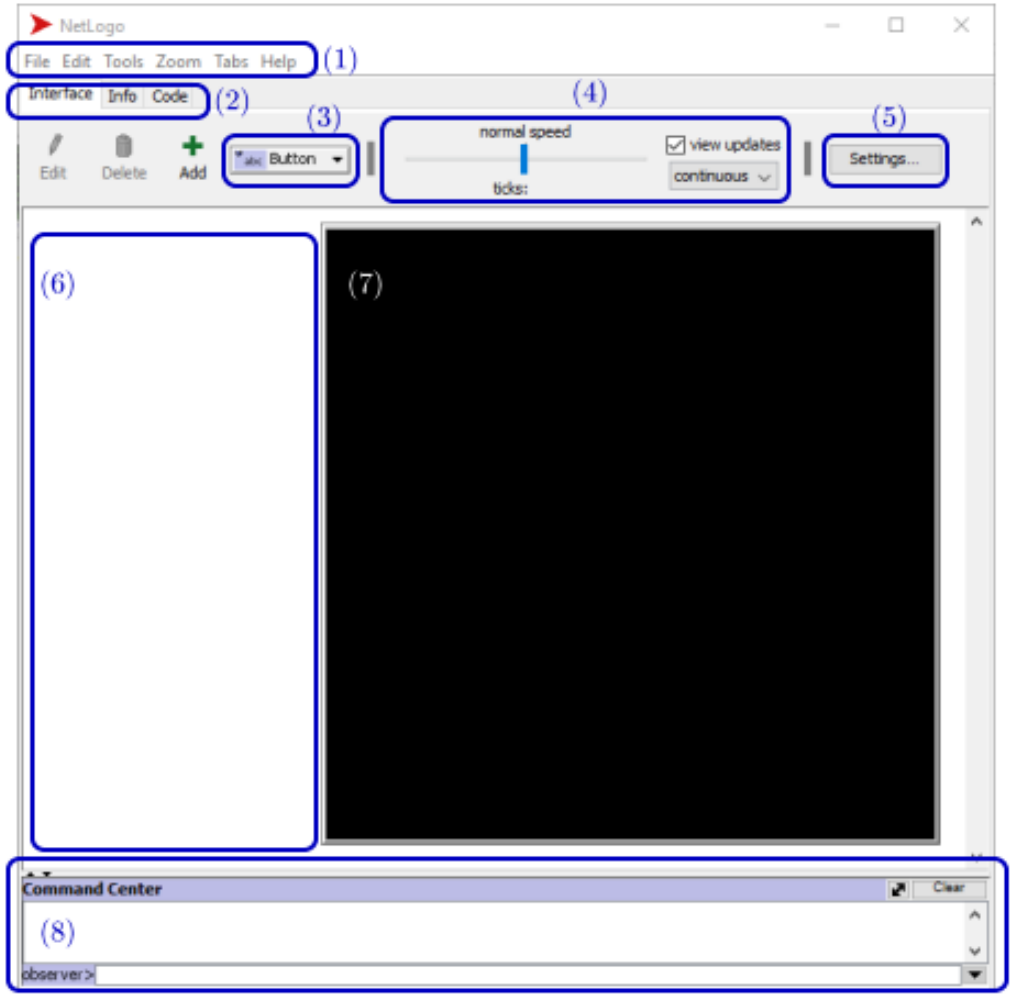
NetLogo orientation



1. Menu
2. Tabs for Interface, Info, Code view
3. Adds widgets to interface
4. Speed slider, update controls
5. Settings for world display
6. Screen area for widgets
7. World, main view of model
8. Command Center – for interactive code entry and results

NetLogo entities

Patches have fixed locations

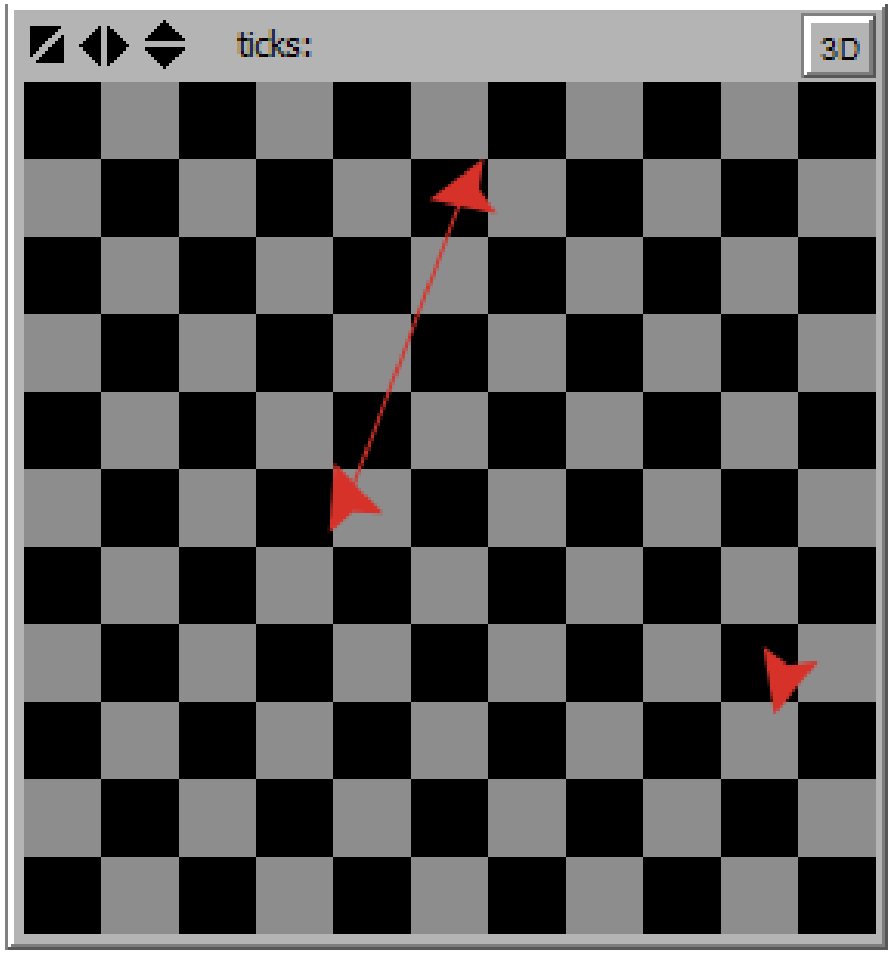
- Black/grey in image
- Typically used for physical environment
- Provide coordinate system for turtle locations

Turtles make decisions

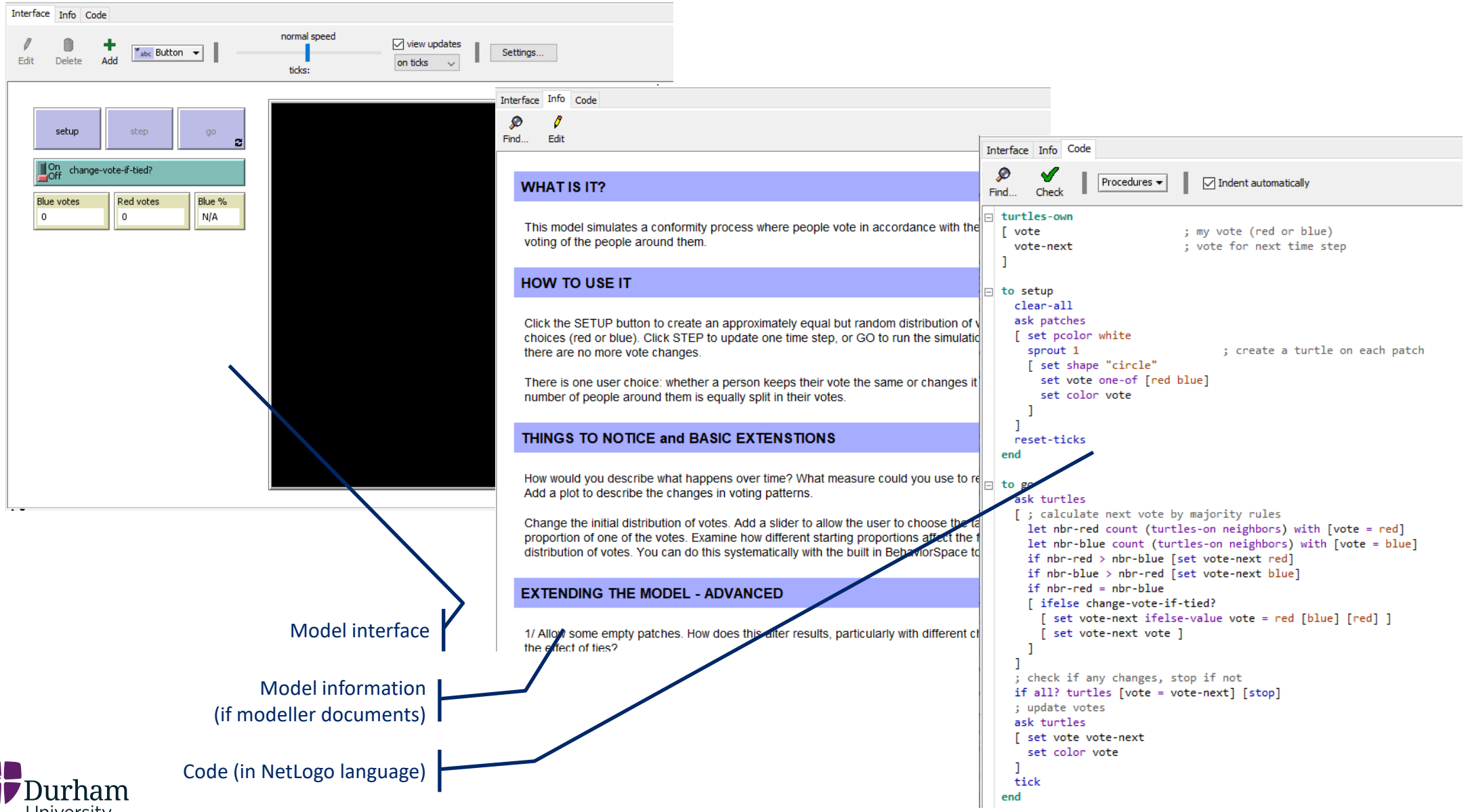
- Red darts in image
- Are mobile
- Spatially aware

Links describe relationships between turtles

- Red line in image



Open Conformity model



Model interface

Model information
(if modeller documents)

Code (in NetLogo language)

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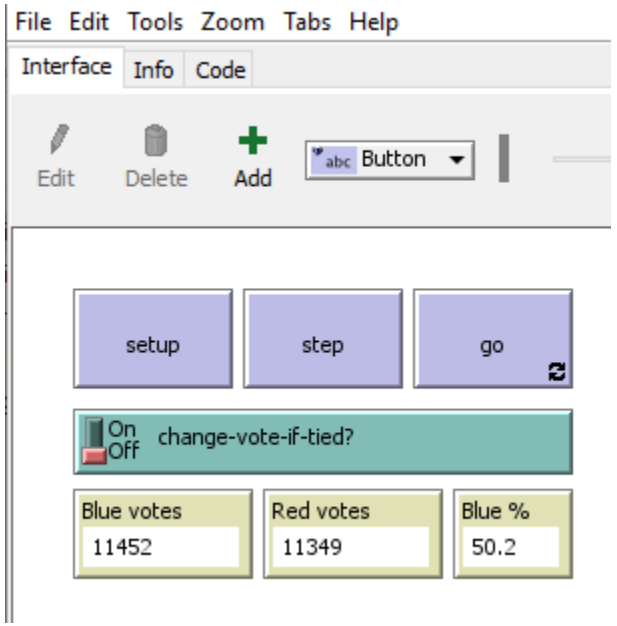
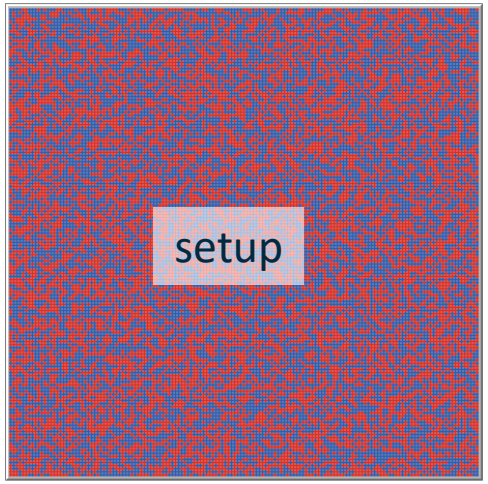
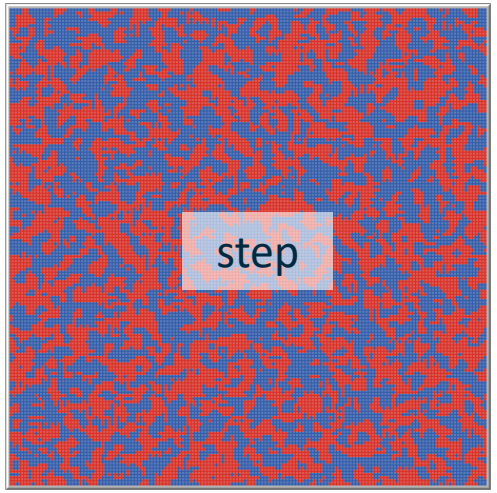
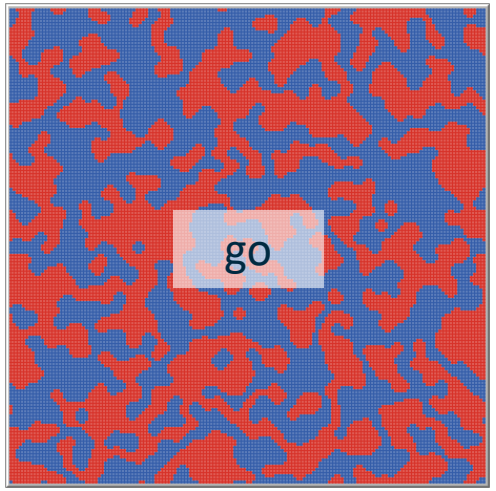
Try it out

1. Press setup
2. Press step a few times
3. Press go
4. Repeat…
5. Change the switch
6. Discussion: what's happening?

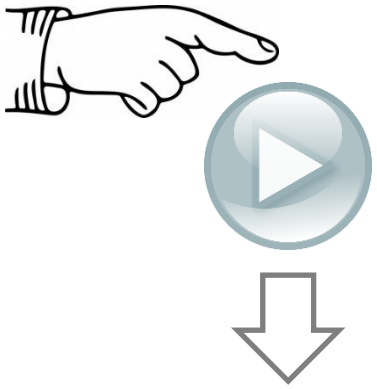






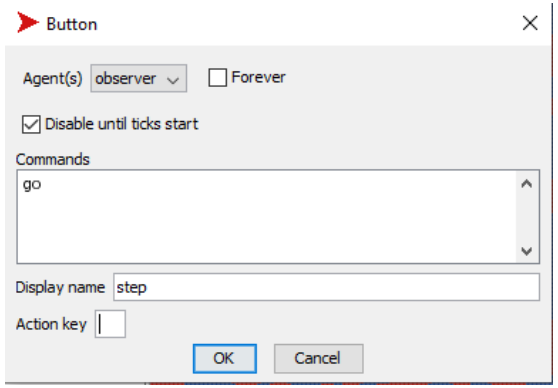


Modular code



named procedure

- to <name>
  - ...
- end



named procedure

- to <name>
  - ...
- end

named procedure

- to <name>
  - ...
- end

...

named procedure

- to <name>
  - ...
- end

in order from calling procedure

Each procedure is made up of primitives and other procedures

What does ‘setup’ do?

Interface | Info | Code

Find… | Check | Procedures | Indent automatically

```
turtles-own
[ vote                          ; my vote (red or blue)
  vote-next                     ; vote for next time step
]

to setup
  clear-all
  ask patches
  [ set pcolor white
    sprout 1                          ; create a turtle on each patch
    [ set shape "circle"
      set vote one-of [red blue]
      set color vote
    ]
  ]
  reset-ticks
end
```

Defines the set of attributes available to each agent (turtle)

Deletes and clears

Each patch in random order, run the block of commands

Creates a turtle and sets attribute values

Vote variable either red or blue, equal probability

Initialises tick counter (timer)

What does ‘go’ do?

Each agent in random order, run the block of commands

Counts the red and blue voting neighbours, stores counts

Chooses an action depending on situation

Access switch on interface

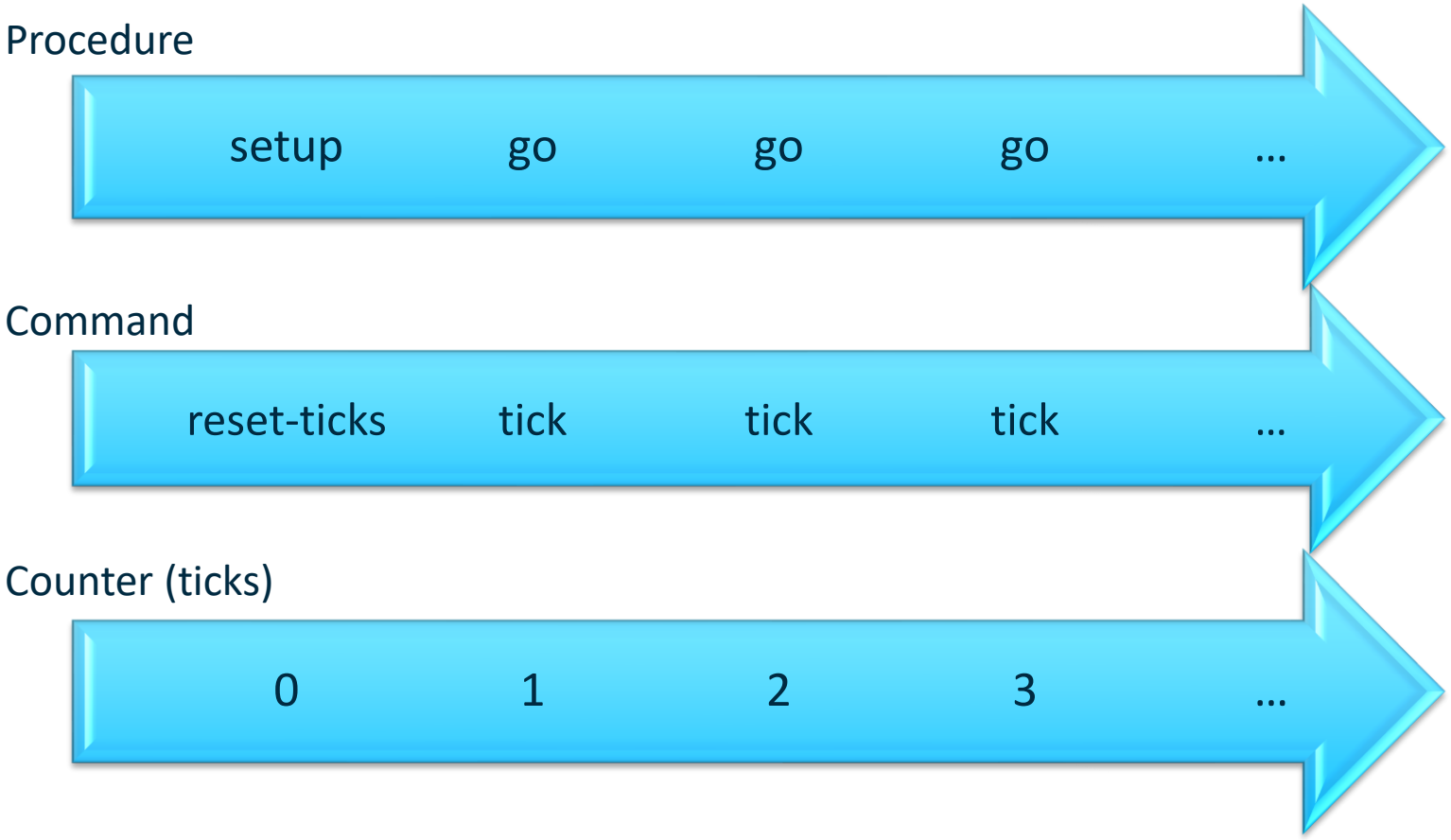
Stops if in equilibrium (all?), Cancels ‘forever’

Implements chosen action

Advances tick counter (timer)

```
to go
  ask turtles
  [ ; calculate next vote by majority rules
    let nbr-red count (turtles-on neighbors) with [vote = red]
    let nbr-blue count (turtles-on neighbors) with [vote = blue]
    if nbr-red > nbr-blue [set vote-next red]
    if nbr-blue > nbr-red [set vote-next blue]
    if nbr-red = nbr-blue
    [ ifelse change-vote-if-tied?
      [ set vote-next ifelse-value vote = red [blue] [red] ]
      [ set vote-next vote ]
    ]
  ]
  ; check if any changes, stop if not
  if all? turtles [vote = vote-next] [stop]
  ; update votes
  ask turtles
  [ set vote vote-next
    set color vote
  ]
  tick
end
```

Time in NetLogo



How is the code ‘doing’ ABM?

Simulation

- State changes: which turtle voting what
- Passage of time: tick counter

Autonomous decisions

- Each turtle makes its own decision based on own situation

Heterogeneity

- Some voting red, some blue

Interaction – social

- Next vote influenced by the votes of the nearby turtles

Extending the model: output

What output do we have?

Current time step

World, showing vote location

Number of red / blue votes

- Calculated blue %

What would be useful?

How would you describe the results of the model to someone who couldn't see it?

What features do you want to capture?

Small group discussion (5 mins)

Extended output

Some measure of concentration

- Proportion blue has minimal change, but clearly the pattern changes
- Simple measure: proportion of agents that are completely surrounded by agents who vote the same way
- Formal measures available
  - Segregation index over neighbourhoods
  - Cluster sizes

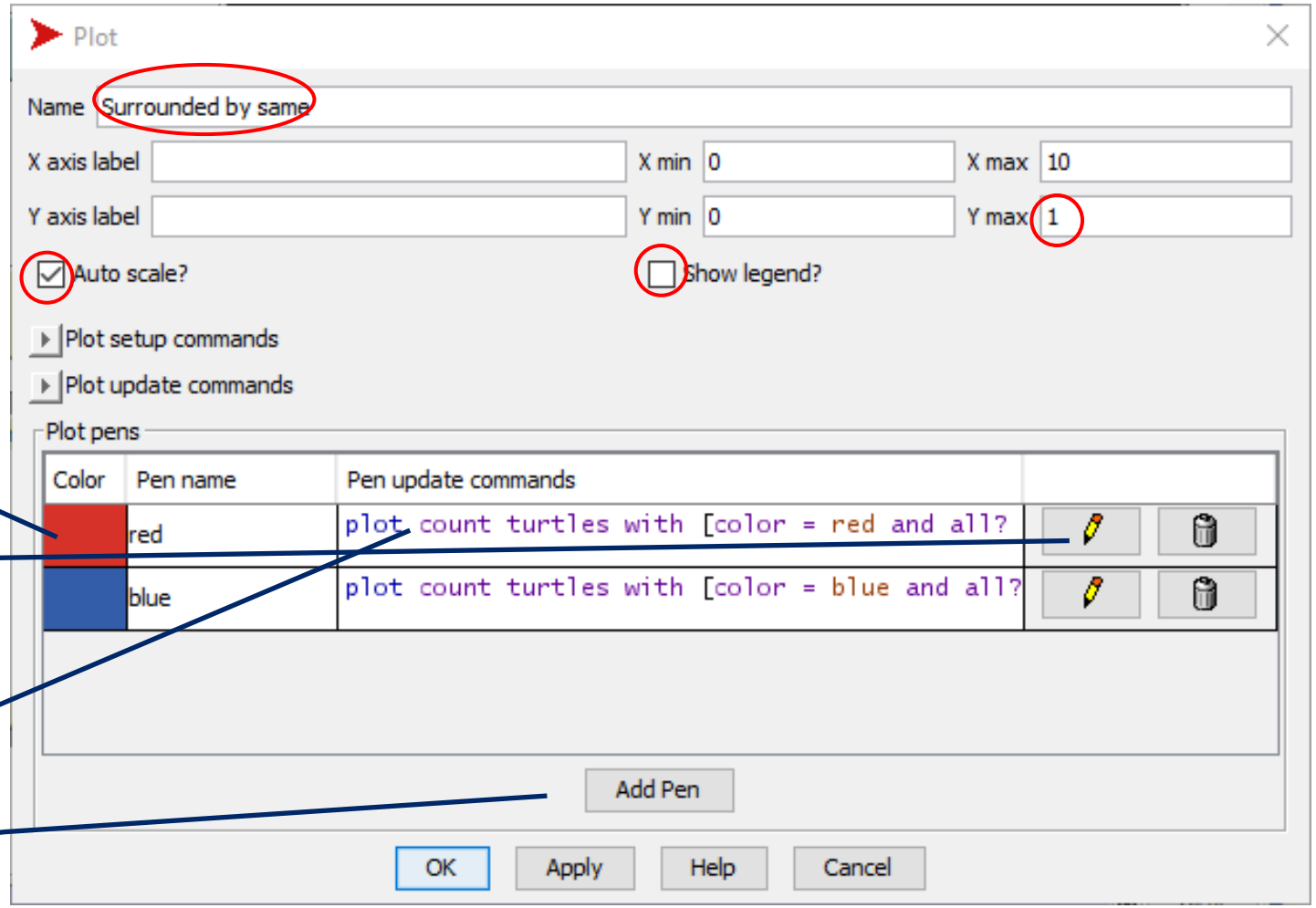
Plot over time

Making the plot

Add plot (interface widget)

- (3) in NetLogo orientation slide

Use ‘select’ to move or resize



click to choose colour

click to expand text box (and then drag border to expand further)

extra row

plot count turtles with [color = red and all? turtles-on neighbors [color = red]] / count turtles with [color = red]

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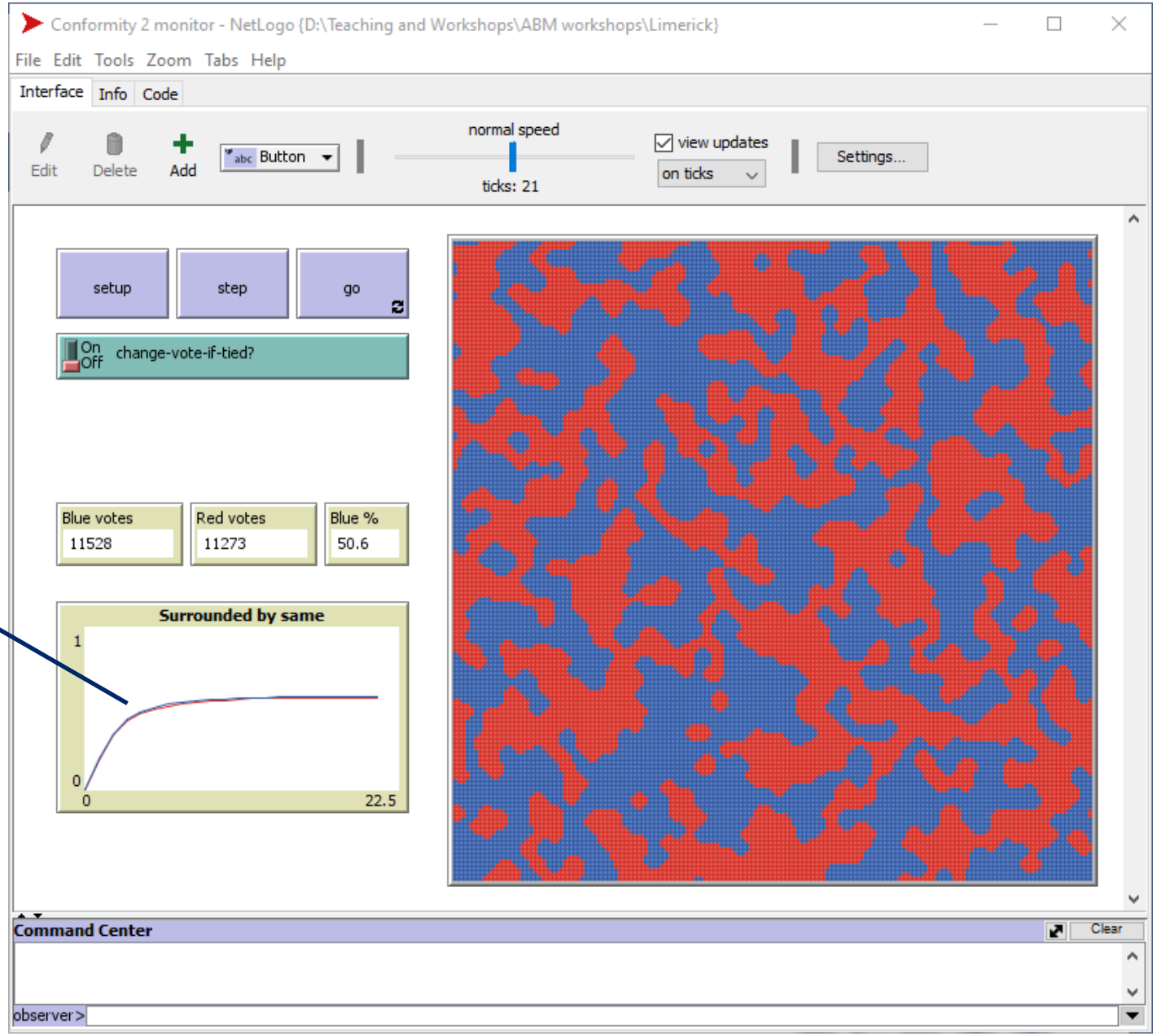
What happens now?

Two lines



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Extending the model

Discussion

- What could we change to ask more interesting questions?
- Small groups for ideas

Each choice requires the mechanism to be fully specified

Start with different blue/red mix

- This is the one we will build

Heterogeneity in number of influencing agents

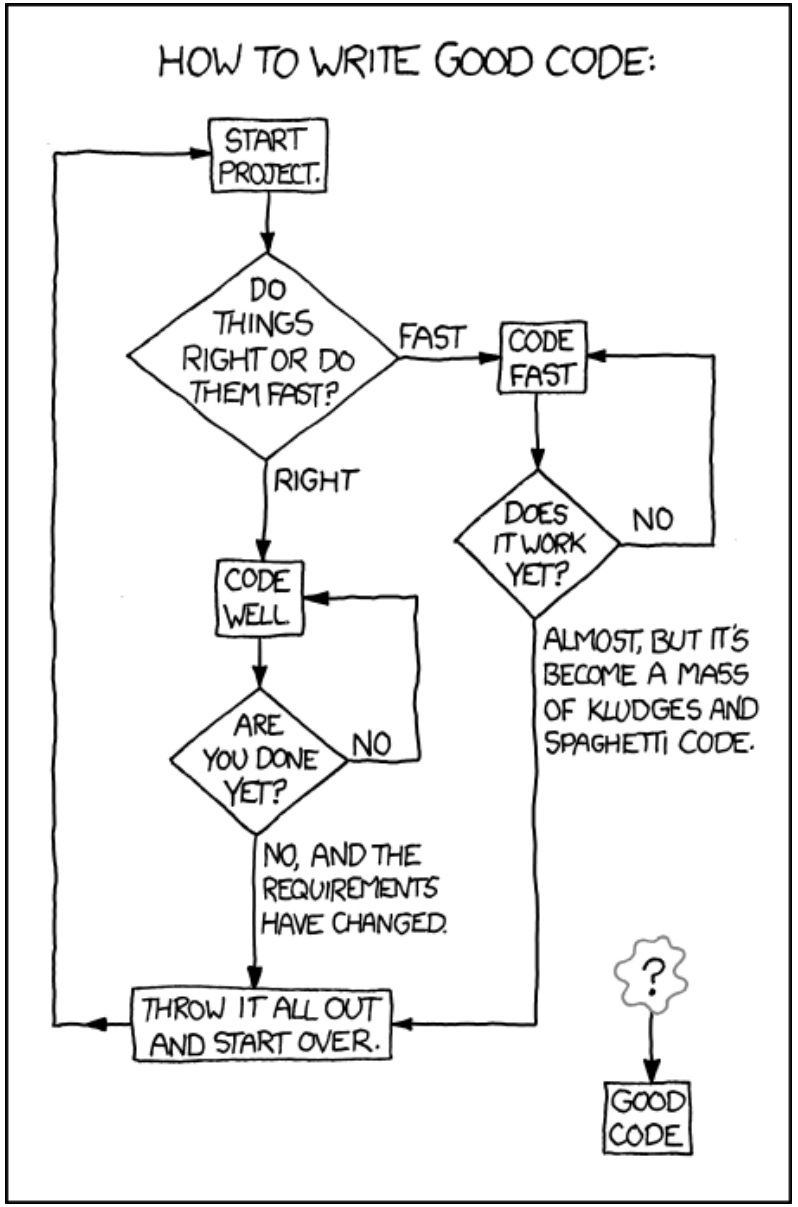
- Allow some empty patches, or more agents per patch
- Agents vary by how far they can see, not just neighbours

Heterogeneity in influence (current has equal contribution by all)

- Additional attribute of ‘charisma’
- Sum of charisma rather than count of votes

Additional voting choice (colour)

- What does majority mean?

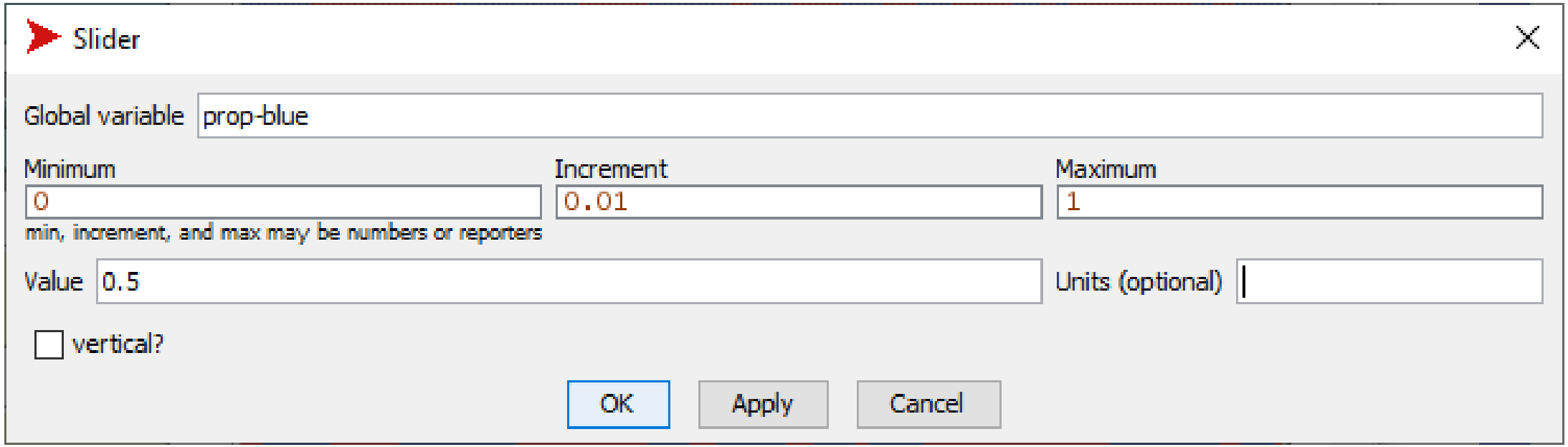


Source: Randall Munroe, xkcd comics
HTTP://XKCD.COM/844/

User control for starting distribution

Create slider for prop-blue

- Another interface widget
- Sliders allow users to set the value of some (global) variable



Using this variable in the model

Slider makes a variable available: proportion of blue voters initially

What procedure needs to use this variable?

What code needs to change?

What does the code need to do? (Design, mechanism, logic)

- Be specific

```
set vote one-of [red blue]

set vote ifelse-value random-float 1 < prop-blue [blue] [red]
```

Use the model

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Play with the model

What happens with different starting proportions?

What starting proportion is needed for both groups to exist?

How would you describe the pattern of blue proportion over time?

What is the relationship between starting proportion and:

- Final proportion?
- Final concentration?
- Do patterns change as inputs change?

Try some values!

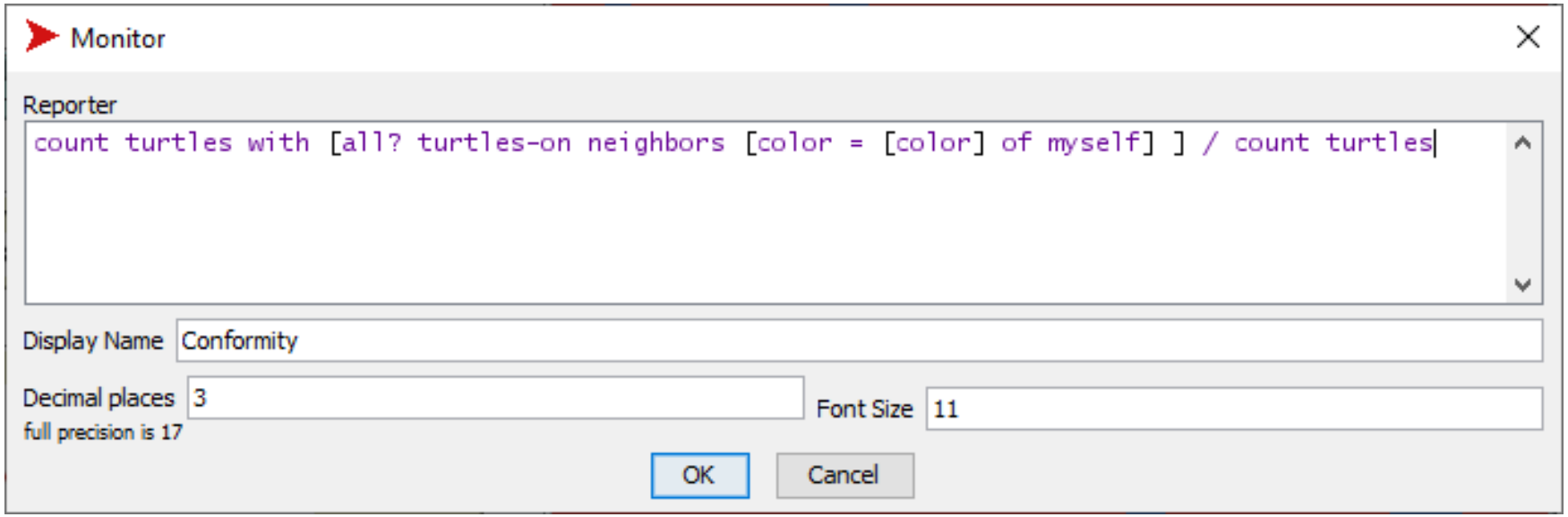
Need more tools

Additional output: conformity monitor

Monitor is a widget the reports the results of a calculation

Similar code construction as the plot of surrounded

But sums the red surrounded and blue surrounded

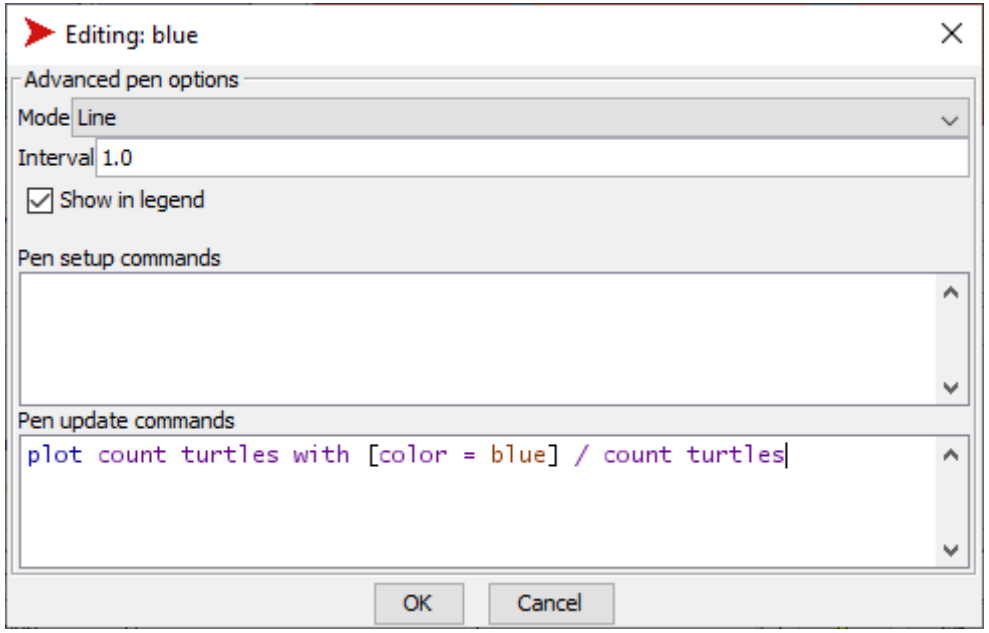


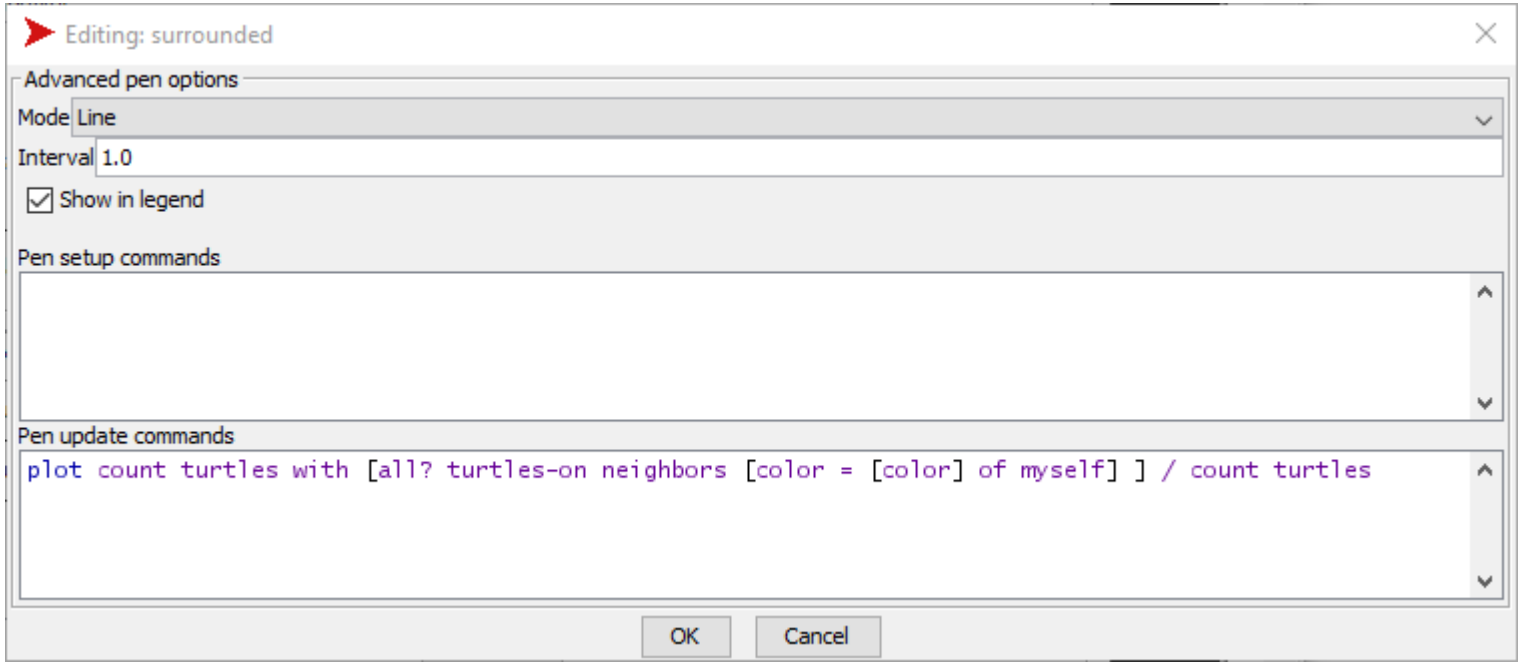
Revised plot

Revise plot pens

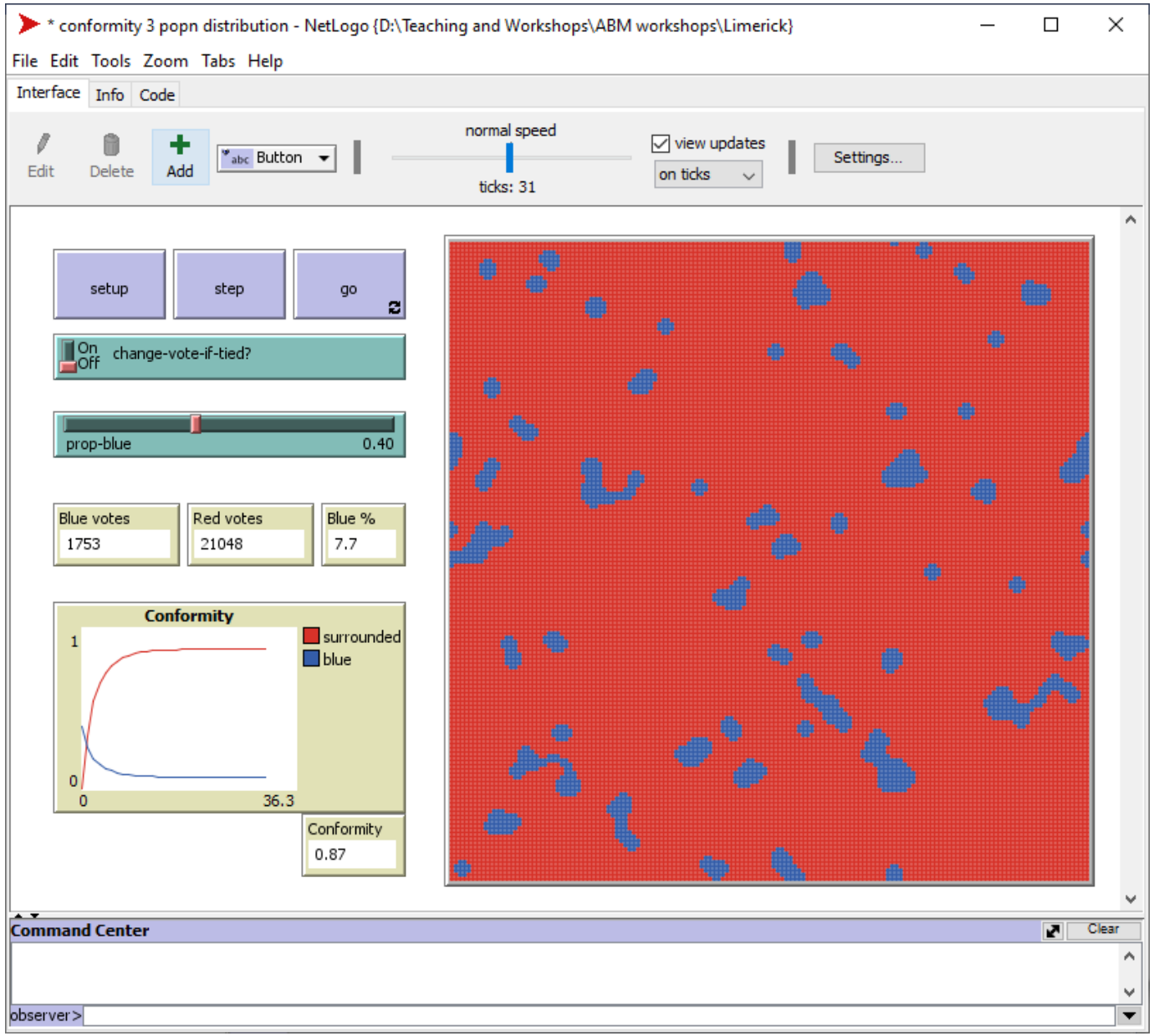
- Conformity: copy the code from the monitor (and add ‘plot’ to front)
- Blue: make it proportion blue

Tick the legend box





Revised model



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Experimentation

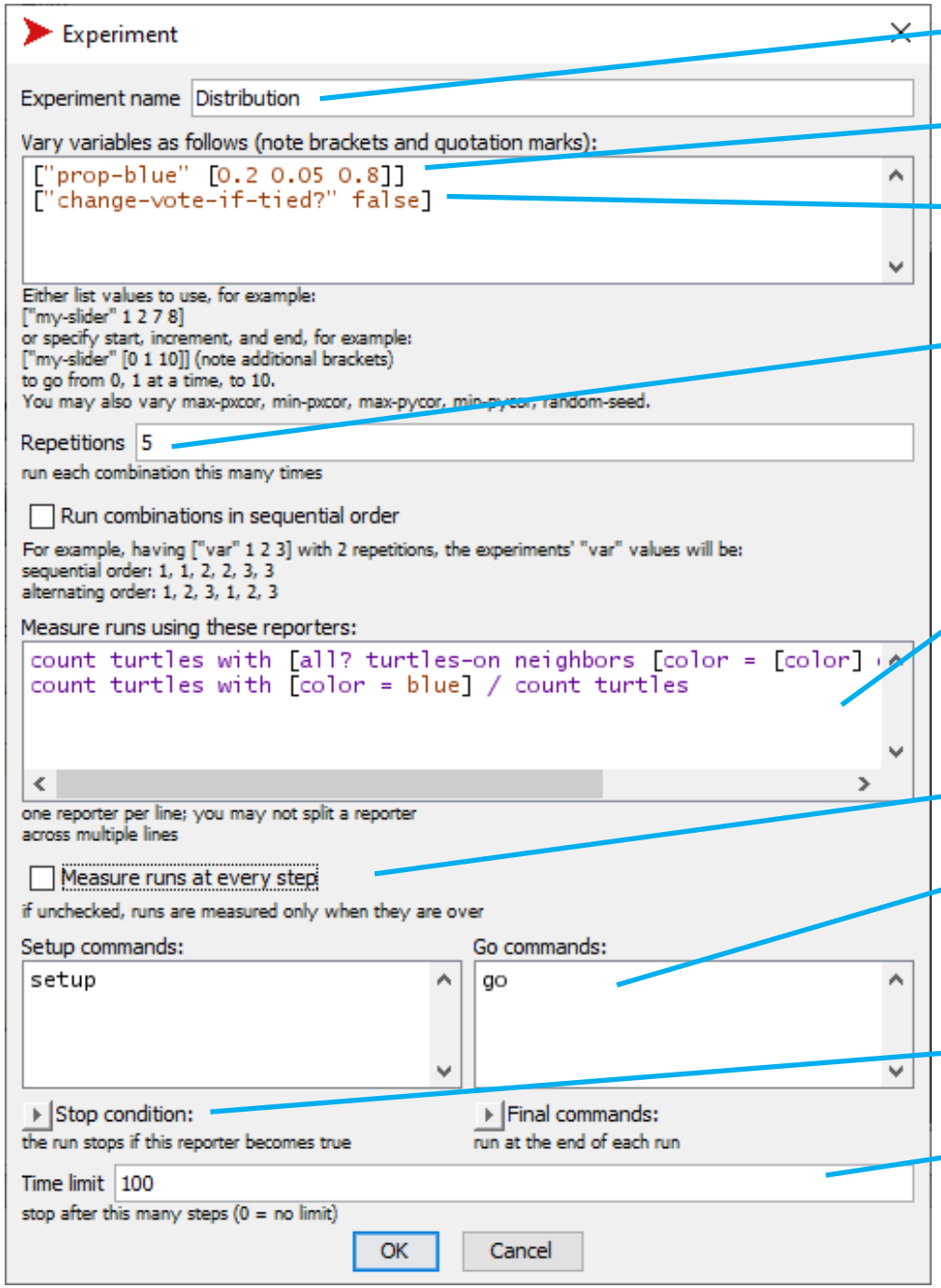
BehaviorSpace to examine

- input: prop-blue
  - fix switch to off
- output: conformity, blue

Open BehaviorSpace (Tools)

New experiment

Save (OK)



name the setup

input sequence

fix all others

simulations

outputs

all or end?

procedures

stop test

stop tick

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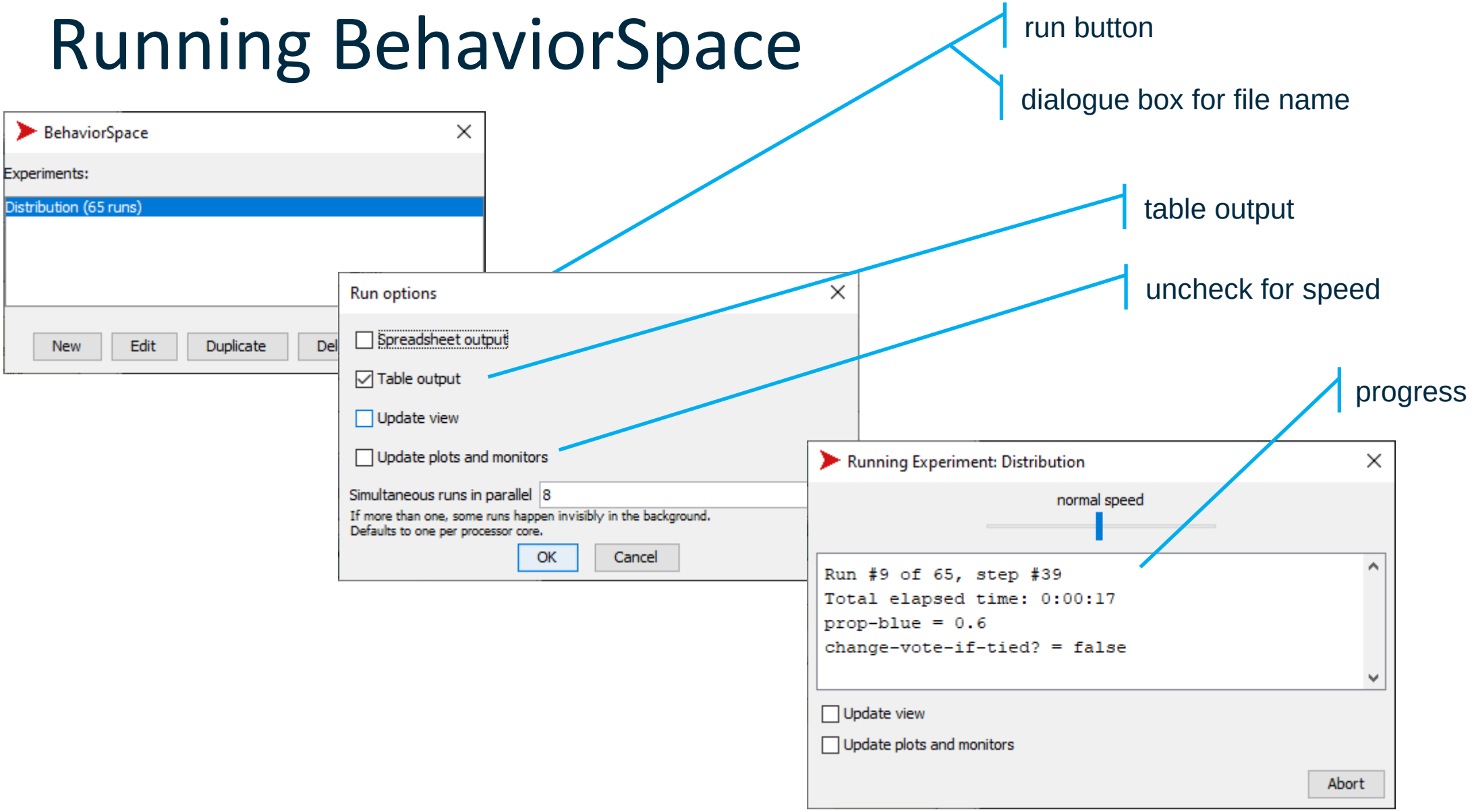
Running BehaviorSpace



Structure of BehaviorSpace table

	A	B	C	D	E	F	G
1	BehaviorSpace results (NetLogo 6.1.1)						
2	conformity 3 popn distribution.nlogo						
3	Distribution						
4	03/02/2020 21:31:46:604 +0000						
5	min-pxcor	max-pxco	min-pycor	max-pycor			
6	-75	75	-75	75			
7	[run numb	prop-blue	change-vc	[step]	count turt	count turtles with	
8	1	0.2	FALSE	4	1	0	
9	2	0.25	FALSE	8	0.998246	7.46E-04	
10	3	0.3	FALSE	12	0.993684	0.002675	
11	4	0.35	FALSE	12	0.950178	0.024473	
12	12	0.75	FALSE	8	0.998597	0.999474	
13	8	0.55	FALSE	25	0.685452	0.774527	
14	7	0.5	FALSE	26	0.566291	0.525635	
15	5	0.4	FALSE	25	0.841542	0.088417	
16	13	0.8	FALSE	4	1	1	
17	11	0.7	FALSE	15	0.992456	0.99693	
18	6	0.45	FALSE	31	0.645849	0.264111	
19	10	0.65	FALSE	20	0.962633	0.982983	
20	14	0.2	FALSE	6	1	0	
21	15	0.25	FALSE	7	1	0	
22	16	0.3	FALSE	9	0.989474	0.004386	

Distribution

Top

- 4 lines file info
- 2 lines world size

Body

- column with run number
- column(s) for parameter values
- column for step number
  - In this case, gives ticks until equilibrium reached
- column(s) for reporters

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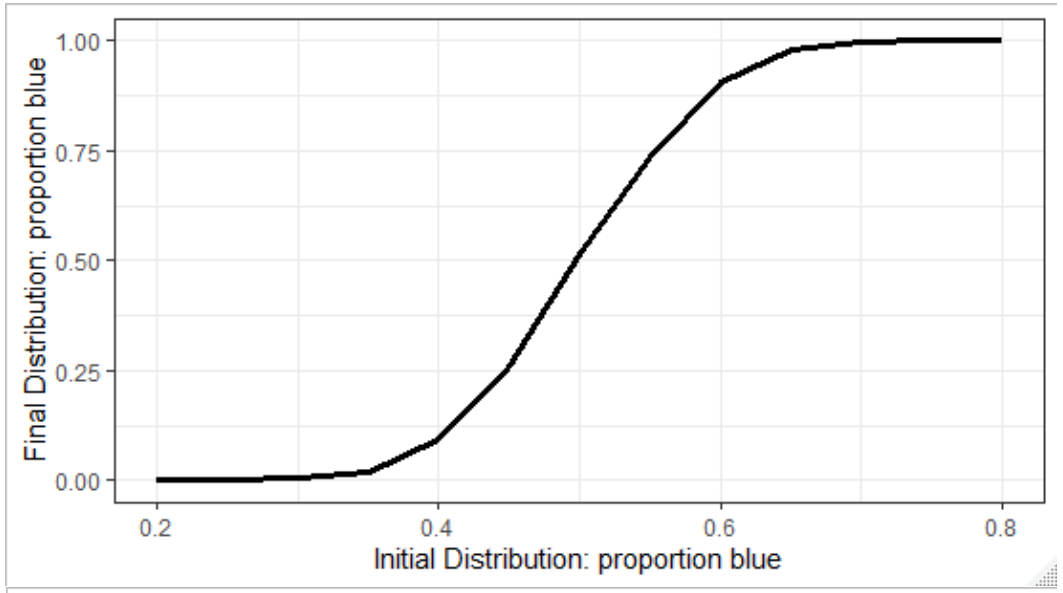
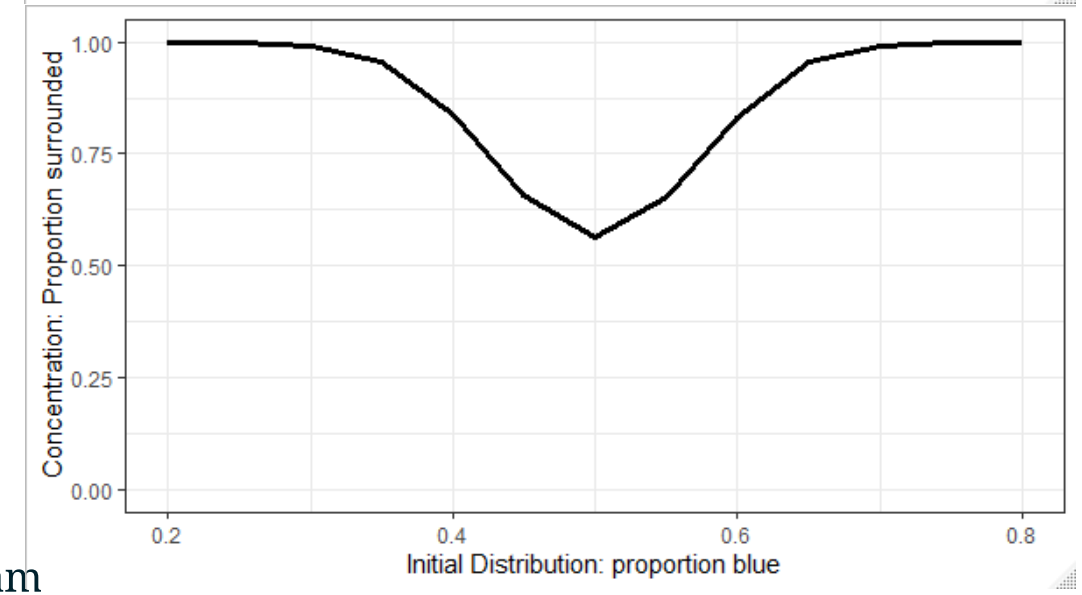
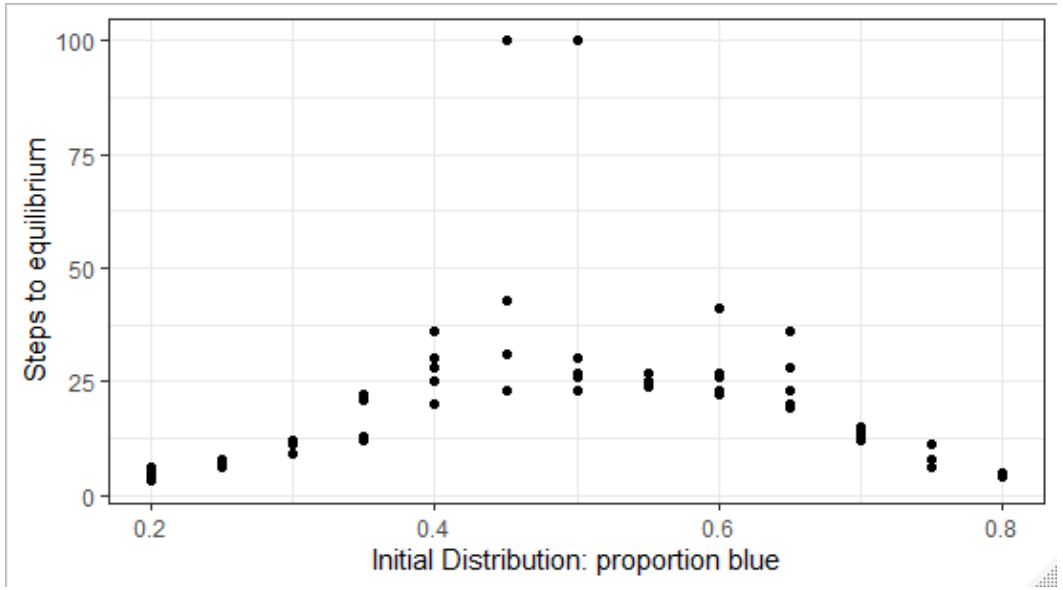
Analyse results







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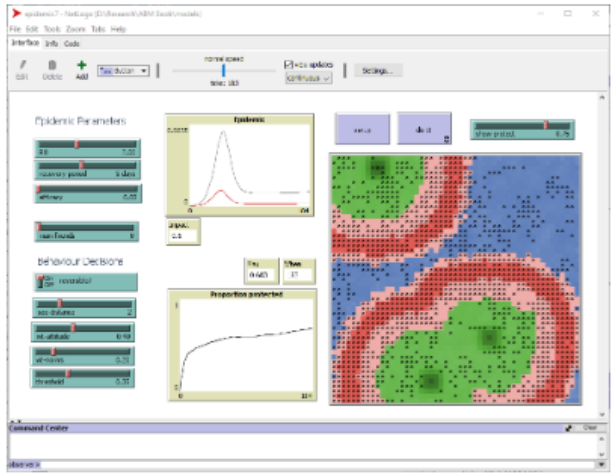
If you want to learn NetLogo…

https://jbadham.biz/Research/ABMBook/

Agent-Based Modelling for the Self Learner



What is this tutorial?

Agent-based modelling is a complex systems method to simulate individuals making decisions based on their own characteristics, social influences and situation. For the past few years, colleagues and I have been running ABM short courses. Those courses include a substantial tutorial in NetLogo, freely available specialist software.

Many people wanting to use agent-based modelling are sociologists, public health researchers, geographers, environmental scientists or other disciplinary based scientists who may not have programming experience or access to experienced agent-based modellers. I have adapted the tutorial from the course so that such people can work through building a model of protective behaviour during an influenza epidemic. As well as the Netlogo language and programming environment, the tutorial is intended to teach the way that agent-based models represent the world and good programming practices. At some point, I hope to extend the tutorial into a full textbook.

I hope you find it useful. Comments and suggestions are welcome, by email.

Jen Badham (June 2019)

What do you need?

NetLogo software is freely available for Windows, Mac OSX or Linux, from the developers at: Netlogo.

Download the (pdf) tutorial here. It assumes no background in programming or agent-based modelling but you are expected to be comfortable with standard computer operations such as saving a file.

Some of the models that you will build are also available:

- Progress versions of the main model (model 1, model 2, model 3, model 4) and the completed model.
- The additional tutorial for mobile agents is only available in completed form.

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Key Ideas

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Modelling a complex system

Concepts

Complex system: Behaviour arises significantly from interactions

Model: Simplified representation of features and relationships

Simulation

- Model of a process
- States change over time

Simulation of a complex system describes some theory about state changes that involves interactions

When to use ABM

ABM only one method for modelling complex systems

ABM used where:

- Autonomous individuals (agents)
  - No central control
- Agents interact with each other and/or their environment
  - Local effects
- Agents are diverse
  - Heterogeneity contributes to different actions

Why NetLogo for ABM?

Easy to learn

- No other language
- Small command set for most requirements

Models are quick to write

- Integrated interface and code
- Few lines of code

Sufficiently powerful

- Suitable for up to about 50,000 agents

Clunky graphics

- Reminds users that they are working with a model, not a predictive tool

Models assist insight

Tool for thinking: Agent-based model captures some theory of process and allows us to examine the implications of that theory