Manual

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System Requirements and Installing Instructions

The model is implemented in the form of a Visual Basic for applications (VBA) model and runs in Microsoft Excel (2007). To improve the visualization of the model results the VisualBots plugin has to be installed. VisualBots is an ActiveX Control for Microsoft Excel for personal use and is a free of charge (downloadable from the websitewww.visualbots.com). It is an agent based simulator that allows to design and simulate multi-agent worlds, e.g., on grid cells. We recommend installing the VisualBots plugin to avoid error messages (though it is possible to run the model without the plugin, see **Using the „model and matrices" sheet**).

To start working with the model, it is best to read this Manual first . If you want to get started soon using the model, have a look at the section **Getting started (using the model)**.

Note that the Excel file makes use of Visual Basic routines which contain the equations of the simulation model, and several other functions used to run the model or to calculate results. You must have Visual Basic for Applications installed in your version of Excel, but a standard PC installation of Excel also installs Visual Basic automatically. To run the model, you must be able to run macros and ActiveX controls. Check your security settings (see section on **Excel Macro Security for Excel 2007 or Later**). While opening the file an excel security warning will appear. Click on "Options…" and say "Enable this content" (enables

macros and ActiveX). If you're asked to update links, click Continue. If the formula cells show an error message, click the keyboard button F9, which should recalculate all the values.

Since the model is using a call to Visual Basic, it does not run on Mac computers. If you want to check the code, you can do so by opening Visual Basic in the Excel from the Developer menu tab.

Please email the first author (nils.schuhmacher@uni-muenster.de), if you have any problems installing or starting the model.

Quick installation guide

- ***Operating System: Windows XP, Windows Vista, Windows 7 or above***
- ***Runtime environment:***
  - ***Microsoft Excel 2002, 2003, 2007 or above***
  - ***VisualBots-Plugin (www.visualbots.com)***
- *Installing instructions and system requirements for VisualBots can be found here (http://www.visualbots.com/documentation/topics/topInstallation2.htm)*
- ***Modify your Excel macro security settings (see section* Excel Macro Security for Excel 2007 or Later *below)***
- ***Open the file with Microsoft Excel***
- ***Set security options to enable content (Macros & ActiveX)***

Further notes

- Most of the simulation model has been developed with a Windows 7 machine using Microsoft Excel 2007.
- The simulation model should work with different Microsoft Excel (e.g., 2002, 2010, or 2013) and Windows versions (e.g., Vista, Windows 8) as well (though this has NOT been tested by the authors, so there is no guarantee).
- If you are a Mac-User you can use the model running Windows on your Mac, e.g. with the help of Parallels Desktop (this has NOT been tested by the authors).
- It is possible to run the model without installing the VisualBots plugin (see section on **Using the "model and matrices" sheet**). However, the authors recommend installing the VisualBots plugin to avoid error messages.

Excel Macro Security for Excel 2007 or Later

Open Excel.

1. Click on Office Button> Excel Options> Trust Center > Trust Center Settings.
2. Select "Macros Settings" tab.
3. Click on the "Disable all macros with notification" option under Macro Settings (this means that if Excel wants to run a macro, it will ask for your permission to do so).
4. Check the "Trust access to VBA project object model" option under Developer Macro settings.
5. Select "ActiveX Settings" tab.
6. Click on the "Prompt me before enabling all controls with minimal restrictions" option.
7. Check the "Safe mode" option.
8. Click OK, close Excel, and reopen Excel with the new settings.

Warning: Making the above changes to the Excel security level can put your computer at additional risk. You should only make these changes if you understand and accept these risks and if you have installed anti-virus protection software.

Getting started (using the model)

In general there are two different ways to run the model:

- 1. Using the "model" sheet (VisualBots Simulator)
- 2. Using the "model and matrices" sheet

Both options are explained in more detail below.

Short model description

The present model is a combination of a discrete dynamical systems and an agent based model. The formal model consists of a number of coupled equations and decision rules that work in an iterative way. Our model consists of agents with individual property matrices for: behavior, similarity, preference, mutuality, interaction, interaction value, popularity and evaluation. The agents can perform two types of behaviors, namely conventional behaviors (i.e., study, sports and work) and risk behaviors (i.e., use of alcohol, display of aggressiveness and use of soft drugs). The proportional distribution of these properties determines if the agents have a risky, conventional or average lifestyle. The properties behavior and similarity are divided into perceived and real behavior and perceived and real similarity respectively. For further information on the agents' properties, model formulas, calculations and a detailed description of an updating cycle please see Schuhmacher, Ballato, & van Geert (submitted).

Using the "model" sheet

You can use the VisualBots Simulator for Excel to run the model. After having set up the parameters (see section on **Setting up the parameters**) simply click on the play button. You can also pause the model, change to advance mode (by pressing the advance button) or stop the model (this will end the simulation and print out the results, if the *Save results* control is set to "Yes", see section on **Model controls**). See also figure 1 for the different control buttons to run the model.

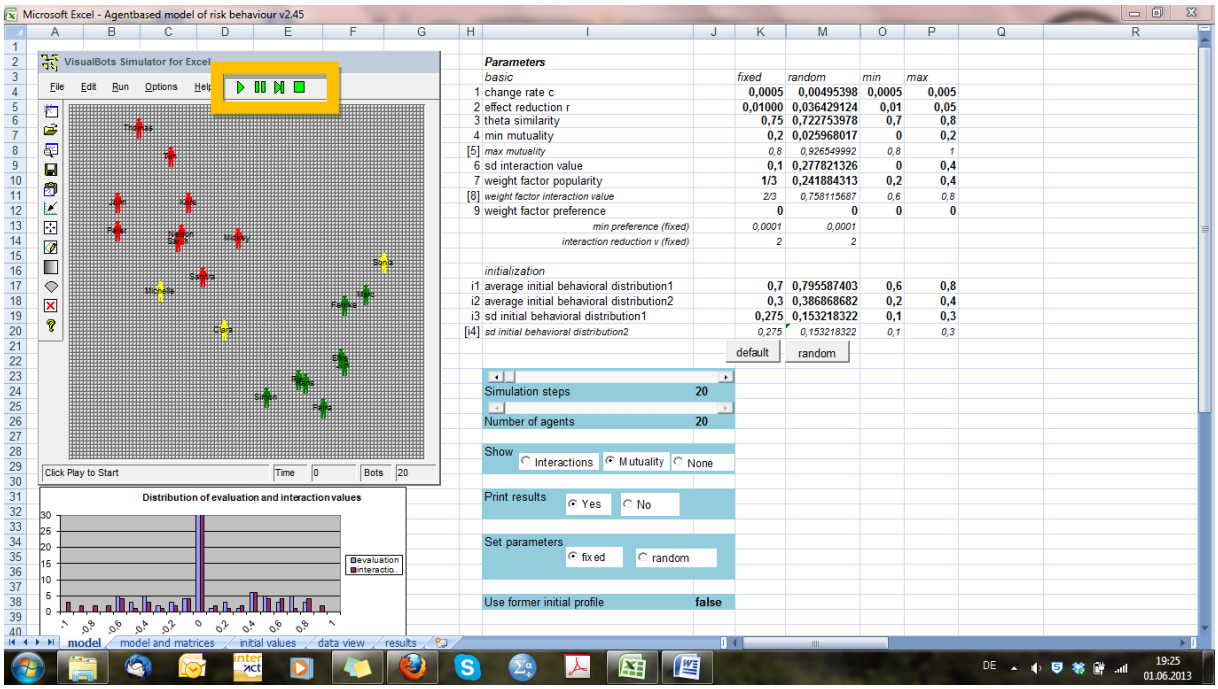

Figure 1: Screenshot of the "model" sheet. The control buttons to run the model are highlighted in the orange box.

Note: If you are a "model novice" you can use the VisualBots Simulator to get familiar with the model. TheVisualBots Simulator runs fast and you can easily change active sheets during the simulation.

Using the „model and matrices" sheet

The "model and matrices" sheet is an alternative way to run the model (see figure 2). Click the "Play (run model x times)" button to start the simulation. Click the "Pause" button to pause the model run or click the "Stop" button to stop the run (this will end the simulation and print out the results, if the *Save results* control is set to "Yes", see section **Model controls**). The parameters that you have defined at the "model" sheet will be used for the simulation here as well (see section on **Setting up the parameters**). Furthermore, you can start several simulation runs in a row clicking the "start monte carlo analysis" button (see figure 2 and section **Starting several runs**).

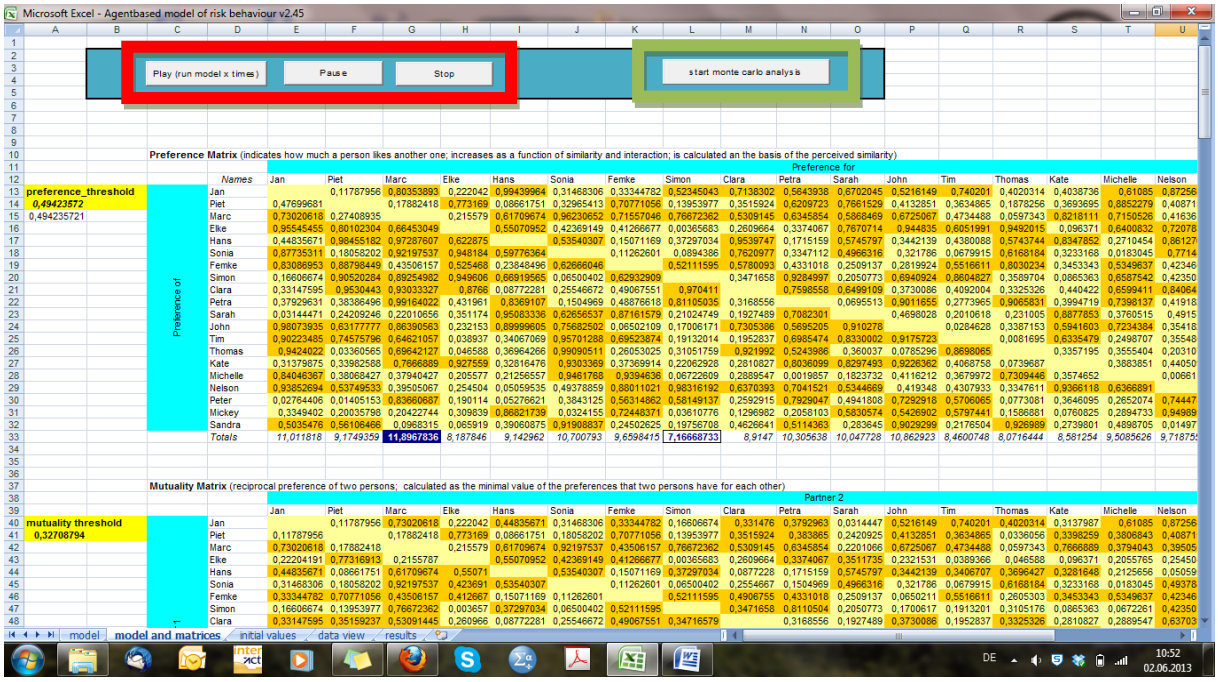

Figure 2: Screenshot of the "model and matrices" sheet. The control buttons to run the model are highlighted in the red square. The button to start several model runs ("start monte carlo analysis") is highlighted in the green square.

Note: With the "model and matrices" sheet you can start the model without installing the VisualBots plugin. It is possible to start several simulation runs in a row clicking the "start monte carlo analysis" button (see section **Starting several runs**), which is not possible using the VisualBots Simulator. Generally, the performance of the model in this sheet is not optimal. Furthermore, there is no advance button (but it as possible to pause and play the model at every simulation step, which gives literally the same functionality).

Starting several runs (monte carlo analysis)

In order to start several model runs in a row you can click the "start monte carlo analysis" button (see figure 2). An input box appears and you are asked to specify the number of simulation runs that you would like to conduct.

Initial parameters will be drawn randomly or set fixed, depending on your specifications for the *Set parameters* control (see also section **Setting up the parameters**). Furthermore, you

should choose to save your model results setting the *Save results* control to "Yes" (see also section on **Setting up the parameters**; otherwise your monte carlo analysis hardly produces any observable output). You have to define a path for saving the results files (you will be asked automatically to do so after having specified the number of simulation runs). Results will be printed and saved in separate result files for each simulation run.

Caution: Using the "start monte carlo analysis" function automatically disables the display (the updates of the matrices in the "model and matrices" sheet as well as the usage of your cursor). You won't see any model progress (except of the "This is run X out of Y" in the statusbar), but all values will be calculated and internally stored. This is done to improve processing time (but depending on the number of simulation steps and the number of simulation runs the processing still may take some time). You can stop the macro at any time pressing the esc-button on your keyboard (try to press the esc-button several times, if the model doesn't stop immediately). This will lead to a loss of data for the simulation runs calculated so far. Results are printed and saved at the end of each simulation. This may take some time (again).

Setting up the parameters

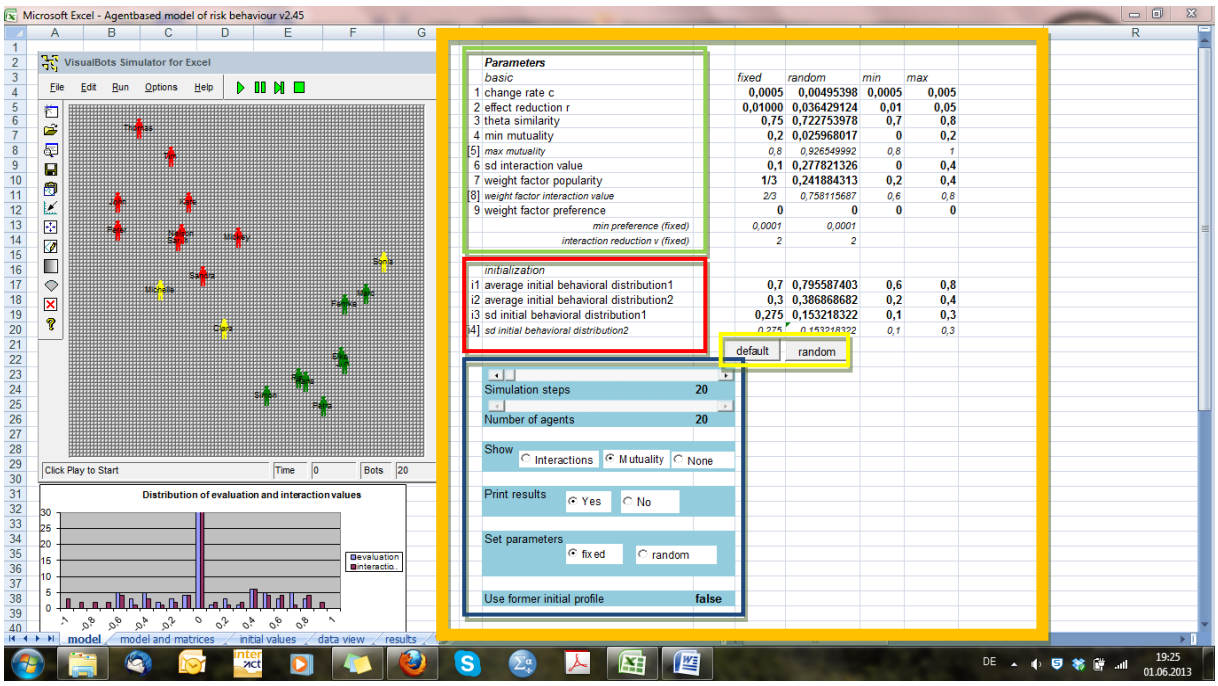

Figure 3: Setting up the parameters in the "model" sheet.

Model controls

The following controls are available in the model (see the blue box in figure 3) and explained in more detail below:

a) Setting the number of simulation steps (Scrollbar)
b) Setting the number of agents (Scrollbar)
c) Show … in VisualBots Simulator (Radio buttons)
d) Save results (Radio buttons)
e) Set initial parameters randomly or static (Radio buttons)
f) Use former initial profile (Boolean value)

a) Setting the number of simulation steps (Scrollbar)

Here you can set the number of simulation steps (value between 10 and 2000 simulation steps). You can either use the scroll bar or type in the value (Cell J24).

b) Setting the number of agents (Scrollbar)
This scrollbar is **disabled**. The number of agents is set to 20 agents (by default) and should NOT be changed (a model version to modify the number of agents is already planned).

c) Show … in VisualBots Simulator (Radio buttons)
The radio buttons "Interactions", "Mutuality" or "None" are available. Choose "Interactions" to draw lines between interacting agents (with blue lines indicating negative interactions and golden lines indicating positive interactions) in the VisualBots Simulator. Choose "Mutuality" to illustrate friendships between the agents (friendship is defined as a high mutuality value > .80). Choose "None" to disable this function.

d) Save results (Radio buttons)
Set "Save results" to "Yes" in order to save the model results at the end of a simulation run. Choose "No" if you don't want to save your simulation results. At the beginning of the (first) simulation run you are asked to specify a folder, where to save your result file(s). Choose a destination folder in the Explorer window and click "OK" (clicking "Cancel" or forgetting to define a folder leads to an error message during the simulation). At the end of the simulation run results are printed out in the "results" sheet and saved in a results file (for further details on the content of the results files see section **The "results" sheet and result files**). If you run a monte carlo analysis, a separate results file is saved for each simulation run.

e) Set initial parameters randomly or fixed (Radio buttons)
You can choose to set parameter to "random" or "fixed" values. Choose "fixed" to use the fixed parameter values from column K (Cells K4:K20). Choose "random" to use the randomly drawn parameter values from column M (Cells M4:M20). Click the "default" button to set the fixed parameters range to default values. Click the "random" button to generate a new set of random parameters (see the yellow box in figure 3 or section **Set parameters "fixed" or "random"**). If you select the *Set parameters* control to "random" and start a monte carlo analysis, a random parameter set is drawn at the beginning of each new simulation run.

f) Use former initial profile (Boolean value)
If you set this control to "true", the former initial profile of the behavioral matrix and preference matrix is used. In other words, the initial values of the previous simulation run will be used for the new simulation run (see also section **The "initial values" sheet**). If you set this control to "false", a new set of initial preference and behavioral profile values is drawn for the simulation run.

Basic, initialization and advanced parameters

To set the parameters, type in the values in the "fixed" column K (Cells K4:K20). Parameters are categorized as basic, initialization and advanced parameters. The parameters are explained in more detail in the table below (for further details on the parameters and model formulas see also Schuhmacher, Ballato, & van Geert, submitted, or additional web materials). Parameters can be set to default values (Click the "default" Button) or to random values (Click the "random" Button). See also section **Set parameters "fixed" or "random"** for more details.

Note: If you are a "model novice", simply set the parameters to default values. As soon as you seem to be familiar with the model, try to set parameters manually. Suitable ranges for setting the parameters are given in the "min" and "max" columns (Cells O4:O20, P4:P20). Experienced user can manually set and vary the advanced parameters.

#	*Parameters*	*Symbol*	*Description*
	Basic		
1	change rate	*c*	With this rate the speed of the behavioral change can be modified. The higher the rate, the faster the behavioral change.
2	effect reduction	*r*	Reduces the magnitude of the increase in preferences. The smaller the value, the higher the reduction.
3	theta similarity	θ_S	Threshold for the „true" similarity. θ_S is used for calculating the interaction value. If the similarity is below the threshold, the probability of a positive interaction is rather low vice versa.
4	min mutuality	$\min_M$	Minimum value of mutuality. If the mutuality value is smaller than min mutuality, it is set to min mutuality.
5	*max mutuality*	$\max_M$	Maximum value of mutuality. If the mutuality value is bigger than max mutuality, it is set to max mutuality. Max mutuality should be set to 1-min mutuality.
6	$sd_{interaction\ value}$	σ_V	Defines the standard deviation for the interaction value.
	Weights[1]		
7	weight factor popularity	w_{Pop}	Specifies the effect of the popularity value on the evaluation calculation.
8	*weight factor interaction value*	w_V	Specifies the effect of the interaction value on the evaluation calculation. If weight factor preference is 0, weight factor interaction value should be set to 1-weight factor popularity.
9	weight factor preference	w_P	Specifies the effect of the preference value on the evaluation calculation. The default value is 0, which means that the preference has no influence on the evaluation of an interaction.
	Static		
	min preference	$\min_P$	Minimum value of preference. If there is a preference value smaller than min preference, it is set to min preference. The default value is 0.0001. The parameter value is static and should NOT be changed.
	interaction reduction	v	Can be used to regulate the overall interaction frequency. A value bigger than 1 reduces the general probability for an interaction. The default value is 2. The parameter value is static and should NOT be changed.
	Initialization (basic)		

[1] Constraint: The sum of all used weight factors has to be 1, so $w_{Pop} + w_P + w_V = 1$

i1	average initial behavioral distribution1	$\mu_{B1,0}$	Defines the mean value 1 for the initialization of the behavioral profile.
i2	average initial behavioral distribution2	$\mu_{B2,0}$	Defines the mean value 2 for the initialization of the behavioral profile.
i3	sd initial behavioral distribution1	$\sigma_{B1,0}$	Defines the standard deviation 1 for the initialization of the behavioral profile.
[i4]	sd initial behavioral distribution2	$\sigma_{B2,0}$	Defines the standard deviation 2 for the initialization of the behavioral profile. This value is automatically set to the value of i3.

Advanced

	Enable perceived behavior		This enables perceived behavior (respectively perceived similarity). It means that the agents inaccurately perceive other agents' behaviors. That means that the perception can differ from the real underlying behavioral values. The agents' perception of other agents' behaviors improves during the simulation (the difference between perceived and real behavior gets smaller over the course of the simulation process, see also parameter 10 below).
10	Alpha	α	Alpha can be used to speed up or slow down the amount of time an agent needs to perceive the real behavioral profile of the other agents.
11	theta perceived similarity	θ_{S*}	Threshold for the perceived similarity. If we disable the ability of subjective perception (by setting the initial distortion to 0), theta perceived similarity and theta similarity have to be equal ($\theta_{S*} = \theta_S$). θ_{S*} is used for calculating the preference (and additionally for calculating the evaluation).
	number of conventional agents		Defines the number of conventional agents.
	number of semi-conventional agents		Defines the number of semi-conventional agents.
	number of semi-risky agents		Defines the number of semi-risky agents.
	number of risky agents		Defines the number of risky agents.

Initialization (advanced)

i5	average initial behavioral distribution3	$\mu_{B3,0}$	Defines the mean value 3 for the initialization of the behavioral profile.
i6	average initial behavioral distribution4	$\mu_{B4,0}$	Defines the mean value 4 for the initialization of the behavioral profile.
i7	sd initial behavioral distribution3	$\sigma_{B3,0}$	Defines the standard deviation 3 for the initialization of the behavioral profile.

[i8]	sd initial behavioral distribution4	$\sigma_{B4,0}$	Defines the standard deviation 4 for the initialization of the behavioral profile. This value is automatically set to the value of i7.
i9	sd initial perceived behavior	$\sigma_{B,0}$	Defines the standard deviation of the initial perceived behavior. The larger this value, the more the initial value of the perceived behavior differs from the real behavior.

Set parameters "fixed" or "random"

Click the "default" button to set the parameters to default values. Click the "random" Button to set parameters to default values (see also yellow box in figure 3). If you want to use the "fixed" parameters for your simulation run, please select "fixed" for the *Set parameters* control. If you want to use "random" parameters, please select "random" for the *Set parameters* control (see blue box in figure 3 and section on **Model controls**).

Overview of additional worksheets

The next sections give an overview of the additional worksheets in the simulation model.

The "initial values" sheet

In the „initial values"-worksheet agents' initial preferences and behavioral profiles are saved (see figure 4). The initial preference values are (simple) random values between 0 and 1 (see randomized preference matrix = red box in figure 4). The initial behavioral values are randomly drawn from (two different) normal distributions (see randomized behavioral matrix=blue box in figure 4). Means and standard deviations of these normal distributions are defined by parameters i1-i4 (see red box in figure 3 and section **Basic, initialization and advanced parameters**).

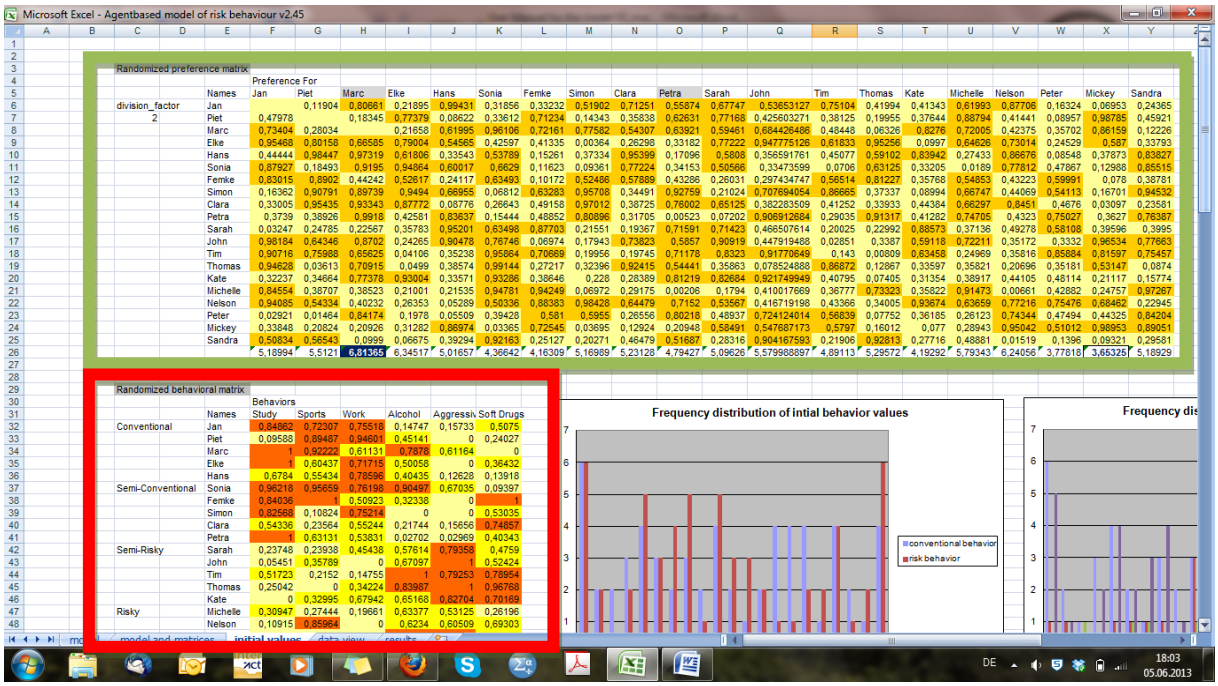

Figure 4: Screenshot of the initial values sheet.

The "data view" sheet

With the "data view" sheet you can plot and compare the simulation results of two different agents. Choose the agents you want to compare (agent A and B) from the dropdown lists

(steps 1 und 2, see also figure 5). Select the output with the checkboxes in step 3 (Similarity, Mutuality, Popularity, Interaction, Evaluation, Preferences) and step 4 (conventional behaviors: study, sports, work; risk behaviors: alcohol, aggressiveness, soft drugs). Additionally, you can choose to plot the perceived as well as the true behavior. It is possible to select all checkbox items at once (though the authors recommend selecting a maximum of 4 items). Finally, click the "plot graph" button. All result data are printed out (in columns R to IX) and the different graphs are plotted in the chart object.

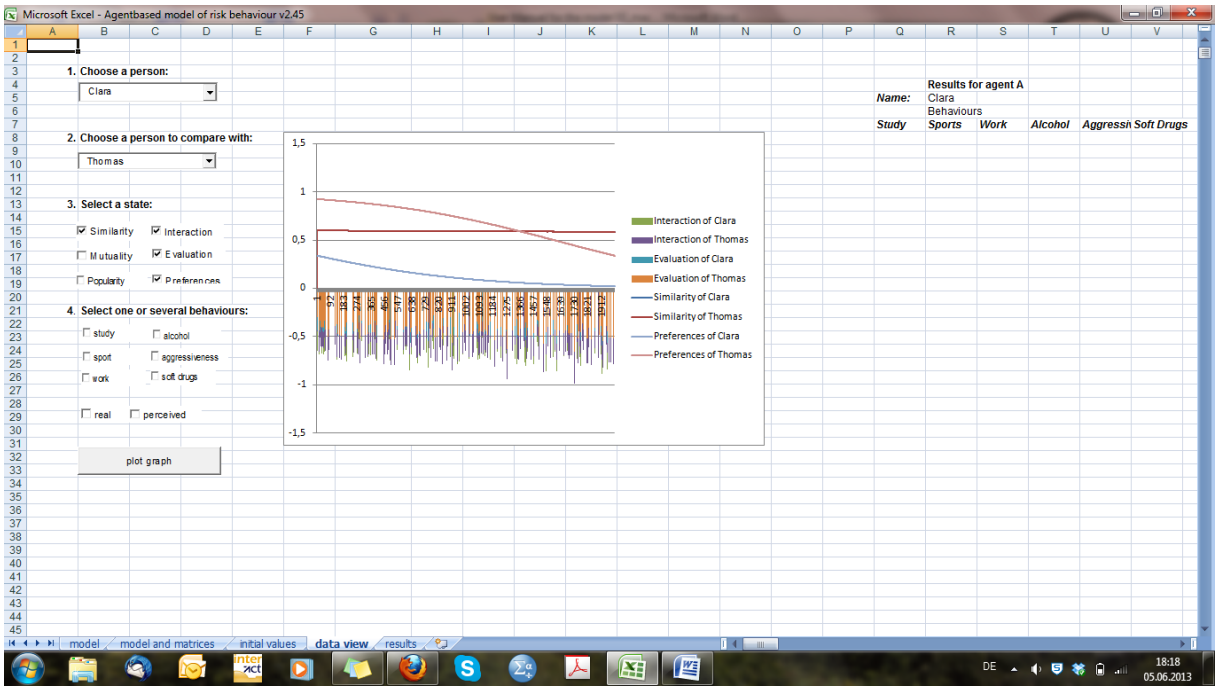

Figure 5: Screenshot of the "data view" sheet showing some results for two different agents.

Notes:

- You have to conduct a model run first, before plotting results.
- Sometimes internally saved model results get lost (e.g., if you close the file or a certain times has passed after a simulation run) and therefore cannot be plotted. In this case you have to conduct a new simulation run.
- It is only possible to plot the real similarity (NOT the perceived similarity).
- Mutuality (as well as similarity) values are identical for agent A and agent B.
- You can (manually) rescale the chart object to a preferred size.

The "results" sheet and result files

In this sheet model results are printed (only if the *Save results* control has been set to "Yes", see section on **Setting up the parameters**). The results of all agents and their values are printed (except for perceived behavior and perceived similarity values) of every 10th simulation step (this has been done for performance reasons and to reduce file sizes).
Data in the results file are identical to the data in the "results" sheet. Additionally, parameter settings are stored in the results file as well (see "Sheet 1" in the results file). If you stop the simulation run before the end of the simulation (defined by the number of simulation steps you have chosen in the parameter settings, see section **Model controls**) all values until the current simulation step are saved (values from current step to end of simulation are set to 0).

Notes: Sheets of a new workbook have to be named in English (Sheet 1, Sheet 2, Sheet 3), otherwise there will be an error message and the model cannot save the results file). Please contact the author if you need any advice in handling this error. In order to solve this problem you have to adapt the source code. If a results file (with the same name) already exists in your destination folder, windows will ask you automatically whether you want to override the existing file or not. If there is a Microsoft Excel Message
"The following features cannot be stored in macro-free workbooks:" click "Yes".

General hints, notes and recommendations

- Please don't try to start several simulation runs in parallel (e.g. starting the model with the VisualBots Simulator AND in the „model and matrices" sheet).
- With the current model version it is only possible to simulate (exactly) 20 agents (new model version with varying number of agents is already planned).
- If you use the "model and matrices" sheet to run the model, performance might be low. To enable using the display during simulation a wait function was implemented. This function slows down the simulation process, but allows you to control the Excel GUI (e.g. you can use the cursor to scroll up and down in the worksheets or switch active worksheets).
- You can visualize the emerging friendship networks (e.g., using NetDraw, https://sites.google.com/site/netdrawsoftware/download).
    - In your results folder a dichotomized result file of the agents' mutuality values (for t=10 and t=2000) is saved as well. You can use this file as an input file for NetDraw. You can use any mutuality or preferences values from the results file to generate/visualize the friendships network as well (e.g., to observe changes in this network of the course of simulation).
- If you want to make any changes in the model sheets, please notice the following instructions:
    - **Please do not change the names of the existing worksheets!**
    - **Please do not rename the filename of the model (this will cause problems in printing the results)**
    - **Please do not insert any cells in the existing worksheets**
- You can stop the macro at any time pressing the esc-button on your keyboard (try to press the esc-button several times, if the model doesn't stop immediately)
- If you want to check the source code, you can do so by opening Visual Basic in the Excel from the Developer menu tab. The different functions and variables are documented in the source code (see comment blocks in the source code).
- Is it possible to change the *Show…* control of the VisualBots Simulator (see section **Model controls**) during simulation, but you should pause the model first before changing these settings.