1 Advances in Complex Systems, Vol. 11, No. 2 (2008) 1–11
 © World Scientific Publishing Company

3 GETTING AWAY FROM NUMBERS: USING QUALITATIVE 5 OBSERVATION FOR AGENT-BASED MODELLING

5 LU YANG* and NIGEL GILBERT†

7 *Centre for Research in Social Simulation,
 Department of Sociology, University of Surrey,
 Guildford, Surrey, GU2 7XH, UK*

9 **l.yang@surrey.ac.uk
 †n.gilbert@surrey.ac.uk*

11 Received
 Revised

13 Although in many social sciences there is a radical division between studies based on
 15 quantitative (e.g. statistical) and qualitative (e.g. ethnographic) methodologies and their
 associated epistemological commitments, agent-based simulation fits into neither camp,
 17 and should be capable of modelling both quantitative and qualitative data. Neverthe-
 less, most agent-based models (ABMs) are founded on quantitative data. This paper
 explores some of the methodological and practical problems involved in basing an ABM
 19 on participant observation and proposes some advice for modellers.

Keywords: Agent-based models; qualitative data; ethnography.

21 *The right question isn't: Does the number mean anything? The right ques-*
 23 *tion is: Does the number correspond to a difference that makes a difference*
in the kind of world being modelled.^a

25 1. Introduction

25 Most agent-based models (ABMs) are intended to simulate some real-world phe-
 27 nomena and are therefore designed and validated by referring to data collected from
 the social world. Most often, such data are in numerical form. For example, the data
 may record the number of agents over time, obtained from organisational or gov-
 29 ernment records; agents' opinions about some issue, derived from attitude surveys;
 or the number of transactions and their prices obtained from market records. There
 31 are well-developed statistical techniques for summarising such data and comparing
 them with the outputs of simulation models.

33 Unlike most other modelling approaches, there is nothing inherently quantita-
 tive about agent-based modelling. It should be as easy to develop and validate

^aAlthough the best-known techniques make assumptions about the statistical distribution of the data that may not be appropriate for many ABMs, e.g. those that generate power-law distributions.

2 *L. Yang and N. Gilbert*

1 ABMs with qualitative data as it is with quantitative data. Nevertheless, this is
 2 far less often done (a noteworthy exception is Agar [1,2]). In the next section, a
 3 distinction is made between two types of qualitative data: one that can be used in
 4 almost the same way as quantitative data and one that for methodological reasons
 5 must be treated quite differently. Section 3 briefly describes an example of build-
 6 ing a model based on qualitative data, and Sec. 4 considers the extent to which
 7 ethnographic data match the ABM methodology. Section 5 concludes with a few
 tentative guidelines for using such data for agent-based modelling.

9 **2. Qualitative Data and Ethnographic Research**

10 At its simplest, qualitative data cannot be converted into numeric values with-
 11 out distorting the information they contain. There are two types of such data and
 12 they are fundamentally different in nature. First, there are data that are collected
 13 using social measurement techniques such as surveys. The data may be gathered
 14 using nominal (e.g. black, white, green) or ordinal (e.g. agree, neutral, disagree)
 15 scales, rather than interval or ratio (i.e. numerical) scales [3], but, like conventional
 16 quantitative data, the measurements are made on variables with one value for each
 17 respondent and can be stored and analysed as a variable/actor matrix. Such quali-
 18 tative data can be collected, managed and analysed using methods similar to those
 19 developed for quantitative data, with the exception of statistical techniques that
 20 require arithmetic operations on the values [4,5]. For instance, with a categorical
 21 scale such as “political party voted for in the last election”, it would be inappropri-
 22 ate to calculate the mean vote, although it is still possible to find the modal (most
 23 frequent) party voted for. Because categorical and ordinal data can be used in the
 24 construction and validation of ABMs in much the same way as quantitative data,
 25 this type of data will not be further considered here.

26 The idea of qualitative data also encompasses an entirely different type of data
 27 (and the common use of the term “qualitative” to cover both often leads to confu-
 28 sion). These are data that are generally textual in form, such as field notes obtained
 29 from observation, transcripts of interviews, and published documents, although
 30 they can sometimes consist of images, video or audio. Such data are not read-
 31 ily converted into a variable/actor matrix without losing information or doing an
 32 injustice to the data. The important feature of such data is that they are about
 33 the meanings that participants ascribe to events and actors. To distinguish such
 34 data from the categorical data mentioned above, they will be called “ethnographic”
 35 data [6].

36 Ethnographic data are often collected and analysed on the basis of epistemolog-
 37 ical and ontological assumptions that are significantly different from those typically
 38 adopted by quantitative researchers. At first sight, these assumptions may seem to
 39 get in the way of their application to the design and validation of ABMs, but in
 fact the difficulties are not as great as they appear. The basis for most ethnographic

1 data collection^b includes:

- 3 (1) Epistemological orientation: Ethnographic researchers often espouse naturalism — seeking to understand the particularities of a social phenomenon in its own terms in rich detail — while quantitative researchers often, although not
5 always, adopt a covering law model of explanation seeking deductive laws that are of universal or near-universal application. Agent-based modellers tend to
7 adopt a middle way, expecting their models to have some degree of generality, but rarely proposing that the models could have universal application (although
9 some game theorists come close to that ambition).
- 11 (2) Causation: While quantitative research is generally concerned with identifying correlations between variables, ethnographic studies are more interested in causal mechanisms, i.e. “by what intermediate steps, a certain outcome follows
13 from a set of initial conditions” [7].
- 15 (3) Ontological perspective: Ethnographic studies are frequently based on constructivism [8], which considers that social actors continually (re)construct their social world (rather than it being objectively available to them *a priori*).
17 This contrasts with the positivist or, more frequently, realist orientation of most quantitative and agent-based modellers [9]. Critical realism [10] takes the
19 approach that there are some “real” social processes or mechanisms existing that generate the observations that actors and researchers perceive.
- 21 (4) Methodological orientation: Ethnographic researchers generally adopt an inductive approach, in which theoretical categories are generated from consideration
23 of the data (e.g. the procedure called “grounded theory” [11]). In contrast, quantitative research usually involves testing hypotheses and, at least in their
25 writings, modellers tend to adopt a deductive approach, in which a simulation, designed on the basis of some prior theory, is tested to see whether it conforms
27 to observed data.
- 29 (5) Importance of generalisation: Many ethnographic researchers adopt an idio-graphic stance, i.e. aiming to understand the particular and contingent character of the case they are studying, and tend to be sceptical about the
31 possibility and the value of generalisation to universals. Agent-based modellers often assume that their models express some general patterns and structures,
33 although they will be instantiated with particular parameters to represent some specific case.^c
- 35 (6) Emic versus etic orientation: An emic description is one that is formulated in terms that are meaningful to the actor [13]. Typically, ethnographic data
37 are emic, in contrast to etic data, which are formulated using concepts meaningful to the researcher, but not necessarily to the actor. Both quantitative

^bInevitably, not all ethnographic, quantitative and agent-based studies exactly match the descriptions suggested in this list, but the majority do.

^cFor example, a “history-friendly” model [12].

4 *L. Yang and N. Gilbert*

Table 1. Characterisation of three types of social research.

	Quantitative	Agent-Based	Qualitative
Epistemological orientation	Deductive-statistical laws		Inductive laws
Causation	Correlational	Mechanism	Process
Ontology	Positivist	Realist	Constructivist
Methodology	Hypothesis testing	Model validation	Grounded theory
Generalisation	Seeks general laws	Seeks middle range models [15]	Idiographic
Emic/etic	Etic	Etic	Emic
Temporal and context emphasis	Cross-sectional and context-free	Time-important	Context-sensitive

- 1 theories and ABMs often use concepts (e.g. power law, evolution, utility) that
 2 are unlikely to be meaningful to those whose behaviour is being modelled.^d
 3 (7) Process and context: There is a strong emphasis in most ethnographic research
 4 on the process, i.e. on how and why things change over time. Mainly because it
 5 is often difficult or expensive to collect time-varying quantitative data, there is
 6 less emphasis on the process in most quantitative studies. In this respect, agent-
 7 based modelling, in which the passage of time is represented by simulated time
 8 steps, is closer to ethnographic than to quantitative research. Ethnography
 9 also emphasises context: that the meaning of actions depends on the context in
 10 which they are carried out. This is also a usual element in ABMs, where agents
 11 are given rules of behaviour that are context-specific (i.e. whether and how a
 12 rule is activated depends on the current state of the agent and its environment).
 13 These similarities and differences between agent-based modelling and ethno-
 14 graphic research are summarised in Table 1 and illustrated in the next section,
 15 which describes research on the socialisation of members into service work teams.

3. An Example

- 17 Lu Yang has been conducting a study of the socialisation of newcomers into existing
 18 organisational groups, and examining how the entry of a new member reshapes the
 19 members' interactions and the structure of the group [16]. Data were gathered
 20 by participant observation of two service work groups: one in a library, where the
 21 group task was to record book loans and returns, stack returned books and perform
 22 routine administration; and the other in a nursing home, where the group task was
 23 to carry out personal care for a number of bedridden patients. Each observation was
 24 conducted for a period of six months by participation in the work group as a new
 25 team member. The study generated copious and detailed field notes recording the

^dBut this is not always true: see the companion modelling movement [14] and participatory modelling more generally.

1 researcher's observations and providing direct evidence of the activities of members
and changes in group behaviour.

3 The "translation" of these field notes into a rule-based computer program
involved two stages. First, a narrative account of the socialisation process was
5 constructed. This began with an overall picture of the setting, the culture and
the members' everyday procedures. For example, the nursing home was situated in
7 the countryside of south-east England. It is privately owned, medium in size, and the
residents there are old and with various clinical needs. The functioning of the nurs-
9 ing home, including details such as how many nurses and carers were employed,
what kind of work they engaged in and the procedures they used, was described.

11 Then, a number of themes were identified, and illustrated with stories about
specific events and incidents that were observed. The observation data were used to
13 discuss, for instance, the high employee turnover rate, variations in the quality of
service, the boundaries of friendship groups, the hostility of existing staff towards
15 newcomers, etc. Explanations of these features of life in the nursing home were
formulated in terms of themes, e.g. that the care workers established their identities
17 partly by reference to their ethnicity, that co-workers often got angry with others
due to task conflicts, and that new carers learnt practical skills not from formal
19 training but from working with more experienced carers.

21 Much ethnographic research stops at this point, with a plausible narrative that
aims to explain the observations by reference to descriptions of social processes.
However, such descriptions tend to be vague and difficult to validate. We wished to
23 take the analysis a stage further by constructing an ABM that represented abstract
versions of these processes.

25 The second stage of the analysis therefore consisted of the design and implemen-
tation of an ABM that encapsulated some of the essential features of socialisation
27 observed in the two settings. As recommended by Dey [17], qualitative data analysis
"involves a process of abstracting from the immense detail and complexity of our
29 data those features which are most salient for our purpose". The ABM holds the
promise of helping to identify which features are most salient, ensuring that the
31 extracted features are consistent and coherent, and providing a way of validating
our conclusions by running the simulation. A recurring problem, however, was how
33 to model aspects of the settings without making them more precise or concrete
than the observational data would warrant (cf. Whitehead's "Fallacy of Misplaced
35 Concreteness" [18]).

37 The model, implemented in NetLogo [19], was designed to have the following
features:

- (1) Agents work on tasks. Agents and tasks are each represented as objects (i.e. as
39 "turtles" in NetLogo). A decision had to be made about how many of each type
of object to create. For example, this involved "abstracting" from the number
41 of carers that were employed in the nursing home (the actual number varied
from one week to the next and by shift) to a constant number of agents (that

- could varied from 1 to 9 between runs) and categorising the activities of the carers into precisely 10 tasks.
- (2) Agents have attributes. It was observed that people's demographic characteristics (e.g. age, gender, race and "aggressiveness") were salient in their relationships with other team members. In the model, each characteristic is represented by the value of an agent attribute. The attributes are used to calculate the initial attraction that each agent has to the others. There are many social-psychological studies that support the proposition that demographic attributes affect social integration (e.g. [20–22]). However, neither these studies nor our observations are able to quantify the degree of attraction given by these attributes, nor do they say anything about the attributes' relative importance or the functional form of the relationship. Consequently, an arbitrary choice was made (a function based on the Pearson product-moment correlation coefficient) and a sensitivity analysis conducted to see whether variations made a substantial difference to the outcomes (they did not).
- (3) Tasks have a priority level and a completion time. Since there are a maximum of 10 tasks at any time, the priority level ranges from 0 to 9. When applied to the library service team, priority level 9 represents front-line service; priority 8 means sorting book trolleys, and so on. The rank ordering of priority was based on what had been learned from observation of library work. The time taken to complete each task and the increase in speed at which a task is performed when more than one person works at it were also estimated from the observations. However, while in the model all tasks were assumed to take the same amount of effort, in reality different tasks took different times and the rates at which they were carried out depended on many factors beyond the number of workers assigned to them.
- (4) Agents that leave are immediately replaced by new, unsocialised agents. Observation confirmed that a new employee will be recruited to replace a worker who leaves. For simplicity, the model was designed so that one worker left and was replaced after a fixed number of time steps; in the settings, the timing of resignations was irregular.
- (5) Agents have "emotions". The field notes showed that emotion played a key role in the socialisation of new team members in both settings. A typical instance is shown in Fig. 1, an extract from the observer's notes.

This was represented in the model by formulating rules of interaction such that if any one agent displays certain emotions, other agents check their attraction value towards this agent. If an agent decides to respond to the one who displays emotion, the attraction matrix is updated. Unfortunately, however, it is not clear how to decide on how much the attraction value should be increased. Nor is it easy to settle on a value for the emotion display threshold. There is no theory or empirical basis for these and other numerical manipulations.

Day 10:

Markus started to arrange the working group.

'Gayle group 1, Flora group 2, Cora group 3, Shana group 4, Abigail group 5 and Lu group 6.' Gayle left the room.

'YOU CAN NOT DO THIS TO ME!' Abigail sat straight up, stared at Markus, and shouted at him. (I know, of course, it's me! Group 5 and 6 work in the wing of the home, which is the part that has the most resident care needs. This part is considered to be the hardest part of the job. It's normally the last part to finish every morning. The morning washing and dressing job should be finished by 10:30am, maximum 11am. Sometimes, if other groups finish earlier, they normally come and help the wing groups; however, they are not obliged to do so.) Markus didn't say a word, but looked pained. I can see he's trying to think how to deal with this. (Well, I don't think he has any choice though.) Then you heard different voices rose up, cross-netted (mainly Cora, Abigail and Flora), I had no clue what exactly they were talking about, the only thing I knew was that it concerned the groups! (I have no right to say, or, maybe more accurate, better not to say anything), I kept silent, but looked at them shouting to each other. (I felt sorry for them, but well, I am new, I am new! And that's the fact; I cannot change it in one night! I need to learn and learning takes time, simple as that. I'm already trying my best.) Finally, there ended up with a solution, Flora turned to me,

'Lu, there is a change about the groups, now, you are with Gayle upstairs and I'm with Abigail on the wing. OK?'

'Ok.' What else I can say. Abigail's still looking angry at Markus. (poor him! Sorry.)

Fig. 1. Extract from field notes recorded on the tenth day of participant observation at the nursing home. [All the participants' names have been changed except for the observer's (Lu).]

1 Despite our efforts to reduce the number of unsupported numerical constants
 3 and arithmetical operations within the model, it did not prove possible to eliminate
 5 many of them. One could "cheat", removing numbers by tricks of coding, or increase
 7 the apparent quantification by using numerical instead of symbolic values for all
 9 constants. While the presence of unjustifiable, "magic" constants in the code was
 11 the clearest example, it was not the only instance where the model had to be made
 13 more definite than the ethnographic record could justify. For example, in the model,
 15 agents that leave are immediately replaced (i.e. in the next time step). It looks as
 17 though there is no quantification here, but there is an implicit zero number of time
 19 steps between one agent leaving and the next arriving. In practice, in both the
 21 library and the nursing home, there was almost always some time gap before a new
 23 member of staff could be recruited, trained and formally inducted.

13 To resolve this problem, it was necessary to engage in a further process of
 15 abstraction. As noted above, both ABM modellers and ethnographic researchers are
 17 interested in mechanisms, i.e. the processes or sequences of events that causally link
 19 initial conditions and outcomes [7, 23]. A mechanism is a theoretical construction
 21 described in abstract terms (for example, the mechanism of an epidemic involves a
 23 virus infecting a susceptible victim, who in turn infects another victim — here the
 concepts "virus" and "victim" are theoretical terms). The ethnographer observes an
 instantiation of the mechanism (Ann infects Bob, or, in the nursing home, Charles
 has an argument with David) and infers the mechanism from his or her observa-
 tions, through a process of abstraction. In doing so, many quantities, even if they
 are observed at all, are discarded (for example, the account of the epidemic may

8 *L. Yang and N. Gilbert*

1 ignore the time taken for the virus to make the victim infectious; in the library,
 2 the ethnographer may record but then disregard the number of arguments between
 3 Charles and David and simply note the existence of conflict). The modeller has to
 4 go the other way: given an abstract social process or mechanism, he or she has to
 5 invent some numbers in order to fill out the theory sufficiently to create a work-
 6 ing implementation. The important issue in inventing these numbers is not their
 7 specific values, but that the implemented model must be an instantiation of the
 8 desired mechanism.

9 **4. The Relationship Between ABMs and Ethnographic Data**

10 The purpose of building an ABM to represent the library and nursing home case
 11 studies was to formalise and verify the set of mechanisms that led to the main
 12 features of the settings that were observed. This involved creating a specification
 13 of the model and the behavioural rules to be followed by the agents, implementing
 14 and running the model, and comparing the outcomes with the ethnographic record.
 15 In terms of the issues listed in Table 1 of Sec. 2, this requires:

- 16 (1) A realist orientation, in which observable social action is considered to be gen-
 17 erated by the modelled social processes. Although critical realism is usually
 18 associated with an objectivist stance, it is possible to couple realism with con-
 19 structivism if one allows for agents to construct the meanings and concepts
 20 they use as a response to the social environment in which they act. However,
 21 given the fairly primitive models of cognition and language use in almost all
 22 current ABMs, modelling of such aspects is unusual.
- 23 (2) Either a deductive approach, in which the model is formulated and then tested
 24 against the ethnographic data, or an abductive one, in which a theory and thus
 25 a model is induced from the data and then the model is tested against the data
 26 and discrepancies used to improve the model.
- 27 (3) A concern with generalisation. ABMs normally represent a general theory about
 28 how some social phenomenon works. Ethnographic data about one particular
 29 setting can be used as a case study or a “critical case” that can be used to help
 30 to validate a model — more precisely, to falsify the model if it is incapable of
 31 generating a representation of the behaviour observed in the setting.
- 32 (4) An etic approach, i.e. one that uses the analyst’s concepts, but where actors’
 33 concepts are, as far as possible, allowed to emerge from the operation of the
 34 model.
- 35 (5) The usual interest in process and context that can be found in most ABMs.

36 Working within these constraints, it seems possible and useful to construct an
 37 ABM that represents the processes or mechanisms that have been discovered from
 38 ethnographic research. However, the model cannot be expected to confine itself to
 39 representing the ethnographic data and no more, for an ABM will inevitably require
 many “numbers” or, more accurately, modelling assumptions, that are not to be

1 found in the data. This is not a difficulty provided that the model does represent
 2 at some abstract level the same mechanisms as are identified in the ethnographic
 3 analysis.

5. Conclusions

5 It has been suggested that it is possible to use ethnographic data, such as field
 6 notes from participant observation in the design and validation of ABMs, but that
 7 there are a number of areas where a modeller will find himself or herself having
 8 to move away from the conventional assumptions and methods of ethnographic
 9 research. While the agent-based modelling community needs to gain more experi-
 10 ence of using ethnographies in their work, some advice can already be formulated
 11 for those contemplating using ethnographic data:

- 13 (1) Ethnographic data are usually very rich and detailed, while simulation models
 14 tend to be somewhat abstract. In order to bridge the gap, it will be necessary
 15 to develop analyses of the ethnographic data, possibly using computer-aided
 16 qualitative analysis (CAQDAS) tools^e to help manage, code and search the
 17 textual data.
- 18 (2) Although typically an ethnographic study describes just one particular setting,
 19 it can be used as a case study of a more general class of settings. It may be
 20 useful either to conduct more than one ethnographic study, so that settings can
 21 be compared, or to locate descriptions of other settings that can substitute for
 22 first-hand data collection.
- 23 (3) Ethnographic data are often good sources of information about relationships,
 24 among actors and between actors and objects. A model of the data will need
 25 to represent such relationships, i.e. the model is likely to be based on networks
 26 of agents.
- 27 (4) Ethnographies usually contain descriptions of social processes that are equiv-
 28 alent to the kinds of mechanisms that are typically modelled by ABMs. This
 29 helps to lay out these processes explicitly in the ethnographic analysis before
 30 attempting to model them.
- 31 (5) The modeller will have to add “concreteness” to the model beyond the evi-
 32 dence in the data (e.g. choosing numeric values for thresholds and multipliers;
 33 selecting distributions for random number generators; assigning attributes to
 34 agents either at random or in some arbitrary way). This is an inevitable part
 35 of the process of using ethnographic data as the foundation of an ABM. As far
 36 as possible, such choices should be justified by conducting a sensitivity analysis
 37 and showing that they do not have a significant effect on the outcomes of the
 simulation, while recognising that it is impracticable to test the sensitivity of
 every aspect of a model.

^eSee, for example, the reviews and resources available at <http://caqdas.soc.surrey.ac.uk>

10 *L. Yang and N. Gilbert*

- 1 (6) While a great deal of ethnographic data concern the observation of individual
 3 action, some structural and group data can also be gathered (e.g. who talks
 5 to whom and when; what collective events occur; who is involved in rituals).
 These “macro” features of the setting are valuable for the modeller. The model
 may generate outcomes and patterns that correspond to these features, and if
 it does, this helps to validate the model.
- 7 (7) The modeller should consider the implications of a stance that proposes that
 9 the way people structure their worlds is not based on an external reality but a
 culturally generated and fluid categorisation that is self-organising and emer-
 gent. While this constructivist perspective is hard to accommodate, given the
 11 state of the art in agent-based modelling, one can at least try to represent some
 of its implications.

13 Ethnographic data, we contend, are no less relevant to building ABMs than
 quantitative data. However, while there is already much experience in using quan-
 15 titative data to design and validate ABMs, there are relatively few examples of
 ABMs based on ethnographies and little advice to guide the modeller. We hope
 17 that this paper will inspire more consideration of how ethnographic data can best
 be used by modellers.

19 **Acknowledgment**

We acknowledge the partial support from the project “EMIL: EMergence In the
 21 Loop: simulating the two-way dynamics of norm innovation”, funded by the Euro-
 pean Commission Sixth Framework Programme — Information Society and Tech-
 23 nologies — Citizens and Governance in the Knowledge-Based Society.

References

- 25 [1] Agar, M., My kingdom for a function: modeling misadventures of the innumerate,
Journal of Artificial Societies and Social Simulation **6** (2003) 8.
- 27 [2] Agar, M., Agents in living color: towards emic agent-based models, *Journal of Arti-*
ficial Societies and Social Simulation **8** (2005) 4.
- 29 [3] Sirkin, R. M., *Statistics for the Social Sciences* (Sage, Thousand Oaks, California,
 1995).
- 31 [4] Babbie, E., *The Practice of Social Research* (Wadsworth, 2004).
- [5] Stevens, S. S., On the theory of scales of measurement, *Science* **103** (1946) 677–680.
- 33 [6] Agar, M., *The Professional Stranger: An Informal Introduction to Ethnography*
 (Academic Press, 1996).
- 35 [7] Mayntz, R., Mechanisms in the analysis of macro-social phenomena, *Philosophy of*
the Social Sciences **34** (2004) 237–259.
- 37 [8] Berger, P. L. and Luckmann, T., *The Social Construction of Reality: A Treatise in*
the Sociology of Knowledge (Anchor, 1967).
- 39 [9] Gilbert, N. and Chattoe, E., Hunting the unicorn: an exploration of the simulation
 of small group leadership. In: Saam, N.J. and Schmidt, B. (eds.) *Cooperative Agents:*
 41 *Applications in the Social Sciences* (Kluwer, Dordrecht, 2001), pp. 109–124.

- 1 [10] Archer, M., *Realist Social Theory: The Morphogenetic Approach* (Cambridge University Press, 1995).
- 3 [11] Glaser, B., *Basics of Grounded Theory Analysis* (Sociology Press, Mill Valley, California, 1992).
- 5 [12] Malerba, F., Nelson, R., Orsenigo, L. and Winter, S., History-friendly models: an overview of the case of the computer industry, *Journal of Artificial Societies and Social Simulation* **4** (2001) 6.
- 7 [13] Headland, T., Pike, K. and Harris, M., *Emics and Etics: The Insider/Outsider Debate* (Sage, 1990).
- 9 [14] Barreteau, O., Our companion modelling approach, *Journal of Artificial Societies and Social Simulation* **6** (2003).
- 11 [15] Merton, R. K., *Social Theory and Social Structure* (Free Press, New York, 1968).
- 13 [16] Yang, L. and Gilbert, N., *Case-Based Model of Emotional Expression Influence on Work Group Socialization and Performance* (1st World Congress on Social Simulation, Kyoto, Japan, 2006).
- 15 [17] Dey, I., *Qualitative Data Analysis: A User-Friendly Guide for Social Scientists* (Routledge, London, 1993).
- 17 [18] Whitehead, A. N., *Science and the Modern World* (Free Press (Simon & Schuster), 1925).
- 19 [19] Wilensky, U., *NetLogo* (Center for Connected Learning and Computer-Based Modeling, Northwestern University, Evanston, Illinois, 1999).
- 21 [20] Hoffman, E., The effect of race-ratio composition on the frequency of organizational communication, *Social Psychology Quarterly* **48** (1985) 17–26.
- 23 [21] McPherson, M., Smith-Lovin, L. and Cook, J. M., Birds of a feather: homophily in social networks, *Annual Review of Sociology* **27** (2001) 415–444.
- 25 [22] Ward, R.A., La Gory, M. and Sherman, S. R., Neighborhood and network age concentration: does age homogeneity matter? *Social Psychology Quarterly* **48** (1985) 138–149.
- 27 [23] Hedström, P. and Swedberg, R. (eds.), *Social Mechanisms: An Analytical Approach to Social Theory* (Cambridge University Press, 1998).
- 29