The Micro-Macro Link in DAI and Sociology

Michael Schillo[1], Klaus Fischer[2], Christof T. Klein[3]

[1]Multi-Agent Systems Group, Saarland University, Im Stadtwald,
66123 Saarbrücken, Germany, schillo@virtosphere.de
[2]DFKI GmbH, Stuhlsatzenweg 3, 66123 Saarbrücken, kuf@dfki.de
[3]Department of Sociology, Saarland University, Im Stadtwald,
66123 Saarbrücken, Germany, ctk@ags.uni-sb.de

Abstract: No matter if a population is human or artificial, we can surely identify phenomena that can be described as micro or macro phenomena. In this paper, we discuss micro and macro aspects of a population from a DAI and a sociological point of view. We analyse similarities and differences in these viewpoints, and identify misperceptions in the DAI community about the micro-macro terminology. We explain these misperceptions and argue for the transfer of sociologically founded concepts to agent-based social simulation. Our research is done in the DFG focus programme socionics. We cooperate with sociologists from University Hamburg-Harburg with the intention to transfer knowledge from sociology to DAI as well as from DAI to sociology. In cooperation with DFKI Saarbrücken we work on improving agent theories to be applied in large sized multi-agent systems in the freight logistics domain.*

1 Introduction

The problem of how individual action and structural rules in a set of agents interact is a foundational issue for both DAI and sociology, also known as the micro-macro problem. The understanding of the link between micro and macro would mean a substantial advance in designing agents for dynamic and large-scale agent-based social simulation, as well as a deeper understanding of human societies. Furthermore, modelling the macro aspect in agent theories is considered to be essential for DAI research, as this concept substantially contributes to the distinction between artificial intelligence and distributed artificial intelligence (DAI). For this enterprise, a scientific cooperation with sociology can be of great benefit to DAI. However, we found that a mutually agreed terminology cannot be assumed.

The micro-macro problem is perceived in distributed artificial intelligence (DAI) research as a central issue because it directly refers to such problems as coordination and scalability. And indeed, the definition of distributed AI as opposed to the parent discipline of artificial intelligence heavily depends on aspects that are only introduced by the problems that occur when multiple actors face the results of each other's actions [47]. Not surprisingly, there are differences of definitions of the micro-macro problem as researchers perceive it in the DAI community and the perspective taken in mainstream sociology. DAI definitions of the macro level either intend to abstract

from the individual and to summarise certain features of a group of agents (performance, communication overhead etc.) or aim at mechanism and organisational design. While the former is a descriptive approach, the later is normative. Sociology does study the same level of abstraction from the individual, but takes a different (and usually only descriptive) perspective. In sociology the macro level of a society is itself a structure, which possesses to a certain degree it's own autonomy: it survives the individual and is (primarily) independent from the influence of any single individual. A further important feature of the macro level is that it reproduces itself over and over again by channelling the interests of the individuals.

While organisational theory by definition does not make any claims about how a society (including a number of organisations) is composed, reducing the complexity of a society to a multi-dimensional performance vector does not pay tribute to the complex dynamics that can be observed at the macro level of human societies. This does not render the cooperation of the two fields obsolete. On the contrary, looking further at sociological theory is most fruitful to DAI research. Apart from the solely action-oriented or structure-oriented theories, there is a selection of hybrid theories that try to explain the connection between individual action and social structure (Giddens, Bourdieu etc.).

In the discussion section we propose and start to analyse the habitus-field theory of Pierre Bourdieu, which tries to explain the effect of individual behaviour on societal structures **and** vice versa. This is where the great strength of the theory lies and where we expect that DAI will find a lot of concepts for overcoming the micro/macro gap. For example we state that the theory on this reciprocal relationship is the medium that answers Castelfranchi and Conte's [7] question of how cognition can be structured by society and what is essential for the emergence of structure from micro-interactions. Our research is done in the context of the field of *socionics* [34]. In this area sociologists and computer scientists try to transfer methods and theories from one discipline to the other. Our main concern is the modelling of interactions in the domain of shipping companies. This scenario is defined by its openness and complexity as we encounter a great diversity of agents as well as tasks and time restrictions. Typically is also the large scale of such MAS in the magnitude of thousand agents that requires not only interaction on a micro level but also macro structures to function efficiently, and coherently. Our work leads us to the conclusion that building social agent architectures that can deal with both, micro and macro phenomena is not solely for the purpose of human adequacy but has also strict engineering reasons. This emphasises the importance of sociologically founded theories applied in DAI research.

2 The Micro Level in DAI and Sociology

The micro level is the area where we can expect to find mostly agreement between the two disciplines. The micro level is composed of individual actors (humans and agents, respectively) that interact. However, both disciplines emphasise different aspects. DAI focuses on the cognitive architecture and the theory of how to model knowledge acquisition and memory, perception and problem solving. This results in a focus on designing algorithms that produce for a given input an appropriate (rational?) output,

as expressed by the widespread acceptance of decision and game theory. Sociology on the micro level however, focuses on *inter*action and relationships between actions and actors. Also, sociologists consider social actions, i.e. actions that are aimed at changing the actions, effects of actions or beliefs of another individual. It is important to note that this excludes actions like unwillingly causing an effect on another person and actions aimed at objects, but includes actions like threatening another person (social in the sense of related to other individuals and not in the sense of caring).

These differences may seem subtle at first. As we go on to take a look at the macro level, this differences become more important, as the perception of *what* is interacting on the macro level diverge significantly.

3 Overview on Perspectives on the Micro-Macro Link in Sociology

An exhaustive discussion of the definition of the macro concept in sociology definitely exceeds the space provided here (and our competence). In fact, this discussion fills volumes and some will even argue that this discussion is equivalent to doing sociological research. We can note that many definitions exist, all tailored to a specific theory, with no apparent success in the discipline to generalise from specific theories. A second problem with presenting a clear-cut definition of the sociological notion of the macro level may be that there is no corresponding physical fact in reality. Even the phenomena usually connected with certain levels (e.g. interaction for the micro level) are hard to pin down as they sometimes are used with slightly differing connotations (e.g. when talking about the interaction of religion and politics as their bi-directional influences, which are phenomena of the macro level).

Depending upon perspective of observation, the subject of social sciences can be examined thereafter similarly from micro, meso, to macro or metasociological perspective. The missing of a generally accepted theory of the social leads to distortions and formation of different schools with according to differentiated research programs. Thus different paradigms co-exist for the study of the emergence of social structure in contrast to Kuhn's thesis on „changes of paradigms" [26]. A brief description of the four perspectives follows:

Micro-level: Sociology as science of social concern and interhuman behaviour. Investigation of the influences of small groups on the non-standard behaviour (concern, perception and thinking), e.g. groups and exchange theories.

Meso-level: Sociology as science of the social institutions and organisations. Investigation of the influences from social organisations, e.g.: organisation sociology, work sociology, technique sociology, sociology of education.

Macro-level: Sociology as science of the whole society, its stability (static aspects) and change (dynamical aspects). It analyses which forces are responsible for stability and change: religion, economics, culture, institutions etc. Investigates the influences of the 'society' and culture, e.g. general system theory, sociology of culture.

Meta-level: Sociology as science of the ideas about society and as criticism of ideology. Investigates society and culture constructing ideas, objects and values, e.g. knowledge sociology, social philosophy, critical society theory (Frankfurter Schule).
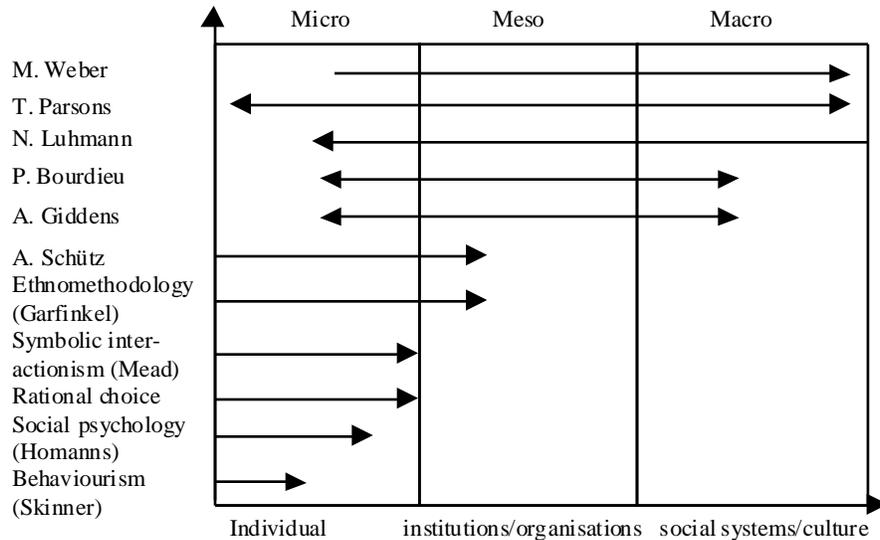
Micro   Meso   Macro

M. Weber

T. Parsons

N. Luhmann

P. Bourdieu

A. Giddens

A. Schütz

Ethnomethodology
(Garfinkel)

Symbolic inter-
actionism (Mead)

Rational choice

Social psychology
(Homanns)

Behaviourism
(Skinner)

        Individual   institutions/organisations   social systems/culture

Fig.1 Overview on foundational strands in sociological theories.

For example the introduction of a bank holiday will surely provoke a wide discussion in a society. Politicians, trade unions, employer associations, even the churches will engage in a debate on the advantages and disadvantages, all parties with their respective motives. Observing the influences of the different fields that interact here (economics, politics, religion) is observation of the society on the *macro* level. A *meso* level view would be e.g. the investigation of the different groups involved. Maybe a new movement will form that aims to prevent this bank holiday. An investigation of this movement would be a meso study. A *micro* level observation would be, if we looked at individuals in a group confronted with this topic and how they interact, which group processes exist that shape the interaction etc. A *meta* observation could be how eastern societies and western societies differ in decision making on topics that involve economics, religion and politics.

When evaluating current sociological theory, we need to take into account the classical theoretical works in this discipline. The literature on social theory presents itself as complex and multi-layered. The social life as the shared object of investigation was re-built as a complex variation of phenomena, depending on observation levels by the examining scientists and their specific ways of examination. In order to classify the parts of the social universe, it was broken up into four levels as described above.

In a short overview we will present a collection of social theories and briefly discuss their ranges and main features from the perspective of DAI. We divide the broad range of theories into theories focusing on the micro level, focusing on the macro level and theories that try to translate from the micro to the macro level and back (see Figure 1). As we focus on the micro-macro link, we leave the more abstract meta level out of scope of this discussion. Of course, this overview is reducing the theories to an absolute minimum and will by many (sociologists) be viewed as lacking

respect for the complexity of the theories. However, this overview is not intended to cover the theories in their details, this would be impossible in the space given to a paper and a complete meta-analysis is left to scientists with more competence.

3.1 The Macro-Approaches

In the centre of these approaches lie large social formations or collective processes (the objective structure). Their objects are for example the structure and the change of governmental organisations and institutions (e.g. capitalist society formations as strata, classes, parties). The main interest is to attempt the analysis of the whole society by its objectified social structures. The aim of this macro-orientation on social life phenomena is to describe and explain processes of reproduction (static aspect) and social change (dynamic aspects) of societies under economical, social and cultural points of view. The society is to be considered as an reality of its own, which can not be deduced from individual contexts (i.e.. from acting and behaviour). In this view the society does not comply with the sum of its parts.

The individual subjects play a minor part for the constitution of social life and its actual conditions. In fact, by reconstructing the social in macro-models their influence on social structure merely occurs as exchangeable data (contingent functions of individuals). See for example the so called *normative paradigm* of Parsons' action-theory [36]: Confronted with social expectations (may-, shall-, must-expectations), the owner of a social position (objective social structure) will, in spite of Parsons voluntarist assumptions, be forced under societal conditions with different degrees of sanctions to adapt to the objective structure. Thus, the *homo sociologicus* is viewed as fulfilling obediently the integrative and forced upon function of the more abstract layer in the social system. To give an example: In Luhmann's conception of social systems [28][29] the actors were completely excluded with the definition of communication as the basic element of modern societies and the selective process of *information, mediation* and *understanding*, his theory of social systems defines the individual (*psychical systems*) as *environment to the system*, which can only participate to the social by communication. (cf. [36, 38, 1, 2, 46]).

3.2 The Micro Approaches

The micro-sociological approaches study the social by observing the individuals and their interaction behaviour (e.g. [17]). The issue most important in this research area is: How can individual behaviour (action, mind, cognition) with no explicit and planned coordination create the social, i.e. the emerging of social coordination and the given structures[1]. The dependence on the social structure, surrounding the individuals is not rejected, but plays a minor part in this perspective. As a reaction and critique on the objective (i.e. macro-) perspective and its assumptions of a social organism, of functional adaptation of individuals to the system in the first half of the century, the

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[1] The following references give an overview to these approaches: The phenomenological approaches in succesion of *Alfred Schütz,* for instance [4] or [42]. For the symbolic interactionism see [32, 5, 18, 13]. For the utilitaristic/behaviourist paradigm see [22, 9, 19].

micro-perspectives received increased attention (see the critiques on Parsons by Schütz, Mead, Blumer etc.). A second motivation was the intention to reduce the scope of society analysis to the social psychology scope of learned behaviour and exchange processes in group theory [21].

Micro-perspective approaches try to investigate how humans typically act under the assumption of the presence of *the generalised other* (see Mead's concept of identity as intersubjectivity and human gestures as *significant symbols).* These approaches pose the question of which motives and expectations guide the individual's behaviour. They try to reconstruct these motives and expectations from observed situational contexts and behaviour (see the *interpretative paradigm*, a notion which summarises the approaches of Schütz and Mead as well as their followers).

3.3 The Hybrid Approaches

The opposition between micro and macro-approaches belongs to the classical debates of the sociological community. But besides the traditional antonyms corresponding to the micro-macro clash as for example subjectivism-objectivism, system theory vs. theory of action, collectivism vs. individualism etc., we have to note a „renaissance,, of the question about the relation of society (structural aspect) and the individual (action or cognition aspect). The main target of the „hybrid movement,,, was to explain social life in relation to both action and the structure, like for example Anthony Giddens did [16].

One of the sociologists with great importance in this respect, not only in France, but all over the world, is Pierre Bourdieu. The conceptualisation of the habitus concept (first 1967) allowed Bourdieu to develop the dialectic relation of objective structure and subjective action/cognition by the assumptions of internalising the structure and reproducing social structure in individual life styles, according to the position in the social space. In contrast to Giddens who created his concept of *structuration structure* for theoretical reasons, the habitus was created and based on Bourdieu's practical work in ethnographic field research in North Africa [7].

4 A brief Summary of the Notion of the Macro-Level in Sociology

Viewing the macro-level of a society means to attribute autonomy to the structural aspects of a social context. These aspects cause stability and change and can be summarised by such concepts as religion, economics, culture, institutions etc. Autonomy here means that no individual does have the power to change these structures and it will even be difficult for a group of individuals. It also means that the structure is not dependent on the existence of a specific individual, the structure survives the individual. While this independence of structure from a specific individual holds, it is also true that the structure depends on the whole population for reproduction of the structure (where reproduction is the only aspect the individuals can influence). It is important to note that this reproduction happens even without explicit knowledge of the individuals. The dynamic that exists in any given social structure is created by the malallocation of resources to individuals. The structures

that develop are created as means of reduction of the complexity of life. In this sense society or organisation can only exist if and only if participation of the individual is the „reasonable" thing to do.
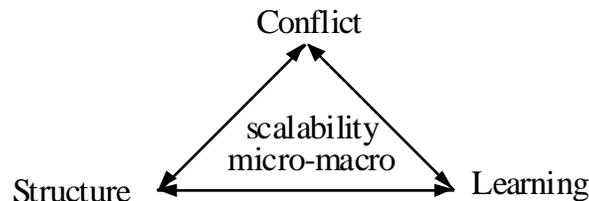

Fig. 2 The relationship of structure, conflict and learning from a *socionics* perspective [31].

In this context it is interesting to remark the connection between structure and learning (or adaptation) on the individual level (see Figure 2). Learning is a cause for structural changes (changing goals, needs and ways of the reproduction of structure) and structure shapes the rules that constrains what and how the individual can learn. This is a connecting point to the idea of the construction of intelligence from the societal context [15]. But there is a second (indirect) connection via the concept of conflict: conflicts are stimuli for learning (e.g. reinforcement learning) and learning may lead to conflicts. Conflict again is connected to structure, as the change of structure often leads to conflicts and conflicts tend to be the causes for such structural changes [27].

5 In Contrast: The Macro Level in DAI

Firstly, we will look at the trends in sociologically motivated agent-based simulation and will give a brief survey of the different applications of the micro-macro distinctions. Secondly, we will look at what can be called application-oriented multi-agent systems. Conte and Moss [12] divide social simulation (not DAI) roughly into these two approaches and we will adopt their terms. The first (sociologically motivated) set of research seeks to develop the foundations of social theory by using DAI in theory testing by simulation, which Conte and Moss call the foundational approach. The other approach, which they name the representational approach, develops modelling techniques and agent specifications to represent observed social and institutional processes. The first set of models and implementations can be viewed as being primarily object to knowledge transfer from DAI to social sciences, whereas the second set may benefit from sociological knowledge in terms of better system performance.

5.1 Agent-Based Social Simulation: The Foundational Approaches

Firstly, there is social simulation research that is inspired by game theoretic approaches, which for instance includes the works that build on Axelrod's research [24][3]. These works concentrate on modelling attitudes (altruism vs. egoism, benevolence vs. individual rationality) and improve these notions e.g. by mechanisms

for protecting cooperative agents from self-interested agents [34]. These works can be viewed as looking at the micro, i.e. interaction level of societies.

A more behaviourist strand of research is the work on platforms like SUGARSCAPE and SWARM (e.g. [23]). Here the macro level is perceived as patterns that emerge from simple behaviours in large sized populations. However, this cannot be attributed as *social actions* as in these models there is no notion of self and others and no action that is intended to influence another individual's belief or actions, which is the very prerequisite of *social* action[2]. A definite exception in this strand of research, are anthropological models that try to elicit emergent structures from social behaviour (behaviour that is directed at other individuals). An example of such research is the EOS project [14], which can demonstrate the emergence of in-group hierarchies, which in sociological terms is a meso-level feature (as the relations of groups are the subject of study).

In the previous approaches the macro-level is perceived as the overall behaviour of a population of agents, an emergent structuring that is not hard-wired by the designer. This is different from the sociological point of view in the respect that sociology would require a number of hierarchies and groups to form, interact and cause changes bi-directionally between micro and macro level.

There is also a strand of research that tries to explicitly model macro structure of a society. However, such multi-level social simulation does not necessarily imply the full bandwidth of sociological concepts of societal levels. For some good reasons (modelling effort, simulation speed) it is common practice to restrict the simulation to only a uni-directional relationship between micro and macro level, which still render impressive results. E.g. Troitzsch [44] describes a multi-level simulation where individual (behaviour) was simulated to make predictions about money spending behaviour of a population, attitude formation in a population with no structural changes, gender desegregation in schools etc. In these kinds of simulations the macro level information consists of an aggregation of the micro level data. The design rules out any possibility for the individual to change the structural constraints imposed on the population. According to Conte and Castelfranchi [11] the preference of the uni-directional link for social simulation in current research does not only hold for the micro-to-macro direction but also for the reverse.

5.2 Application-Oriented Multi-Agent Systems: The Representational Approaches

According to Weiß [47], the micro-macro problem poses a question, which raises the issues that define the term of DAI research itself. Therefore we will revisit these issues, before we try to make out important strands of current research and how they relate to the micro-macro discussion. It is important to note that although the micro-macro problem plays such a central role, it is not a standard term in the literature (e.g.

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[2] However, we note that in agent research it is now a common understanding that social ability for an agent does not only mean that the agent can communicate via an agent communication language, but it also implies that the agent is able to model itself and others, reason about *when* to communicate *with whom,* about *what* and in *which way.*

[25]). In most of the literature it is referred to only implicitly by trying to decompose the problem into several subproblems.

The first influential collection of such subproblems where we can study at least the implicit notions in DAI of the micro-macro problem is the book by Bond and Gasser [6]. They list five central issues for DAI:

- How to enable agents do decompose their goals and tasks, to allocate sub-goals and sub-tasks to other agents, and to synthesise partial results and solutions.
- How to enable agents to communicate. What communication languages and protocols to use.
- How to enable agents to represent and reason about the actions, plans, and knowledge of other agents in order to appropriately interact with them.
- How to enable agents to represent and reason about the state of their interaction processes. How to enable them to find out whether they have achieved progress in their coordination efforts, and how to enable them to improve the state of their coordination and to act coherently.
- How to enable agents to recognise and reconcile disparate viewpoints and conflicts. How to synthesise views and results.

Please note that compared to the sociological notion of the macro level, these issues are more dealing with agent interaction than societal issues. Moulin and Chaib-Draa [33] add a software engineering (or normative) perspective to this perception of DAI:

- How to engineer and constrain practical multi-agent systems. How to design technology platforms and development methodologies for DAI.

Jennings, Sycara and Wooldridge [25] focus on the coordination aspects in DAI when they add:

- How to effectively balance local computation and communication.

They approach the macro-level from a pragmatic point of view when formulating the last issue for DAI:

- How to avoid or mitigate harmful (e.g., chaotic or oscillatory) overall system behaviour.

This issue is also addressed by a range of game-theory-inspired research, usually summarised under the term *mechanism design* (e.g. [39]). Weiß reformulates these last two issues into the following desiderata:

- How to enable agents to negotiate and contract. What negotiation and contract protocols they use.
- How to formally describe multi-agent systems and the interactions among agents. How to make sure that they are correctly specified.
- How to realise „intelligent" processes such as problem solving, planning decision making, and learning in multi-agent contexts. How to enable agents to collectively carry out such processes in a coherent way.

Especially the last notion seems to be central in DAI: The design of agents that behave coherently. This notion reflects the system designer perspective of a MAS and for the application of MAS we assume that this notion is a cornerstone of the

perception of the macro concept. Only occasionally the macro concept is made as explicit in the DAI literature as by Nwana [35]:

> *„macro issues, such as the interaction and communication between agents, the decomposition and distribution of tasks, coordination and cooperation, conflict resolution via negotiation, etc. [The goal of macro research] was to specify, analyse, design and integrate systems comprising of multiple collaborative agents.“*

Please note that none of the listed issues deals with the features required by sociology for societies, e.g. power, institutions etc. The term conflict only occurs in the efforts to avoid it (this is the aim of work on *coordination* and *conflict resolution)* and although there is a tremendous concern for patterns of actions, until now there seems to be no theoretical framework to formally analyse such patterns. Verhagen and Smit [45] attribute this to the different approaches of sociology and DAI, where DAI (by its continuingly strong connection to the cognitive sciences) is more concerned about action selection and cognition than the limitations imposed by societal structure on the individual and the effects of knowing about these limitations. Although there is some work on recognising and reasoning about relationships, namely goal/task dependence [40] and role definition and role dependence [20], we cannot say that they approach the far more complex forces that are active on the macro level. Rather, these theories cover the group or organisational level of society.

The confusion of the macro concept between sociology and DAI is partially due to the fact that there is also a (minor) perception of macro as being the structures and rules on the top level of the social context as it is perceived by the individual. In this sense, any given simulated population will have a macro level modelled as well. This holds for prehistoric human communities as well as for even the simplest community model in DAI. However, the majority of social scientists views the most complex level of today's human society as the measure with which the macro level of a population ought to be analysed.

6 Four Misperceptions in DAI Research about Social Phenomena

In this section we apply the sociological notion of the micro and macro level of society for a discussion of the use of these metaphors in DAI research.

1)   Mechanism design is macro-level design

Mechanism design is usually the coordination of actions of individuals to achieve some invariants of the behaviour of a group of individuals ([39]; etc.). However, unless there is structure or dynamics in the system that goes beyond the single interaction, there will be no manifestation of societal structures or institutions. In social psychology there is a collection of work inspired by game theory on penalty systems and their emergence in games (e.g. [48]). This could be viewed as advancing to the meso (group) level. Modelling processes among individuals is to be located at the sociological micro level

2) Macro-level behaviour is emergent behaviour

According to Langton [27] emergence is a „result that was not defined statically„ (i.e. before run-time). Such a „not-predefined„ result is not necessarily a macro level result: see for instance SWARM-like simulations. Although they can produce patterns (of action) they do not lead to the emergence of higher-level institutions that shape and keep a society together. A similar argument holds for the reverse direction: macro-level structures can be implemented in a simulation statically without the need to let them emerge.

3) Value aggregation is an analysis of macro phenomena

One way to distinguish attributes for modelling and reasoning, is to differentiate between dimensional (i.e. numerical attributes) and structural (e.g. relationships on cause-effect, or acquaintance, trust, influence etc.). In this differentiation the sociological approach on the macro level (namely to look at structures) is extremely opposed to the one used in current DAI research. The macro perspective here means to aggregate values from the individual to the group layer and focus on dimensional parameters like score, speed, number of communication acts, voting results etc., where aggregation is straightforward. The structural interpretation that could lead to more sophisticated social reasoning, like it is done by Sichmann et al. [33], is rarely applied.

4) Populations of artificial agents are artificial societies

Especially for applied multi-agent systems (the representational approach) it holds that these agents are created with the intention of delegating actions (and in fact *delegation* is viewed as a central notion in DAI: e.g. by Castelfranchi and Falcone [8]). In this sense many assumptions about human behaviour and the user's goals and desires are represented by the agent acting in the multi-agent system. Therefore observed phenomena in this population will not only be caused by artificial actors, but also by the intentions of the human user. As a consequence it would not be correct to speak of an artificial society, the nature of the intersection of intentions requires this to be termed a *hybrid* society. In addition, sociologists would require that this population exhibits macro aspects of the human society (see above) before it can be considered an artificial *or* hybrid society.

7 Towards a Micro-Macro Definition for DAI

We are not in the position to give a final definition for the macro concept for agent-based simulation (either foundational or representational) or decide whether the more complex macro notion of sociology should be applied in DAI. From our research however, we conclude that we can identify three different strands of research where the question of the micro-macro link arises with different magnitude:

a) For moderately sized multi-agent systems (which is still the large majority of today's applications) the list of problem definitions mentioned in Section 4 is sufficiently complex and is most useful due to its well understood distinction in subproblems and its precision.

b) This view is not sufficient when complexity is increased: Open and large multi-agent systems require transfer from the social sciences in order to build systems that are adaptive, scalable and laid out with the potential to resolve unpredictable conflicts. A stronger notion of the macro aspects (institutions, power, fraud etc.) becomes necessary and sociology is a source of inspiration for flexible architectures for scalable MAS. In close analogy to the progress which AI research has made by approaching cognitive psychology, DAI can be expected to be brought forward by the cooperation with sociology.

c) For the knowledge transfer from DAI to the social sciences an adequate conceptualisation of the macro aspect as it is perceived in sociology is necessary to guide agent-based simulation and make the results transferable to sociology.

The approaches in paragraphs a) and b) can be considered representational approaches, whereas c) corresponds to the foundational approach. Paragraph b) views the agent as depending on features like flexibility, autonomy and social competence (where sociologists would argue that the social ability already assumes the flexibility).

Having established that for a number of problems the adoption of a complex and well-founded notion of the macro level is desirable, we would like to discuss some implications for future work.

8 Discussion

A general observation from what has been said so far, is that it may be advisable to use sociologically founded concepts, but computation of bi-directionally interacting micro and macro-level simulation appears to be too complex and too hard to achieve and is therefore hardly existing. When looking at this shortcoming of up-to-date social simulation, it appears that there is a need to investigate, which sociological theory can on the one hand improve the simulated model (e.g. the bi-directional interaction of micro and macro) and on the other hand simplify the design of agents (frameworks for socially more competent agents).

These are the requirements of a hybrid theory that has the explanatory power which stretches from individual behaviour to structures of the social context and back to the individual action. A theory that might come to mind is the theory of Anthony Giddens. The strength of this theory lies in the concept of duality of structure and action. Conte and Castelfranchi [11] criticise that although Giddens' theory „is process-oriented, it actually does not take into sufficient account the role of the cognitive processes linking the micro and macro levels". In our ongoing research we have found that the habitus-field theory of Pierre Bourdieu is a theory which covers a similar spectrum between action and structure, while at the same time having a greater explanatory power on the very subject that Conte and Castelfranchi describe as the shortcoming of Giddens' theory. Bourdieu's concept of habitus consists of a set of dispositions to actions and ways of perception. These dispositions depend on the history of the individual and what it experienced in the past, they may be incorporated or imitated, i.e. learned by observation and acquired by advice. We suggest that the concept of these dispostions is a perfect starting point to connect bounded rationality research with the DAI research of social contexts. Furthermore, the fact that Bourdieu

emphasises the practical application of his theory and has reported extensively on his practical work, gives us the hope that his methodology can be used for application in DAI.

For Bourdieu, the habitus is the result of processes that adapt to the surrounding social structure according to the logic of this social context. This marks the importance and the influence of the structure of the agent society on the behaviour of the individual, while still explaining how the individual shapes the structure. Bourdieu views the individual with its desires and actions as the force behind the development, change and reproduction of social structure. For us, this results in a call for more effort in additional reasoning about structures instead of reasoning about aggregated values for agents in social simulation. We believe that with the habitus-field theory we have found a sociological theory that provides what Conte and Castelfranchi [11] demand, when they write:

> *We believe that the micro-macro link is not only a two-fold issue: it is not only a matter of relating macro-structures and micro-interactions, society and action, as many social scientists including Giddens, seem to think. In our conception, it is a three-faceted issue, including (a) external forces and structures, (b) agents' cognition, and (c) their actions. Cognition plays a fundamental linking role between the external forces and the agent's behaviours. ...*

> *a) unlike what is commonly called rationality, cognition reflects and embodies in various ways objective pre-conditions, societal prescriptions and institutions, and reinforcing effects. Cognition is undoubtedly structured by society. The question is how is this possible?*

> *b) macro-social phenomena may emerge, unintentionally, from micro-interactions. However, they not only directly emerge from behaviours, but also derive from the agent's cognitive representations and state. For example, while some conventions directly emerge from behaviours, some structures of interdependencies emerge from the interrelationships among the internal properties of agents situated in a common world.*

Bourdieu describes his habitus as the structure that is *structured* by the individuals social context and that is also *structuring* the social context by the individuals participation in this context (the „structured and structuring structure"). The incorporation of this structure is the process of learning heuristics for action and perception that are adequate for different contexts. According to Bourdieu these heuristics will not be actively reconsidered before the habitus leads to a crisis. This is an interesting pointer to learning algorithms like reinforcement learning and will guide our future research.

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