A conceptual linkage between cognitive architectures and social interaction

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Abstract

Cognitive representations are being shaped and determined by interaction with the environment. The social environment constitutes an important part of this environment. Yet in formal models of cognition, there is little attention for processes resulting from social interaction. On the other hand, in formal models of social interaction, little attention has been spent on the cognitive origins of social interaction. Recently, a few studies have been published combining cognitive representations with social interaction. In this article, we discuss how social cognitive representations (SCRs) provide a concept for a further linkage of cognitive models and social interaction. The paper concludes with requirements for the use of SCRs for different levels of research questions, and identifies a number of promising venues for further research.

Keywords: *social theory; MAS; cognitive plausibility; multi-disciplinary research; modelling.*

1. Introduction

By looking at studies that simulate social phenomena, we see a number of theories that are formalized into simulation programs (e.g., Troitzsch 2005; see also the journals JASSS, SIMPAT, CMOT or JAAMAS). Within the field of social simulation studies, we can distinguish two approaches. The first approach involves the study of sociological systems, social networks, and social interaction (Axelrod 1984; Zeggelink 1993; Kitts, Macy and Flache 1999; Back and Flache 2006). The second approach involves the study of the behavior of cognitive plausible agents (Carley and Prietula 1994; Helmhout 2006; Sun 2006b). Whereas the first approach does not focus on a plausible description of the cognitive

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properties of the agents, the second approach does not apply sociological or social-psychological theories to its models (Zoethout 2006). Only a very few scholars focus on both the individual and the social level (e.g., Conte and Paolucci 2001). The exploration of the links between the two approaches may provide a perspective on modeling and simulating processes of social interaction in a more plausible way (Zoethout 2006; Sun 2006b). This brings us to the central question of this paper: *How are the possibilities of cognitive models able to contribute to the limitations of social models*?

To answer this question, we will shortly describe the current situation in cognitive and social science, focusing in particular on the possibilities for a conceptual linkage to reconcile both disciplines. As a starting point for such linkage, we make use of the concept of *Social Cognitive Representation* (SCR), i.e., a cognitive representation of a particular social element. This concept has been based on the concept of *Social Construct*, i.e., representations of cooperation and coordination based on conventions, commonly expressed by tokens, agreements, etc. (Liu 2000; Gazendam 2003: 205; see also Helmhout 2006). Because of the strict meaning of the concept of Social Constructs within the area of semiotics, we will use the looser concept of SCR that refers to a much broader disciplinary scope and usage. Globally speaking, a cognitive scientist's point of view focuses on the relation of a SCR to its underlying cognitive architecture whereas social science concerns how SCRs determine the interactions between individuals and groups of people. Hence, the concept of SCR contributes to the reconciliation of different fields in order to create models that are more plausible.

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Although the existence of the area of social cognition proves that such a conceptual linkage is not new (e.g., Nye and Brower 1996), existing usage of likewise concepts is merely static with respect to social behavior. Most research in the field of social cognition focuses on the cognitive substratum of social behavior but does not address the cognitive and social dynamics, nor the way in which both levels are intertwined. Social cognition concerns the cognitive basis of social interaction whereas the use of SCRs can also be related to the way people influence each other cognitively (Helmhout 2006: 70). From the area of social simulation, we may contribute to an integrated dynamic perspective on SCRs, which may support developing models addressing different types of research questions.

But what does this contribution look like? To answer this question, we will first describe the interrelationship between cognition and social behavior by focusing on different kinds of research questions. Second, we will discuss the usefulness of some cognitive and social models with re-

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spect to a possible linkage by discussing their strengths and weaknesses. On the basis of this, in the final section we will focus on the demands for formal models that combine cognitive processes with social interactions. Starting from this, we will sketch a perspective on the contribution of a formalized concept of SCR with regard to research questions at the level of sociology, social psychology, and cognitive psychology. We finally conclude that a common framework would facilitate the translation of different models to address different levels of research questions.

2. The relation between cognition and social behavior

The interconnectedness of cognition and social behavior is a straightforward observation. Any interaction of social organisms is somehow rooted within some kind of cognitive architecture, simple as with ants, or complex as with human beings. Further, any human interaction will result in the formation of new SCRs — as simple as it may be — or the adaptation of existing ones. We may, for example, cognitively store the experience that a person is nice, smart or selfish. Hence, human beings have a set of SCRs describing their representation of the social environment, and their set of SCRs will be shaped by the deliberate and coincidental interactions and can be understood as resulting from these interactions.

Obviously, SCRs have a strong impact on future social interactions. For example, if a person is perceived to be selfish, the likeliness of further interactions with this person is lower than in case of a more collaborative experience. In a same vein, having a negative experience with a person who is perceived, i.e., according to his/her set of SCRs as belonging to some (out)group, may result in avoiding interaction with other members that are perceived as belonging to the same group.

2.1. *The whole and its parts*

The latter example illustrates how higher level properties, i.e., the belongingness to some group, results in lower level behavior, i.e., avoiding interaction with out-group members. This is called "downward causation." Originally formulated by Campbell (1974; see also Heylighen 1995; Gilbert 2002), downward causation refers to the notion that all processes at a lower level of a hierarchy are restrained by and act in conformity to the laws of a higher level. A group determining the behavior of its members (e.g., Zeggelink 1993) is a social example of this.

The opposite of downward causation is the notion of "emergence" and "emergent properties." Emergent properties refer to higher level properties, i.e., from the group, which cannot be reduced to lower level properties, i.e., the individuals (Heylighen 1997; Klein and Kozlowski 2000). The notion of emergence originates from General Systems Theory (GST) that states, using Aristotle's words, that the whole is more than the sum of its parts (e.g., Von Bertalanffy 1968). This approach contradicts a reductionist approach that states that the whole *equals* the sum of its parts. According to the latter approach, the whole could be studied just by studying its parts. For instance, a crowd could be studied just by describing the properties of individuals; the brain of an individual could be understood just by studying each neuron separately, etc. According to the reductionist approach, to comprehend social interaction, the mind is enough. As we will see in the following section, this is sometimes used as an argument of cognitive psychologists not to focus on social theories. However, it seems to be as impossible to know the parts without knowing the whole as it is to know the whole without knowing the parts in detail (cited from Pascal 1995). Therefore, according to GST, we must study our subjects of research on different aggregation levels and relate these levels to another. This implies that, by studying a crowd, we must focus on the behavior of both the individual and the crowd level, and by studying the brain, we must relate a description of the brain to the properties of a neuron.

The Aristotelic interrelatedness of whole and parts again shows the need to relate groups to individuals and social interaction to cognition. In the following section, we will discuss some examples that illustrate how the use of SCR may clarify some underlying principles of social interaction.

2.2. *Social interaction and the need for cognition*

A common observation in the context of social interaction is that similarity attracts (e.g., Festinger 1954). People sharing the same interests, ideas, and belonging to the same groups are expected to interact more often and have a larger influence than people that are less similar. Similarity is often expressed in terms of homophily (Lazarsfeld and Merton 1954). Homophily expresses the degree to which individuals in a dyad share traits such as demographic variables, beliefs, preferences, and values (Touchey 1974; Infante, Rancer, and Womack 1997). The traits that define homophily thus refer to a multidimensional space. The theory of homophily has received wide support in diverse contexts. Both the chances of inter-

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acting and the influential force of interactions are determined by similarity. Concerning the chances to interact, the theory of homophily states that most social interaction will occur between people sharing similar traits (Yuan and Gay 2006). Concerning the impact of social interactions, it has been shown that similarity has a great impact on the influence level of word-of mouth (Moschis 1976) and the efficacy of word-of-mouth (Price and Feick 1984; Brown and Reingen 1987; Gilly et al. 1998), as it facilitates the communication between people and hence makes word-of-mouth more effective (Lazarsfeld and Merton 1954; Price and Feick 1984).

Since similarity and communication reinforce each other, an important aspect of homophily theory is the dynamic nature between them. The more communication there is between members of a dyad, the more likely they are to become more similar; the more similar two individuals are, the larger the likelihood that their communication will be effective. In terms of SCRs, this implies that the more congruent the SCRs of people are in terms of the traits they have in common, the larger the chances and higher the frequency of them engaging in interaction. Additionally, it implies that frequent interactions between people thrive their SCRs to become more similar, although some traits such as age, gender, and ethnicity of course are not to be affected by social interaction.

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The research questions emerging from the above relate to different levels, which can be identified as sociological, social psychological and cognitive psychological. Sociological research questions typically address aggregated phenomena, such as the formation of networks, groups, and clusters. Here, relative simple and fixed SCRs consisting of traits relevant for the research question at hand could be used as a kind of tag determining the likeliness of people to interact (see, e.g., Hales and Edmunds 2005). Issues such as the spreading of cooperation, spatial segregation (e.g., Axelrod 1984), and the emergence of social networks could be studied using such a simple formalization of SCRs. During the development of agent based simulation models at this level, the SCRs could be fixed and only serve to connect agents, and the behaviors resulting from these interactions would not be directly connected to the traits in the SCR.

At a social psychological level, one would be interested in the role of SCRs in the dynamics of social interaction, in particular with respect to the exchange of information and the formation of interpersonal relationships. Processes relating to informational exchange in social contexts, e.g., persuasion and attitude change, could be related to the degree of similarity between the SCRs of interacting people. Issues such as trust and motivation to comply could be related to these SCRs. Concerning

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the formation of interpersonal relationships, the dynamics of SCRs may play a critical role. Especially the conditions propagating people to become more similar (integration or assimilation of SCRs) and interact more frequently, in contrast to interactions that do not establish a lasting relation or even result in negative SCRs of the other, are worthwhile to study (e.g., Amblard and Jager 2008). In a formalized model this would require that agents are equipped with changeable SCRs. Moreover, in studying informational exchange also cognitive representations (CRs) of, e.g., attitudes and opinions should be formalized as adaptive entities. The formalization of SCRs in this social psychological context should focus on the perception and change of traits represented in SCRs due to social interaction.

At a cognitive psychological level one would be interested in how SCRs are being formed, and how they affect the internal dynamics of CRs. For example, when receiving dissonant information from another person, both the SCR one has of the other person as well as one's own CR can be adapted. Obviously, these kinds of processes are determined by the firmness of the (Social) CRs, which may relate to the earlier processes shaping them. Here, for example, direct experience might result in more stable representations than rumors and hearsay. In formalized models it would be necessary to make structures of representations in order to be capable of experimenting with their internal dynamics following social interaction.

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The question that arises here is to what extent existing formalized models are including or are capable of bringing in the social dimensions as sketched above. In the following section, we will first address cognitive models in exploring the existing architectures for formalizing (S)CRs, thus focusing at the level of cognitive psychology. Following that, we will discuss some main insights from the field of social cognition, which relates to the level of social psychology, and discuss to what extent these insights are being used in formalized models of social interaction, which basically will address the sociological level.

3. Cognitive and social models

According to General Systems Theory, the integration of theories will result in a more complete description of a system and understanding of its behavior, which obviously is the goal of scientific endeavors. However, does the modeling practice require that models of social behavior are being related using a cognitive model that includes social behavior?

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To answer this question, we must focus on the restrictions of models in general.

First, we have to know what the downward restrictions are of a model with respect to the aggregation levels it covers. Downward restrictions point at the lowest aggregation level that still produces extra explanatory power regarding the system's behavior. For instance, it is hardly useful to describe social behavior at a molecular level, or cognitive behavior at an atomic level, but it can be useful to describe the cognitive substratum of communication. Second, we must know what the upward restriction of the model is. Upward restriction refers to the possibilities of a model to describe phenomena at a higher aggregation level: Existing cognitive architectures that are being used to describe different aspects of cognitive behavior in great detail (see also Section 3.1), the so-called "heavy" cognitive models, are perhaps able to describe communication processes within a dyad, but are they sufficient to describe macro-sociological phenomena as well? Is it theoretically possible to explain cognitive behavior in terms of processes at the molecular level? Is the mind enough to describe social interaction? If not, to what extent can we aggregate the outcomes of our models to higher levels? By answering these questions, we are able to define the boundaries that create the range of behavior we want to describe with a model.

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In the next sections, first we will discuss some social models and some "heavy" cognitive models with no apparent linkage to their respective counterparts. Most descriptions that focus on social interaction do not involve a structural description but are limited to functional models. Rules to describe processes of social interaction are often formulated rather ad-hoc, focusing only on a particular aspect of the interaction process, e.g., imitation. We can easily state the assumption that at the functional level these social models are not related. For example, processes of imitation are usually not related to principles of social learning, which constitute a cognitive substratum of imitative processes. As such, a fragmented collection of incoherent models and theories is being used in simulating social interaction. Here a meta-theory, capturing the full system in a conceptual framework, may contribute to aligning the various mechanisms and rules in a more theoretically valid way (Vallacher and Nowak 1994; Jager 2000).

Multi-agent descriptions that involve "heavy" cognitive agents are less incoherent, since this area is dominated by only three architectures: SOAR (Wray and Jones 2006; Laird, Newell, and Rosenbloom 1987), ACT-R (Anderson et al. 2004; Anderson 1983), and CLARION (Sun 2006a, 1997). But, as we will discuss more elaborately in the next section, these models have the disadvantage that their relation to social behavior

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is very limited because at the best they only provide a *possibility* to describe social behavior, but have not related this to existing social theory yet.

Second, we will propose some examples that do relate both fields. Although social models seem scattered and cognitive models at the best have a very parsimonious relation with social interaction, we nevertheless can distinguish a number of approaches of integrating social and cognitive theories within the area of multi-agent simulation. The first approach uses the 'heavy' cognitive models, i.e., models with a cognitive plausible architecture to describe social phenomena (e.g., Helmhout 2006). The second approach describes social phenomena in terms of cognitive processes (e.g., Conte and Paolucci 2002). The third approach involves models that describe phenomena at both the cognitive and the social level (e.g., Zoethout 2006). The fourth approach focuses on relatively simple cognitive models, used as a general framework to describe social phenomena (e.g., Thiriot and Kant 2007; see also Shoda et al. 2002).

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3.1. *"Heavy" cognitive models*

In cognitive science, we can distinguish two approaches with respect to the description of human behavior: the symbol systems approach and the connectionist approach. The symbol systems approach describes behavior (cognition) at the functional level and is originally based on a functional comparison of computer and cognitive architecture (Newell et al. 1989). A motivation for this approach can be found in the statement that we do not need to understand the hardware, i.e., the brain, to comprehend the software, i.e., the mind. Hence, this approach does not study how the functional level could be related to the underlying physical or physiological level. The connectionist approach originates as a reaction to the symbol systems approach with the statement that the structural architecture of the brain does matter, because software on a computer is written by a programmer, but the mind somehow emerged from the brain and is therefore bounded by its limitations and possibilities (Rumelhart and McClelland 1986).

Cognitive architectures that are used in multi-agent studies nowadays either reflect a functional description, such as Soar (Wray and Jones 2006; Laird et al. 1987), or consist of a hybrid system that combines a connectionist and symbolic description such as ACT-R (Anderson et al. 2004; Anderson 1983) or CLARION (Sun 2006a, 1997). Both Soar and ACT-R are extensively tested, validated, and widely used in all kinds of settings (Carley and Prietula 1994; Ye and Carley 1995), including social

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contexts such as combat flight simulation (Jones et al. 1999) or game situations (West et al. 2006). However, although some architectures indeed produced a rudimentary form of social behavior, a plausible relation to social theory has not been made yet, probably because these architectures mostly focus on individual behavior.

3.2. *Social models and their relation with cognitive theory*

Now that we described some cognitive architectures that hardly focus on social behavior, we move to the other end of the spectrum. Here we find social models that do not seem to need cognitive theory. As Axelrod clearly demonstrated, in some cases, simple agents only aiming at their own personal goals are sufficient to simulate the emergence of social structures (Axelrod 1984). This would imply that research questions related to this do not even need cognitive models. Furthermore, social organisms, much simpler than human beings with only a very rudimentary form of cognition, are also able to let higher order structures emerge based on local interactions (Zoethout 2006). For instance, social insects such as bees and ants, which are both simple creatures compared to us, are able to form complex organizations that are able to adapt flexibly to a changing environment (Gordon 2001; Camazine et al. 2001; Hemelrijk 2002). Therefore, since simple organisms are able to create complex social structures, simple agent based models are capable of describing the emergence of complex social structures.

If we look further in the field of social simulation, a vast number of studies have been published on how the behavior of interacting individuals result in aggregate outcomes at the group level, and how these outcomes affect individual behavior in their turn. Some popular research topics that study effects of social interaction are related to market dynamics and innovation diffusion (see, e.g., Gilbert et al. 2007), opinion dynamics (e.g., Jager and Amblard 2004), crowding (e.g., Batty 2006), traffic control (e.g., Klügl and Bazzan 2004), evacuation (e.g., Murakami et al. 2002), team composition and performance (e.g., Zoethout, Jager and Molleman 2006a, 2006b), and financial markets (e.g., Hoffmann et al. 2007). Whereas in social psychological and sociological literature there is an abundance of theories on social interaction processes, the formalized rules in these simulations usually range from very simple to very basic formalizations of theories. A very simple formalization would be an agent in a regular lattice that is being informed by a direct neighbor (Moore environment) about the utility of a product, a formalization typically being used in percolation models (e.g., Solomon et al. 2000). Some more elaborated formalizations include notions on the shape of networks, social pressures, and similarity of others as critical factors and processes in social interaction (e.g., Jager and Mosler 2007). The latter formalizations are usually based on simplified notions from Word-of-mouth literature, social psychology, and sociology.

Therefore, it looks as if the downward boundaries that we mentioned in the former section imply that for social models cognitive properties do not result in extra explanatory power. Indeed, from a sociological perspective an important reason not to use cognitive theories is *relevance* (Squazzoni 2007; Vallacher and Nowak 1994).

Another important reason for sociologists not to use cognitive theories is *simplicity* (Squazzoni 2007; Vallacher and Nowak 1994). This argument refers to the notion that modelers want models to explain as much as they can, yet being as simple as possible. By extending a model towards other aggregation levels, they argue, complexity of the model will grow, which may easily end up in what is known as Bonini's Paradox. This paradox states that the more realistic and detailed a model becomes, the more it resembles the modeled system, including its incomprehensibility (Starbuck 1976: 1101). Hence, the choice is made to simply stick to the realms of what is known best. This stance implies a lack of contribution to a higher goal such as a general model of human behavior, resulting in a wide area of incoherent mini-theories (Vallacher and Nowak 1994).

Hence, sociological and social-psychological models are not much concerned with cognition. Moreover, if we look at the enormous amount of mini-theories, they do not even care about each other. Does this lead to the conclusion that cognitive models cannot describe social processes and social models do not care that much about cognition? Are we trying to relate two disciplines that do not want to be related at all? As the next section shows, we only started to describe the two ends of the bridge we are trying to build, to focus on models that focus on the bridge itself.

3.3. *Approaches that relate cognition and social interaction*

The first approach that we will mention is Rbot (Helmhout 2006). The multi-agent model is being based on ACT-R, being enriched with social constructs and representations, and social mechanisms (Helmhout 2006: 156). It is based on the notion that in order to explain human behavior we should start from the bottom and work or way up (e.g., Newell, Rosenbloom, and Laird 1989). The great benefit of the Rbot approach is that it uses a cognitive plausible description in relation with SCRs, and is actually able to produce social behavior, which is, at least from the area of cognitive science, a great step. However, the Rbot approach has three disadvantages. First, although the model describes some rudimentary forms of social behavior, it is not being related to social theory. Second, the model complexity suggests that simulation of more advanced forms of social behavior will be too complex to understand. Third, because of the model complexity, multi-agent simulations of social behavior of multiple agents will be very slow.

The second approach is the so-called social-cognitive approach of Conte et al. (Conte and Castelfranchi 1995; Conte and Paolucci 2001, 2002). This approach has developed a number of models, that focus on particular social phenomena such as social learning, norms (Conte and Paolucci 2001), and reputation (Conte and Paolucci 2002) and relate these to the underlying cognitive basis. The models are much simpler than the "heavy" cognitive architecture of the former approach, and are much more suited for multi-agent simulations. Furthermore, they actually relate social to cognitive theory using the notion of SCR. However, in a sense, the social-cognitive approach contributes to the large but fragmented collection of incoherent models and does not contribute to an integrative framework.

The third approach involves the WORKMATE simulation model (Zoethout 2006). WORKMATE is used to describe self-organizing processes of task allocation. Self-organizing processes of task allocation involve both an individual component, i.e., expertise and motivation, and a social component, i.e., power and attraction. Therefore WORKMATE focuses especially on the bridge between social and cognitive models, by constructing a simple model that can be elaborated into both the cognitive and the social direction. The model is simple, it offers a possibility for an integrative framework and it relates social and cognitive behavior by using a basic form of SCRs. However, although potentially fruitful, explicit relations to both cognitive and social theory are yet to be made.

The last approach focuses on social behavior by using a specific kind of cognitive models, i.e., conceptual networks (e.g., Thiriot and Kant 2007, see also Shoda et al. 2002). Conceptual network models originate from the connectionist approach. They describe some aspects of cognition, especially declarative memory, as a set of concepts that are related via associations that are represented as (variable) connections. Conceptual networks are used to describe various kinds of social behavior, such as preferences regarding personality (Shoda et al. 2002) or the diffusion of innovations (Thiriot and Kant 2007). Not only may this approach serve as a step towards an integrated framework, it uses a rather simple yet plausible cognitive architecture. This architecture is not only easy to relate to social behavior, it may also serve as a linkage with a lower level description of human cognition by using neural networks. Moreover, the concept of SCR seamlessly allies with the architecture. However, its relation with higher order cognitive processes, as described with the "heavy" cognitive architectures is difficult to make.

4. Conclusion and discussion

The previous sections illustrated some examples of the state-of-the art in cognitive and social models, and demonstrated that the first formal applications are being developed in which the cognitive and social level are being connected. We expect this development to become increasingly relevant in studying the effects of social interaction in the formation of cognitive representations. This implies that both from cognitive sciences and from social sciences steps are taken to include the concepts used in their neighboring fields. These steps have demonstrated that the use of SCRs is a necessary condition in linking the cognitive and social approach. However, in formalizing SCRs in simulation models, one has to take into account the limitations with respect to transparency of results and computing power to address different levels of research questions.

In bringing social interaction into cognitive models, the formalized SCRs used could be quite complex. Especially when we want to study how two (or a very small group) of simulated agents influence each other's cognitive representations in general, elaborated models of SCRs may be required to capture the complexities of interacting representations. For example, we are more likely to accept both social and non-social opinions from other persons with whom we share important traits. Here we can envisage that formal models of SCRs for any social contact may mirror the formal architecture of CRs. SCRs form a subset of the general set of cognitive representations, and hence are less elaborate. SCRs may be rather simple, addressing just one or a few traits and generalizing them over a whole group of people. The most complex SCRs will refer to the representation one has of a spouse or of close friends.

In bringing the cognitive into sociological models, the formalization of SCRs could be quite simple. Particularly when studying the dynamics of large populations of interacting agents, the SCRs used in simulation models should be simple as to allow for the interpretation of the resulting dynamics, and to keep models transparent for interpretation. Here, SCRs would not be formalized as dynamic entities, but rather as fixed tags that would determine the chance and frequency of agent interacting, which would primarily focus on group formation.

In studying social psychological processes, an intermediate level of complexity would be required. Here, one may be interested in, e.g., how attitudes and opinions change as a function of a (dis)similarity of SCRs. Hence, not only does the SCR determine the chance and frequency of interaction, it would also affect the extent to which information is being adapted. Information from a more similar other might have a stronger impact than the same information being provided by a rather dissimilar person.

The main conclusion we draw is that a formalization of a set of SCRs may be based on a generic principle, but that the details in this formalization will be a derivate of the research question for which it is being used. Yet, some generic requirements can be formulated, based on the above.

As a general requirement of SCRs, we mention their context dependency: a colleague at work triggers other SCRs then a colleague in a football stadium. Furthermore, the usage of SCRs for linking cognitive and social models implies both cognitive and social requirements. Cognitive requirements relate to the need for a storage device and a social recognition function. SCRs should store the representations of other agent's traits, and thus would allow for a formalization of traits defining similarity and differences when comparing with an agents self-representation in terms of traits. Furthermore, a recognition function would allow for an easy identification of another agent (using a tag) as friend/acquaintance, and use the existing SCRs for this person. Social requirements relate to the ability for social exchange of SCRs between agents.

Based on the use of SCRs, we now will formulate some possible challenging applications and venues for further research. First, formalized SCRs would open the possibility for using cognitive processes, such as induction, deduction, and categorization, as a substratum for social interaction. Hence, from a cognitive perspective, the most important use for SCRs is the linkage to the social world. This could result in a formal cognitive description of experimentally demonstrated social effects such as priming and stereotyping. Since the research question focuses on the possibilities of cognitive models to contribute to the limitations of social models, from a social psychological and sociological perspective, the use of SCRs offers many more possibilities. We mention a few. First, by using SCRs the chance of meeting and interacting with other agents, and developing relationships, can be formalized in a much more plausible way, i.e., as a function of the activation of the same traits of both agents. Second, in processes of attitude change and persuasion, the concept of SCR offers a simple cognitive description which can be easily related to social source effects.

To conclude, both in cognitive science and in social psychology and sociology important research questions can be asked and answered by using SCRs as an interconnecting concept. This paper provided first thoughts on how SCRs can be formalized in addressing research questions at different levels.

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