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Knowledge in Connection: A Cognitively Grounded Social Research Approach to Understanding Change in People’s Knowledge Representations During Social Interaction

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Abstract: In this paper knowledge from sociology, cognitive psychology and artificial intelligence is integrated to develop a cognitively grounded social research approach to study changes in people’s views during social interaction. To illustrate this approach a study is described that tests the ‘thesis of harmonization’. This thesis states that the cognitive representations of people move towards more homogeneous views under the influence of social interaction. It was found that a group discussion about ‘Lord of the Rings’ led to an average increase of 100% in the homogeneity of associations considering Lord of the Rings. Furthermore, a continuing effect was observed: two weeks after the experiment the homogeneity increased with another 53%. The complete increase in homogeneity in comparison to just before the discussion was 180%. It is proposed that, in addition to this experimental approach, it could be rewarding to test the validity of cognitive memory models in a social context, as they could give more insight in the socio-cognitive processes that take place during group discussions. Following this line of thought, we introduce the idea that the exchange of knowledge might be studied using connectionist semantic memory models as agents in a multi-agent model of social interaction.

Keywords: Connectionism, Symbolic Interactionism, Constructivism, Group Discussions, Computational Modeling

Introduction

IN THIS PAPER knowledge from sociology, cognitive psychology and artificial intelligence will be integrated to present a cognitively grounded social research approach to study changes in people’s views during social interaction. It is proposed that certain cognitive or ‘connectionist’ ideas could improve the study of the socio-cognitive process of the exchange of knowledge and definitions. Since it is knowledge that leads to (social) action, social scientists should keep in mind how knowledge and definitions work on the level of the individual. How are definitions formed? How is knowledge in the individual stored, maintained and altered? Asking these questions, we enter the field of cognitive psychology and its conception of semantic memory.

In addition to the general idea that people exchange knowledge and ‘views about the world’ during social interaction, we propose the possibility of conceptualizing this knowledge in a more detailed, cognitive manner: as how knowledge is stored in human semantic memory. To do this, a model of semantic memory, like the connectionist models of McClelland (2003), could be used. The main idea behind this kind of cognitive models is that knowledge is represented in the brain as connections between neurons, the main brain cells that can dynamically form connections with each other and could be seen as the smallest processing units in the brain. In the practice of everyday life it is thought that one can often see this ‘connectedness’ of the brain in the associative way people think and remember.

Connectionist models have proven to be successful in explaining properties of human memory that are found in the experimental branch of cognitive psychology and may also prove to be a good conceptualization of knowledge in social contexts. A thorough explanation of connectionism would not fit this paper, but for anyone interested in connectionism Rumelhart et al. (1986) is a mandatory read. McClelland (2003) would be an excellent introduction into connectionist modelling of semantic memory.

For social scientists, knowledge is a product of social interaction. Sociologists within, for example, the symbolic interaction-paradigm, conceive reality as ‘a socially constructed’ phenomenon. It has been said that without interaction there would be no such thing as reality. Sociologists and anthropologists observe that a shared definition of reality is essential for productive interaction. A commonly used example is the ‘taken for granted’ everyday usage of money. In the anthropologist’s view this method of ‘symbolic transacting of resources’ functions entirely because of our shared definition of ‘cash’ (Simmel, 1990). If someone violates ‘common sense’ defini-

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tions (like the usage of money), they will be socially sanctioned, as Harold Garfinkel elegantly described (Garfinkel, 1972). For social scientists shared knowledge is essential to productive interaction and a premise for acting.

Since social scientists are interested in social interaction and language is the main mechanism behind social interaction, we can observe an ever-increasing interest in language by social scientist over the recent decades. A 'solid social phenomenon', like for example the concept of power, is nowadays conceived as rooted in the usage of language (Willems, 1989). The concepts that are used by social scientist to describe language and knowledge tend to metaphorically refer to division. In the social sciences language is seen as something that 'frames' and thus reflects and enables social division and inequality. Shared knowledge is not only a product of productive social interaction and essential for it, it is also strongly related to power.

During the classic era of sociology, sociologists already needed concepts to describe the shared character of knowledge. Their work provides us a rich repertoire of concepts (all with their own emphasis) to describe the process in which actors 'retrieve shared meaning' during interaction. Exemplar labels for this process are: 'social framing' (Schutz, 1964), 'bracketing' (Husserl in Mohanty, 1982; Garfinkel in Scott, 2001) and 'externalisation' (Berger and Luckman, 1966). To the knowledge that was produced during the interaction sociologists have referred as 'the stock of knowledge' (Schutz, 1964; p 158), 'mutual knowledge' (Giddens, 1984),) 'the generalized other' (Mead, 1934) and 'common sense knowledge' (Garfinkel in Scott, 2001). This 'shared meaning repertoire' is still in common use by contemporary social scientists.

The fact that knowledge is shared and created during interaction does not mean that knowledge is seen as universal. Quite the contrary: knowledge is bound to groups. There is a vast quantity of literature that describes the ways in which a system of 'group tied knowledge' is preserved trough the educational system, how it influences and produces conflicts between social groups and how it suppresses or enables social mobility (Bourdieu, 1984; Boudon, 1973; Giddens, 1981).

It might be said that, for social scientists, the central question surrounding knowledge is how knowledge and social relations interact. In one direction, knowledge is conceived as a premise for acting, related to power and bound to groups. In the other direction, it is a product of social interaction. An underlying assumption of the repertoire that is used to describe knowledge itself (and the process by which it is produced) is the idea that social interaction leads to shared definitions.

Knowledge and definitions about the world have become an important aspect of many sociological theories. Sociologists often assume that a product of social interaction is the movement of the individual semantic representations of reality towards, on the level of the group, more overlapping, more 'harmonic', representations. We have called this assumption the *thesis of harmonization*. This paper describes a study in which the process of sharing and adapting each other's conceptual framework about the world around us during social interaction and the thesis of harmonization is further looked upon.

In the upcoming section we will describe a cognitively grounded social research methodology to study knowledge and social interaction. As an exemplar application, an empirical experiment using this method will be described. In this experiment, groups of five real-life subjects discussed a specific subject. Before and after this discussion a 'free-association task' was performed as an indication of the semantic structure (knowledge) of the discussed concept in the individuals. This data was later used to calculate the level of 'harmonization' that took place during this specific social interaction. The subject of the discussion in this particular study was 'Lord of the Rings', it was mainly chosen because it is a rather neutral subject and forms a 'reality of itself' and thereby has a rather limited number of possible associations.

This study might have scientific relevance for two main reasons. Firstly, we try to experimentally ground the 'thesis of harmonization', which in our view is an implicit basis of many sociological theories. Secondly, we have combined and integrated the scientific fields of sociology, experimental psychology and artificial intelligence into an interdisciplinary approach, trying to bridge the study of the individual with the study of groups of individuals. This methodology might prove itself to be a promising approach for further research on the exchange of knowledge in social contexts.

Methodology

Measuring Changes in Knowledge Representations over Time

The subject of interest of this study was the change in people's views over time (in this case before and after a specific 'social situation'), so these views had to be obtained and 'measured' at multiple instances. In our study this was done at three points in time: just before the group discussion (t1), just after the group discussion (t2) and two weeks after the group discussion (t3).

Free Association Task

At these moments subjects[1] performed a task which is known as a free-association task. They were asked to produce a list of concepts '*that come to mind when thinking about Lord of the Rings'*. For three minutes they could write down a maximum of 50 defining concepts. This list was labelled *Ltotal*. Such a list is a rather coarse - but valid - indication of the individual semantic representation of a particular concept. A task of this sort (with a pre-defined wordlist) was also used by Rumelhart and McClelland (1986) and is grounded within the connectionist paradigm described above.

As an additional indicator, another task was also performed. In this task subjects had to indicate which 10 concepts of their complete list they thought were *'most defining*'. These concepts formed a second list of only ten main defining concepts. This list was called *L10*.

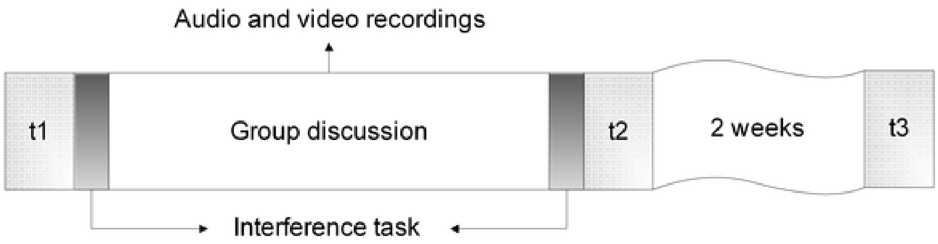

Figure 1: Timeline of the Experiment: during the Experiment, Three main Moments in Time can be Discerned. These Moments are called t1, t2 and t3. At these Three Moments a Free-association Task was Performed

For every subject six lists were obtained: three (t1, t2 and t3) short lists of 10 concepts (*L10*) and three (t1, t2 and t3) long, overall lists (*Ltotal*).

To focus the discussion, the subjects were instructed as a group to produce a list of the five 'most defining' concepts considering *Lord of the Rings*. Every member of the group had to agree with this list. When this list of five items was agreed upon, the discussion was ended.

Since we were interested in unconscious, 'structural' changes in semantic memory and wanted to exclude the influence of subjective experiences about the free-association task and the group discussion as much as possible, a much-used interference task[2] was performed shortly after t1 and shortly before t2.

Tokens

In the group discussion two 'tokens' were used to structure the discussion and to make it possible to discern turns within the discussion. This was done to be able to transcribe the video recordings of the discussion to structured data that could be used in a computational model. During the discussion subjects were allowed to talk only when they possessed the 'talk-token'. When a member of the group wanted to check if consensus was reached about a particular concept that should be on the list, the subject had to grab the 'consensus-token'.

Formalization of Concepts

In free-association tasks subjects write concepts down themselves. These tasks are therefore very error-prone, especially in situations where the comparison between the individual lists is done by an automated system, as was the case in our study. Most mistakes made in our task were of the categories substitution, deletion and insertion.

Results of the method improved as these kinds of errors were corrected. For example: 'gollm' became 'gollem' and 'wizzard' became 'wizard'. We also used a basic stemming idea: we transformed all plurals into singulars. Since our subjects combined Dutch and English words in the free-association task, English words were translated into Dutch where this was appropriate, for example 'middle earth' was translated into 'midden aarde'. In our study we decided to apply a minimum of generalization: words were only substituted to other words when it was absolutely clear that the same concepts were meant. For example we did not change 'that old, bearded guy' to 'Gandalf'.

Measuring Overlap in Definitions

After the experiment, the similarity between the individual free-association lists has been measured, as the similarity of the lists is an indication for the homogeneity of the representations of the concept

[1] Thirty-four subjects participated in our experiment, most of them students at the University of Amsterdam (UvA). From these subjects 7 groups, consisting of 4 or 5 people, were formed.
[2] Subjects had to make a random series of letters as a group by saying a letter out loud one by one for 1 minute. This puts a heavy burden on the cognitive system, thereby diminishing encoding of explicit memory. See Baddeley (1998)

within a group of subjects on a certain point in time. Two group lists were generated from concepts on the individual lists of a group at every point in time. One composed of all the top ten *L10*-lists and the other was composed from the total lists *Ltotal*. These group lists can be seen as the 'total group repertoire'.

By comparing the individual lists per actor *a* with the group lists by counting the number of shared concepts θ, the homogeneity at that point in time could be measured. By using multiple measurements of homogeneity at multiple moments in time, a measurement of the harmonization per individual was obtained.
Here, our formula for the proportion of overlap or homogeneity *H* is proposed:

$$H_a(t_i) = \frac{\theta_a - n_a}{N - n_a}$$

Formula 1: Measure for the harmonicity H for actor a at time t_i

The variable θ represents the amount of matches between the words on the actors (unigue) list of associations with the (non-unique) list of the total group repertoire. Since the group repertoire also contains the actors own associations we have to compensate for these obvious matches by using variable n_a (which represents the number of concepts written down by the actor *(a)* at the point in time t_i). This 'compensated count of matches' is divided by the variable *N (that* represents the total number of concepts written down by the group).This makes sense because we divide the number of shared concepts by the number of concepts that can maximally be shared per actor. That means that if everyone wrote down the same concepts *H* would equal 1 for every subject, while if no concepts were shared *H* would be 0.

Used Statistics

An interest in change over time using the same subjects makes it necessary to statistically test the change in individual homogeneity. This has been done using a repeated-measures ANOVA. The within-subjects-factor here was the relative individual homogeneity, consisting of three levels, each level representing one time point of measurement.

Results

The most important results of the experiments are shown in figure 2 and table 1. The extent to which harmonization has taken place is given by the proportion on the y-axis. As explained earlier, for every individual three 'top ten' lists (L10) and three 'overall' lists (Ltotal) were obtained. Both lists show an increase in homogeneity between t1 and t2. Two weeks after the group discussion L10 shows an even further increase, but Ltotal remains fairly stable on the same level. The total increase of homogeneity of the Ltotal-lists between t1 and t3 is 52%, the increase between t1 and t2 is 72%. The increase of homogeneity of L10 between t1 and t2 is 100% and 180% between t1 and t3.

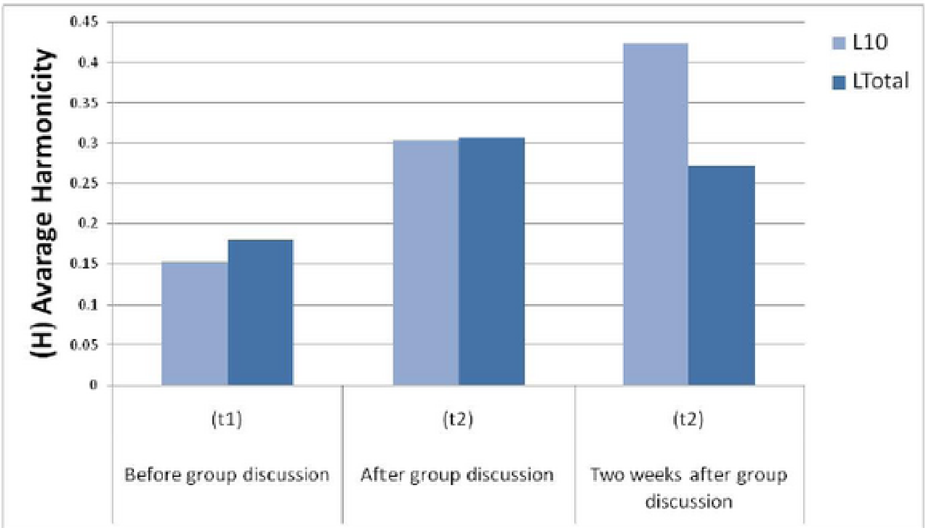

Figure 2: Graph of Homogeneity on t1, t2 and t3

Table 1: The Homogeneity in Associations on t1, t2 and t3

	Before group discussion (t1)	After group discussion (t2)	Two weeks after group discussion (t3)	t2- t1	t3 - t1
Ltotal	0,179	0,307	0,272	0,128	0,093
L10	0,152	0,304	0,425	0,152	0,273

The results have been statistically tested using a repeated-measures ANOVA in SPSS. The increase in homogeneity of L10 and Ltotal over all t's was significant (respectively $F(0.61) = 19.244$, $p<0{,}001$ and $F(0.43) = 54.801$, $p < 0.001$). The increase in homogeneity of L10 between t2 and t3 was also significant ($F(0.083) = 10.38$ $p = 0.04$); the decrease of Ltotal between t2 and t3 was not significant ($F(0{,}001) = 0{,}469$, $p > 0{,}05$).

Considering these results the thesis of harmonization seems plausible. Indeed, there was a large and significant increase in homogeneity after the group discussion, measured as the overlap between the individual free-association lists within a group. The extra increase in homogeneity between t2 and t3 for L10 was not predicted and could be an interesting object of further research.

Understanding Exchange of Knowledge Using a Connectionist Multi-agent Model?

The research method described above can be used to study how knowledge is exchanged during social interaction. Using this method support for the idea that people tend to gain and use more and more shared knowledge and definitions when they interact has been found.

Since on the individual level knowledge is represented in the brain, it could be rewarding to consider the possibility that the properties of human memory and cognitive processes are of importance for the interpersonal process of harmonization. Even so, since expertise from the cognitive sciences only provides insight on the workings of knowledge 'within' the individual, we should also look at this interpersonal process from a more social scientific perspective to be able to provide worthy answers on social research questions. We propose that multi-agent models could bridge this gap between the cognitive science of the individual and the social science of the interpersonal. Such models could prove to be useful to, firstly, validate cognitive memory models in a social context, and, secondly, to help us understand more of the socio-cognitive processes during group interaction.

A connectionist model in a social context could form the basis for the simulation of exchange of knowledge during social interaction. Such a model would need to combine a representational model (like a semantic memory model) with a social multi-agent model. A representational model describes the way an agent stores new information. A multi-agent model describes the interacting between these agents. All the statistical and formal rules in these models are based on socio-cognitive assumptions. If the model's results are comparable to empirical results, these assumptions are made more plausible.

Harmonization might prove itself to be an emergent property of interaction between human minds. Cognitive scientists have many well-grounded ideas about how the human mind and, more specific, semantic memory works and how it is structured. These ideas can be tested using computational models that could also be implemented in a more complex multi-agent model. Such a model could for example simulate group discussions such as the one used in this experiment. Transcriptions of group discussions could provide input for such a model. An advantage of combining a computational research approach with the here above described experimental setting is that the data from the free associations tasks (as said: combined with using transcriptions of the discussions) enables us to compare the output of our computational model with experimental data.

As an explorative study, we have built a model such as the one described above. We implemented a connectionist model, based upon a model by McLelland and Rumelhart (1986). Every agent in this model has an individual Hopfield- network, containing all possible concepts (all concepts written down in the experiment) and the strength of connection between them, or 'weights'. All these weights together represent the current 'conceptualization of Lord of the Rings'. Using these representations, the homogeneity of the knowledge representations of the individuals can be calculated. Using a transcription of the discussion, a group discussion can be simulated in which the representations of each actor can be updated every turn (the moment one actor is speaking) based on the 'key concepts' that were uttered during the real-life discussion in the experiment. The computational model can produce a virtual free-recall task after the discussion (it 'writes down' the 'x' concepts with the highest activation) and by using the method described above the homogeneity between the virtual agents can be measured before and after the virtual discussion.

Although we are still working on refinement of the described computational approach, (and thus not yet able to provide exact numbers) we are pleased to say that the first results of the connectionist multi-agent approach described above seem promising. Harmonization indeed seems to be an emergent property of connectionist memory models when put in 'social' context. In addition, the strength of harmonization (on the individual level) within our 'virtual' agents has a fairly high predictive value (a correlation between .6 and .8) for the level of harmonization of our 'real-life' subjects. We intend to publish the results of this approach when the model has been further refined and more data has been obtained.

Final Discussion

The methods and results described in this paper might be relevant to social scientists in several ways. At first: the results might be interpreted as a valuable critique on the 'naive' theory of knowledge distribution in some (network) models and methods in computational social sciences like 'Construct' (Carley, 2004). Social multi-agent models of knowledge distribution tend to state that during interaction all or a random sample of knowledge is shared. We think that beneath the social process of sharing knowledge there lies a complex cognitive process that, as argued, could be successfully modelled using a connectionist paradigm.

During this study support for the thesis of harmonization has been found in an experimental setting. An additional finding is the fact that this process seems to continue two weeks after the interaction took place. More research on this observation would be necessary to produce a structured insight in the exact importance of it. Since this study focused on 'only one' group discussion we are very curious what happens with the representation and the level of harmonisation in the case of repetitive interaction. It has not escaped our notice that this strongly relates with the 'interaction ritual chains' idea recently proposed by Anthony Giddens (Giddens, 2004). Other interesting future work might focus on socio-individual factors that influence how a discussion takes place and how representations are carried over and shared. These might include factors like (social) intelligence, charisma and verbal abilities.

The methodology described in this paper could prove to be valuable in further research on exchange of knowledge. In addition to anthropologically observing that something like harmonization seems to occur, our method could be used for testing the conditions under which harmonization sustains or seizes to exist. It enables social scientists to investigate the specific characteristic of exchange of knowledge and views upon the world in specific situations.

In a broader sense, we think that the interdisciplinary methodology described above might also prove itself to be helpful in the study of knowledge distribution in general. We suppose, for example, that the described method could be useful for research not only on the influence of group discussions, but also the influence of media like newspaper articles, television broadcasts etc. Instead of generalizing on the broad 'underlying' linguistic and semantic structure of the text, our method might be used for researching the influence these media on specific groups of individuals. We believe that this method, in combination with semantic and social network analysis, could be used for comparing knowledge representations between different social groups.

In comparison to linguistics, our method has the advantage of offering a way of looking at knowledge which is not based on a 'top-down' search for 'structure in knowledge' based on 'structures in language', but on a 'bottom-up' conception of knowledge based upon scientific work on the actual representation of knowledge in the human brain.

Ideally, social scientists are expected to purify their work from metaphysical or psychological assumptions that are not open to explicit testing within their specific research itself. In practice, we observe a tendency in the social sciences to base the approach towards 'knowledge in the human being' on non-scientific and intuitive views. Embracing the knowledge within the cognitive science might help social scientist to keep away from muddy discussions on 'the essence of human action'. To speak in terms of the Dutch sociologist 'Abram de Swaan' "It would be good to have one science focused on *how people act and interact*" (de Swaan, 2004)[3]". This research project might be seen as a flirtation with a more cognitive sociology. We hope that this flirtation pleases.

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[3] original citation is in Dutch: *"hoe mensen in en aan elkaar zitten"*

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