Modeling the Social Dynamics of Online Discussion Sites

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ABSTRACT
This paper describes an investigation of the social dynamics in an online discussion group. In particular, the phenomenon of emerging status or social rank is considered. In this study, the concept of giving attention or "grooming" is used to identify social interactions. Furthermore the concept of the "groom balance" is introduced as a way to describe the relative degree of social grooming within the group. By constructing the groom balance graph, the social rank of the group members over time can be visualized. The analysis was performed for an online discussion group with 187 members and 1604 postings. A validation showed good correlation with status as judged by test persons who read printouts of the postings. A simulation model was developed that replicate the social structure found in the observed data. The model is probabilistic and programmed in Mathematica. The modeling shows that the emergent social structure can be explained by a few micro-level interactions: an individual who post but do not receive any attention is less likely to post again, an individual with a high current groom balance will be more likely to be groomed, and an individual that receive little attention from the group is more likely to leave the group.

Categories and Subject Descriptors
G.4

General Terms
Theory, Human Factors, Experimentation

Keywords
Social media, social network/community, social status, social ranking, simulation model, social dynamics, Mathematica

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1. INTRODUCTION
The Internet carries a dream of being the true democratic media where it doesn't matter where you come from, what you look like or what income you have.

At international online discussion sites people from around the globe can exchange knowledge and opinions and become virtual friends. Even if these people never meet face to face, it seems that a social hierarchy develops within such groups. Some get a lot of attention whereas others get almost none. Now this is interesting since the media does not give away any of the clues we are used to interpret in real life. We know that in real life, appearance, voice, accent as well as body language affect how we appraise other people and thus contribute to the social rank structure in a group. None of these clues are available in a virtual group. Because of this it is interesting to know what factors are influencing the social structuring in virtual groups.

There is currently high interest in doing social network analysis of groups. A social network analysis makes it possible to visualize the connections that exist between the different members of the group. This can be very useful for understanding influence and information flow. However, critics of social network analysis point out that it only gives a static picture of a group and is not useful when you want to study the development over time in a group.

Of particular interest is the notion of social status in the group. This can be seen as a property of the group that emerges out of the many social interactions between the group members. We can say that the micro-behavior of the group members give rise to the macro-behavior of the group.

To be able to study such phenomenon we need to model the social interactions between group members so that the development of the social rank structure over time can be visualized. This paper presents a method of analysis and a simulation model that address this need.

2. BACKGROUND
This section presents some concepts from social psychology which are useful for understanding the social dynamics of groups. It also presents some of the research done on online groups, and introduces the particular properties of online discussion groups. Finally different modeling methods are presented.

2.1 Social interaction and the emergence of status in groups

Social status replicates itself across different social circumstances. An important distinction is between maintenance of status and emergence of status. Maintenance of status occurs when the group members already are ranked. Emergence of status however is what happens when individuals that do not know each other come together. Processes of social interaction between the members result in the emergence of status rank in the group [1]. Low status members of a group can be either rejected members or neglected members. Rejected members are characterized by aggressive and disruptive behavior whereas the neglected members are characterized by getting very little attention from the other members [1].

2.2 Social attention analysis

In social attention analysis the objective is to measure the attention that people give to each other over time. To do this a particular metric is used. This metric keeps track of who gave attention to whom at what time. By analyzing such data it is possible to assess the communities attention to a group member, the group members impact over time and the group members diversion of attention over time [2].

2.3 Social grooming

Social grooming or allogrooming is an activity in which individuals bond and reinforce social structures. Acts of grooming can in animals be to clean or maintain each other´s bodily appearances. By studying who grooms whom, and how much, it is possible to explore the status rank in a group. In humans, people can be said to "groom" each other by small social interactions and exchanges, that constitute "active social relationships" that together make up the social cohesion that is the "glue" that bring people together [3]. An act of grooming in the setting of an online discussion group must of course be text-based. Giving attention, a compliment, using a nickname for someone can be thought of as acts of grooming in an online setting. [1]

2.4 Online groups

In a face-to-face situation there are a number of signs that can be used to assess status. Examples are erect posture, glares, eye contact and assertive speech [4]. In online discussion groups there are no such signs, thus status has to be assessed based on the information available in the discussion group pages. The only information available about a member most often is a nickname and maybe the gender and geographical location. This makes it an open question what factors contribute to the social ranking, if such occur.

2.5 Social networks analysis

An online discussion group can be studied either as a group or as a social network. In most social network analyses the boundary of the group is fixed and the resulting network graph is static in time. In online discussion groups however, members are entering and leaving the group over time. The social rank structure thus cannot be a fixed structure but probably changes over time.

[1] Unfortunately the concept of grooming have been associated with actions deliberately undertaken with the aim of befriending and establishing an emotional connection with a child for criminal purposes.

2.6 Methods for modeling social dynamics

Different types of methods have been used to model social dynamics. A systems dynamics approach was used by Yan and Vassileva to study the incentive mechanisms in a virtual community [5]. They successfully modeled the dynamics of how members raised to higher and higher status in the group as measured by their status class that was assigned to them by the system.

Agent based methods models the essential characteristics of the individual, as well as the rules and the global consequences of the interactions between individuals. Zhang and Tanniru made an agent based study where the characteristics included expertise level, activeness level, sharing level and social gain [6]. In an artificial society, the model is a multi agent system: a set of autonomous agents that operate in parallel and that communicates with each other [7]. By this method it is possible to focus on micro-to-macro emergence. This is how interactions between the different agents on the micro level result in macro-properties of the group. Sabater and Sierra has constructed a model of reputation that generates sociograms that show the relations between individuals [8].

Within the field of bibliometrics, a particular form of status have been extensively analyzed, this is the notion of status as measured by the number of citations that authors of scientific publications receive over time [9]. Many interesting results have been found regarding the notion of status and its relation to a tree structure of citations of citations, however this is quite a different form of status compared to the basic social status that we try to model in this work.

There have also been a number of studies trying to find the most influential people in an online group with the purpose of directing marketing activities directly to these people. These analyses track the information flow between individuals in blogs and manage to pick out the most influential people [10].

Some interesting work has also been done in analyzing posting behavior in online communities [11]. It was found that if a person received feedback on their first post in the group, the probability of posting again increased by 12 % compared to if no feedback was received. Also the probability that a person stops contributing varied inversely with the number of contributions already made.

In the study described here the focus is on how a relatively small collective of posting people, that do not know each other in real life, develops into a group of friends that exchange, not only information, but social interactions over a time span of months or even years.

3. RESEARCH QUESTIONS

3.1 Methods for analysis of the social dynamics of a group

Can we find a method for analysis of the data taken from the web page of an online discussion group to visualize more of the social interactions over time than the traditional social networks analysis

and in particular can we visualize the emergence of social status over time.

3.2 Simulation of the social dynamics of a group

Can we make a simulation model of the interaction in an online discussion group that is able reproduce the emergent social rank structure based on micro-behavior of simple agents .

3.3 Investigating factors that influence social interactions in an online group

Can we make use of such a simulation model of the interaction in an online discussion group and compare the results with observed data to find out which factors that possibly influence the social interactions in an online discussion group.

4. METHOD

4.1 Analysis of an online discussion group

In this analysis the concept of groom was defined as a social reward, in this case attention from other group members. Attention was operationally defined as one of two things, either that a group member explicitly *quotes the member* or, a group member *mentions his or her name*.

Example of a quotation:

> *Quoting Sara : "glad you like'em, this one's for you!"*
>
> *thank you. and thank god for nicks model-like bone-structure*

Example of a mentioning of name:

> *Nice photos, Bella! Here's some more. I like how they look very cool without seeming to have put too much effort into it.*

These acts were possible to identify in the data. If a group member received attention in this way, it was said that the he or she was *groomed*, or received a *groom*. At all times a *groom balance* could be constructed that consisted of all grooms a group member had received minus all grooms that the group member had given to others. It is assumed that this groom balance, that changes continuously over time, reflects the current social status in the group.

4.1.1 Selection of the group

The group selected for the analysis is a particular thread in a discussion group about fashion, *The Fashion Spot*. This is a forum for people interested in fashion. On the website it is described as "*a fashion-centric online community that covers designers, photographers, models, fashion careers, and trend spotting*". The selection was made in part because it was a group of suitable size to be able to do content analysis post by post as well as to get enough data for statistical analysis, and in part because the author was familiar with the topic of discussion, (which had not been the case if a group discussing for instance sports had been selected). Another reason was that the group members did not know each other in real life and because of that it was possible to study the *emergence* rather than *maintenance* of social rank structure. The group was followed for a period of three and a half year. The groups had a geographically dispersed set of members: Argentina, Australia, Belgium, Brazil, Canada, China, Colombia, Czech Republic, Denmark, El Salvador, England, Finland, France, Germany, Israel, Kenya, Latvia, Netherlands, Norway, Philippines, Poland, Russia, Scotland, Spain, Sweden, Turkey, Ukraine, USA.

4.1.2 Material

The basis for the analysis is the set of textual material that resulted from copying the discussion from the web pages. The content of this material consists basically of the name of the poster and the date and time of the post followed by the message in the post as text. The downloading of the material was done in 2008. The number of posts were 1604 with an average posting rate of 1,35 posts per day.

4.1.3 Analysis

First, the description of the group members in terms of gender and geographical location, as given by themselves, were recorded and statistically described.

The program Mathematica was used to perform the analysis. First, the text material was imported to Mathematica, thereafter the different nicknames used by the group members were replaced by numbers corresponding to when they joined the group. By doing so it was possible to keep track of how the group varied in size over time. The first poster was assigned number 1, the next poster number 2 and so on. Each post was also assigned a number. This number corresponded to the time from the start of the discussion group to the last post. Each time a member of the group was cited by another member was counted as a groom. Also, if a group members name was mentioned by another member it was counted as a groom. The program was made to pick out quotations and mentions in all of the posts. However, the mentions had to be manually edited because of frequent misspelling of the names of members. For each member the program kept track of the number of posts made, the number of grooms given to others and the number of grooms received from other group members.

4.2 Validation of the status data

As we intend to achieve a measure of the individual status of the members in the online discussion group it is important to validate this measure in some way. A preliminary validation was made by asking people to assess the status of the group members based on reading the posts in the discussion.

4.2.1 Method of validation

To validate the way status is assigned in terms of grooms and groom balance a preliminary validation study was made. In the study a group of students were asked to read the print-outs from the discussion and asked to pick out three subjects of high status and three subjects of low status. Status points were assigned to the subjects in the following way: plus one point for each time a subject was selected for high status and minus one point for each time a subject was selected for low status. The points for each subject were then compared to the following variables: the total number of posts for the subject, the groom balance for the subject and the total number of grooms received by the subject.

4.2.2 Material for the validation study

The students were presented with print outs of the 802 first posts, or half, of the discussion. The reason for not giving them the complete material was that this is very large and did not fit within the time limits of the study.

4.2.3 Subjects in the validation study

The 12 subjects in the preliminary validation study were master students in human-computer interaction. Participating was a part of their obligations. They worked in groups of 2 and used about an hour for the assignment. The number of men and women were approximately equal.

4.2.4 Procedure of the validation study

The groups of two were sitting isolated from the rest and had each one of them a print out of the discussion. On a paper form they noted the nicknames of the individuals that they considered as high-status members and correspondingly, as low status members.

4.3 Constructing a simulation model of the social dynamics in an online discussion group

The social dynamics of an online discussion group will be modeled as a program that takes total number of posts, total number of grooms and total number of group members as input and then generate the data describing the social dynamics of the group in terms of posting activity over time, distribution of posts and grooms and the groom balance over time.

4.3.1 Selection of modeling type

For this purpose an event-based model was selected. This means that time is represented as events rather than as continuous time. An event in this context is a post made by a member of the group. The members of the group are represented as agents although in a very simplistic way. At each point in time, the agents have access to all current information from the discussion text. Based on this information they determine whether to continue posting or not and whether to groom someone or not. The decision-making by the agents is modeled as probabilistic functions of the variables: number of posts and number of grooms. Thus the simulation model can be said to be of Monte-Carlo type.

4.3.2 Representation of events

For each new post in the simulation the following things must be determined: -which member will post next? -will there be any grooms given?, if so, -which member will be groomed?, -will a member leave the group?, if so, -which member will leave the group?

4.3.3 Change of group members over time

New members enter the group and members leave the group. This is modeled as a probability for each event that a new member enters the group. This probability is determined from the observed data and is calculated as number of total group members divided by the number of posts.

Members also leave the group. This is modeled by means of a probability for each post that a person will leave the group. The probability is estimated from observed data as follows: The average staying time is calculated as the difference in number of posts between the first and the last post for each person. This calculation gives that someone should drop out of the group on average every 53 posts. This can be used to give a probability of 0,033 per post or about one third of the probability that someone will join the group.

4.3.4 Representation of events

Each post in the online discussion group is represented by a posting event that is described by the following variables: the post number, the posting subject, a flag to show that grooming is taken place, and if so, the number of the groomed subject. For each new post in the simulation the following things must be determined: -which member will post next? -will there be any grooms given?, if so, -which member will be groomed?, -will a member leave the group?, if so, -which member will leave the group? For each determination one of a set of methods could be applied. The methods for determinations are described in the following section.

4.3.5 Modeling of dependencies

For a particular member the probability of posting could be based on different methods. One is random, that is all current members have the same probability of posting. Another method is that the probability of posting is higher if the member has received a groom for its first post and lower if the member did not receive any groom for its first post. Yet another method is that the probability of posting is based on how many grooms a member have received. A member who has received many grooms would thus have a higher probability to make a new post.

The probability that a certain post include a groom will be set to the total number of grooms divided by the total number of posts. If a groom will be given in the post, the determination of which member will be groomed can be determined by different method. One method is of course to choose the member to be groomed at random. Another method is to choose the member based on the current groom balance. That is a member with a currently high value of the groom balance will have a higher probability to be groomed than a member with a low value of the current groom balance. Another method is to base this selection on the number of posts that a member has made. This means that a member that has made a high number of posts will have a higher probability to be groomed compared to a member with a low number of posts made. Another possibility is that the selection of the member to be groomed is based solely on the quality of the content. Popular posts are often *witty* in the sense that they are humorous or well formulated. We can call this a *wit-based* selection. All agents are given a *wit-value* that is picked from a normal distribution of wits over the whole group of members. According to this method of selection the member who has the highest wit value will be most likely to be picked out for grooming.

Finally, a group member may leave the group. If a member will be dropped from the group, we need to determine which one will be dropped. This could be made by different methods. One method is of course by random selection. Another method is based on the inverse of the number of grooms that a member has got, that means that the probability of leaving the group is higher for members who have received little grooming compared to members that have received many grooms. Finally there is yet another method that could be used and that is that the member to be dropped is selected based on time so that the longer a member has been in the group, the higher the probability is that the

member will leave the group and correspondingly that a member that recently entered the group will be less likely do drop out of the group.

In summary we will have the following methods to implement and investigate:

For selection of the posting member:

- random based (all members have the same probability of making a post)
- groom status based (members that have been groomed have a higher probability of making a post than members that have never been groomed)
- groom sum based (members have higher probability of making a post the higher the number of grooms they have received)

For selection of the groomed member:

- random based (all members have the same probability of being groomed)
- groom balance based (a member has a probability of being groomed proportionally to the value of his/hers current groombalance)
- post sum based (a member has a probability of being groomed proportionally to the number of posts he/she has made)
- wit-value based (a member has a probability of being groomed proportionally to his/her assigned wit-value that is drawn from a normal distribution)

For selection of the member that will leave the group:

- random based (all members have the same probability of leaving the group)
- inverse groom sum based (a member has a probability of leaving the group inversely proportionally to the number of grooms he/she has received)
- anti-old based (a member has a probability of leaving the group inversely proportionally to the time he/she has spent in the group)

The model and the different methods will be implemented in Mathematica and the different methods will be investigated.

4.4 Comparing simulated data with observed data

The model will be used to produce the same visualizations as was done based on the analysis of the observed online group. This graphs are: - posting activity over time for all members, - distribution of posts among the group members, distribution of grooms among the group members and finally the groom balance over time for all group members. The methods that best describe the observed data will be identified based on how similar the graphs are to the observed data.

5. RESULTS

Here I will first describe some of the results of the analysis of the observed online discussion group, (a more thorough analysis will be presented elsewhere). I will then describe the results of the simulations and how well the different methods could explain the observed data.

5.1 Results of the analysis of the online discussion group

The studied group is not cooperating towards an explicit goal. The purpose was to discuss and exchange information and opinions. It is actually a collective of people that are socializing together. They make jokes, gossip, compliment each other and upload photographs.

5.1.1 General description of the group

The group had 187 members who together made 1604 posts during the observed time period. The activity level varied a little over time, but on average it was 1,4 posts per day. 80% were female and 9% were male. 11% choose not to disclose their gender. 36% were from English-speaking countries and 15% from non-English speaking countries. 50% choose not to give information about their geographical location. The average length of the text in the posts were very short, only 253 characters. The total number of grooms given was 434. 297 of these were in the form of quotes and 137 in the form of mentions of names. The number of posts per user varied between 1 and 160 Std Dev 20,225. Females posted more than males. People from English-speaking countries posted more than people from non-English speaking countries. The probability for making a second post increased from 0,267 to 0,714 if the posting person was groomed.

5.1.2 Posting activity over time

The posting activity over time can be seen in Figure 1. Each dot represents a post. On the x-axis is the time represented by posting events, this runs from the first post to the last. On the y-axis we can wee the number of the posting subject. Posting subject number one starts the discussion and then we can see how new subjects enter the group over time. We can see that some group members make a large number of posts and that many members only posts once. We can also see that some members stop posting and leave the group.

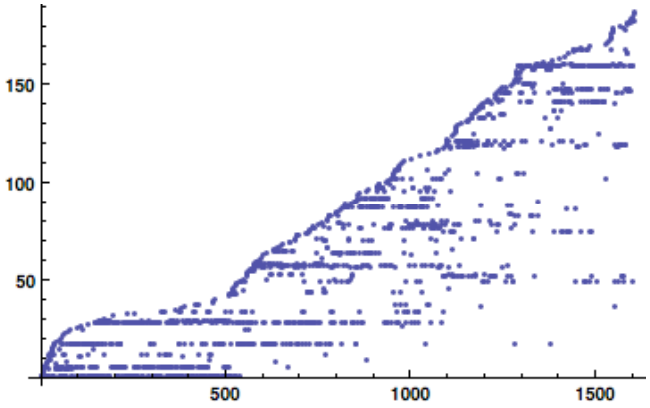

Figure 1. FASHION observed data. The posting activity over time for the online discussion group. Every dot represents a post. The number on the y-axis is the subject number and the x-axis show the post number.

5.1.3 Distribution of posts and grooms

The distribution of posts was uneven so that a few subjects made many posts while many made only one. The distribution can be seen in Figure 2 where the number of posts for each group member is plotted in a sorted order.

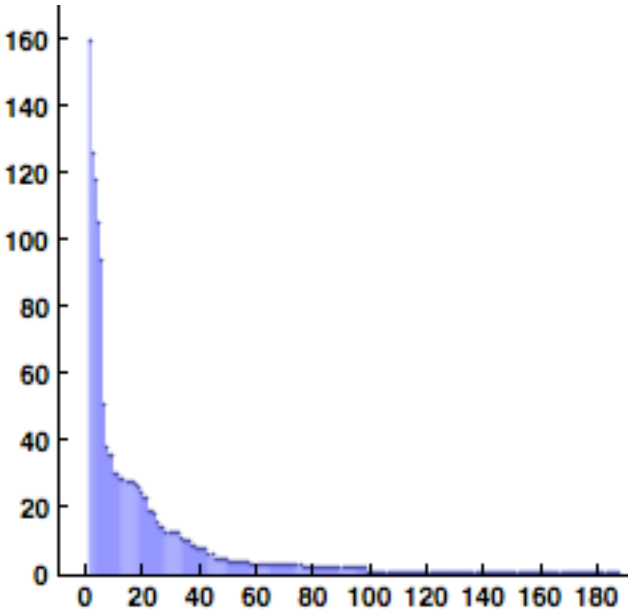

Figure 2. FASHION observed data. The distribution of posts. We can see in these graphs how the number of posts were distributed. A few subjects made many posts and many subjects made only one or a few posts.

In a similar way the distribution of grooms were also unevenly distributed among the group members.

5.1.4 The groom balance

The groom balance was calculated for each time step as the number of grooms a subject had received minus the number of grooms a subject had given to others. In Figure 3 we can see the groom balance over time for two different subjects in the FASHION group. The subject to the left gives a lot and gets a lot thus fluctuating around a level of zero. The subject to the right gives a lot but receives very little. In this analysis we see this as a sign of low status.

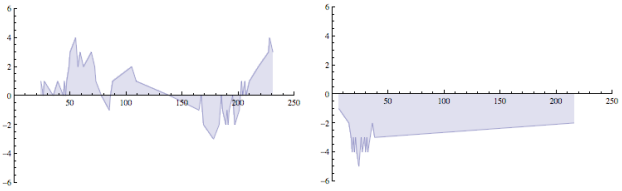

Figure 3. FASHION observed data. Groom balance for two members of the FASHION group. The subject to the left gives and gets grooms and fluctuates around the zero-level. The subject to the right (male) gives quite a lot but do not get much back which means that his groom balance never reaches above the zero level.

The complete groom balances including all subjects in the FASHION group can be seen in Figure 4.

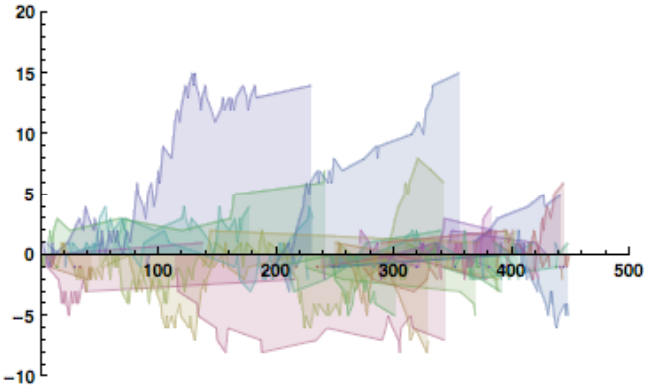

Figure 4. FASHION observed data. The groom balance for all members of the group. We can see that after a while (at approximately event 100), one of the subjects gets a very high status. When this subject leave the group (event 220), another subject rises in status until also this subject leave the group (event 360).

5.2 Validation of the status data

The status points assigned in the preliminary validation study to different members of the group were compared to three other measures for each group member. Correlation was highest between status points and the groom balance, 0.90. Correlation between status points and number of posts was almost as high, 0.89. Finally, correlation between status points and total number of grooms received was 0.88. So it seems that the concept of the groom balance seem to represent the subjectively appreciated status quite well. However this is true also for the other two measures: number of posts and number of grooms received.

5.3 The simulation model

The simulation model was implemented in Mathematica. The input parameters were taken from the observed data. The program was initiated with two subjects. The main program loop was as follows:

```
Do[{
  srr = RandReal[];
  If[newsubjectq, assignnewsubject, assignpostingsubject];
  If[groomq, assigngroomedsubject, Continue];
  If[dropsubjectq, dropsubject, Continue]},

{i, 3, numberofposts}];
```

For each assignment of a subject there was a method switch implemented that could be set to either one of the methods described in section 4.3.5 or a combination of more than one method.

5.4 Comparisons of observed data and simulated data

The simulation was run with all of the methods described in section 4.3.5 and with combinations of the methods.

5.4.1 Random methods of assignment

Generally the random methods of assigning subjects did not give graphs similar to the observed data as can be seen in Figure 5.

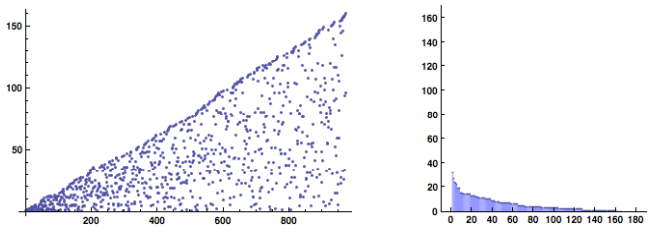

Figure 5. FASHION simulated data. This is the result of using the *random* method for assignment of subjects. We see that this method does not reproduce the stratification of the posting activity or the uneven distribution of posts found in the observed data.

The combinations of methods that best mimic the observed data will be described below.

5.4.2 Simulation of the FASHION discussion group

For the FASHION group the activity over time was best described by a combination of the following methods: - assignment of the posting subject was based on a combination of groom-status and number of grooms received. This means that the model that assumes that

a) the probability of posting is higher if the person have been groomed

b) the probability of posting is proportional to the number of grooms received

gave the best results. The factor in b was about 2 times as strong compared to a.

- assignment of the groomed subject was based on the groom balance and the number of posts a subject had made. This means that the model that assumes that

a) the probability of being groomed is higher if the person currently have a high positive groom balance

b) the probability of being groomed is proportional to the number of posts already made

gave the best results. The factor in b was about 2 times as strong compared to a.

- assignment of the subject to leave the group, was based on a combination of an inverse of the number of grooms received and the anti old method. This means that the model that assumes that

a) the probability of leaving the group is inversely proportional to the number of grooms a person have received

b) the probability of leaving the group is proportional to the time since the first post

gave the best results. The factor in b was about 2 times as strong compared to a. (The wit-based method was not able to reproduce the successive emergence of high status members observed for this group.)

In Figure 6a-d we can see comparisons between the observed data and the simulated data.

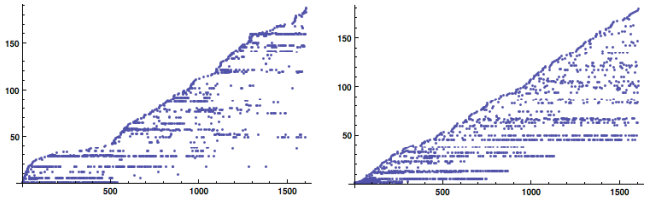

Figure 6a. FASHION. Observed data (left), simulated data (right). The posting activity over time. We can see that the stratification is reproduced in the simulated data as opposed to the random method described earlier.

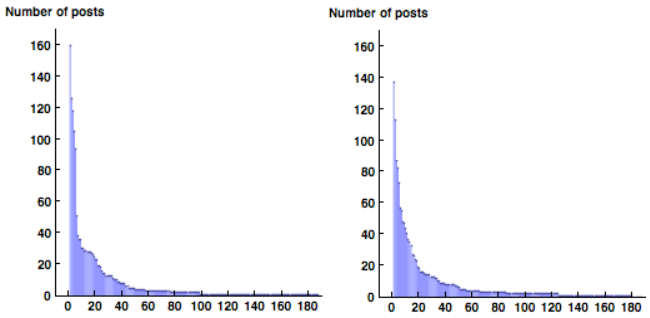

Figure 6b. FASHION. Observed data (left), simulated data (right). The distribution of posts over the different subjects in the group. We can see that the uneven distribution is reproduced in the simulated data contrary to when the random method described earlier was used.

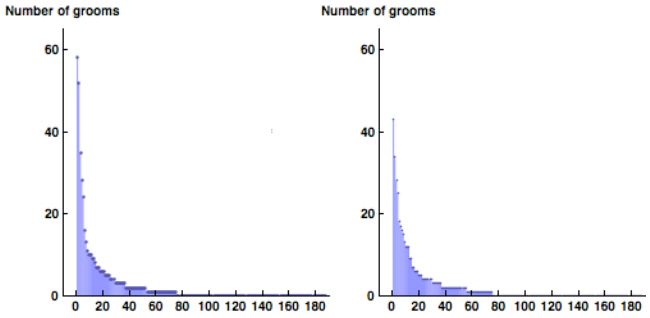

Figure 6c. FASHION. Observed data (left), simulated data (right). The distribution of grooms over the different subjects in the group. We can see that the uneven distribution is reproduced in the simulated data contrary to when the random method described earlier was used.

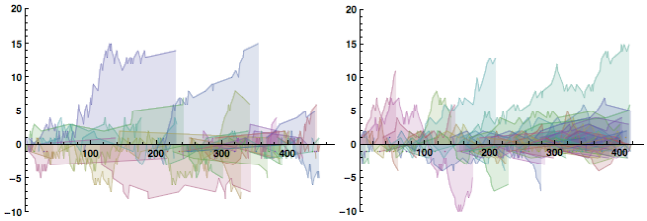

Figure 6d. FASHION. Observed data (left), simulated data (right). The groom balance over time for all subjects in the group. We can see that the pattern of successive high status members is somewhat reproduced in the simulated data contrary to when the random method described earlier was used.

6. CONCLUSION

This study show that including the concept of groom and the groom balance over time can give a new perspective on the social dynamics in groups. When applied to the observed online discussion group it could give a complementary picture to the traditionally social network analysis.

6.1 The method of analysis

The method of analysis worked well to visualize the development over time of the social interaction in groups. In this study, grooms were operationally defined as quotations and mentions. The method could be applied to any group were the concept of groom can be operationally defined in some quantifiable way.

6.2 The method of simulation

The method of simulation used show that it can reproduce certain characteristics of the interaction in groups. It can also be used to test hypothesis for which factors influence the social dynamics in a group.

6.3 Conclusions about the social dynamics in the group

From the comparison of the observed data and the simulated data it was found support for the following relations.

- the probability of posting is higher if the person have been groomed
- the probability of posting is proportional to the number of grooms received
- the probability of being groomed is higher if the person currently have a high positive groom balance
- the probability of being groomed is proportional to the number of posts already made
- the probability of leaving the group is inversely proportional to the number of grooms a person have received
- the probability of leaving the group is proportional to the time since the first post

7. DISCUSSION

In this study it was found support for that a person who receive attention for his/her first post tend to continue posting more than people that get no attention for their first post. This is well in line with the findings of Wilkinsson 2008 [12] who also found that attention given after the first post increased the likelihood of posting again. This study is limited to only one group and therefore the possibility to generalize is low. Further studies will include more groups and a comparison with a content analysis of the posting contents. The work described in this paper can be seen as a first step towards finding methods and models of groups of larger sizes. One of the problems that will have to be solved is to automatically elicit the mentioning's, even if they are misspelled. The string pattern facilities in Mathematica can hopefully be used for solving this problem.

8. REFERENCES

[1] Coie, J. D., Kupersmidt, J. B. A Behavioral Analysis of Emerging Social Status in Boy´s Groups. Child Development, Vol 54, No 6, (Dec 1983), pp. 1400-1416.

[2] Maisonneuve, N. Basic Social Attention Analysis. The webblog of INSEAD´s Centre for Advanced Learning Technologies (CALT). 2007.

[3] Tufekci, Z. GROOMING, GOSSIP, FACEBOOK AND MYSPACE. What can we learn about these sites from those who won't assimilate? Information, Communication & Society Vol. 11, No. 4, June 2008, pp. 544 – 564

[4] Mazur, A. A Biosocial Model of Status in Face-to-face Primate Goups. Social Forces [0037-7732] Mazur 1985, Vol:64 iss 2.

[5] Yan, M., Vassileva, J., Grassman, W. A System Dynamics Approach to Study Virtual Communities. Proceedings of the 40th Hawaii International conference on System Science, IEEE 2007.

[6] Zhang, Y. W., Tanniru, M. An Agent-based approach to Study Virtual Learning Communities. Proceedings of the HICSS´2002, Big Island, Hawaii, 2002.

[7] Yamada, K., Nakakoji, K, Ueda, K. A multi-agent approach to analyze online community activities. The Fourth International Conference on the Advanced Mechatronics (ICAM 04)

[8] Sawyer, R. K. Artifical Societies: Multiagent Systems and the Micro-Macro link in Sociological Theory. Sociological Methods Research 2003;31;325.

[9] Simkin, M. V. Roychowdhury, MV. P. A mathematical theory of citing. Journal of the American Society for Information Science and Technology, 58(11):1661--1673, 2007

[10] Agarwal, N. Huan Liu, Lei Tang. (2008) "Identifying the influential bloggers in a community" Proceedings of the international conference on Web search and web data mining 2008, Palo Alto, California, USA February 11 - 12, 2008

[11] Wilkinson, D. M. Strong regularities in online peer production. Proceedings of the 9th conference on Electronic commerce 2008, Chicago, Il, USA, July 08-12, pp. 302-309.