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Power Structure and the Evolution of Social Networks in Massively Multiplayer Online Games

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Recommended Citation
Putzke, Johannes; Fischbach, Kai; and Schoder, Detlef, "Power Structure and the Evolution of Social Networks in Massively Multiplayer Online Games" (2010). *ECIS 2010 Proceedings.* Paper 159.
http://aisel.aisnet.org/ecis2010/159

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Power structure and the evolution of social networks in massively multiplayer online games

Journal:	*18th European Conference on Information Systems*
Manuscript ID:	ECIS2010-0130.R1
Submission Type:	Research Paper
Keyword:	Gaming, Networks, Online communities, Social entities

POWER STRUCTURE AND THE EVOLUTION OF SOCIAL NETWORKS IN MASSIVELY MULTIPLAYER ONLINE GAMES

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Abstract

This paper examines the evolution of a social network in a Massively Multiplayer Online Game (MMOG) by modeling the players' interaction network as a continuous-time markov chain. Results indicate that social hierarchy emerges out of an anarchical situation in which social actors participate voluntarily, have equal access to virtual resources from the beginning, cannot show their physical superiority and cannot show physical gestures during their communication / interaction. Our study findings hence contribute to the current interdisciplinary debate whether hierarchy is an emergent phenomenon that can be attributed to variations in individual qualities or whether hierarchy is an artificial outcome that is enacted on societies by parties that are privileged from birth.

Keywords: Massively Multiplayer Online Games, MMOG, Hierarchy, Social Network Analysis, Exponential Random Graph Model, SIENA

1 INTRODUCTION

Power structure (syn. social hierarchy) terms a network of dominance-subordination relationships. Although considerable research has been devoted to the emergence of social hierarchy in different disciplines and in a variety of different settings (for an overview of the literature, see, for example, Sidanius & Pratto 2001), the authors are not aware of any formal model that tests for the emergence of social hierarchy within Massively Multiplayer Online Games (MMOGs).

However, such a study might provide useful insights for scholars examining the emergence of social hierarchy (not only in the domain of information systems, but also in the domains of biology, anthropology, sociology, psychology political economy and management research), because it can address the question whether social hierarchy emerges out of anarchical situations in which social actors participate voluntarily, have equal access to virtual resources from the beginning, cannot show their physical superiority, and cannot use physical gestures during their communication / interaction.

Results of this study provide evidence that social hierarchy even emerges when controlling for these factors which leads to several theoretical and managerial implications. Particularly, the findings contribute to the current interdisciplinary debate whether hierarchy is an emergent phenomenon that can be attributed to variations in individual qualities or whether hierarchy is enacted on societies by parties that are privileged from birth, and hence hierarchy is rather an artificial outcome (see, for example, Bonabeau & Theraulaz & Deneubourg 1999, Gould 2002).

The article is structured as follows. The next section provides the conceptual underpinning, illustrates the current debate about the origin of hierarchies in a variety of different disciplines and develops a research hypothesis. The authors then describe the methodology employed, data collection and sample, and develop an empirical model. The next section, data analysis and results, highlights the study findings. The article concludes in the discussion section with theoretical and managerial implications as well as limitations of the study, and provides some suggestions for further research.

2 CONCEPTUAL UNDERPINNING, LITERATURE REVIEW AND RESEARCH HYPOTHESIS

Power structure (*power hierarchy*, *dominance hierarchy* or *social hierarchy*) is a core construct in a variety of different academic disciplines. In the remainder, the authors will refer to this construct as *social hierarchy*, because *social hierarchy* reflects the meaning of most constructs in the related academic disciplines.

The etymological roots of *hierarchy* stem from the greek words *hieros* (engl. sacred) and *archein* (to rule). Originally hierarchy was used in a clerical context only. However, in today's use hierarchy is defined as any ordered set of entities that can be classified as being inferior, superior or on the same level as one other. The authors prepend the attribute *social* to characterize a hierarchy in which the entities under observations are individual social actors. A social actor is any agent that is embedded in a network of agents whose actions and reactions influence each other.

Several (conflicting) paradigms in the different academic disciplines provide patterns of explanation for the emergence of social hierarchies.

In psychology, there is a recent research stream called "social dominance theory" (for an overview of the literature see, for example, Sidanius & Pratto 2001). Social dominance theorists argue that complex social systems are predisposed to form social hierarchies for the following reasons: Each individual of a social system is member in a particular social group, and all individuals tend to draw distinctions between in-group and out-group members. Each individual has a certain tendency to dominate individuals belonging to out-groups (called social dominance orientation). Therefore, over time a social hierarchy will evolve in society. One of the main research questions in social dominance

theory is which factors determine an individual's social dominance orientation, and how social hierarchy is maintained over time. Similar streams of thought in psychology can also be found in "social identity theory" (e.g. Tajfel & Turner 2004).

Biology has a long tradition in examining the emergence of hierarchies. In biology, these hierarchies generally are called *dominance hierarchies* when actors are animals and *social hierarchies* when actors are primates. As early as 1908, Wallace Craig (1908) published an article about social control in a group of pigeons. This stream of thought has been continued by researchers who mainly examined hierarchy in a group of birds (e.g. Chase 1982, Masure & Allee 1934, Schjelderup-Ebbe 1922). Meanwhile, dominance hierarchies have been examined for a variety of different species (for a review see, for example, Bonabeau et al. 1999) including primates (Mendoza & Barchas 1983). However, it is still disputed whether the formation of dominance hierarchies results from a self-organizing process or whether it results from preexisting differences between individuals. Current empirical data do not allow any statements about which assumption is right (for a review see, for example, Bonabeau et al. 1999).

A similar question is put up for discussion by sociologist and economists (see Gould 2002). Whereas some theories emphasize that hierarchies emerge and persist, because competent, hardworking and charismatic individuals are rewarded by society for their individual capabilities (e.g. social exchange theory (Blau 1964, Homans 1958) and human capital theory (Becker 1964)), other theories emphasize that an individual's position in a hierarchy can rather be attributed to his / her (family) background, because over time some groups of individuals have excluded weaker individuals from access to valued resources (e.g. social change theory, Tilly 1999).

To summarize, across all disciplines there are two dominant schools of thought about the origin of hierarchies in societies. Whereas the first stream of thought argues that hierarchy is an emergent phenomenon that can be attributed to variations in individual qualities, the second stream of thought argues that hierarchy is enacted by privileged incumbents and is largely independent of individual qualities. Rather, hierarchy is supposed to be an artificial outcome (Gould 2002).

It would seem, therefore, that further investigations are needed in order to figure out whether hierarchy emerges out of anarchical situations in which each individual is furnished with the same resources from the beginning, participates voluntarily, cannot show his / her physical superiority and cannot use physical gesture during interaction (which is the case in the Massively Multiplayer Online Game under examination).

When examining this research question, is it also important to consider the findings of IS researchers that deal with the emergence of social hierarchies.

According to our knowledge, IS researchers have not yet developed a comprehensive theory about the emergence of social hierarchies. Nevertheless, there are several related streams of IS research such as adaptive structuration theory (e.g. DeSanctis & Poole 1994, Giddens 1979), critical social theory (e.g. Habermas 1979, Hirschheim & Klein 1994, Truman & Baroudi 1994), social network theory (e.g. Newell & Tansley & Huang 2004, Teigland & Wasko 2009), and leadership theory (e.g. McLeod 1992, Wakefield & Leidner & Garrison 2008) that contribute to our understanding about the emergence of hierarchies. Particularly, studies in the domain of leadership theory provide results that are highly relevant for this research. For example, Yoo and Alavi (Yoo & Alavi 2004) distinguish between emergent and designated forms of leadership. Whereas emergent leadership develops through group processes over time, designated leadership is accorded due to authority spontaneously. In their research, Yoo and Alavi (2004) neglect designated leadership, but identify factors that lead to emergent leadership in virtual teams. Hence, they make an important contribution to the literature. However, hierarchy theory can extent leadership theory, because it does not focus on individual actor characteristics (at one hierarchical level) only (i.e. characteristics that lead leaders become leaders), but examines the emergence of leadership at several hierarchical levels at the same time.

Another stream of IS research that is of relevance to the research question are studies about MMOGs. However, despite MMOGs being on the research agenda for more than ten years (e.g. Parks & Floyd 1996), there has been surprisingly little research on this topic, and these studies are mainly descriptive (Putzke et al. in print). The authors are aware of only one formal model that tests a theory of social selection and influence in MMOGs. Putzke et al. (in print) analyzed the evolution of the players' interaction network in the German MMOG *Ocean Control*. They find that the same structural effects and demographic variables as in the real world influence the evolution of the players' interaction network. Furthermore, they do not find evidence, that the players' virtual performance in the game influences the process of network evolution (vice versa). The findings by Putzke et al. (in print) will particularly considered when selecting the control variables for this study.

Since IS researchers have not yet developed a comprehensive theory about the emergence of social hierarchies, the research hypothesis development will also draw on theories from related academic disciplines.

When examining the emergence of social hierarchies, a focal point of analysis is who seeks to interact with whom. Principally, there are two reasons for players to seek interaction in a social hierarchy.First, players who are high in hierarchy seek to dominate players that are low in hierarchy or on the same hierarchical level. Dominating means, that players try to influence the other players' actions by threat of sanctions in case that low hierarchy individual do not act in their interests (compare Katz & Kahn 1966). Second, players that are low in hierarchy seek advice and / or support from players that are high in the players' social hierarchy (Deutsch & Coleman & Marcus 2006, Yamaguchi 2003), or they seek interaction to those high in hierarchy to pledge for behaveor toward them in a need gratifying fashion (Cohen 1958). In the first case, the players who want to dominate seek to interact with people on lower (or the same) hierarchical levels, and in the second case the players who seek for advice / support seek to interact with players on the same or higher hierarchical levels. However, they usually do not tend to seek advice from lower hierarchical levels (Yamaguchi 2003).

A qualitative analysis of the dataset used in this study (see section 3.2) revealed that most communication in the game analyzed was task related, and that players sought for support when seeking for interactions. The following dialogue illustrates a typical communiation between two random actors:

User_1427: ”*Could you borrow me some steel, otherwise I cannot advance. I will return the favor. Mfg*”

User_1146: ”*Of course, how much do you need and to where shall I deliver? Best greetings*”

User_1427: ”*I have place for 10000 and please deliver to LOCATION NUMBER ANONYMIZED and I will allow you to use the petrol station and you will get petrol for free. thx in advance*”

User_1146: ”*Hmm, I only do have 7000 at the moment. But this is better than nothing. *g* You do not have to grant me access to the petrol station. If I fit into the harbor, I can get petrol for free there* :)”

Hence, the research hypothesis development will focus on social hierarchy that emerges due to seeking for support. (However, the same argumentation holds for hierarchy that emerges due to seeking dominance over other players).

In this context, it is important to introduce the concepts of *transitive triplets* and *intransitive triplets* in a social network (see Chase 1982, Davis 1970).[1] Figure 1 depicts an *intransitive triplet*. The boxes in Figure 1 depict three actors i, j and h. The arrows between the players indicate which player is seeking to interact with whom. It can be interpreted as ”If player *i* seeks to interact with player *j* and player *j* seeks to interact with player *h*, also player *h* should seek to interact with player *i*.”

[1] The definition of a social network is beyond the scope of this paper. The reader is referred to introductory text books about social network analysis (Wasserman & Faust 1994).

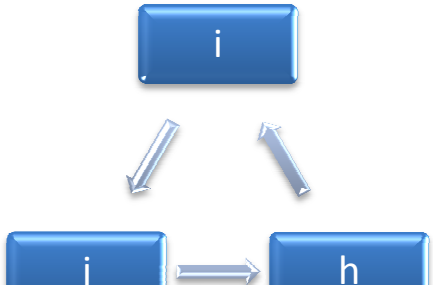

Figure 1. Intransitive Triplet

As evident from Figure 1, the number of intransitive tripelts should be low in a social hierarchy, because if actor *i* seeks support from actor *j*, and actor *j* seeks support from actor *h*, actor *h* should not seek support from actor *i*, because actor *i* is supposed to be on a lower hierarchical level.

Rather, players should strive to seek ties that close transitive triplets (see Figure 2). A *transitive triplet* can be interpreted as "If player *i* seeks to interact with player *j* and player *j* seeks to interact with player *h*, also player *i* should seek to interact with player *h*". The number transitive triplets should be high, because players on low hierarchical levels should seek support from players that are on the same or higher hierarchical level.

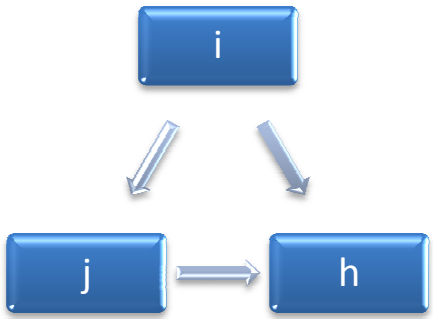

Figure 2. Transitive Triplet

In the remainder of the paper, this type of tie seeking behavior (i.e. avoiding ties that close intransitive triplets and seek ties that close transitive triplets) will be referred to as *tie seeking that establishes a social hierarchy*.

The counterpart to the aforementioned tie seeking behavior is a *random tie seeking behavior*. In the context of this study, *random tie seeking behavior* means that players do not consider players' hierarchical level when seeking their partners for interaction. Rather, after controllling for all other factors (i.e. actor characteristics, network characteristics and other control variables) actors are equally likely to seek ties to partners who are on different hierarchical levels.

In summary, the authors expect that a players' likelihood of seeking a tie that establishes a social hierarchy his higher than the likelihood of a random tie. Hence,

H1: Players are more likely to seek a tie that establishes social hierarchy than seeking a tie that does not establish social hierarchy.

3 MODEL DEVELOPMENT AND DATASET

3.1 Methodology

The authors test the hypothesis using a stochastic actor-driven modeling approach proposed by Snijders (e.g. Snijders & van de Bunt & Steglich 2009). This approach stands in the tradition of models examining the evolution of social networks (for an introduction, see Doreian & Stokman 1997, Robins & Snijders & Wang & Handcock & Pattison 2007, Wasserman & Pattison 1996). The authors decided to employ this methodology because it is the most advanced methodology to draw statistical inferences about tie-oriented network dynamics when analyzing a given node set in a longitudinal study. For example, the methodology also allows drawing inferences about network changes and controlling for actors' attributes (such as gender) and structural micro effects simultaneously. Furthermore, most standard statistical methods cannot be employed when analyzing social network data due to structural autocorrelation and violation of the i.i.d. assumption. The first application of this methodology in IS research and research about MMOGs is a recent study by (Putzke et al. in print) that also provides further reasoning for the choice of the methodology and will serve as a basis for this research.

3.2 Data Collection and Sample

To test the proposed hypothesis, the authors used Putzke and colleagues' dataset (see Putzke et al. in print, for a detailed description of the dataset). This dataset comprises all interactions and activities of the first 2,000 registered players in the German MMOG *Ocean Control* over a period of six months in 2006.

The basic idea of *Ocean Control* is that players own islands. These islands provide the players with the necessary resources for building up states. Players can fight against each other and conquer foreign islands by training and commanding military units. Players can also support each other by exchanging and trading resources, as well as establishing contracts for mutual support during fights. Players can obtain information about the other players either by observing the other players' actions in the game, or by inspecting the other players' profiles. These profiles contain, amongst others, different performance metrics (e.g. the players' current rankings in the game), the players' alliance memberships (as well as performance metrics of the alliances) as well as free text fields.

The dataset is an interesting basis for further analysis, because all players in the game are furnished with the same amount of "physical resources" and the same "social status" when starting the game. All players started playing the game at approximately the same moment in time. Furthermore, they can neither show their physical superiority nor use physical gestures during their interactions. Finally, all players participate voluntary in the game, and the game starts with an "anarchical situation" without previous interactions between players.

Following Putzke et al. (in print), we used the same subsample of actors and divided the dataset into three two-month periods. In the following, $X(t)=X_{ij}(t)$ denotes an n×n adjacency matrix where $x_{ij}=1(0)$ represents a tie (no tie) from actor *i* to actor *j* (i,j=1,…n) in period t, that is, player *i* sends at least two messages to player *j* ($i \rightarrow j$) (for a reasoning of the cut-off value of two see Putzke et al. (in print)). We opted for the same three two-month periods, and not a greater number of shorter periods, to keep the number of tie changes between subsequent observations high enough to allow for reasonable estimations. Indeed, the Jaccard distances between two subsequent observations (J_δ (t_1, t_2) =.716; J_δ (t_2, t_3) =.647) fall within acceptable levels (compare Snijders et al. 2009).

3.3 Model Development

Following Snijders (for an introduction see, for example, Snijders 1996, Snijders et al. 2009), we model the network evolution as a Markov-process Y(t)=(X(t), Z(t)) on the space of all adjacency matrices X(t), as well as all actors' characteristics Z(t). We calculate the transition intensities of the

transition matrices between the different states y(t) of the Markov-process by discrete choice models (for an introduction see, for example, Train 2003). During each choice, an actor is either allowed to change a tie variable, change one of his / her characteristics or not to change anything. The choices are supposed to arrive for each actor at randomly determined moments in time that follow an exponential distribution. In the choice models for tie choices, the probability of an actual change taking place is modeled by an actor's so called "objective function". The objective function reflects the value an actor attributes to the current network configuration. The objective function is supposed to capture all relevant information and resembles an ordinary regression function. At the randomly determined moments in time, each focal actor tries to maximize her/his "objective function" by changing her/his personal network configuration. Hence, the parameters and variables of the objective function can be interpreted in a similar way like the parameters of an ordinary discrete choice model / logistic regression. For example, the most basic effect included in almost every model is an actor's outdegree ($\beta^{outdegree} \sum_j x_{ij}$). This effect increases an actor's objective function by value 1 if this player seeks a new tie, because the corresponding value in the adjacency matrix x_{ij} equals 1 if there is a tie present (and is 0 otherwise). Hence, a negative parameter estimate $\hat{\beta}^{outdegree}$ indicates that each tie is associated with some "cost" for the player and he does not seek as much ties as possible.

3.4 Operationalization

3.4.1 Hierarchy

To draw inferences about the players' tendency to seek ties that establish hierarchy, the authors added two triadic effects to the players' objective function. The first effect reflects the number of player *i*'s transitive triplets $\beta^{transitivity} \sum_{j,h} x_{ij}\, x_{jh} x_{ih}$. The product $x_{ij} x_{jh} x_{ih}$becomes 1, only if all ties between players *i*, *j* and *h* as illustrated in Figure 2 are present (and equals 0 otherwise). Hence, a positive estimator $\hat{\beta}^{transitivity}$ indicates that player's are more likely to seek for a tie that closes a transitive triplet.

The second effect added to the players' objective function reflects player *i*'s tendency to seek for intransitive triplets $\beta^{intransitivity} \sum_{j,h} x_{ij}\, x_{jh} x_{hi}$.[2] Hence, a negative parameter estimate $\hat{\beta}^{transitivity}$ indicates that players are less likely to seek a tie that closes an intransitive triplet.

In summary, a positive parameter estimate $\hat{\beta}^{transitivity}$ and a negative parameter estimate $\hat{\beta}^{intransitivity}$ both at the same time provide strong evidence that players tend to seek ties that establish social hierarchy.

3.4.2 Control Variables

Following Putzke et al. (in print), the authors included the following control variables:

- An outdegree effect $\beta^{outdegree} \sum_j x_{ij}$ that has already been explained above, and indicates whether seeking ties is associated with some "cost".
- A reciprocity effect $\beta^{reciprocity} \sum_j x_{ij}\, x_{ji}$ that captures whether players' are more likely to seek interactions with other players that also seek to interact with them. Hence, a positive parameter $\hat{\beta}^{alliance\ homophily}$ indicates that players are more likely to seek ties to other players that seek ties to them.
- An effect controlling for alliance homophily $\beta^{alliance\ homophily} \sum_j x_{ij}\, I\{alliance_i = alliance_j\}$ where *I* is an indicator function that takes a value of 1 if both players belong to the same alliance, i.e. a positive estimate $\hat{\beta}^{alliance\ homophily}$indicates that players are more likely to seek interaction with other players that belong to the same alliance in the game.

[2] Intransitive triplets are sometimes also called intransitive triads, triangles, pecking triangles or 3-cycles.

- Three effects controlling for gender homophily: (1) a gender ego effect $\beta^{gender\ ego} \sum_j x_{ij} gender_i$ where gender is coded 1 for men and 2 for women (i.e. a positive estimate $\hat{\beta}^{gender\ ego}$ indicates that women are more likely to seek partners for interaction) (2) a gender alter effect $\beta^{gender\ ego} \sum_j x_{ij} gender_j$ that indicates whether women are more likely to be sought as partners for interaction, and (3) a gender homophily effect (see above) $\beta^{gender\ homophily} \sum_j x_{ij}\, I\{gender_i = gender_j\}$ (compare above).
- An age ego effect $\beta^{age\ ego} \sum_j x_{ij} age_i$ indicating whether old people are more likely to seek partners for interaction.

Finally, Putzke et al. (in print) control in their paper for "popularity of alter", i.e. whether players are more likely to seek ties to other players that have a high popularity. They calculate the popularity of alter effect by $\beta^{popularity} \frac{1}{n} \sum_j x_{ij} \sum_l x_{lj}$ which reflects 1/n times the in-degree of all other players *j* to whom player *i* is tied. Since the same popularity of alter effect cannot be estimated with the new version of SIENA (3.17s) anymore, the authors decided to control for popularity of alter by adding $\beta^{popularity} \sum_j x_{ij} \sum_l x_{lj}$ to the objective function.

4 DATA ANALYSIS AND RESULTS

The authors conducted a nested model comparison to test the proposed hypothesis (see Snijders et al. 2009). All models were estimated using SIENA 3.17s. In a series of Neyman-Rao tests, the authors compare a model that allows both hierarchy parameters to vary freely against a baseline model that restricts one (or both) hierarchy parameters to be zero, but includes all control variables. The authors do not report any measure of explained variation, because there are as yet no satisfactory measures for this stochastic-actor driven modeling approach.

The series of Neyman-Rao tests indicate that the inclusion of both hierarchy effects into the model (see Table 3) at the same time increases model fit (χ^2 = 639.997; d.f. = 2; p < .0001), and that the increased model fit can be attributed to both effects, i.e. to transitivity (χ^2 = 202.223; d.f. = 1; p < .0001) as well as to linear structuring / intransitivity (χ^2 = 136.5124; d.f. = 1; p < .0001).

Furthermore, both effects are found to be statistically significant (p <.001) and in the expected direction. *Hence, hypothesis 1 is supported and it can be concluded that players are more likely to seek a tie to a partner that establishes social hierarchy than seeking a random tie, even if all players are furnished with the same resources from the beginning of the game.*

	Beta	s.d.	t-value	p-value
Rate Parameter (t=1)	28.8844	5.1460	5.6130	.00000
Rate Parameter (t=2)	23.2919	3.1553	7.3818	.00000
Outdegree	-2.7378	.1401	-19.5418	.00000
Reciprocity	3.1922	.1743	18.3144	.00000
Popularity	-.0258	.0136	-1.8971	.05782
Alliance Homophily	.5595	.0753	7.4303	.00000
Gender Alter	.2846	.1599	1.7799	.07510
Gender Ego	-.0505	.1587	-.3182	.75033
Gender Homophily	.0198	.0882	.2245	.82238
Age Ego	.0184	.0056	3.2857	.00102
Transitive Triplets (Hierarchy I)	.4202	.0546	7.6960	.00000
Intransitive Triplets (Hierarchy II)	-.5645	.1097	-5.1459	.00000

Table 3. Model Results

Concerning the control variables, the results are in line with the results obtained by Putzke et al. (in print). However, the authors did not find some of the effects to be statistically significant (at α=.05) that were found to be significant by Putzke et al. (in print) such as the "gender alter" and the "popularity" effect. The nonsignificant effects might be explained by the relatively low Jaccard

coefficients and the two additional "control variables" in the behavioral function. It is very likely that a greater number of tie changes between two subsequent periods would lead to significance of those parameters. Furthermore, the authors controlled for a slightly different popularity effect, because the effect estimated by Putzke et al. (in print) cannot be estimated with the new version of SIENA (3.17s) anymore.

As a final step of analysis, the authors respond to Putzke and colleagues' (in print) call for research, and analyze whether men are more likely to seek interaction with women (*vice versa*). Although the authors do not draw any inferences about these effects in this paper, they use the parameter estimates obtained from the model (see Table 3) to answer this research question by calculations.

The three gender effects were added to the players' objective function as the linear combination

$\beta^{gender\ ego} \sum_j x_{ij} gender_i + \beta^{gender\ alter} \sum_j x_{ij} gender_j + \beta^{gender\ homophily} \sum_j x_{ij}\, I\{gender_i = gender_j\}$.
The value that a particular tie is adding to the players' objective functions can be calculated by replacing the parameters through their estimates (i.e. $\hat{\beta}^{gender\ ego}$=.051; $\hat{\beta}^{gender\ alter}$=.285; $\hat{\beta}^{gender\ homophily}$=.018) and centered values (i.e. $gender_i$=.814 for female and $gender_i$=-.186 for male). For example, a women who seeks a tie to another women increases her objective function by

$$\Delta = -.051 * 1 * .814 + .285 * 1 * .814 + .018 * 1 * 1 = 0.210$$

		Alter	
		Female	Male
Ego	Female	.2104	-.0940
	Male	.2411	-.0237

Table 4. Summary of Gender Effects

Table 4 summarizes these calculations for all four different types of dyads (i.e. female seeking ties to female, female seeking ties to male, male seeking ties to female, and male seeking ties to male). The results can be interpreted as follows.

Both, female and male players have a tendency to seek females as partners for interaction ($\Delta > 0$). Furthermore, both, female and male players, have a tendency to avoid men as partners for interaction ($\Delta < 0$). That means, whereas there is homophily between female players (Δ =.2103), male players tend to avoid ties to the same gender (Δ = -.024).

5 DISCUSSION

5.1 Theoretical Implications

This study tests a hypothesis about the emergence of social hierarchies in MMOGs. The authors are not aware of any other formal model analyzing social hierarchies in MMOGs. Results indicate that hierarchy even emerges out of anarchical situations in which each individual is furnished with the same resources from the beginning, participates voluntarily, and cannot show its physical superiority or use physical gestures during interaction. Since Putzke et al. (in print) provide evidence that findings from MMOGs regarding social selection and influence might also hold in the real world, this study might contribute to the long-lasting debate whether the emergence of (human) social hierarchy can be attributed to situations that individuals encounter due to chance by birth, or whether hierarchy is a process that can be attributed to other individual characteristics. In MMOGs, a hierarchy emerges even if players are equipped with the same resources from the beginning of a game.

For this study, the authors used the same dataset as Putzke et al. (in print). As part of their findings, they replicated the results obtained by Putzke et al. (in print). Replicating the results is important, because the employed estimation procedures are stochastic in nature. In general, the obtained results are in line with Putzke et al. (in print). However, the authors do not only replicate these findings, but

give further reasons for splitting the data into the same three periods (i.e. Jaccard distances ≈ .7). Finally, they also illustrate how to calculate whether female are more likely to seek male as partners for repeated interaction (*vice versa*). They find that both genders have a tendency to seek female as partners for interaction, and both genders tend to avoid male as partners for interaction. Whereas there is a homophily effect between women (i.e. women prefer to seek other women as partners for interaction), men preferably do not seek other men as partners for interactions.

5.2 Managerial Implications

The demonstrated effects regarding the emergence of hierarchies are also pertinent to a managerial audience.

First, results indicate that hierarchy emerges out of anarchical situations by itself. Therefore, even in corporate cultures / work groups that emphasize that they do not have a (formal) hierarchy, it is necessary to keep track of emerging informal hierarchies to avoid the emergence of unmanageable forms of hierarchy.

Second, managers are often criticized by the left for having achieved their social status and hierarchical positions due to chance by birth, educational credentials and the social capital they encountered. This study, however, provides evidence that hierarchies are not only imposed on society by a predominant elite that is privileged by birth, but that hierarchies rather result from a process of individual behaviour. Hence, this study offers reasoning and justification in the moral debate on social hierarchy.

5.3 Limitations and Future Research

As with any empirical study this work is subject to limitations that offer interesting ways for future research.

First, although all players are furnished with the same resources from the beginning of the game, their behavior in the game might be influenced by their social status in real life. Therefore, future research should analyze whether players that have a high social status in the game's hierarchy also have a high social status in real life.

Second, players might participate in several MMOGs at the same time, use the same nickname in different games and transfer their virtual status from one game to the other. Future research should hence analyze these effects in more detail.

Third, this study is subject to some limitations imposed by the methodology employed (see Snijders & Steglich & Schweinberger 2007) and by the data used for model testing (see Putzke et al. in print). Particularly, there have not yet been developed any satisfactory measures of explained variation. Future research should try to develop such a measure.

Despite its limitations, we hope that this paper has the potential to stipulate interesting discussions at ECIS 2010 in Pretoria, and contributes to the current debate whether hierarchies are enacted on society by parties that are privileged from birth or whether hierarchies even emerge out of anarchical situations in which each actor is equipped with equal access to resources.

References

Becker, G. S. (1964). Human Capital: A Theoretical Analysis with Special Reference to Education. New York: National Bureau of Economic Research.

Blau, P. M. (1964). Exchange and Power in Social Life. J. Wiley, New York.

Bonabeau, E., Theraulaz, G. and Deneubourg, J.-L. (1999). Dominance Orders in Animal Societies: The Self-Organization Hypothesis Revisited. Bulletin of Mathematical Biology, 61 (4), 727-757.

Chase, I. D. (1982). Dynamics of Hierarchy Formation: The Sequential Development of Dominance Relationships. Behaviour, 80 (3/4), 218-240.

Cohen, A. R. (1958). Upward Communication in Experimentally Created Hierarchies. Human Relations, 11 (1), 41-53.

Craig, W. (1908). The Voices of Pigeons Regarded as a Means of Social Control. The American Journal of Sociology, 14 (1), 86-100.

Davis, J. A. (1970). Clustering and Hierarchy in Interpersonal Relations: Testing Two Graph Theoretical Models on 742 Sociomatrices. American Sociological Review, 35 (5), 843-851.

DeSanctis, G. and Poole, M. S. (1994). Capturing the Complexity in Advanced Technology Use: Adaptive Structuration Theory. Organization Science, 5 (2), 121-147.

Deutsch, M., Coleman, P. T. and Marcus, E. C. (2006). The Handbook of Conflict Resolution: Theory and Practice (2nd ed.). Jossey-Bass, San Francisco, CA.

Doreian, P. and Stokman, F. N. (1997). Evolution of Social Networks. Gordon and Breach, Amsterdam.

Giddens, A. (1979). Central Problems in Social Theory: Action, Structure, and Contradiction in Social Analysis. Berkeley: University of California Press.

Gould, R. V. (2002). The Origins of Status Hierarchies: A Formal Theory and Empirical Test. American Journal of Sociology, 107 (5), 1143.

Habermas, J. (1979). Communication and the Evolution of Society. Beacon Press, Boston.

Hirschheim, R. and Klein, H. K. (1994). Realizing Emancipatory Principles in Information Systems Development: The Case for Ethics. MIS Quarterly, 18 (1), 83-109.

Homans, G. C. (1958). Social Behavior as Exchange. American Journal of Sociology, 63 (6), 597-606.

Katz, D. and Kahn, R. L. (1966). The Social Psychology of Organizations. Wiley & Sons, New York.

Masure, R. H. and Allee, W. C. (1934). The Social Order in Flocks of the Common Chicken and the Pigeon. The Auk, 51 (3), 306-327.

McLeod, P. L. (1992). Are Human-Factors People Really So Different? Comparisons of Interpersonal Behavior and Implications for Design Teams. Journal of Management Information Systems, 9 (1), 113-132.

Mendoza, S. D. and Barchas, P. R. (1983). Behavioural Processes Leading to Linear Status Hierarchies Following Group Formation in Rhesus Macaques. Journal of Human Evolution, 12, 185-192.

Newell, S., Tansley, C. and Huang, J. (2004). Social Capital and Knowledge Integration in an Erp Project Team: The Importance of Bridging and Bonding. British Journal of Management, 15, 43-S57.

Parks, M. R. and Floyd, K. (1996). Making Friends in Cyberspace. Journal of Communication, 46 (1), 80-97.

Putzke, J., Schoder, D., Fischbach, K. and Gloor, P. A. (in print). The Evolution of Interaction Networks in Massively Multiplayer Online Games. Journal of the Association for Information Systems.

Robins, G., Snijders, T., Wang, P., Handcock, M. and Pattison, P. (2007). Recent Developments in Exponential Random Graph (P*) Models for Social Networks. Social Networks, 29 (2), 192-215.

Schjelderup-Ebbe, T. (1922). Beitrage Zur Sozialpsychologie Des Haushuhns, *Zeitschrift für Psychologie* (Vol. 88, pp. 225-252).

Sidanius, J. and Pratto, F. (2001). Social Dominance: An Intergroup Theory of Social Hierarchy and Oppression. Cambridge University Press, Cambridge, UK.

Snijders, T. A. B. (1996). Stochastic Actor-Oriented Models for Network Change. Journal of Mathematical Sociology, 21 (1/2), 149-172.

Snijders, T. A. B., Steglich, C. E. G. and Schweinberger, M. (2007). Modeling the Co-Evolution of Networks and Behavior. In K. v. Montford, H. Oud and A. Satorra (Eds.), *Longitudinal Models in the Behavioral and Related Sciences*. Newark, NJ: Lawrence Earlbaum.

Snijders, T. A. B., van de Bunt, G. G. and Steglich, C. E. G. (2009). Introduction to Stochastic Actor-Based Models for Network Dynamics. Social Networks, in press.

Tajfel, H. and Turner, J. C. (2004). An Integrative Theory of Intergroup Conflict. In M. J. Hatch and M. Schultz (Eds.), *Organizational Identity: A Reader* (pp. 56-65): Oxford University Press, New York.

Teigland, R. and Wasko, M. (2009). Knowledge Transfer in Mncs: Examining How Intrinsic Motivations and Knowledge Sourcing Impact Individual Centrality and Performance. Journal of International Management, 15 (1), 15-31.

Tilly, C. (1999). Durable Inequality. University of California Press, Berkeley, CA.

Train, K. E. (2003). Discrete Choice Methods with Simulation. Cambridge University Press, Cambridge, UK.

Truman, G. E. and Baroudi, J. J. (1994). Gender Differences in the Information Systems Managerial Ranks: An Assessment of Potential Discriminatory Practices. MIS Quarterly, 18 (2), 129-142.

Wakefield, R. L., Leidner, D. E. and Garrison, G. (2008). A Model of Conflict, Leadership, and Performance in Virtual Teams. Information Systems Research, 19 (4), 434-455.

Wasserman, S. and Faust, K. (1994). Social Network Analysis: Methods and Applications. Cambridge University Press, Cambridge, UK.

Wasserman, S. and Pattison, P. (1996). Logit Models and Logistic Regressions for Social Networks: I. An Introduction to Markov Graphs Andp. Psychometrika, 61 (3), 401-425.

Yamaguchi, K. (2003). A Liang-Zeger Method for Modeling Dyadic Interdependence in the Analysis of Social Networks. Sociological Methodology, 33 (1), 343-380.

Yoo, Y. and Alavi, M. (2004). Emergent Leadership in Virtual Teams: What Do Emergent Leaders Do? Information and Organization, 14 (1), 27-58.