Virtually There: Exploring Proximity and Homophily in a Virtual World

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***Abstract*— Virtual space eliminates the constraints of physical distances on communication and interaction. In this study, we examine the impact of offline proximity and homophily of players on their online interactions in EverQuest II. The results show that spatial proximity as well as homophily still influence players' online behavior.**

Keywords- distance, proximity, homophily, ERGM

I. INTRODUCTION

With the advent of globalization and the development of Information and Communication Technologies (ICTs), distributed teams have become a prevailing form of collaboration in contemporary work and social settings. Scholars and practitioners have been increasingly interested in exploring the interplay between geographic dispersion and group processes [1-3]. Although research to date has significantly extended our understanding of dispersion and team work, most studies tend to operationalize proximity as a dichotomous and unidimensional variable and measure its effect on simple and clear-cut relations.

The present study is designed to fill this gap by examining the interplay between proximity and human behavior in a large virtual world. The emergence of virtual worlds such as Second Life and online games offers rich data traces of individual interactions and behavior, the lack of which might have been the largest obstacle for previous scholarly endeavors. From a team standpoint, virtual worlds are ideal test beds for examining how people form relations in a distributed environment. One of the fundamental questions is whether the basic theories of proximity and homophily are still valid in virtual worlds. Are people closer and similar in the physical world more likely to interact in a virtual world?

More importantly, the relations in virtual worlds are indeed dynamic and complex: some stem from previous personal ties and the rest are solely based on activities in the virtual world. Instead of focusing on one relation in established and stable teams, understanding the differences among various types of online relations is more important to reveal the nature of individual behavior in virtual space.

In this paper, we study the impact of proximity and homophily in a large virtual world – EverQuest II. Although virtual worlds eliminate the constraints that physical distances put on communication and interaction, offline player attributes such as gender and age as well as offline player relationships like distance may still affect the likelihood of players to interact in the virtual space. Through analyzing the data from EverQuest II, we construct precise measures of proximity and homophily and identify four types of online relations: partner, instant messaging, trade, and mail. We then examine whether an online geography is actually free from the restrictions of offline space and how that different dimensions of proximity affect different relations.

In the following section, we briefly review previous research on the theories of proximity and homophily. In Section 3 we extend these theories into virtual worlds and propose eight hypotheses. Section 4 describes the proximity measures and online relations we develop using EverQuest II data and Section 5 tests the hypotheses using Exponential Random Graph Models (ERGM). We conclude by discussing the implications of the analysis results.

II. LITERATURE

The effects of proximity and distance on social and collaborative dynamics have been well researched. In recent years, the development of advanced information and communication technologies has dramatically increased our capability of interacting and collaborating with people across greater distances. A recent study unpacked "virtuality" into four distinct components: geographic dispersion, electronic dependence, dynamic structure, and national diversity [1]. O'Leary and Cummings [3] further suggested a multi-dimensional conceptualization of geographic dispersion, including spatial and configurational characteristics. In sum, proximity is a multi-faceted concept that includes related but distinct dimensions. The prevailing approach to examine spatial proximity is inadequate to move forward our understanding of proximity. In this study, we examine two dimensions of

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proximity in particular: spatial (physical distance) and social (individual characteristics).

A. Spatial Proximity

There is a long tradition of examining the impact of spatial proximity on communication. Since the 1930s, researchers studied how spatial proximity affects friendship, romantic relationships and other variables such as the amount of communication [4]. When the spatial distance between workers reached 30 meters and beyond, their frequency of spontaneous communications dropped drastically [5]. With the advent of communication technology, scholars began to research whether spatial proximity still operates within computer-mediated communication [6-8]. While most scholars have focused on how individuals that know each other offline communicate for work-related purposes using computers, little research examines how individuals that do not know each other offline communicate online for entertainment purposes. In general, this research shows that individuals who are located closer to each other are more likely to communicate than individuals who are located further away from each other, regardless of whether or not communication is face-to-face [9].

B. Homophily (Social Proximity)

Individuals can also be socially proximate or distant according to their attributes such as gender and age. In general, social proximity facilitates communication, as elaborated by the theory of homophily and well illustrated by the old saying "birds of a feather flock together." Monge and Contractor [10] summarized two lines of theoretical underpinnings of homophily: the similarity-attraction hypothesis and the theory of self-categorization. The similarity-attraction hypothesis postulates that people are more likely to interact with those who have similar traits [11]. Self-categorization theory argues that people tend to self-categorize with regard to race, gender, socio-economic status, etc., and they differentiate between similar and dissimilar others based on these attributes [12, 13]. Homophily, especially with regard to gender, ethnicity, and occupation, has been found as a critical factor of relationship formation in entrepreneurial teams [14], work team composition [15], as well as the formation of social networks in general [16].

III. HYPOTHESES

A. Spatial Proximity

As summarized in the theory section, researchers have found that spatial proximity exerts an important impact on individuals' interactions in both face-to-face and computer-meditated contexts. It is reasonable to believe, therefore, that this impact of spatial proximity on interactions would also hold true for virtual worlds, where various activities such as communication, economic transaction, and group collaboration take place among individual players distributed across geographical distances. Hence, we propose the following hypothesis:

Hypothesis 1: (Spatial proximity) Individuals who are proximate in geographical distance are more likely to engage in online interaction than those who are not proximate.

Most of the empirical findings on proximity and interaction come from the field of Computer Supported Cooperative Work, which generally examines the interaction between people within distributed work teams, usually consisting of colleagues who have worked with each other before. In other words, the impact of proximity has been tested on individuals with pre-existing relations, while little is known about whether comparable effects could be found among individuals with no history of interaction. In virtual worlds, activities differ with regard to their technological configurations, leading to affordances and constraints that could condition individual interactions. For example, in EverQuest II, individual players can use a partnership to achieve their goals together only if they are virtually next to each other; instant messaging with other players, on the contrary, can happen anytime, anywhere between two or more players as long as they are logged into the system. For economic transactions in EverQuest II, item trading can only occur between two players who are virtually close to each other, but mailing could occur between two players regardless of their virtual distance, hence it presumes a higher level of trust between the players than that of a completely impersonal transaction. Along another dimension, the partnership and instant messaging are interpersonal and require repeated interaction such as coordinated attacks and text exchange. Trade and mail relations, however, are built on one-time transactions. Table I summarizes the different types of relations in EverQuest II.

TABLE I. FOUR TYPES OF RELATIONS IN EVERQUEST II

	Synchronous	**Asynchronous**
Interpersonal interactions	Partnership (same in-game location) Instant messaging	
Transactional interactions	Trade (same in-game location)	Mail

These types of activities could be roughly aligned on a spectrum with regard to the degree of prior relationship required to accomplish them, i.e. interpersonal interaction requires more prior relation than transactional interaction. It could provide insight on whether proximity has comparable impact on interactions between individuals with various levels of prior relationship. Therefore, we unpack the general term of "interaction" and make separate predictions for different types:

Hypothesis 2: (Interaction types) Individuals who are proximate are more likely to engage in online interpersonal interactions (i.e. partnership and instant messaging) than transactional interactions (i.e. trade or mail).

B. Homophily

The theory of homophily posits that people of the same attributes tend to interact with each other. In virtual worlds, demographic attributes such as gender and age are expected to display similar effects as in other social contexts, even though those social attributes are not explicitly shown. In addition, we expect that players tend to interact with others with similar

level of achievement, as measured by experience points. Experience is one of the important, if not the most important, attributes of the players, as it represents the player's level of knowledge, status, and tenure in the game.

Hypothesis 3: (Gender) Individuals of the same gender are more likely to engage in online interaction than those of opposite genders.

Hypothesis 4: (Age) Individuals who have smaller age differences are more likely to engage in online interaction than those who have larger differences.

Hypothesis 5: (Experience) Players who have smaller differences in years of game experience are more likely to engage in online interaction than those who have larger differences in their years of experiences.

C. Hypotheses for Network Structures

Through many activities and different types of interactions, players develop some relatively stable relations in the game which are similar to friendship in the real world. Therefore, the network structures of relations in a virtual world are likely to have some similar network characteristics such as selectivity, popularity, and transitivity.

Hypothesis 6: (Selectivity) Individuals are not likely to engage in interaction randomly in a virtual world.

Hypothesis 7: (Popularity) Individuals with many interactions are more likely to engage in interaction than those have a few interactions.

Hypothesis 8: (Transitivity) Two individuals who both interact with the third parties are more likely to engage in interaction than those do not have common parties between them.

IV. DATA DESCRIPTION

A. General Description on EverQuest II Data Set

The sequel to the highly successful EverQuest, EverQuest II launched in November of 2004. Both EverQuest II and its predecessor maintained a large share of the North American market until the launch of World of Warcraft, the current US MMO leader. Despite losing its market lead, the EverQuest franchise continues to expand and still attracts several hundred thousand players.

EverQuest II has 19 servers located in the United States. Servers are the worlds where players play the game. The basic settings, such as map topology, exploring the in-game world, and socializing with other players, are the same on all servers; but some special modes of interaction are allowed or preferred on specific types of servers. For example, players can create imaginary storylines on role-play servers. For most activities, players are only allowed to interact with those who are on the same server. Transferring characters from one server to another is not encouraged and requires a charge. Therefore, a server can be considered as a stand-alone virtual world with a stable population of players. Every player is allowed to create multiple characters, represented by avatars in the game, and choose one archetype from Fighter, Scout, Priest and Mage for each character. In addition, players also select professional classes for their characters to develop "tradeskills." These skills are necessary for characters to craft particular types of in-game items for trade with other desirable in-game items, or for sale in exchange of in-game currency.

In this paper, we focus on players' partnership, instant messaging, trade, and mail activities on the Antonia Bayle server. A data log provided directly from Sony describes players' demographic information and almost all individual and collective activities occurred within the game, such as economic transactions, in-game communications, questing, combating, crafting, and so forth. Although players can create multiple characters, based on players' unique account id we can aggregate all activities and relations of multiple characters to one real individual player.

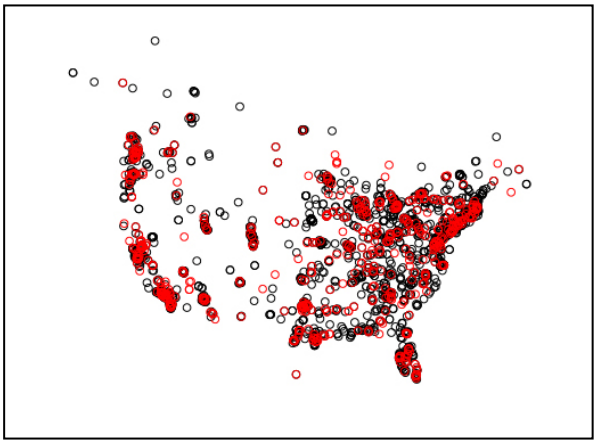


Figure 1. Geographical Distribution of the Sample Population

Because the Antonia Bayle server is designed for players in North America, this study focuses on players in the United States and Canada. Our sample set includes 3,140 unique players who are involved in grouping, player trade, or mail activities from August 25th to 31st, 2006 in Antonia Bayle (2,998 in the United States and 142 in Canada). The geographical locations of the players are illustrated in Figure 1.

B. Dependent variables – Network relations

To measure player relationship, we constructed four types of inter-player ties: partnership, instant messaging, player trade, and mail.

Partner Relation: In the world of EverQuest II players are allowed to form "*groups*" among themselves in order to complete tasks and play together. If two players (and only two) group together and earn experience points in combat activities such as fighting monsters, we construct a partner relation between them. We only consider the group of two because this form of collaboration represents a stronger dyadic relation than the interactions in bigger groups. The extracted relations are used to construct a binary and undirected graph where nodes represent individual players and edges are their partnership.

Instant Messaging Relation: Sony provides a universal chat system for all its online games including EverQuest II. Using

the chat log, we can detect instant messaging (IM) communication between players in Antonia Bayle.

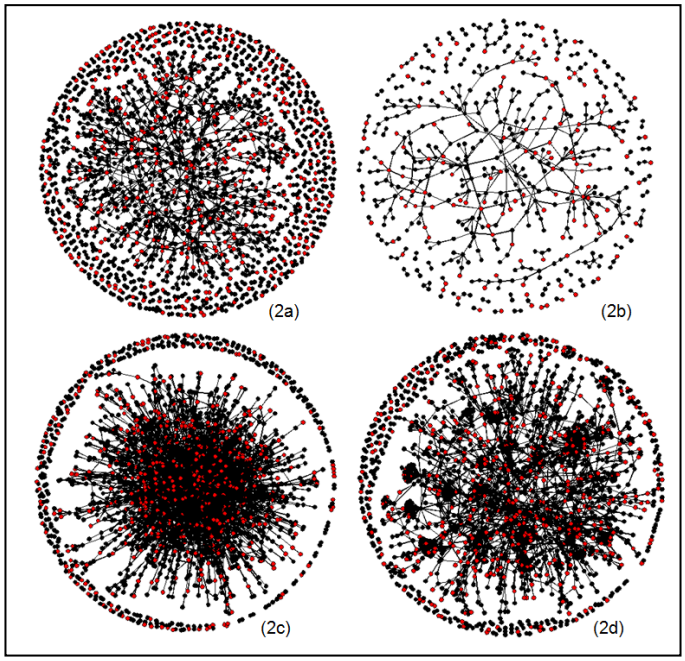
Player Trade Relation: EverQuest II players can gather and produce in-game items and trade with other desirable in-game items or in exchange of in-game currency. Item trading develops new social interactions and fosters a sense of community. One type of player-to-player trade is face-to-face item exchange. Different from market based trade, face-to-face item exchange reveals individual connections between the players: the two parties need to know each other's names and meet physically in the game to finish the transaction. Based on the players' face-to-face trade, we construct player trade relation as a binary and undirected tie if two players have exchanged at least one item during the sample time period.

Mail Relation: Similar to the U.S. Postal Mail, EverQuest II provides an in-game mail service called the Norrathian Express. To send and receive mail players must use aNorrathian Express kiosk located in most zones, or available via an express box players can purchase for their home. In addition to text, mails can also contain items or coins. Table II summarizes the network statistics of the four relation networks. The network structures are illustrated in Figure 2.

TABLE II. NETWORK DESCRIPTIVE STATISTICS OF FOUR RELATIONS

Network	Nodes	Edges	Density	Degree (mean)	Degree (max)	Centralization (degree)
Partner	1924	1789	0.097%	1.860	14	0.63%
Instant messaging	548	517	0.34%	1.887	10	1.49%
Trade	2456	3812	0.13%	3.104	24	0.85%
Mail	2090	3120	0.14%	2.986	84	3.83%

Figure 2. Partnership (2a), Instant Messaging (2b), Trade (2c), and In-game Mail (2d) Networks (Black indicates male players and red indicates female)



C. Independent Variables

In the data set, the demographic table provides player attributes including their gender, birthday, account registration date, zip code, and country code. Based on this raw data, we developed seven dyadic variables to measure homophily and proximity in EverQuest II. Three network variables and three attribute variables are included to capture the network effect and individual effect.

Homophily Measures: In the sample population, 2,447 players are male and 693 are female. We develop a dyadic variable $Same\_gender_{ij}$ which equals to one if players i and j have the same gender. Using reported dates of birth we can calculate $Age\_difference_{ij}$–the differences of players' age (in years). Similarly, the differences of players' account registration dates $AcctAge\_differernce_{ij}$ are used to estimate players' online experience.

Proximity Measures: We map players' zip code, and country code to latitude/longitude using ZIPList5 and Canada Geocode databases from ZipInfo.com. Using the latitude and longitude coordinates, we calculate the shortest distance between any two players based on the Spherical law of cosines:

$$\text{acos}(\sin(\text{lat}_i)\times\sin(\text{lat}_j)+\cos(\text{lat}_i)\times\cos(\text{lat}_j)\times\cos(\text{long}_j-\text{long}_i))\times 6371 \text{ Km}$$

$Log\_distance_{ij}$ represents the distance between players i and j using the standard logarithm scale.

Network Variables: We use three network statistics to measure selectivity, popularity, and transitivity in the networks: the number of edges (*Edges*) indicates the network density; the geometrically weighted degree distribution (*GWDegree*) summarizes the degree distribution in a network; geometrically weighted edgewise shared partners (*GWESP*) measures the number of players connecting two other players in a network [17].

Control Variables: Age_i, $AcctAge_i$, $Female_i$ are used to control the main effect of player i's age, game experience, and gender. Tables III and IV show the descriptive statistics of some player attributes and Quadratic Assignment Procedure (QAP) correlation between relation networks and distance.

TABLE III. DESCRIPTIVE STATISTICS OF PLAYER ATTRIBUTES

	Min.	1st Quartile	Median	Mean	3rd Quartile	Max.
Latitude	18.27	33.88	38.89	38.28	42.11	71.29
Longitude	-158.00	-112.00	-88.38	-94.19	-80.58	50.71
Age	5.67	25.41	31.35	32.34	37.55	71.04
AcctAge	0.003	1.01	1.80	2.45	3.28	9.40

TABLE IV. QAP CORRELATION BETWEEN RELATION NETWORKS AND DISTANCE

	Distance	Log10(Distance)
Partnership	-0.043***	-0.049***
Instant messaging	-0.062***	-0.032***
Trade	-0.018***	-0.045***
Mail	-0.025***	-0.037***

Signif. codes: *** $p < 0.001$

V. NETWORK MODELS AND RESULTS

Considering the endogenous correlation among the relations, we use Exponential Random Graph Models (ERGM) [18-20] to estimate the impact of proximity and homophily on online relations.

We test the hypotheses in three models. As a base-line model, Model 0 only includes network statistics *Edges*, *GWdegree*, and *GWESP* which capture the network structures of the relations. Model 1 tests gender, age, and experience homophily while controlling for network effect and individual attributes. Model 2 tests spatial proximity. The four relation networks are estimated separately using Statnet v2.1 with R-2.8.0. The results are reported in Tables V to VII.

TABLE V. RESULTS FOR THE BASELINE MODEL – NETWORK EFFECT

	Partner Model 0	IM Model 0	Trade Model 0	Mail Model 0	Hypotheses
Network:					
Edges	-8.72*** (.28)	-7.12*** (.20)	-6.02*** (.03)	-5.94*** (.03)	H6: supported
GWDegree	1.07*** (.18)	1.36*** (.20)	-1.12*** (.06)	-1.27*** (.06)	H7: partial
GWESP	1.49*** (.03)	1.25*** (.005)			H8: supported
Log likelihood	-13643	-3137	-29107	-23514	

Signif. codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < + < 0.1

TABLE VI. ERGM ESTIMATION RESULTS FOR HOMOPHILY HYPOTHESES

	Partner Model 1	IM Model 1	Trade Model 1	Mail Model 1	Hypotheses
Network:					
Edges	-8.587*** (.28)	-6.687*** (.20)	-5.780*** (.03)	-5.525*** (.03)	H6: supported
GWDegree	1.253*** (.18)	1.407*** (.20)	-0.905*** (.06)	-1.145*** (.06)	H7: partial
GWESP	1.454*** (.04)	1.237*** (.04)			H8: supported
Homophily:					
Same gender	-0.152*** (.02)	-0.148*** (.03)	-0.061*** (.01)	-0.059*** (.01)	H3: not supported
Age difference	-0.035*** (.001)	-0.026*** (.002)	-0.025*** (.0007)	-0.031*** (.001)	H4: supported
AcctAge difference	-0.115*** (.005)	-0.063*** (.01)	-0.144*** (.003)	-0.086*** (.003)	H5: supported
Control:					
Female	-0.201*** (.02)	-0.080* (.04)	-0.041*** (.01)	0.024** (.009)	
Age	0.005*** (.0002)	-0.002*** (.0005)			
AcctAge	0.007** (.002)	0.038*** (.005)	0.032*** (.001)		
Log likelihood	-13547	-3123	-29001	-23386	

Signif. codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < + < 0.1

In Model 0, the negative coefficients of the number of edges support Hypothesis 6. The relations in EverQuest II are sparse and individuals are not likely to engage in interaction randomly. The positive coefficients of geometrically weighted edgewise shared partners (*GWESP*) in Model 0 for partner and IM relations indicate that if two individuals have common partners or IM with the same persons, they are more likely to be partners or IM with each other. Hypothesis 8 is supported for partner and IM relations. We cannot test the transitivity hypothesis in trade and mail networks because the models with *GWESP* are not stable.

Geometrically weighted degree distribution (*GWDegree*) has positive impacts on partner and IM relations. This suggests popular individuals with more partners or IM are more likely to engage in partner or IM relations with each other. However Models 0 have the opposite results for trade and mail relations. Players with more trade and mail transaction parties are less likely to interact with each other. Hypothesis 7 is partially supported.

Model 1 tests the homophily hypotheses. The negative coefficients of *Age_Difference* and *AcctAge_Difference* support Hypotheses 4 and 5. Individuals tend to play with people who have similar age and online experience. Among the two, online experience, i.e. the difference in account registration dates, has a bigger impact than age. However, the gender homophily (Hypothesis 3) does not hold for grouping relations. The results show that individuals with the same gender are less likely to interact with each other.

TABLE VII. ERGM ESTIMATION RESULTS FOR SPATIAL PROXIMITY

	Partner Model 2	IM Model 2	Trade Model 2	Mail Model 2	Hypotheses
Network:					
Edges	-1.759*** (.04)	-5.251*** (.22)	-1.848*** (.07)	-2.211*** (.03)	H6: supported
GWDegree		1.958*** (.02)	-0.710*** (.01)	-1.209*** (.05)	H7: partial
GWESP	1.027*** (.08)	1.073*** (.05)			H8: supported
Homophily:					
Same gender	-0.196*** (.02)	-0.172*** (.03)	-0.062*** (.01)	-0.074*** (.007)	H3: not supported
Age difference	-0.030*** (.002)	-0.025*** (.002)	-0.023*** (.001)	-0.029*** (.001)	H4: supported
AcctAge difference	-0.107*** (.003)	-0.050*** (.01)	-0.115*** (.003)	-0.084*** (.003)	H5: supported
Proximity					
Log (Distance)	-1.642*** (.007)	-0.999*** (.07)	-1.315*** (.03)	-1.065*** (.002)	H1-2: supported
Control:					
Female	-0.217*** (.02)	-0.086** (.03)	-0.054*** (.01)	0.035*** (.01)	
Age	0.003*** (.0004)	-0.003*** (.0004)			
AcctAge	0.011*** (.003)	0.026*** (.005)			
Log likelihood	-12562	-3245	-27563	-22512	

Signif. codes: 0 < *** < 0.001 < ** < 0.01 < * < 0.05 < + < 0.1

In Model 2, the coefficients of *Log(distance)* are negatively significant for all four relations. This shows that geographical distance reduces the likelihood of interaction. For example, the odds of individuals 10 Km away from each other to become partners are 5 times that of individuals 100 Km apart. Distance has a stronger impact on partnership than that on IM, trade, and mail relations. Hypotheses 1 and 2 are supported.

VI. DISCUSSION AND CONCLUSION

The results show that proximity as well as homophily in age and game experience have strong impacts on players' online behavior in creating relations. Table VIII shows the summary of hypotheses tested.

TABLE VIII. SUMMARY OF HYPOTHESES

	Hypotheses	Partner	IM	Trade	Mail
H1	Spatial proximity	Yes	Yes	Yes	Yes
H2	Interaction types	High	Low	Medium	Medium
H3	Gender homophily	*No*	*No*	*No*	*No*
H4	Age homophily	Yes	Yes	Yes	Yes
H5	Experience homophily	Yes	Yes	Yes	Yes
H6	Selectivity	Yes	Yes	Yes	Yes
H7	Popularity	Yes	Yes	*No*	*No*
H8	Transitivity	Yes	Yes	n/a	n/a

Similarly to the previous research studies in the real world, spatial proximity of distance still has a strong impact on players' online behavior even though people cannot detect their physical distance in virtual worlds. One way to explain this result is that individuals may bring their offline relations into the virtual world such as playing with friends in a game. In a survey conducted in EverQuest II [21], almost 70% respondents played together with the persons they know offline. This explanation is also consistent with Hypothesis 2. Distance has a bigger impact on interpersonal relations which could be more related to their per-existing ties than that on transactional relations which are develop based on specific online events such as trade and mail. These transactional relations are less personal.

Geographical proximity has different levels of impacts on the four types of relations in EverQuest II. Proximity has the biggest impact on partner relations, which have more personal interactions and require high-level collaboration. Similar to friendship, partner relations have the characteristics of selectivity, popularity, and transitivity. Trade and mail relations, however, are built upon specific in-game activities and have some inherent structures, e.g. many players with high degrees in the trade network are specialized in producing and exchanging in-game items. Therefore the network structures of these relations are highly influenced by the game mechanisms.

As predicted in Hypotheses 4 and 5, age and experience homophily exists in virtual worlds. Individuals are more likely to interact with others of a similar age and online experience. However, gender homophily is not supported. In fact the similar gender has a negative impact on all four types of relations. A detail analysis indicates that the negative impact is mostly from female-female matching, i.e. female players are very unlikely to interact with female players especially for partnership. This may be related to a special usage pattern – 32% of people play with a romantic partner, e.g. spouse, fiancé, boyfriend/girlfriend [21] – which brings many male-female ties into the game.

In this study, we analyze the impacts of distance, players' gender, age, and game experience on their online interactions in partnership, instant messaging, trade, and mail relations. The results show that spatial proximity of distance, as well as homophily in age and game experience have a strong impact on players' online behavior in creating relations. However, there is no evidence of gender homophily in EverQuest II. The findings indicate that theories of proximity and homophily appear to be valid in virtual worlds. On the other hand, by analyzing different types of relations in EverQuest II, we find that relations are not all the same. The design of a virtual world may determine the characteristics of transaction based relations and mask the underlining social relations.

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