

The Evolution of Social Ties Online: A Longitudinal Study in a Massively Multiplayer Online Game

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How do social ties in online worlds evolve over time? This research examined the dynamic processes of relationship formation, maintenance, and demise in a massively multiplayer online game. Drawing from evolutionary and ecological theories of social networks, this study focuses on the impact of three sets of evolutionary factors in the context of social relationships in the online game EverQuest II (EQII): the aging and maturation processes, social architecture of the game, and homophily and proximity. A longitudinal analysis of tie persistence and decay demonstrated the transient nature of social relationships in EQII, but ties became considerably more durable over time. Also, character level similarity, shared guild membership, and geographic proximity were powerful mechanisms in preserving social relationships.

How do networks of social interaction formed in online worlds change over time? Are online relationships merely random, short-lived encounters or lasting and substantive connections? What makes some relationships more durable than others? These questions are important because they highlight the dynamic processes of relationship formation, maintenance, and demise in online worlds, an issue rarely examined in the extant literature despite repeated calls for more research employing longitudinal analyses (Ellison, Steinfield, & Lampe, 2007; Harris, Bailenson, Nielsen, & Yee, 2009; Lewis, Kaufman, Gonzalez, Wimmer, & Christakis, 2008; Panzarasa, Opsahl, & Carley, 2009; Williams, 2007). Further, an understanding of the stability, or rather, fragility, of online relationships provides a crucial context by which to qualify the significance and generalizability of findings obtained in

empirical studies relying on cross-sectional data. Last, answers to these questions could shed light on the quality of the relationships formed in these online spaces, which have become a mainstay for millions of participants.

This research is an attempt to tackle these questions in the context of personal relationships formed in a large massively multiplayer online game (MMOG), EverQuest II (EQII). MMOGs have become increasingly vibrant sites of social interactions among groups and communities (Castronova, 2007; Williams et al., 2006). Researchers have started to examine the naturally occurring virtual relationships that result from their various social and collaborative processes (Bainbridge, 2007; Huang, Shen, & Contractor, 2013).

Evolutionary theories, as represented by Campbell's work on sociocultural evolution (1965) and recent extensions to network evolution (Monge, Heiss, & Margolin, 2008), represent a useful framework to study the longitudinal transformation of social networks in online worlds. The evolutionary framework is applied to player relationships in EQII to derive hypotheses based on three sets of evolutionary factors: the aging process (including tie age and node age), social architecture, and homophily and proximity. These hypotheses are then tested using longitudinal behavioral logs obtained directly from EQII servers. Results demonstrate the transient nature of social relationships in EQII, but player ties became considerably more durable over time. Also, character level similarity, shared guild membership and geographic proximity were powerful mechanisms in preserving social relationships.

Theory and Hypotheses

Variation, Selection, Retention

An influential line of research in modern social theory can be traced back to Campbell's 1965 paper titled "Variation and Selective Retention in Socio-Cultural Evolution," in which he

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used evolutionary ideas, analogous to the natural selection processes in biological evolution (Darwin, 1859), to explain the emergence, transformation, and termination of human social systems. Variation, selection, and retention (V-S-R) describe the general processes of change. This evolutionary framework rests on the premise that the resources that sustain individual entities in a social system are ultimately scarce. Variations are the source of differences among social entities. Over time, some features or behaviors of individual entities are solidified and maintained through preservation, duplication, or diffusion in the social system whereas other variations fail to survive (Campbell, 1965; Hawley, 1986). The selection criteria are consistent and ensure “evolution in the direction of better fit to the selective system” (Campbell, 1965, p. 27). Many empirical studies have demonstrated the usefulness of evolutionary thinking to study phenomena within and across organizations (Aldrich, 1999).

Monge, Heiss, and Margolin (2008) articulated an important extension of the V-S-R processes to social networks. In their framework, nodes represent entities in a community, and ties connecting individual nodes can be considered as mechanisms of resource exchange among these nodes. A network community is constrained in (a) its member carrying capacity, which defines the upper limit of *nodes* the community can support, and (b) its relational carrying capacity, which defines the upper limit of *ties* the community can support (Monge et al., 2008). For relational carrying capacity, *resource* is conceptualized as the capability to initiate and maintain ties. For a given node in the network, the capability to make connections is finite, thus it cannot accommodate all the possible linkages. For example, in a network of a thousand nodes, the maximum number of ties for any node is 999. Yet, because of resource constraints, the number of connections of a single node is often much smaller than 999. Variations can be considered as the numerous possibilities of tie formation among all the available nodes in the network, and all possible ties are also selected based on their fitness, “the propensity for a relationship to sustain itself” (Monge et al., 2008, p. 462). Studies of inter-organizational networks have examined the various factors affecting the V-S-R processes of ties. For example, a comprehensive study of the biotechnology industry, comprising populations of research institutions, pharmaceutical companies, venture capital firms, and government regulators, demonstrated that the evolution and dynamics of the community are shaped by various logics of tie formation: accumulative advantage, homophily, follow-the-trend, and multi-connectivity (Powell, White, Koput, & Owen-Smith, 2005).

The Evolution of Social Ties in EQII

The evolutionary perspective reviewed above provides a useful framework to understand change in online social networks. The unit of analysis, then, is the tie between two nodes (individuals). It is necessary to contextualize this framework with the specifics of the relationships within MMOGs in general and EQII in specific, as substantive

differences of relationships and networks have important implications on evolutionary dynamics (Leskovec, Kleinberg, & Faloutsos, 2007; Monge et al., 2008).

MMOGs are a popular genre of online games, where players may interact with the persistent and graphical gaming environment as well as with each other, by controlling their “avatars” (Castronova, 2005; Williams, Yee, & Caplan, 2008; Yee, 2006a). EverQuest II (EQII) launched in November 2004 as the popular sequel to EverQuest and features game rules and goals that are representative of the MMOG genre. For individual players, EQII provides many potential opportunities for social relationships to form. Among them, the most important and emblematic of the MMOG genre are collaboration ties through which players work with each other to achieve common goals. Some collaboration ties are deliberately chosen by players themselves, such as questing and raiding together online with one’s offline family and friends. Other connections may result from various arbitrary factors exogenous to the two individuals involved. For example, EQII requires that a player could only interact with those currently logged into the game (and for most activities, on the same server). To collaborate in ad hoc groups or raids, individual players and existing groups may use built-in search functions like “LFG” (looking for group) and “LFM” (looking for more) and search for others who meet their criteria, such as a specific character level range (e.g., a level 30 character joining a level 28–32 group) or character specialty (e.g., a Paladin who wishes to serve as a “tank” in combat joining a group looking for tanks).

The notion of relational carrying capacity recognizes that the number of personal ties one player can hold at a given time is limited. Indeed, ties are costly to initiate and maintain over time. Specifically, online interpersonal relationships may incur two costs: time and cognitive effort (Donath, 2007; Dunbar, 2008; Roberts, Dunbar, Pollet, & Kuppens, 2009). First, social interactions take time to complete. Although weak and episodic ties may only take a nominal amount of time, building strong and trusting relationships often requires long-term effort. Second, to maintain social ties, individuals often have to pick up various signals from their contacts (Donath, 2007), to keep track of the status of these relationships, and to perceive the changing social structure as a whole (Krackhardt, 1987). The amount of time and cognitive effort required to sustain relationships varies according to the type of network, with the strongest and most intense relationships most costly to maintain. Empirical evidence has largely supported this argument. In offline worlds, studies have shown that the size of most human social networks has an upper limit, the so-called “Dunbar number” (Dunbar, 1996). Even with the aid of digital and social media, a similar level of relational carrying capacity was found in online spaces (Gonçalves, Perra, & Vespignani, 2011). Therefore, it is reasonable to expect that the number of ties one can initiate and maintain in EQII is also constrained by one’s limited relational carrying capacity.

Selection and retention mechanisms are in place to “winnow out” excessive ties based on their fitness—their propensity to sustain themselves and the extent to which they can provide benefits to the players involved. In the social world of EQII, the acquisition of resources (e.g., knowledge, skills, armors, and weapons) is an important function of EQII ties, as the game is designed to promote player interaction through an intricate division of labor. Social and collaborative action helps players finish quests, kill monsters, and develop their character more rapidly and successfully. In addition to instrumental reasons, players also come together because they enjoy each other’s company. As Simmel and Hughes (1949) wrote, “Sociability is the art or play form of association, related to the content and purposes of association in the same way as art is related to reality. Although sociable interaction centers on persons, it can occur only if the more serious purposes of the individual are kept out” (Simmel & Hughes, 1949, p. 254). In EQII and other MMOGs, connections with other players offer the resources to reach instrumental goals as well as the pleasure of the company of others. As such, the selective retention of ties is determined by the extent to which they can be valuable in supplying instrumental benefits as well as good company.

This study focuses on three specific sets of selection criteria in relation to tie survival and decay: aging and inertia, social architecture, and homophily and proximity. Aging and inertia are endogenous processes that most social relationships experience throughout their lifecycle. Social architecture captures exogenous selection criteria that are specific to the design of the EQII game world. Finally, homophily and proximity represent dyadic preferences of the two individual players involved in any social tie.

Aging and Inertia

As the evolutionary perspective suggests, many individual relationships in EQII originate from random chance and haphazard encounters regardless of individual preferences. Therefore, individuals who become connected due to exogenous factors will often not enjoy each other’s company or collaborate well. Players of EQII and other MMOGs usually have diverse motivations and playing styles (Bartle, 1996; Yee, 2006b). The possibility of finding the ideal sidekick or even building the perfect alliance out of strangers is extremely slim. Thus, when people discover that their relationships are less satisfactory for their instrumental and social goals, it is natural for them to part ways and find more compatible partners. Through this selection process, more compatible players replace existing incompatible ones, leading to the strengthening of some ties and the weakening, or decay, of others.

Following the logic of relational cost and carrying capacity, individuals are constrained in their ability to develop and maintain interpersonal connections. To achieve a certain relational goal (e.g., acquiring expertise from a fellow

player), it is usually more costly to initiate a new relationship with a previously unknown partner than to exploit existing network resources (Lazer & Friedman, 2007). Therefore, individuals are motivated to “recycle” their existing contacts over exploring new ones. So instead of assembling a new team every time, individuals are more likely to repeat their past ties for potential collaboration opportunities. Over time, these ties are then filtered based on their perceived benefits, with only a subset of them selected and reproduced in future interactions. As the selection and retention processes continue, those repeated ties are strengthened, leading to decreased ego-network size.

The phenomenon that one-off ties are less likely to persist is also referred to as “liability of newness,” which stems from the lack of time available for new or young members of a community to learn how to perform reliably and establish legitimacy (Burt, 2000; Carroll & Hannan, 2000; Stinchcombe, 1965). New players in EQII also suffer from this learning curve disadvantage. Even if they may have played similar MMOGs before and carry with them knowledge and experiences that may be transferrable to another MMOG, EQII still represents an unfamiliar territory where game rules and mechanics all have to be learned through experimentation. Therefore, it is expected that novice players will tend to form a large number of weak ties to experiment with connections with different sets of partners. This stage of experimentation represents an important “trial-and-error” process. Compared with more seasoned players, novice players tend to cast a wider net by engaging in social interaction with more contacts, resulting in a larger network. The promiscuity of connections tends to wane as players advance in the game and have a better understanding of the world. This “trial-and-error” process is manifested in the changing size of players’ dynamic social networks in the virtual world. Therefore,

H1: There is an initial burst of social network size when players are at lower levels, followed by a contraction at later stages.

Similarly, as players spend more time playing the game, they not only are better at *identifying* potential compatible partners, they are also better at *keeping* them by developing routines and strategies with them. According to Hannan and Freeman (1989, p. 80), “new organizations typically rely on the cooperation of strangers. Development of trust and smooth working relationships takes time, as does the working out of routines. Initially there is much learning by doing and comparing alternatives. Existing organizations have an advantage over new ones in that it is easier to continue existing routines than to create new ones or borrow old ones (Nelson and Winter, 1982: pp. 99–107). These arguments underlie the commonly observed monotonically-declining cost curve at the firm level, the so-called ‘learning curve.’” In interpersonal contexts such as EQII, seasoned players become better connectors, because they have developed social routines of online interactions, and are also at an advantage in identifying potential partners that are

compatible. Thus, ties involving players who have spent more time playing EQII have a better chance of survival.¹

H2: Ties involving players who have spent more time playing EQII are less likely to decay.

Learning not only occurs as players accumulate experiences in the game, it also occurs when a specific relationship matures over time (Burt, 2000; Carroll & Hannan, 2000). Burt (2000) argued that the rate of tie decay slows over time because the longer a tie has survived, the more likely that the two individuals involved are compatible. In addition, as two individuals are engaged in a relationship, they have more time and opportunities to learn the social routine of working together and to appreciate the benefits of the connection (Burt, 2000). In other words, compatibility or tie fitness grows as ties age. In the context of EQII, it is difficult to complete a challenging task with pick-up groups (known as “pugs”) that consist of players who have never collaborated before, because there is little shared understanding of the tasks at hand, the play styles of other members, or the norms of coordination, leadership, and reward distribution. Rather, players prefer to group or raid with regulars they have collaborated with before because it takes repeated interactions to build the social routines of playing together. Thus, it is not surprising that many guilds or regular raid groups require a trial period during which a new recruit has to collaborate with existing members in less important tasks before they can join other collective activities with greater significance.

This argument is consistent with the idea of network inertia, the phenomenon that networks tend to preserve and reproduce past structures (Gulati & Gargiulo, 1999; Ramasco & Morris, 2006; Walker, Kogut, & Shan, 1997). Within organizations, evolutionary theories argue that organizational structures tend to stay unchanged because selection forces favor reliable and accountable systems (Hannan & Freeman, 1984). Networks also tend to stay unchanged because established relationships help provide rich and reliable information, build mutual trust and attraction, and constrain partners’ opportunistic behaviors (Walker et al., 1997). Inertia is essentially a natural process to preserve and accumulate social resources from existing structures (Walker et al., 1997). This phenomenon has received empirical support from studies in many contexts, including the formation of open source project teams (Hahn, Moon, & Zhang, 2008), the creation of biotechnology start-up networks (Walker et al., 1997), and the establishment of the network of HIV/AIDS nongovernmental organizations (Shumate, Fulk, & Monge, 2005). In online gaming communities, a similar process of network inertia and tie decay is expected. Therefore:

H3: The longer a tie has been maintained between two players, the less likely it is to decay.

Social Architecture

An important set of selection forces are external to the entities vying for survival. In the organizational evolutionary literature, these forces may consist of environmental shocks, market forces, and conformity to institutionalized norms (Aldrich, 1999). Similarly, some selection forces of social ties in virtual worlds are also external to the ties and nodes involved. They stem from the opportunities and constraints inherent in the social environment of EQII. The social world of EQII has norms and rules imposed by game mechanics that incentivize certain types of interactions and constrain others (Lessig, 2006). In fact, one of the most fundamental mechanisms to promote sociability, the division of labor among characters as manifested in the character class system, is deeply embedded in almost all aspects of game interactions. Each character class is associated with a distinct set of skills and strengths for combat. Players choose to belong to one of four general class archetypes—Fighter, Priest, Scout, and Mage—and usually assume different roles in collaborative activities. Fighters can serve as the main “tank” of the group which absorbs the attack damage from monsters and protects other group members. Priests are healers who restore the health and strength of group members whereas Mages and Scouts are fare better at dealing damages to monsters. EQII game mechanics specifically encourage collaboration among players with different character classes. As dictated by game design, a tie between players of different classes brings more potential benefits than a tie between players of the same class, thus is less likely to discontinue. Therefore,

H4: Ties between players of the same character class are more likely to decay.

Another constraint is the level of experience. As discussed previously, the game play experience in EQII is highly structured—players usually follow the same general path of progression. As quests, monsters, and zones are all aligned by level, players would have to tackle them in a relatively linear order. This imposes a level hierarchy on the formation of social interactions. Collaborative play in groups or raids requires that all the members have similar levels, otherwise the higher level members tend to absorb most of the experience gain points, a major objective for playing, and this discourages collaboration among players with considerable level disparity. Individuals who have reached similar levels are usually given the same quests and tend to be cheek-by-jowl while exploring the same zones to accomplish these tasks. In addition, players may find others more compatible if they have relatively similar levels in EQII because they have comparable knowledge, status, and familiarity with the game community. In other words, level similarity ensures that players are “on the same page” in their character development, which reduces potential conflicts or misunderstandings. Therefore,

¹Even though “survival” and “decay” describe two distinct consequences of tie evolution, they are theoretically and analytically the same phenomenon. A better chance of survival means less likelihood of decay. In this article we chose to use “decay” in the hypotheses and analyses to be consistent with prior research (Burt, 2000).

H5: Ties between players of similar character levels are less likely to decay.

Whether two players belong to the same guild could also influence tie decay. Guilds are persistent self-organized player associations. Although the level of sociability within guilds can vary widely, guilds provide a reliable way to recruit team members to tackle difficult game objectives (Ducheneaut, Yee, Nickell, & Moore, 2007; Williams et al., 2006). When compared with any random stranger, guildmates typically provide some basic familiarity, shared game ethic and goals (Williams et al., 2006). Joining a guild is a mutual-selection process, in which both the applicant and the guild evaluate their compatibility. Therefore, through the selection and admittance into the same guild, two players are more likely to find each other as compatible game partners. In addition, guild members have access to an array of functionalities that further support sociability. For example, the guild name is automatically attached to one's character name, so that it is easier to identify guildmates during random encounters in the game. All guild members are automatically subscribed to the guild chat channel, in which members can broadcast chat messages to the entire guild. Many guilds have a shared in-game space, the guild hall, where people go regularly to enjoy its amenities, such as teleport stations, or just to hang out. Finally, many guilds also organize collective activities such as scheduled raids, and this information is delivered to each member via an in-game mailbox or is discussed through the guild chat channel. Based on the above reasoning, the following hypothesis is proposed:

H6: Ties between players in the same guild are less likely to decay.

Homophily and Proximity

A final set of selection mechanisms stems from the social and spatial similarity (or difference) between individuals, which has long been found to exert a significant impact on tie formation and dissolution (Burt, 2000, 2002; McPherson, Smith-Lovin, & Cook, 2001). In the organizational evolution literature this set of mechanisms falls into the category of internal selection forces. They represent "pressures toward stability and homogeneity" (Aldrich, 1999, p. 22). As Campbell (1969) suggested, "any social organization tends to move in the direction of internal compatibility independently of increased external adaptiveness" (p. 76). In the context of social ties, the similarity (or difference) between two individuals forms the basis of their compatibility and the cost of interaction, as suggested by the theory of homophily and proximity.

The theory of homophily posits that people with the same or similar attributes are more likely to interact with each other because of their common background and shared interests, whereas proximity predicts that people located in the same area are more likely to communicate. Although demographic attributes and location information in online gaming communities are not always immediately visible, players

may still detect behavioral and linguistic patterns related to these attributes. Furthermore, through online interactions and social activities players may exchange some personal information and become more familiar with each other. Therefore, in online gaming communities, homophily and proximity may still play a role in tie selection (Huang et al., 2013). Players of the same demographic attributes and geographic location are more likely to find each other compatible; thus, they tend to stay in the relationship rather than abandon it. Therefore,

H7: Ties between players of the same gender are less likely to decay.

H8: Ties between players of similar ages are less likely to decay.

H9: Ties between players of geographic proximity are less likely to decay.

Methods

Data

The owner of EQII, Sony Online Entertainment (SOE), provided anonymized behavioral data from the game's large back-end databases, which were used to construct longitudinal networks of player interaction. Specifically, in the world of EQII, players are allowed to form temporary "groups" to complete challenging tasks together. The game mechanics require that the players who form a group have to be at similar character levels to earn experience points together.² EQII allows players to look for groups to join through the "Looking For Group (LFG)" function. Players are able to specify their responsibilities in the group, such as what roles they are willing to undertake (e.g., primary tank, primary healer, etc). Alternatively, existing groups are also able to advertise their current task and try to find more players through the "Looking For More (LFM)" function by specifying their needs as well as their expectations of potential group mates. Characters have to convene in one virtual location in the game world to perform their tasks. One character could send an invitation to another character to group, and once grouped, characters are also free to leave the group. Several functions are available in EQII to facilitate collaborative play in groups. For example, players have access to a group chat channel where they can freely communicate with their group mates. They can also negotiate and select a specific option to distribute loot.

Hypotheses were tested using longitudinal data from June 1 to August 30, 2006, on the Guk server. Similar to other MMOGs, EQII operates on numerous servers, which are parallel versions of a persistent virtual world. The server

²In groups, if two players in the same group have different character levels, the lower-leveled player cannot receive experience points or quest rewards. EQII designed a "mentoring" system to mitigate this situation by allowing the more advanced player to temporarily level down to match the lesser player. But the mentor has to bear the cost of lowered character level and some repeated game content.

Guk was selected because it represented the most common server type in EQII: Player versus Environment, where players fight against nonplayer characters but do not directly confront other players in combat. If two or more players group together and earn experience points in combat or quest activities such as fighting monsters, a grouping relationship was constructed between every pair of players, where nodes represent individual players and links represent their collaboration.

Player networks were constructed with a weekly frequency. Previous MMOG research shows a consistent weekly distribution of play session frequency and duration that corresponds well to common work schedules, with more frequent sessions occurring later in the day and longer sessions occurring during the weekend (Mahmassani, Chen, Huang, Williams, & Contractor, 2010). The June to August time period contained a total of 13 consecutive weeks. To observe the evolution of ties during this period, it was important to ensure that the set of nodes (players) remained available for connections. In other words, the existence of players themselves was the prerequisite of the existence of ties among these nodes. A necessary first step was to know the total number of players in the EQII world who were available for social interaction. However, during the 13-week observation period, a considerable proportion of players were constantly entering and exiting the population of active players, adding an additional layer of complexity to the evolutionary process. The Jaccard index³ for nodes between any two consecutive weeks was consistently lower than 0.6, indicating a high rate of player churn between observations. Therefore, the players chosen for analysis were the subset of the total player population who were active and available for connections throughout the 13 consecutive weeks. The total number of this subpopulation was 1,442. It should be noted that the 1,442 players included both connected players as well as “solo-ers” or network isolates.

Measures

Network size. Network size was measured by counting the number of unique direct contacts in a person’s individual network. This measure is the same as degree centrality, or degree, of the ego-network (Freeman, 1979; Wasserman & Faust, 1994).

Tie duration. The duration of a tie was calculated as the number of consecutive weeks a tie appeared. For example, if the same tie appeared from Week 2 to Week 5, the tie duration was 4 weeks.

Demographics. Information on gender and birth date was self-reported when players registered their profiles with EQII. Whether two players are of the same gender was

coded as a dichotomous variable (Yes = 1). Players’ age was calculated by subtracting their year of birth from 2006. The absolute difference between the ages of two players was then calculated.

Total play time. The behavioral log recorded the total number of seconds a character had been played, which was then transformed into the total number of hours.

Character level. Every player’s character level was recorded in the server logs. The minimum level was 1 and the maximum level was 70 for the current data set.

Proximity. All players self-reported their state and country as part of the player profile. The geographic proximity between two players was measured as a dichotomous variable, with 1 indicating that two players were located in the same state, and 0 indicating that two players were located in different states.

Character class. EQII has 24 character classes, which can be condensed into four archetypes, Fighter, Priest, Scout, and Mage. Character class was computed as a dyadic dummy variable to indicate whether two players were of the same class archetype (Yes = 1).

Guild membership. Individual characters’ guild membership was measured by a dyadic variable describing whether two players belonged to the same guild (Yes = 1).

Analysis

H1 predicts that network size decreases as players advance in the game. It was tested by examining the number of unique contacts in each player’s individual networks using two way mixed-measures analysis of variance (ANOVA). Based on their character level, players were split into four groups: level 1–20, 21–40, 41–60, and 61–70. The level 20 cutpoint was selected because 20 represented a critical milestone in character development. For example, starting at level 20, players could start earning Achievement Points, which could be used to customize the development trajectory of their character. Level 20 also marks the time when a player has to decide a specific trade skill profession (e.g., alchemist). Therefore, for this analysis, the within-subject factor was time (13 weeks) and the between-subject factor was character level (four groups).

To test Hypotheses H2 through H9, Burt’s approach (2000, 2002) was used to model tie decay as a hazard function. As the longitudinal network data were collected every week for a total of 13 consecutive weeks, event history data were constructed by populating 13 time-event records for each tie during its existence. Altogether, there were 19,384 relationships and 35,271 total observations (one observation means one tie-week record). 17,674 ties (91.18%) failed during the 13 weeks, suggesting that ties among EQII players were remarkably transient.

³The Jaccard index was calculated based on the number of players present at both weeks, the number of new players entering the population at the second week, and the number of players exiting.

Three models were constructed to test H2 through H9. The first model included total play time (H2) and tie duration (H3). Because the collaboration networks examined here were symmetric, that is, two players were connected as a result of their mutual choice, the mean of their total play time (originally measured at the individual level) was used as a dyadic variable to test H2. The second model added variables measuring whether players belonged to the same character class (H4), their difference in character level (H5) and whether they belonged to the same guild (H6). The third model further added gender homophily (H7), age difference (H8) and geographic proximity (H9). All the test statistics were adjusted for autocorrelation at the individual player level (i.e., the same individual involved in more than one tie) using the “cluster” routine in Stata.

Results

H1 predicted that the size of player social networks would shrink as they advanced in the game. A two-way mixed-measures ANOVA was conducted to evaluate the effect of character level on the size of individuals’ collaboration network across time. The within-subjects factor of time had 13 levels (repeated measures of network size from week 1 to week 13). The between-subjects factor of character level included four levels 1–20, 21–40, 41–60, and 61–71 respectively. The time main effect was tested using the multivariate criterion of Wilks’s lambda (Λ) because the sphericity assumption was not met, Mauchly’s $W = .00$, $df = 77$, $p < .001$. Results indicated a significant within-subjects time main effect, $\Lambda = .97$, $F(12, 1427) = 3.57$, $p < .001$, partial $\eta^2 = .03$, a significant between-subjects character level main effect, $F(3, 1438) = 48.71$, $p < .001$, partial $\eta^2 = .09$, as well as a significant interaction (time \times character level) effect, $\Lambda = .92$, $F(36, 4216.96) = 3.45$, $p < .001$, partial $\eta^2 = .03$, but all the effect sizes were fairly small. Post hoc analysis of the four groups based on character level using the Scheffe test showed that all the comparisons were significant except between the 21–40 group and the 41–60 group (see Table 1). Therefore, when characters advanced in time and character level, their network size decreased.

The interaction effects of time and character were less straightforward and suggested that the longitudinal trend differed for the four groups. As shown in Figure 1, over the 13 weeks of observation, the “beginners” with the lowest character level expanded their social networks, while the

other more advanced groups, especially those over level 60, tended to keep their network size stable. Taken together, these results provide partial support for H1. An additional exploratory analysis tested whether the networks themselves stabilize as players level up (i.e., less churn of alters). The results showed that the players of the four level groups did not display a consistent trend with regard to the stability, or churn, of their networks over the course of 13 weeks. Rather, the rates of overall tie decay during the 13 weeks were all quite high for the four groups (90%, 90%, 92%, and 91%, respectively).

Chi-square tests were conducted between Models 1, 2, and 3 that were developed to address H2 through H9. Results showed that the log likelihood increased significantly as more independent variables were added into Model 2 and Model 3, $p < .001$ for both tests. Therefore, coefficients in Model 3 were interpreted as the final results (see Table 2).

H2 hypothesized that a tie is less likely to decay between two players with greater total play time. The average play time in Model 1 had a significant and negative coefficient, coefficient = -0.0002 , $p < .001$, indicating that play time decreased the likelihood of tie decay. However, this effect disappeared in subsequent Models 2 and 3, coefficient = -0.00002 , $p = .21$; coefficient = -0.00002 , $p = .20$. Thus, H2 was not supported.

H3 predicted that the longer a tie was maintained between two players, the less likely it was to discontinue in the future. This hypothesis received strong support. Results showed that tie duration had a significant and negative effect on the hazard of tie decay, coefficient = -0.17 , $p < .001$. Substantively, with every additional week during which two players stay connected, the likelihood of tie decay in the future decreased by 16% ($\exp(-0.17) = 0.84$).

H4 predicted that players of the same character class would be more likely to discontinue their ties than players from different class. On the contrary, the results showed that players of the same character class were not prone to tie decay, coefficient = -0.003 , $p = .89$. Therefore, H4 did not receive empirical support.

H5 predicted that players of similar levels tend to keep their connections. Results showed support for H5, coefficient = 0.002 , $p = .004$. The hazard function showed that a one unit increase of level difference between two players added 0.2% greater chance of tie decay ($\exp(0.002) = 1.002$).

TABLE 1. Post hoc comparisons between character level groups.

	Level	Mean network size	1 ^a	2 ^a	3 ^a
1	1–20	185.79			
2	21–40	121.38	64.42 (18.46)**		
3	41–60	94.58	91.21 (16.99)**	26.79 (12.67)	
4	61–	26.37	159.42 (16.43)**	95.00 (11.91)**	68.21 (9.47)**

Note. ^aValue represents the difference in mean and standard error (in parentheses).

* $p < .05$; ** $p < .01$.

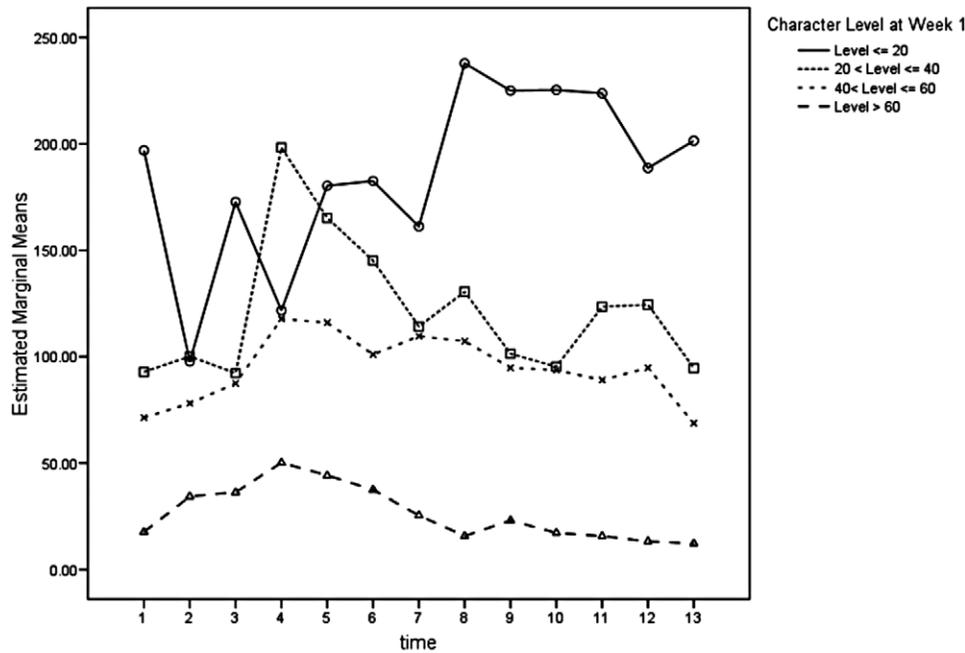


FIG. 1. Estimated marginal means of network size over 13 weeks.

TABLE 2. Event history models predicting tie decay.

	Model 1	Model 2	Model 3	Hypothesis
Constant	-0.03*	-0.06**	-0.08**	
Average play time	-0.0002**	-0.00002	-0.00002	H2
Tie duration	-0.25**	-0.17**	-0.17**	H3
Same character class (D)		-0.002	-0.003	H4
Level difference		0.003**	0.002**	H5
Same guild (D)		-0.72**	-0.71**	H6
Same gender (D)			0.02	H7
Age difference			0.001	H8
Same state (D)			-0.15**	H9
df	2	5	8	
Log likelihood	-23402.33	-22625.10	-22585.40	
Chi-square	3824.76**	5379.22**	5410.11**	

Note. D indicates dummy variable. Numbers represent logit coefficients predicting tie decay, adjusted for autocorrelation between relationships involving the same individual. All models are estimated across the 19,384 relationships (35,271 total observations).

* $p < .05$; ** $p < .01$.

H6 predicted that players who belonged to the same guild would be more likely to keep their connections over time. This hypothesis received strong support, coefficient = -0.71 , $p < .001$. In other words, belonging to the same guild decreased the hazard rate of tie decay by more than 50% ($\exp(-0.71) = 0.49$). As shown in Figure 2, there is a marked difference of smoothed hazard rate estimates between the ties connecting guildmates and the ties connecting people from different guilds or unguilded players. Ties between guildmates have a substantially lower hazard of tie decay.

H7 predicted that people of the same gender would be more likely to keep their connections. This hypothesis did not receive empirical support, as the variable on gender homophily did not generate a significant coefficient,

coefficient = 0.02 , $p = .14$. H8, which predicted the impact of age homophily, was not supported either, coefficient = 0.001 , $p = .40$. H9 predicted that ties between people located in geographic vicinity (measured by whether two players are from the same state) would be more likely to survive. The results showed a negative and significant coefficient produced by geographic proximity, coefficient = -0.15 , $p < .001$. Being in the same state attenuated tie decay by 14% ($\exp(-0.15) = 0.86$), thus H9 was supported.

Discussion and Conclusion

An ecological framework was employed to examine the variation, selection, and retention processes of player

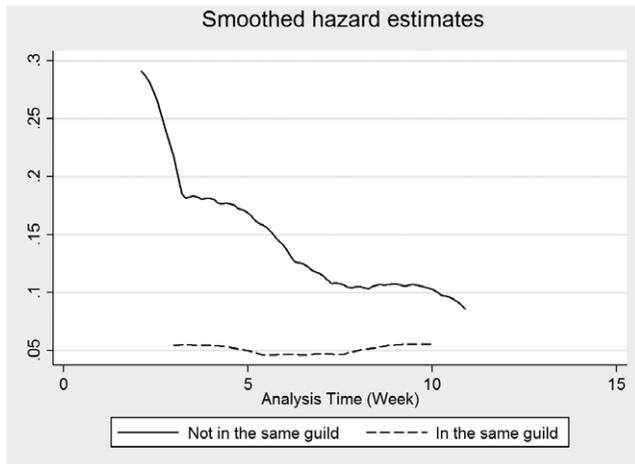


FIG. 2. Hazard estimates of tie decay by guild membership.

collaboration ties during a period of 13 weeks. Individuals are viewed as being limited in their carrying capacity to create and maintain ties. The numerous ties generated through random and haphazard encounters in the EQII world are then subject to multiple selection forces. For individual ties, three sets of selection mechanisms were tested: aging and inertia, social architecture, and homophily and proximity.

The longitudinal network data provide a context in which variation, selection and retention processes of network ties unfolded as players advanced in the game. The beginners were “hyper-connectors” who interacted with a large number of players to experiment with different partners as well as different strategies of connection, but these connections were extremely volatile and ephemeral. As players reached higher levels, the variability in connections also waned. They accumulated more experience in identifying compatible partners, resulting in smaller and more selective networks. Contrary to expectation, the total time spent playing EQII did not show a significant effect on tie decay. Instead, character level seemed to be a better indicator of individuals’ learning and maturation processes. Another important factor of aging is the duration of ties. The findings show that the longer a tie had been maintained between two players, the less likely it was to discontinue. Together, the findings were indicative of two types of learning: (a) learning to identify compatible partners and (b) learning the social routines of collaboration to stay connected with existing partners. Both learning processes took place concurrently as players experimented with different networking strategies and aligned their goals and objectives with their ensemble of network partners.

The effects of aging and inertia on the evolutionary trajectory of player networks are not very different from longitudinal studies conducted in offline settings. Although it is difficult to compare the degree of network turnover across different research contexts, social ties established in the offline world are also quite transient. For example, a longitudinal study of 33 residents in Toronto showed that only

27% of intimate ties persisted after a decade (Wellman, Wong, Tindall, & Nazer, 1997). Burt’s (2000) systematic study of tie decay based on a 4-year panel study of investment bankers also showed that three in four relationships disappear one year later. Similar to what was observed here in the online world of EQII, aging and inertia processes constituted an important set of predictors of tie persistence and decay among bankers. Both node age, as measured by bankers’ age, seniority, and job rank, and tie age, as measured by the duration of ties, significantly slowed down the speed of tie decay (Burt, 2000).

The results also highlighted the important role of social architecture in retaining collaborative ties. Difference in character level contributed to the likelihood of tie decay, but the effect was relatively small. This finding was not surprising given that EQII imposes a penalty on collaboration between players with disparate levels: the higher level character would absorb most of the experience points, leaving the lower level player empty-handed. Because people may differ in their time commitment to EQII, it is quite likely that two players who started together would find themselves not able to collaborate after a month because of their level difference.² Clearly, these elements of the collaboration mechanism in EQII hindered the creation and development of sustained social networks by effectively restricting the pool of players available for connection. When a player is trying to look for a group or when a group is seeking more members, character level becomes one of the most important parameters to “filter” possible candidates, which significantly limits the potential opportunities for social interaction. This also suggests that empirical studies examining MMOG sociability should not overestimate the population size of available players. In other words, at a specific time point, if there are 1,000 active characters on a specific server, for each character, the pool of potential playmates is often significantly smaller. Taking into consideration the different real life schedules and the potential time commitment for a specific group task, it is not uncommon that players can have a hard time finding suitable others to play with; thus “soloing” becomes the only choice.

Belonging to the same guild reduced the risk of tie decay between two players by half (see Figure 2). This suggests that much of the collaboration is structured around guild members. As player-created social institutions, guilds help partition the vast social space of EQII into smaller and more intimate units. Just as neighborhoods provide a basis for place-based interactions (Wellman & Gulia, 1999), guilds provide a virtual “locality” for like-minded players to socialize and collaborate. Feld’s (1981) concept of “social foci” offers a useful way to understand the social function of guilds. Social foci are anything that co-locates people, creating opportunities for relationship formation and development. Examples are a classroom co-locating children, a research project co-locating scholars, and a parent-teacher association at a local school co-locating parents of children attending the same school. Guilds could also be conceptualized as social foci, which bring together players who share

the values and play styles compatible with those of the guild. This finding is particularly interesting given that guilds can be quite unstable and often involve a high level of churn (Chen, Sun, & Hsieh, 2008; Ducheneaut et al., 2007). Also, entering and leaving a guild incurs little cost to the player (Galston, 2000). Nonetheless, even a social institution with very low exit and entry costs can prove to be effective in strengthening ties and building cohesive networks among players. An interesting future research direction is to examine how guild turnover, guild stability, and guild internal dynamics (e.g., management style) influence the longevity of interactions among guildmates.

Finally, the effects of homophily and proximity on tie decay were tested. Age homophily and gender homophily did not have a significant effect on tie decay. This finding was not surprising, as demographic attributes such as age and gender are not immediately visible in virtual worlds. Also, several studies have shown that a significant portion of female players started participating in MMOGs to spend time with their romantic partner (Williams, Consalvo, Caplan, & Yee, 2009; Yee, 2006a), which may explain why gender homophily was not observed. By contrast, proximity was found to be a basic logic determining the risk of tie decay. This finding is particularly interesting because virtual worlds are supposed to mitigate the clustering effects of location on social networks. Two mechanisms may be at play here. First, although location details are not immediately visible to others in EQII, players can communicate with each other about basic information and decide whether to maintain the relationship. Second, individuals may have already known each other offline and migrate their offline relationships into virtual worlds. These migrated relationships, with their pre-existing history in the offline world, are stronger and more likely to persist. It should be noted that this research used the same state as the measure of proximity. Future research should adopt more nuanced measures, such as the actual distance between two players, so that it may offer more insights about how offline proximity functions in online worlds.

Three important limitations of this research should be noted. To control for the additional complexity brought by player churn, this study included only a subset of players who logged in consistently during the 13 consecutive weeks. This may limit the study population to those habitual or “hardcore” gamers, while the evolutionary patterns of ties between less committed gamers remain unclear. Second, this study focused on collaboration ties only, while other social interactions in EQII, such as trade or mentoring ties, were not considered in the analysis. Burt and Schott (1985) suggest that the “content” of social relationships may significantly influence the creation and maintenance of ties. Therefore, some selection criteria for collaboration ties may not be equally applicable to other connections, a topic that warrants future research. Finally, the analysis presented here focused only on EQII players during a three month period in 2006. Given that this is one of the first studies of longitudinal evolution of online relationships, more empirical

research of social relationships in other virtual worlds is needed to establish the generalizability of the findings presented here.

Applying the framework of ecology and network evolution, this research examined the dynamic processes of relationship formation, maintenance, and demise in online worlds. Three sets of selection criteria were tested in the context of social relationships formed in a large-scale online game: the aging and maturation processes of players, social architecture of the virtual world, and homophily and proximity. Using behavioral server logs from EQII, a longitudinal analysis of tie persistence and decay demonstrated the transient nature of social relationships, but player ties became considerably more durable over time. Also, character level similarity, shared guild membership and geographic proximity were powerful mechanisms in preserving social relationships.

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