*This is a draft chapter for a book tentatively titled “Structural Holes in Virtual Worlds.” I am grateful to the Booth School of Business for financial support during my work on the chapter. The work was facilitated and enhanced by exchanges in the network of colleagues around Nosh Contractor who arranged through his SONIC laboratory to clean and house the virtual world data used in this paper. I am grateful to Yun Huang for facilitating my 2008 access to the Second Life data, to Dora Cai for continuing help with access to the EverQuest II (EQ2) data in 2009, to Dmitri Williams for originally obtaining the EQ2 data and making it available, and for student support from Air Force Research Laboratory contract FA8650-10-C-7010. Cuihua Shen and Muhammad Ahmad provided invaluable advice on the EQ2 data, with which I produced a report on the closure-trust and brokerage-achievement associations presented here (“A note on housing, mentoring, and trade networks in EverQuest II,” May 2010), and distributed the report within the Virtual World Exploratorium (VWE) along with network scores so that network metrics would be more accessible within the VWE (VWE is a collaborative network of people working on virtual worlds, see Williams et al., 2011). Initial Second Life results for this paper were presented at the 2009 Academy of Management meetings and a 2009 VWE meeting in Chicago. The manuscript benefitted from comments by John Levi Martin, two reviewers for the journal Social Networks, and discussion with workshop participants at the New York University "Workshop in Information Networks," the Northwestern University "Complexity Conference," Texas A&M University, the University of Chicago, and Xi’an Jiaotong University. A current version of this manuscript is available online (http://faculty.chicagobooth.edu/ronald.burt/research).
Three
Network Advantage in Virtual Worlds

Virtual worlds are so different from the real world that research interest in the virtual for its analytical advantages can be inhibited by a construct-validity question: Are virtual worlds a new context for familiar social processes, or an odd context in which social processes play out in ways that do not generalize to the real world? This chapter shows that the two core principles about network advantage in management (the brokerage principle predicting higher achievement by network brokers, and the closure principle predicting deeper trust between people embedded in closed networks) are similarly evident in two very different virtual worlds: Second Life (a large, heterogeneous virtual world) and Everquest II (a subscription based role-play world of quests and creatures). Differences between the two virtual worlds call for different solutions to basic methodological issues, but sharp differences between the worlds make all the more compelling the similar construct validity each displays regarding network advantage.

Before digging into the details of how network advantage works in virtual worlds, I want to secure an evidence chain back to the real world. I want to be sure that known properties of network advantage in the real world are replicated in virtual worlds so I can be more confident that details learned from the rich data on virtual-world networks have implications for networks in the real world. As Yee et al. (2007:115) expressed the concern: “These online environments could potentially be unique research platforms for the social sciences and clinical therapy, but it is crucial to first establish that social behavior and norms in virtual environments are comparable to those in the physical world.”

The issue is construct validity. The goal is a rigorous criterion for measurement (Cronbach and Meehl, 1955; Smith, 2005): If concept A is in theory correlated with concepts B and C, then a construct validity test for a new measure of concept A is correlation with measures of concepts B and C. This chapter is a kindred test for the
validity of virtual worlds as a research site. If virtual worlds are a valid research site for deeper study of network advantage, then established correlates of advantage in the real world should occur similarly inworld. This search for construct validity with respect to network advantage is in the same spirit as Castronova (2008) and Castronova et al.’s (2009) analyses showing that market demand inworld operates in ways consistent with market demand in the real world, or Horton, Rand, and Zeckhauser’s (2011) demonstration that cooperation and some basic economic results with participants in Amazon’s Mechanical Turk are comparable to results obtained with traditional laboratory subjects, or Castronova and Wagner’s (2011) demonstration that Second Life residents responding to a quality of life survey had levels of satisfaction predicted by the same factors as real-world respondents.¹

The validity evidence sought in the chapter does not require that people replicate in virtual worlds their networks in the real world. Whatever the real-world networks in which we find Robert, he need not have the same networks in a virtual world, any more than he would be expected to have the same network in different contexts in the real world — family, community, work, or play. The evidence sought is not consistent networks, but consistent network mechanisms. If social networks in virtual worlds operate by unique mechanisms unrelated to networks in the real world, then inferences cannot be draw about real-world networks from the scale and precision of network data available in virtual worlds. On the other hand, if social networks inworld operate by the same mechanisms found in the real world, then it is reasonable to use the rich data on virtual worlds to better understand, and prepare people to engage, social networks in the real world.

For example, networks in the real world affect fads and fashion. Opinion and behavior are contagious between people connected or similarly positioned in a network (see Christakis and Fowler, 2009, for general introduction; Rogers, 2003, for review; Monge and Contractor, 2003:Chps 6-8, on alternative network theories). Given network contagion effects observed in the real world, do fad and fashion move...

¹Williams (2010) discusses for communication research the construct-validity question as a "mapping principle."
similarly through networks in virtual worlds? "Yes" is the answer implied by early evidence on gesture diffusion in *Second Life* (Bakshy, Arrer, and Adamic, 2009).

In the real world, institutions and events bring people together who are socially similar, which create opportunities for the people to become acquainted, which results in the social homophily so often observed in networks (see McPherson, Smith-Lovin, and Cook, 2001, for review; Lazarsfeld and Merton, 1954, for foundations; Feld, 1981, on social foci; McPherson, 1983, on Blau space). Friendships tend to occur in the real world between people of similar age. Friendships are often observed between people with similar levels of education. As social homophily is characteristic of social networks in the real world, is it characteristic of networks in virtual worlds? "Yes" is the answer implied by relations tending to occur inworld between people who are socially similar in the real world, and groups forming inworld between family and friends in the real world. On the first point, see Lewis et al. (2008) on *Facebook* friendships between people with similar tastes in the real world, Huang et al. (2009) on partnerships in the *MMO EverQuest II* between people similar in age in the real world, and Dean et al. (2009) on people in *Second Life* tending to over or under report their body weight to match the visibly high or low weight of an avatar interviewer. On the second point, see Williams et al. (2006) on guild membership in *World of Warcraft*, and Subrahmanyam et al. (2008) on friends in *MySpace* and *Facebook*.

This chapter is about the two core network-advantage principles laid out in the preceding chapter: the brokerage principle predicting higher achievement by network brokers, and the closure principle predicting deeper trust between people embedded in closed networks. Supporting evidence of inworld brokerage and closure should exist if networks operate inworld as networks operate in the real world.

Reasonable arguments can be made for and against finding the construct-validity evidence. In support, why should networks operate more differently in virtual worlds than they operate across the variety of real-world contexts in which their effects have been reported? For example, real-world social conventions are often observed inworld between avatars (Becker and Mark, 2002; Yee et al., 2007): shifting one's avatar to face the person addressed, physical proximity for conversation, co-location a distance away from others to signal private conversation, less likely eye contact between
increasingly proximate avatars, annoyed response to an avatar too close during conversation ("You're too close, I can't breathe."). If virtual worlds are no more than a new context in which familiar social processes operate, then there should be clear evidence of the brokerage and closure criteria. With respect to brokerage and the Bavelas-Leavitt results presented in the previous chapter (Figure 2.5), collaborative projects inworld can be expected to falter without a strong central person holding things together — as is true of collaborative projects in the real world. Describing activity in the relatively unstructured virtual world of Second Life, Au (2008: 45) sounds like an author of the Bavelas-Leavitt experiments with their emphasis on the need for a coordinator at the center of things (Figure 2.6): “almost invariably at the heart of the collaborative process is a strong avatar with wit and galvanizing energy, keeping up the team’s cohesion and morale.” Au follows with a quote from a leader in Second Life reflecting on her experience: “It was difficult balancing so many strong personalities . . . responding to drama, trying to find compromises when no one wanted to compromise, having to deal with the result of the compromises wherein everyone was unhappy and feeling cheated . . . at one point I was just logging in to be available for people to bitch at.” That quote, and others like it (Tiegland, 2010:12), would not be out of place in the real world coming from the person managing a large project, especially a project that spans more than one functional or corporate organization.

On the other hand, social networks in virtual worlds could be their own kind of phenomenon, distinct from networks familiar in the real world. Face validity is an immediate issue. I analyze inworld networks of friendship, exchange, and collaboration. These are kinds of relations often analyzed in the real world. But inworld, we are talking about people forming relations by right-clicking on another person's avatar. There are similarities between inworld and real-world friendships, but avatars right-clicking one another are in certain respects their own phenomenon. Can a right-click connection carry the real-world advantages of friendship? Even if friendship has the same advantages in the virtual and real world, consider the cost of maintaining a friendship. It is costly to connect across structural holes in the real world. Those people speak a different dialect. They take as important questions that we understand to be obvious. They take as trivial questions central to our work. In a
virtual world, the coordination cost of bridge relations could be so much lower that everyone ends up connecting across structural holes. Studying networks in a small European bank, Johnson et al. (2012) find that real-world barriers to social communication such as gender, job rank, and organizational boundaries are much less evident in electronic communication. It is attractively democratic to say that everyone becomes a network broker inworld, but everyone being a broker means that no individuals have brokerage advantage, so the real-world correlation between achievement and brokerage might not occur in a virtual world.

On the other hand, the very uniqueness of relations in a virtual world could shape relations in the real world. Historian Johan Huizinga (1938) discusses the importance to society of segregating places and situations with their own rules of conduct in which the usual rules do not apply — judge and advocate in the courtroom, priest and penitent in the confessional, comrades on the battlefield, children playing a game. These are situations demarked in time and place as if by a "magic circle" within which people play a role defined by situation-specific rules, rules distinct from what applies in the surrounding outer world. The magic circle metaphor is apt description of virtual worlds and has been picked up by game designers (e.g., Salen and Zimmerman, 2003). To the extent that a virtual world’s magic circle excites the emotions, time together there can create a bond that endures. As Huizinga (1938:12) expressed it: “the feeling of being ‘apart together’ in an exceptional situation, of sharing something important, of mutually withdrawing from the rest of the world and rejecting the usual norms, retains its magic beyond the duration of the individual game.” For example, I was interrupted while writing this paragraph by a phone call from a stranger who turned out to have served with my father during World War II and wanted to renew the connection now 70 years after their time together in the Pacific. Returning to virtual worlds, Boellstorff (2008:169) quotes a woman responding to newbie’s inquiry about being able to trust men met inworld (“RL” for “real life”): “Well Alice, it takes a lot of time to build up that trust. I met my boyfriend on The Sims Online and then we spent the next year getting to know each other here in Second Life before we decided to take it to RL. I’m moving in with him in about a week.”
Trust can be a complication. Trust and reputation are fruitfully studied where behavioral data are abundant and consequences can be observed, so it is natural to see research focused on trust and reputation in transaction websites like eBay and Amazon (Cabral, 2012). Absent the rich data such sites provide on a person’s trustworthiness, we rely on word of mouth and visible signals to judge trustworthiness. The reputation created by mutual friends in a closed network is insurance against placing our trust in the wrong people — which accounts for trust being associated with closed networks in the real world (Figure 2.11). Absent mutual friends, we fall back on signals. Pentland (2008) discusses influence, mimicry, activity, and consistency as signals. Gambetta and Hamill (2005) discuss taxi drivers giving potential customers a visual once over to determine the threat level posed.

Real-world signals can be less informative in a virtual world. People cling to old habits in reading meaning into avatar appearance. A Second Life resident explained to Boellstorff (2008:130): “I sort of judge people based on their avatar appearance; I don’t tend to like tall skinny blondes.” Of course, any kind of person could be behind that avatar: a child, a predator, a con artist. And policing in virtual worlds is often little more than a neighborhood watch in which the fraud, theft, and grieving that increase with population size is monitored and posted in response to complaints, but criminals can easily create a new avatar and move on to new victims (Elliott, 2008). More, the anonymity that avatars provide could erode reputation’s deterrent to bad behavior. Behavior that I would be embarrassed to be caught doing in person need not be as embarrassing when my avatar is caught in the act. Trust could be such an issue in virtual worlds that people only trust within closed networks of friends from the real world. Given the lack of a state-sanctioned police force, life in a virtual world could resemble the Wild West, with friends one’s only protection. Consistent with the idea that trust is associated with real-world friendship, Williams et al. (2006) report that the people who group together in World of Warcraft tend to be friends in the real world (and Taylor, 2006:52-56, on family ties and guilds in EverQuest). In the extreme of people limiting inworld trust to real-world friends, there would be no value to brokering connections across groups. Brokers would be suspect, much like a rigid bureaucracy in which people are discouraged from engaging activity in other divisions. Such a
limitation on trust could destroy a virtual-world analogue to the real-world correlation between achievement and bridging structural holes.

**TWO VIRTUAL WORLDS**

Closer inspection of the two virtual worlds to be analyzed deepens the above generic uncertainties about construct validity. The worlds yield similar evidence of construct validity, but they are substantively different, and present different analytical issues, so it is productive to look at them both in this chapter (see Bainbridge, 2007, for similar strategic use of Second Life and World of Warcraft).

**Second Life**

Second Life is a large virtual world of about 20 million registered accounts. The world grew rapidly through its first five years, when I was given access to inworld data (see Appendix B on developmental phases). The attractive quality of Second Life, relative to the other world to be studied, is that Second Life contains a large number of diverse people free to behave in relatively unscripted ways. People interact with one another through animated characters discussed as residents. Flexible and popular, Second Life became home to meeting and event facilities run by real-world businesses, churches, foundations, government agencies, universities, and entertainment of high and low sorts. More, residents retain copyright to content they produce inworld, so there are active markets for diverse services including architecture and construction, events and education, as well as more generic goods such as clothing and painless plastic surgery giving one’s avatar an attractive new “skin.” A November 2006 issue of Business Week noted the first millionaire in Second Life — resident Anshe Chung corresponding to real life Ailin Graef, whose holdings in Second Life real estate, stores, and stocks were equivalent to more than a million dollars US. Figure 3.1 contains some screen captures to provide a sense of activity inworld. After registering (I picked the slightly overweight "boy next door" avatar pictured in Figure 3.1), residents can attend a meeting or class, shop for inworld goods, wander the world, or meet, engage, and exchange with folks. There are directories, maps, and people to
guide residents to places and activities. Mobility is a feature of the virtual world not obvious in Figure 3.1. Residents can teleport between locations inworld, and fly over a location to quickly get a sense of what is going on. Look at the "shop" screen in Figure 3.1. The resident avatar is hovering at a height several billboards above the boardwalk. He was in flying mode at the time.

——— Figure 3.1 About Here ———

Second Life is easy to enter and requires neither payment nor credit identity: Go to the secondlife.com website, download the free viewer software, launch the software, and enter the world (White, 2008, is a general guide; Boellstorff, 2008, describes the anthropology of entry and enculturation). Select a name and initial character that will be the resident avatar (which can be edited later), and provide some player demographic data (age, gender, and geographic location). Players can later upgrade from the free membership to a premium membership which provides more avatar options, the right to own land, and an allowance in the Second Life currency of Linden dollars.

The Second Life data to be analyzed in this chapter describe six million people discussed as "residents," connected by fifteen million friendships, and four million memberships in a hundred thousand groups. These are all registered users at the time the data were downloaded. The download day — September 6, 2007 — was selected by employees at Linden Lab, the organization that launched and maintains Second Life. The virtual world had been running commercially for about five years when the data were downloaded. Residents are only identified in the data by Linden Lab’s code numbers so personal identities remained confidential. The downloaded data include a few self-reported attributes (age, gender, geographic location) along with some data on each resident's history in Second Life (date of entry, time spent inworld, activity), a roster of the resident's friends in Second Life, and a roster of Second Life groups the resident founded or with which the resident was affiliated. Most residents were male, 77.8%, but that leaves a million and a half female residents. Most residents came from Western Europe (45.3%) and North American (27.1%), followed by South America (12.2%), Asia (10.8%), then everywhere else (4.7%). The six million residents had an average age of 29.7 years, with a quarter of them in their college
years (27.0% less than 23 years old) at the same time that a substantial minority were middle-age and older (14.4% over 40).²

New people were arriving at an impressive rate at the time of the download. In the first half of 2006, a new arrival had the company of 8,062 other new users arriving in the same week (three days before through three days after ego’s arrival). In the second half of 2006, the number increased to 63,244 per week. Through the first nine months of 2007, the number increased to 138,758 new users per week. Many of the new entrants were no more than tourists who lasted for a day, but many stayed to become residents. The virtual world continued to grow from the time of the download to slightly more than 21 million registered accounts by November, 2011 (Wikipedia).

**EverQuest II (EQ2)**

*EverQuest II* is a virtual world analogous to *World of Warcraft* in which people engage in quests and combat in the role of game-defined avatars discussed as “characters.” Players develop their character up levels of achievement with higher levels reached by earning experience points for killing non-trivial creatures, exploring new locations, and completing quests. I follow the convention of referring to *EverQuest II* as EQ2. Reports are available on the people playing in EQ2 during the observation period (e.g., Williams, Yee and Caplan, 2008; Shen, 2010; Huang et al., 2009; Shen and Williams, 2011). Taylor (2006:Chps. 1-2) describes the experience of entering and maturing within the game.

The data to be analyzed were recorded during an eight-month observation period in 2006 that lasted from January 1 to September 11. The game owner, Sony Online Entertainment, selected the observation period and provided the data. Players and characters are only identified in the data by Sony code numbers so personal identities remained confidential. The virtual world had been operating for about two years

²I exclude from this analysis minors and Linden Lab employees. Minors warrant their own story. I put aside 67,176 residents registered in the region of *Second Life* reserved for people under the age of 18 (and therefore excluded from the adult regions in *Second Life*). Employees are active in the social life of *Second Life*, but they are paid to be, so it seemed best to put them aside as their own story. Non-employee adults in *Second Life* had an average of 2.4 friends and .6 group affiliations. Employees had an average of 18.5 friends and 1.6 group affiliations. I put aside 1,541 residents registered as full or part-time employees at Linden Lab.
before the observation period began, during which time it had emerged as one of the most successful games in its genre, selling over 2.5 million copies with over 400,000 paying subscribers (Jakobsson, 2006).

The study population is a server census of characters active at any time during the observation period — active in the sense that the character advanced to a higher level in the game, sold something to another character, bought something from another character, exchanged items with another character, or was active in collaborative housing or mentoring with another character. The study population contains 44,185 characters played by 13,968 people. The downloaded data include character creation dates, achievements, economic exchanges and acts of support between characters (sharing homes and helping one another reach higher character levels), along with player age, gender, and geographical location. The majority of people lived in the U.S. (88.2%, with another 5.6% in Canada). Most were male (84.3%). The average player was 31.3 years old, with some in their college years (13.4% less than 23 years old), and a substantial minority middle-age or older (15.2% over 40). Time and location are known for each interaction act and each increase in character level.

Figure 3.2 About Here

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3The study population is twice a subset of EQ2 characters and players. (1) The study population is characters on one server. For logistic reasons, the EQ2 virtual world is replicated on multiple servers. The worlds are the same on each server. Relations are limited to characters on the same server and some servers specialize in player-versus-player combat. People entering EQ2 are advised to register on the server where their friends register so they get to play with their friends, to register on a server operating in the player's time zone so there are more characters active when the player is active, and to stay away from the combat servers if the player primarily wants to socialize with others in the game (or seek out a combat servers if combat is desired). The data to be analyzed come from a server called "Guk," a server not designated for player-versus-player combat. Since relations are limited to a single server, there is no reason to run a network analysis across the servers except to obtain more observations, of which we have many thousands from the Guk server. (2) Some characters on the Guk server did not have social or economic contact with other characters and are excluded from the study population. Networks in the study population are unaffected since the excluded characters had no relations with people in the study population. At the same time, people playing the excluded characters are most likely included in the study population because of other characters they played that were active during the observation period. Three fourths (75.4%) of the excluded characters were operated by people who operated active characters in the study population. In sum, the two restrictions on the study population mean that my EQ2 inferences are about players on the Guk server (primarily North Americans) who have social or economic contact with at least one other character inworld. Neither restriction is problematic for the purpose of the chapter and the study population demographics given in the text are not atypical of similar virtual-world populations at the time (Castronova, 2005: Chp. 2).
To give a quick sense of the EQ2 world, Figure 3.2 displays 16 character “races” available during the observation period (more akin to selecting a “species” than a race). Players enter EQ2 by obtaining the inexpensive game software, registering in the game with player age, gender, and geographic location, then selecting a character to play. There is a monthly subscription fee for play beyond past a brief trial period. Different people can play a character avatar in different ways, but characters are broadly defined by the game software to have certain traits and abilities. Male and female versions of the 16 races are displayed in Figure 3.2. Characters are further defined by player-selected "class" (fighter, mage, priest, or scout) and character appearance. Jakobsson (2006) describes character development in the game. My point for the moment is that Figure 3.2 highlights the fantasy nature of EQ2. A person can play the role of a lizard "iksar" known to be people who "delight in cruelty and conquest," or a "gnome," or a "troll," or a "froglock," known for their efforts to "eliminate villainy and corruption" in the community. The networks to be analyzed are composed of social support relations among such characters. There is an immediate face-validity challenge to analyzing networks of these characters to learn about network advantage in the real world. Behavior by people pretending to be the characters in Figure 3.2 can seem an odd, even foolish, foundation for drawing inferences about the real world, especially with respect to managers pursuing career and organization goals. I hope, by the end of this chapter, to have put the concern to rest.

Complementary Virtual Worlds

There are obvious differences between EQ2 and Second Life with respect to size (thousands versus millions), play (game-defined roles versus user-defined behavior), and purpose (develop character up game levels versus user-defined purpose). Certain of those differences shape analytical strategy. Population boundary is an example. EQ2 requires a subscription. We know that people inworld paid to be present. In contrast, Second Life is open to anyone without a fee or credit card, so some number of the people inworld are tourists just visiting to see what is going on. The porous boundary makes it easy for people to disappear, which makes it difficult to trust people to meet obligations to which they’ve agreed, or coordinate sustained
group activity. These are generic difficulties for people leading project work in the real world, but the porous boundary around Second Life exacerbates the difficulties. Tourists are an issue for estimating network effects in an open world like Second Life.

A second difference is the link between people and avatars. A person’s account in Second Life is limited to playing one avatar, but accounts are free, so it is a simple matter for people to have multiple avatars by registering multiple accounts. There is no definitive link between avatars created by the same person, so I cannot say for certain when two avatars are operated by the same person. In contrast, EQ2 allows a person to operate multiple avatars on one account and there is a subscription fee for additional accounts. The result is that I can trace multiple avatars back to the person playing them – which makes it possible to compare networks across avatars played by one person and test for network-effect consistency across avatars played by the same person. I use the person-avatar data to study agency in the next chapter.

A third difference is the data downloads. The Second Life data were downloaded without time stamps. I know that a resident had certain friends and was affiliated with certain groups, but I do not know when relations with the friends or groups began. Absent a time-stamp, the network data on Second Life are similar to the usual network data from a cross-sectional survey in the real world. Although not providing the full potential of virtual-world data, the data available on Second Life are suited to the purpose in this chapter of replicating with inworld data the cross-sectional network effects familiar in the real world. Time stamps are available on the EQ2 data. For actions between two EQ2 characters, I know when the action occurred, which makes it possible to study networks as aggregations and moving averages of interpersonal actions. I use the time-stamped data to study network dynamics in Chapters 5 and 6.

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4 A former Linden Lab employee boasted to me of having 22 avatars. The avatar-person connection is further complicated by differences in how people think of their avatar; some viewing it as a reflection of themselves, others viewing it as little more than a cursor indicating their location in the world. Schultze and Leahy (2009) distinguish eight ways that people connect with their avatar based on interviews with 14 people in Second Life. Imagine the number of person-avatar connections that must exist among the full millions of people inworld. Complications notwithstanding, the limited large-sample evidence available shows that most people create one avatar as their primary inworld identity (Williams et al., 2006), that avatar tends to resemble the real person with some improvements (Messinger et al., 2008), and I cannot do anything about the multiple-avatar issue in Second Life, so I discuss avatars in the text as people or residents.
EVIDENCE OF TRUST LINKED WITH CLOSURE

My closure criterion for construct validity is that if network processes work in virtual worlds as they work in the real world, then trust should be more likely between people embedded in a network of mutual contacts. To keep the focus on construct validity, I put methodological details in the notes and appendices (Appendix A on measuring relations in Second Life, Appendices C and D on measuring relations in EQ2). For now, allow that I have data on the network around each avatar. Network element $z_{ij}$ varies from zero to one with the strength of avatar i’s network connection to avatar j.

Summary Evidence

Figure 3.3 shows trust associated with network closure in the two virtual worlds. A network is built around an avatar as ego and her N contacts. Each ego-alter relationship is analyzed in Figure 3.3 for the closure around it and the probability of trust within it. The networks in Second Life provide 2,218,770 relations between ego and friends. Relations are scaled for trust according to the depth of privileges that ego grants a friend (Figure A4 in Appendix A). The networks in EQ2 provide 336,150 social relations between ego and friends, and 312,212 economic relations between ego and contacts with whom ego bought, sold, or exchanged goods. Relations are scaled for trust according to the depth of house privileges ego grants a contact (Figure C1 in Appendix C). Trust scores vary from zero to one in the appendices, but are multiplied by 100 for the dependent variable here to avoid extremely small coefficients in the models predicting trust.

I measure closure around a relationship by the extent to which the relationship is embedded in connections through mutual contacts. Zero means that ego and alter have no contacts in common (bridge relationship). If ego has one contact who is also a contact for alter, then they share one mutual contact. The horizontal axis in Figure 3.3 continues up through two mutual contacts, three, four, and so on.\(^5\) The more

\(^5\)My initial closure measure was more sophisticated, but yielded the same results as the simple count of mutual contacts, so I only discuss the count measure in the text. To measure the strength of
mutual contacts, the more likely that ego will hear about alter expressing opinion inconsistent with ego’s interests. Knowing that, alter is less likely to speak or act against ego’s interests. Less likely bad behavior makes alter less risky to trust, and so more likely to be trusted. Trust is expected to increase as mutual contacts close the network around a relationship.

That is what Figure 3.3 shows. The vertical axis is the average level of trust within a relationship predicted by the final models for Second Life and EQ2 that include controls for network size, kinds of people/avatars, and homophily. At the top of the graph, trust between friends in Second Life begins at an average strength of 52 between residents with no mutual friends (bridge relations), increases with each additional mutual friend through an initial handful of mutual friends, then more slowly through the next handful, then very little.

The lower prediction lines for trust in EQ2 show that collaboration without trust is more common in EQ2. Of the 336,150 social relations in EQ2, 87% involve collaboration between characters without either character having rights to the other’s house. Nevertheless, the same pattern of increasing trust occurs in EQ2 as social relations are more embedded in mutual social contacts. Still lower in the graph,

connection between ego and contact j through mutual contact k (indicating the probability that news about friend j gets back to ego through k), I multiplied the strongest connection between ego and k (Z_{ek} or Z_{ke}) times the strongest connection between k and j (Z_{jk} or Z_{kj}), where Z_{jk} is the quantitative measure defined in the appendices for the strength of connection from j to k. Summing indirect connections across contacts k in ego’s network (k ≠ j) defines a closure measure that varies from zero (bridge relation, none of ego’s contacts are connected with j) up to M-1 where M is the number of contacts in ego’s network. The maximum, M-1, is reached when ego is strongly tied to all her contacts, all of whom are strongly tied to j. The count of mutual contacts in the text is the same measure computed from binary relations (Z_{jk} equals 1 if j is connected with k, else 0).

I deviate slightly in EQ2 from the measurement in the text: indirect connection in the EQ2 social networks excludes indirect housing. The deviation is only for the estimations in Table 3.2. I exclude indirect housing to avoid overstating the trust association with closure. Here is the problem illustrated for a triad of ego and two contacts, A and B: If ego grants housing privileges to A and B, there is an indirect housing connection between A and B. The indirect connection means that A is a mutual contact embedding the ego-B relationship and B is a mutual contact embedding the ego-A relationship. However, I cannot use that embedding to predict ego’s trust in A or B because the relation predicted is included in the indirect housing connection between A and B that defined the embedding. Therefore, the counts of mutual contacts in Table 3.2 excluded indirect housing relations. Third party k to the relationship between ego and contact j is only a mutual contact if k had direct housing, direct mentoring, or joint mentoring connections with ego and j. Excluding mutuals defined only by indirect housing lowers the number of mutual contacts around the average relationship, but the closure-trust association is not much affected. The 30 and -18 t-test statistics in Model 3 for number and squared number of
buying, selling, and exchanging goods in EQ2 typically occurs without trust. Economic relations in EQ2 are more transactional than clustered: 95% of economic relations occur without either character having rights to the other’s house, 79% occur absent any social connection, and the contacts with whom a character buys, sells, or exchanges goods tend not to do business with each other (density averages 14% in EQ2 economic networks versus 50% in social networks, see Table D1 in Appendix D for detail). Even in the relative absence of trust, however, economic relations show a trust-facilitating effect of closure. The smaller coefficients and flatter prediction line for economic networks in Figure 3.3 show that the closure-trust association is weaker for economic relations than for social relations, but the association has the same functional form as for social relations and is statistically significant.

The key point in Figure 3.3 is that the predictions inworld look like the predictions in Figure 2.11A for managers. There are complications to sort out with control variables, but behavior in both virtual worlds provides evidence consistent with the construct-validity criterion that trust increases with closure. Network closure facilitates trust inworld as it facilitates trust in the real world.

**Detailed Evidence**

Estimates for closure predicting trust are given in Table 3.1 for Second Life and in Table 3.2 for EQ2. Models 1 and 3 predict trust from social network variables alone. Models 2, 4, and 5 include controls for homophily between similar kinds of people and avatars. Multiple models are presented to show the closure-trust association before and after observations are lost due to missing data on homophily variables. I have census data on large populations, so routine statistical inference is not useful here. As a familiar heuristic to distinguish larger associations, I present routine t-tests adjusted down for autocorrelation between relations in the same ego-network. In discussing details, I refer to closure in the EQ2 economic network for consistency with closure in the Second Life and EQ2 social networks, but I focus on the social networks because mutual contacts are 50 and -37 if I include mutuals defined by indirect housing. The 30 and -19 in Model 4 are respectively 21 and -11.
that is where I have more effect variance to work with (indicated by larger coefficients and higher prediction lines in Figure 3.3).

Table 3.1 and Table 3.2 About Here

The first row of Tables 3.1 and 3.2 shows a strong linear association between trust and mutual contacts. The second row shows the dampening effect of many mutual contacts. The dampening effect is weaker than the linear association, but noticeable (t-tests in the second row are about half as large as corresponding t-tests for linear effects in the first row). The linear and dampening effects together define the associations like the ones displayed in Figure 3.3. Trust increases a little more quickly with mutual contacts in EQ2, but the dampening effect of large networks is stronger in EQ2, so the increase associated with a dozen mutual contacts ends up about the same in the two virtual worlds. I get similar results if I measure closure as strength of connections through mutual contacts (see footnote 5). The respective t-tests the continuous measure with 56 and -18 for the first two rows in Model 2, 25 and -21 for the first two rows in Model 4, and 18 and -12 for the first two rows in Model 5. Given similar results using the simpler count of mutual contacts, I focus on results with the simpler measure.7

Broader context complicates the prediction in two ways held constant in the tables. First, partners in one-contact social networks are trusted above and beyond

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7The closure association is sufficiently strong to be evident with still simpler measures. Shen, Monge, and Williams (2012:15) report trust increasing with closure in the EQ2 data when: (a) the five levels of trust in Table 3.2 are replaced with a binary distinction between any housing rights versus none, (b) the measure of closure around an ego-alter dyad in Table 3.2 is replaced with a summary measure of closure around all of ego’s relationships, and (c) the network of direct mentoring, joint mentoring, and housing used to define closure in Table 3.2 is replaced with a network of mentoring alone. I can comment on the cost of the first two simplifications. The binary treatment of trust is not costly. If I replace the five-category measure of trust in Model 3 with the Shen et al. binary treatment (trust present if any housing rights are granted) and estimate a logit regression model, I get about the same results presented in Table 3.2. The 30 and -18 t-test statistics in the first two rows of Model 3 in Table 3.2 become 35 and -26 z-score test statistics. Trust increases a little more quickly with closure and decreases a little faster in larger networks, but a strong closure-trust association remains. The second simplification is costly. If I continue with the binary trust prediction, and replace number of mutual contacts in Model 3 with ego’s network constraint index, the z-score test statistic for constraint’s association with trust is 9, which is about the 11 that Shen et al. report for constraint. Both are small relative to the test statistics for closure in Table 3.2. In other words, within a closed or open network, some relations can be bridges and others can be embedded in numerous mutual contacts. The closure prediction is best conducted with a measure of closure around the individual relationship within which trust is being predicted.
what would be expected from the lack of mutual friends. Mutual friends are zero by
definition in a one-contact network. When it is just ego and one social contact inworld,
the third rows in Tables 3.1 and 3.2 show ego is more likely to trust than would be
expected from the lack of mutual friends. The one-contact network effect is visible in
the zero-order associations between trust and closure. In Figure 3.4, solid lines show
the odds of “high trust” increasing with mutual contacts, and dashed lines show the
odds of “low trust” decreasing. High trust refers to relations in which ego granted
maximum privileges to a contact. Low trust refers to relations in which ego granted no
privileges, or very limited privileges to a contact. Based on the scaling in Figure A4 in
Appendix A, low trust in Second Life is no friendship, friendship without privileges, or
friendship limited to knowing when ego is inworld. High trust is ego granting “modify
objects” privileges. Based on the scaling in Figure C1 in Appendix C, low trust in EQ2
is no housing privileges, or revoked privileges. High trust is ego granting “trustee”
privileges. There are two zero scores on the horizontal axes in Figure 3.4: 0\textsuperscript{a}
indicating a contact connected with ego but not with any other of ego’s contacts, 0\textsuperscript{b}
indicating a contact who is ego’s only contact. There is a continuous association
between trust and closure through 0\textsuperscript{a} to 1 to 2 to 3 on the horizontal axes, but a bump
up in trust over 0\textsuperscript{b}. The bump is slight in Second Life. It is most evident from the dip in
the dashed line. The tendency is striking in EQ2, indicated by the sharp spike up in
the odds of “high trust” within one-contact networks. The one-contact effects on trust
are described by the positive coefficients in the third rows of Tables 3.1 and 3.2.
Network time and energy concentrated in one relationship is an form of “relational
embedding” (Granovetter, 1985; see Uzzi, 1996, on relational embedding measured
by garment manufacturers concentrating purchases in one trusted supplier). Failing to
control for relational embedding in the virtual worlds would exaggerate the average

\textsuperscript{8}Figure 3.4 highlights the lack of “low trust” relations in EQ2. Distrust is expressed differently in
the two virtual worlds. Every friend in Second Life is assigned to a category of low to high trust, so there
are numerous low trust friendships and the dash line to the left in Figure 3.4 shows a clear negative
association with closure. Trust is made explicit in EQ2 by granting house privileges to a person. There
are instances of people explicitly revoking another’s privileges, or stating that certain people have no
privileges, but many more contacts are not mentioned. The unmentioned do not have house privileges.
The result is few records of low trust to display in Figure 3.4. Fortunately, there are two intermediate
levels of trust in EQ2.
level of trust observed in the absence of mutual friends, which would raise the left side of the regression lines in Figure 3.3, obscuring the closure-trust association otherwise apparent through low numbers of mutual contacts.

——— Figure 3.4 About Here ———

Broader context also matters in terms of variation in network size beyond a single contact. Size can matter for purely computational reasons because size sets an upper limit for mutual contacts. Embedding a relationship in six mutual contacts requires a network of at least seven contacts. Beyond computation, many people connected to an individual indicate that the individual is an attractive contact, and has much to lose if he behaves badly. As an indicator of attractiveness and reputation governance, people with larger networks would be safer to trust, making trust more likely. At the same time, size is correlated with social heterogeneity, which would inhibit trust.

Tables 3.1 and 3.2 show positive and negative size effects. Trust is less likely within larger networks in Second Life (fourth row in Table 3.1). At the same time, Second Life residents are more likely to trust contacts with the reputation benefits and controls of a larger network (fifth row in Table 3.1). In EQ2, people are less likely to trust contacts who have large networks (fifth row in Table 3.2). The inconsistent size effects constitute an interesting puzzle to explore, but for the purposes of this chapter, I just want to hold size constant to more clearly see the closure-trust association.  

**Controlling for Homophily between Kinds of People and Avatars**

Models 2, 4, and 5 add controls for homophily effects. Homophily refers to attraction between socially-similar people. The responsible mechanism could be a belief that someone like me would understand my interests, or that a person like me would be more exposed to reputation cost for bad behavior among our people (see Lazarsfeld and Merton, 1954, for the initial discussion of homophily as a sociological concept.  

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9I checked for multicollinearity creating the inconsistent size effects. There could be social homophily between people who were both socially peripheral or both central in a network, which would encourage network connections between people with similar size networks. However, there is no evidence of relations tending to occur between same-size networks. The size of the network around ego is not correlated with the size of the networks around ego’s contacts: .05 for the two Second Life size variables in Table 3.1, .20 for the two EQ2 social-network size variables in Table 3.2, and .26 for the two EQ2 economic-network size variables.
McPherson, Smith-Lovin and Cook, 2001, for thorough overview). Whatever the mechanism, trust is more likely between homophilous people. I have data on kinds of people and kinds of avatars that can be used to control for homophily, but the data are limited. I know the self-reported age, gender, and geographic region of the person behind the avatar. Attribute data on some people or avatars are missing. Many relation observations are lost when the controls are added. It is reassuring to see similar closure-trust associations before and after the controls are introduced.

Tourists
Many of the people in Second Life after 2006 could be labeled tourists. Described in Appendix B, my tourist measure is the probability that an individual is about to exit the virtual world — given the number of days she spent inworld, whether she is a kind of person prone to exit, and the state of the virtual world when she first entered. It would have been unwise for a resident to trust tourists. People just visiting Second Life are socially clumsy, too much work for residents to engage. Tourists are more likely to disappear at any moment, so their commitments should be taken with a grain of salt. Teigland (2010:12) focuses on coordination and trust issues in her ethnographic report on a successful Second Life group project, highlighting the porous boundary around the world: “As many are exploring this new environment and even new personas, people may easily create an avatar, log in, come to an event, provide some ideas, take on some responsibilities, and then just disappear — never to return again.” And people new to Second Life are easy to identify (see Boellsorff, 2008:124-126; Boostrom, 2008, on the stigma of looking like a newbie). They continue to be avoided, unless an experienced resident is feeling altruistic and helpful. A person entering Second Life who wants to engage residents is well advised to acquire some distinguishing characteristics to look like she plans to stay — not unlike the tolerant response one gets in a foreign land when you looks like you have tried to learn the language. The need for distinguishing characteristics drives an active Second Life market for clothing, hair, and skins.

Table 3.1 shows that tourists are likely to trust their friends, but are unlikely to be the object of trust (-40 t-test). Further, consistent with ethnographic accounts, trust in tourists is particularly unlikely from non-tourists (-20 t-test). The magnitude of the
negative effect depends on who is more like a tourist, ego or the friend, source of trust or the object. For ego less of a tourist than the friend, difference in their tourist scores has a -23.97 coefficient predicting ego’s trust in the friend (-87 t-test statistic). When ego is more of a tourist than her friend, the same difference in tourist scores has a much weaker -2.52 coefficient predicting trust (-10 t-test with the same number of observations). In other words, non-tourist residents are particular unlikely to trust tourists they accept as friends.  

Player Geography, Age, and Multi-Character Accounts

Geography is a strong homophily factor. No region stands out as more or less involved in trust, but trust is more likely between people from the same region (40 t-test in Model 2, 29 in Model 4, 28 in Model 5). I tabulated ego’s region by the regions in which his contacts lived, then compared average levels of trust across rows, columns, and cells. For the global Second Life population, I distinguished five regions: North America (27% of the population), Western Europe (45%), South America (12%), Asia (11%), and anywhere else (5%). North Americans were the most involved in trust, but Table 3.1 shows negligible tendencies for them to trust or be trusted more than people elsewhere. The North America effects are the weakest in Table 3.1. The EQ2 server population was primarily North American, so players were coded for region within North America: East Coast northern states (12.5%), states that formed the Confederacy in the Civil War (27.7%), the Midwest (16.9%), mountain states (9.4%), states on the Pacific coast (16.7%), Canada (5.6%), and people anywhere else (11.4%). There were no differences in trust between the regions, but Confederate South is the modal category, so I used that as a region variable in Table 3.2 and again, there are negligible tendencies for players from the region to have been more or

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The tourist control variable is missing for 316,370 people because of missing data on their age, gender, geographic region, or activity in their first day inworld. I computed a second tourist variable for which missing data were imputed from the attributes of friends (footnote 2 in Appendix B). Imputation provides tourist scores for 80,738 friendships missing from the results in Table 3.1. Re-estimating Model 2 with the additional observations does not improve the prediction accuracy, yields almost identical coefficients for the tourist effects in Table 3.1, and yields test statistics identical to those in Table 3.1. It is reassuring to see the effect stability with the additional data, but no issues or advantages are raised with the additional observations provided by imputation, so I only use complete observations in Table 3.1.
less involved in trust. As in Second Life, trust is much higher between EQ2 people who lived in the same geographic region.

Age is another homophily factor. Some variety of age clues must be evident from seeing a player’s avatars because players are unseen but trust is more likely between avatars played by people closer in age (-58 t-test for age difference in Table 3.1, -37 in Model 4, and -13 in Model 5). Huang et al. (2009) also report evidence of age homophily between EQ2 players. They aggregate all relations between any of one player’s characters with any of a second player’s characters to describe the connection inworld between the two players. They find that players more similar in age are more likely to partner, instant message one another, and exchange goods with each other.

An extreme form of homophily in virtual worlds occurs between avatars played by the same person. I cannot identify the person playing Second Life avatars, but I know in EQ2 when characters are played by the same person. Specifically, I know when characters are registered to the same account. The control variable “Characters Played by Same Person” is 1 when ego and a contact are registered to the same account, 0 otherwise. Players do not often exchange goods between the characters they play, but they often have collaborative social relations between their characters. One percent of economic relations are between characters played by the same person versus ten percent of social relations (which is 254 economic relations versus 33,096 social relations). When social relations occur between a player’s characters, trust is very likely (72 t-test in Model 4 versus no effect in the few economic relations). Again, I am less interested in this unique virtual-world form of homophily than I want to hold it constant when estimating the association between trust and closure.

11Of EQ2 accounts in the study population, 56.9% registered more than one character (10,155 of 17,861 accounts), the modal number of characters registered to a multi-character account was two (2,534 accounts registered two characters and the next highest frequency was 1,631 accounts registering three characters), and the average account spent 89.9% of game time playing a primary character. About one in ten relationships involved characters registered to the same account (33,096 of the 336,150 in Table 3.2).
Player Gender

Relative to geography and age, gender is a complicated homophily factor. Women stand out for their trust in other women. To explain why gender is included the way it is in predicting trust, here are average trust scores tabulated by the gender of the person playing a character (row) and the contact gender (column):

<table>
<thead>
<tr>
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<th>M</th>
<th>F</th>
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<th>M</th>
<th>F</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Male players</td>
<td>.540</td>
<td>.520</td>
<td>.106</td>
<td>.105</td>
<td>.060</td>
<td>.105</td>
</tr>
<tr>
<td>Female players</td>
<td>.586</td>
<td>.615</td>
<td>.105</td>
<td>.267</td>
<td>.105</td>
<td>.125</td>
</tr>
</tbody>
</table>

The first averages are for Second Life, the second are for EQ2, and the third are for EQ2 excluding characters played by the same person. Higher trust between women stands out in all three tabulations (.62, .27, and .13). To the extent that there is a gender homophily effect in either virtual world, it is between women. Gender controls in Tables 3.1 and 3.2 sort out row, column, and homophily effects with other factors held constant. Women in Second Life are more likely to trust their friends (48 t-test in Table 3.1), especially if the friend is another woman (13 t-test), but women are less likely to be trusted contacts (-33 t-test). Gender affects relations less in EQ2. Models 4 and 5 in Table 3.2 shows that women are more likely to trust and be trusted, but the heightened tendency for women to trust other women disappears when the other controls are held constant (respective t-tests of -8 and -2; cf. Huang et al., 2009, for a similar lack of gender homophily in instant messaging and trading goods between characters). The disappearing effect for women could be due to the lack of female players in EQ2. Many female characters are played by males. Here is a tabulation of the 21,535 characters for whom I know character and player gender (see Huh and Williams, 2010, on gender switching in EQ2): Of 14,160 male characters, 573 are played by women (4.1%). Of 7,375 female characters, 3,295 are played by women (44.7%). If you play with a male character, you were probably playing with a man. If you played with a female character, you were also probably playing with a man because more than half of female characters are played by men. Inworld female is an unreliable signal of real-world female.
Kind of Avatar

Still, avatar homophily affects trust. I already discussed resident distrust of tourists in Second Life (Model 2). EQ2 provides more explicit evidence. People play pre-defined roles in EQ2 such that kinds of avatars can be recognized on sight. (In contrast, avatars in Second Life have almost unlimited form, so they are not coded by kind in the downloaded Linden Lab data.) At the time of the EQ2 data download, players selected a character from one of the 16 races displayed in Figure 3.2. Character race does not indicate a homophily attribute of the person playing the character, but it does indicate a player’s propensity for good, evil, or neutral behavior when playing the character. Choice also indicates player taste for fantasy (barbarian or human versus frog, lizard, ogre, or troll), which could be a homophily factor for some people drawn to EQ2. I created a 16 by 16 table of ego race versus contact race, and compared average trust scores across the cells looking for races and combinations of races where trust is particularly likely. The results are in the bottom three rows of Table 3.2. “Good” races are slightly more likely to trust and be trusted, but the tendency is slight. The strong race effect is for trust more likely between characters of the same race (15 and 12 t-tests for social and economic relations respectively).

In Sum

My conclusion from Tables 3.1 and 3.2 is that the closure-trust association in Figure 3.3 survives controls for kinds of people and avatars. Reasons for homophily are outside the scope of this chapter, though the effects in Tables 3.1 and 3.2 are consistent with real-world homophily effects (McPherson, Smith-Lovin and Cook, 2001, provide a careful review). I suspect that much of the homophily evidence inworld traces back to real-world friendships: We are friends in the real world, so our avatars are close inworld, friends tend to be homophilous in the real world, which would contribute to the homophily evidence in Tables 3.1 and 3.2. Chuck is an ogre, but he is still my friend Chuck. I do not have real-world network data, so I cannot hold constant real-world friendship. And there is no need to do so here. My concern in this chapter is to see how the inworld closure-trust association holds up against controls.
for homophily. Tables 3.1 and 3.2 show trust stronger between socially similar people and avatars, but the closure-trust association remains strong.\textsuperscript{12}

\section*{EVIDENCE OF ACHIEVEMENT LINKED WITH ACCESS TO STRUCTURAL HOLES}

My brokerage criterion for construct validity is that if network processes work in virtual worlds as they work in the real world, then achievement in virtual worlds should be associated with access to structural holes in the virtual worlds.\textsuperscript{13} Let ego refer to an avatar in a network composed of the avatar's contacts. I measure access to structural holes with effective size, the number of nonredundant contacts in ego’s network. As introduced in the previous chapter, the index is a count of ego’s contacts adjusted down for strong connections among the contacts. The larger the number of nonredundant contacts in a network, the more opportunities ego had to broker connections in the network. One nonredundant contact means access to no structural holes. Two means that ego had access to the structural hole between the two nonredundant contacts. Four means that ego had access to the six holes between her four nonredundant contacts, and so on. A large number of nonredundant contacts means that ego had many friends in otherwise disconnected parts of the virtual world, which means that she had rich access to structural holes between the groups from which she drew friends.\textsuperscript{14}

\footnote{The above evidence is based on a “realized” risk set (footnote 16 to Chapter 2). Of the contacts observed around ego, Figure 3.3 shows that ego is most likely to trust those with whom he shares mutual friends. I focus on closure and trust within realized risk sets because I know exactly who is friend to whom in Second Life, and between whom housing and mentoring relations exist in EQ2. The evidence in Figure 3.3 might be conservative, but it is clear and replicable. I looked into a “potential” risk set defined by the broader economic network data available in EQ2, but the results are not different from the results in Figure 3.3 (see Appendix D).}

\footnote{One can go further to infer user motivations from the opportunities for brokerage and closure in the virtual-world network around a user (Ganley and Lampe, 2009), but the bulk of real-world empirical evidence is on observable network correlates so I take the conservative route here of focusing on the brokerage-achievement and closure-trust criteria in the text.}

\footnote{The equation for effective size is given on page 11 of Chapter 2, for which relation $z_{ij}$ between $i$ and $j$ is defined for Second Life in footnote 6 to Appendix A, and for EQ2 in footnote 9 to Appendix C and Figure D1 in Appendix D.}
Access to structural holes can be measured in many ways. I will show that results with the nonredundant-contacts index are similar if I use alternative network measures, but Table 3.3 illustrates with the Second Life data how effective size covaries with alternative measures introduced in the previous chapter.\footnote{Adding EQ2 data to Table 3.3 does little because there are so many more observations from Second Life, so I illustrate similarities across the structural hole indices using only the larger population. Here is a quick comparison to allay concerns that EQ2 is not represented by the associations in Table 3.3: Across the 723,635 social networks in Second Life, effective size (rows three through twelve of Table 3.3) is correlated .63 with bridge relations, .80 with betweenness, and -.46 with network constraint. Correlations for EQ2 social networks are similar: .61 for bridge relations, .78 for betweenness, and -.59 for constraint, and correlations for EQ2 economic networks are similar: .74 for bridge relations, .82 for betweenness, and -.56 for network constraint. If I include the Second Life residents who had no social network (first two rows of Table 3.3), the respective correlations across all 6,391,823 Second Life residents look more similar to the EQ2 correlations: .68, .79, and -.56.}

People are distinguished down the rows of Table 3.3 by effective size. I round the quantitative measure of nonredundant friends into categories for the table. The first two rows contain people who had no friends. I separate total isolates (row one) from people who had no friends but were affiliated with one or more groups (row two) because the scaling in Figure A4 in Appendix A clearly shows the distinction. The third row contains people who had one nonredundant friend. This does not mean that they had one friend. The table shows that they had at least one friend, but the number of contacts goes up to 33. For example, the illustrative Danish women's network presented in Figure A2 in Appendix A contains 14 friends, but connections between her friends were so strong and dense that the 14 contacts amounted to only 1.30 nonredundant contacts, which rounds in Table 3.3 to one nonredundant contact. Down the rows of Table 3.3, networks provide broader access to structural holes, ending with complex networks containing 17 or more nonredundant friends. An example is the illustrative Midwest women's network presented in Figure A3 in Appendix A. The Midwest woman is connected to 32 friends. Connections between her friends are so asymmetric and variable that those friends constitute 28.92 nonredundant contacts.

Other measures of access to structural holes define columns in Table 3.3. To the right of network size, number of bridge relations increases with number of
nonredundant friends, where a bridge links ego to a friend who has no direct friendship connection with any of ego’s other friends.\(^{16}\) Network betweenness is the number of ego’s friends between whom ego is the only connection (within ego’s network).\(^{17}\) Betweenness is zero in the small networks at the top of Table 3.3. It increases down the rows of the table. Network constraint measures the extent to which ego’s network time and energy is concentrated in a single group. Network constraint is high if ego has few contacts (small network), and the contacts are connected to one another directly (dense network) or indirectly through a central, mutual contact (hierarchical network).\(^{18}\) A score of 100 indicates no access to structural holes (ego had no friends, or all of ego’s friends are friends with one another). Constraint scores are 100 at the top of Table 3.3 and approach zero for the complex networks toward the bottom of the table. The last column in Table 3.3 reports averages for a count of ego's group affiliations. Group affiliations increase down the rows of the table, showing that people with many nonredundant contacts tend to be affiliated with many different groups.

**Summary Evidence**

Before getting into the details of achievement and network advantage in the two virtual worlds, Figure 3.5 displays summary brokerage-achievement associations. To measure achievement on a single dimension is not to say that everyone has the same motivation to achieve in a particular way. Motivations vary inworld (e.g., Bartle, 2003:130; Yee, 2006:319), as they do in the real world. In EQ2, some characters are created to be bookkeepers, or to be sidekicks, or play some other function that has nothing to do developing the character to a higher level. Second Life is less scripted than EQ2, so motivations likely vary more widely. The brokerage-achievement

\^[16]\ The relation from ego to contact k is a bridge relation if ego and k have no mutual friends (zero on the horizontal axes in Figure 3.3). This index is simply a count of ego’s bridge relations. A more specific definition of mutual contacts is given in footnote 5 to this chapter.

\^[17]\ The equation for betweenness is given on pages 12-14 of Chapter 2, for which relation \(z_{ij}\) between i and j is defined for Second Life in footnote 6 to Appendix A, and for EQ2 in footnote 9 to Appendix C and Figure D1 in Appendix D.

\^[18]\ The equation for network constraint is given on pages 10-11 of Chapter 2, for which relation \(z_{ij}\) between i and j is defined for Second Life in footnote 6 to Appendix A, and for EQ2 in footnote 9 to Appendix C and Figure D1 in Appendix D.
principle only says that achievement — when it occurs — is more likely in a network rich in access to structural holes. What constitutes achievement is whatever is generally recognized as achievement. People typically differ in what they want from their jobs (Herzberg, 2003:90), but the achievements of work recognition, compensation, and promotion occur disproportionately for managers in networks rich in structural holes. There are certainly alternatives to the achievement measures used here for the virtual worlds of EQ2 and Second Life, alternatives that warrant exploration. However, the measures used here are basic ones likely to be included in a general assessment of achievement in the virtual worlds. For the moment, the measures are summarized on the vertical axis in Figure 3.5 with a z-score level of achievement predicted by network advantage and various controls for differences in player background and experience.

The tight scatter of data around the regression lines in Figure 3.5 shows that network advantage is closely associated with achievement despite differences in player background and experience. The graph to the left plots z-score achievement across number of nonredundant contacts in an avatar’s network (metric distinguishing rows in Table 3.3). Network brokers are to the right in the graph with many nonredundant contacts. The other graph in Figure 3.5 plots achievement across levels of network constraint, which has a different functional form to its association with achievement. Network brokers are to the left in the graph, at low levels of constraint.

Figure 3.5 About Here

The virtual world evidence in Figure 3.5 replicates in two ways the achievement association with brokerage observed in the real world. First, achievement increases with access to structural holes. Average achievement increases with number of nonredundant contacts, up through a dozen or so contacts, after which increases are dampened by the difficulty of coordinating across many nonredundant contacts. The nonlinear negative associations with network constraint in the Figure 3.5 left-graph resemble the summary association presented in Figure 2.3 for managers.

Second, differences between the prediction lines for Second Life and EQ2 further document construct validity. The prediction lines for Second Life in Figure 3.5 are steeper and reach higher than the lines for EQ2. The lines for EQ2 social networks
are higher than for EQ2 economic networks, but the difference between social and economic in EQ2 is smaller than the difference between either and the prediction line for Second Life social networks.\textsuperscript{19} The difference has an analogue in the real world: Managers who do more ambiguous, complex work enjoy higher returns to network brokerage (e.g., the more senior managers in Table 2.2). The more ambiguous or complex the work, the more success depends on working in a way that engages the interests of other people, so the greater the benefit from a network broker’s information and control advantages. Returning inworld, Second Life residents have wide latitude in their behavior and their success. Some achieve dramatically more than peers. EQ2 behavior is more defined by the game software. Players have flexibility in playing a role, but they also have reliable expectations about how roles will be played. Behavior is less prescribed in Second Life, so the information and control benefits of network brokerage should be more related to achievement, as they are. Access to structural holes is similarly associated with achievement in the two virtual worlds (explained below), but the yield on Second Life brokerage is higher in the that network brokers in Second Life end up more standard deviations ahead of their peers.

\textbf{Detail on EQ2 Achievement}

EQ2 is a game organized around developing characters to higher levels. The goal is entertainment, but the entertainment is organized around developing characters to higher levels. Williams et al. (2008:1005-1006) report from their survey of EQ2 players

\textsuperscript{19}Specifically, five to seven percent of the achievement variance displayed in Figure 3.5 can be attributed to the difference between social and economic networks in EQ2. The graph to the left in Figure 3.5 contains 78 achievement levels in three series (26 for Second Life, 26 for EQ2 social networks, and 26 for EQ2 economic networks, each based on predicted achievement with zero mean and unit variance). The graph to the right in the figure contains 63 achievement levels. Let effective size vary from 0 to 25 distinguishing the 26 displayed levels of nonredundant contacts in the graph to the left, and let CONST vary from 0 to 100 distinguishing the 21 levels of effective size displayed in the graph to the right. Let SL be a dummy variable distinguishing observations from Second Life, and let ECON be a dummy variable distinguishing the EQ2 observations based on economic networks. When the 78 achievement levels in the left-graph in Figure 3.5 are predicted by effective size, effective size squared, SL, and ECON, 36.5% of achievement variance is attributed to effective size, 50.2% is attributed to the difference between Second Life and EQ2 versus 4.7% attributed to the difference between social and economic EQ2 networks (leaving 8.6% attributable to non-network predictors in Table 3.4). When the 63 data in the right-graph are predicted by ln(CONST), SL, and ECON, 55.0% of achievement variance is attributed to log network constraint, 29.6% is attributed to the difference between Second Life and EQ2 (note the smaller SL-EQ2 difference in the graph to the right) versus 6.9% attributed to the difference between social and economic EQ2 networks.
that people rate achievement as their most important motivation, and motivation to achieve predicts time inworld better than any other motivations. From his close study of EQ2 players, Yee (2001:70-72) describes character level as representing manageable steps in task complexity such that the reinforcement of level increases operates like a “virtual Skinner box,” encouraging players to spend a little more time to reach that so-close next level (Ducheneaut et al. 2006:23-24, report a similar image in World of Warcraft, and Bainbridge, 2010:Chp. 7, links character level, self esteem, and social status inworld). Motivation can also be studied in terms of decay. Interviewing long-time players thinking about leaving the game, Jakobsson (2006:224) finds decayed Skinner-box motivation: “Most players connect the loss of passion for the game with having seen as much of it as they can hope to see at their level of play and having so much knowledge about the game that it has in some regard become transparent to them and therefore lost its mystical appeal.”

Brokerage and Achievement

Table 3.4 contains regression models predicting achieved character level. There are three models, each applied to the social network, then the economic network, around a character. Multiple models are presented to show that the results are consistent across social and economic networks and robust to people playing multiple characters. Models 6 are estimated across all characters, with test statistics adjusted down for correlation between characters played by the same person. A more conservative strategy, taken in Models 7, is to estimate effects only for the primary character a person played — so each person appears only once in the data. A primary character is the one in which a player has spent the most time. Models 8 are the same as 7, but with more observations. Self-reported player location, gender, and age are missing on many players, which removes from the estimation characters for whom achievement and network are known. Since age, gender, and location make little contribution to predicting achievement, they are deleted in Models 8 to show that the expected brokerage-achievement association is still evident when the missing observations are returned.
There is strong and consistent evidence of achievement increasing with access to structural holes. The first two rows in Table 3.4 reproduce the association displayed in Figure 3.5. The first row in the table shows a strong linear association. Test statistics in the first row are the largest within each model. The second row in Table 3.4 shows a weaker, but strong, dampening effect from having too many nonredundant contacts. As displayed in Figure 3.5, achievement increases with up to a dozen or so nonredundant contacts, thereafter increasing slowly, then decreasing before the count reaches 20. The summary achievement variable for EQ2 in Figure 3.5 is the achieved character level predicted by Model 8 based on a character’s network of combined social and economic contacts. Table 3.5 shows the same results for Model 8 when the model is re-estimated using other network measures of access to structural holes: a count of bridge relations, network betweenness, and network constraint. Network constraint is reported with a single coefficient because, as illustrated in the previous chapter (Figure 2.3), the linear and dampening effects are combined in the association between achievement and log network constraint.

The brokerage-achievement association does not depend on the inactivity of isolates or extreme contributions from characters with the largest networks. I get the results reported in Table 3.4 if I re-estimate the models excluding characters who had no social connections through housing or mentoring. Also, I included a control in the third row of Table 3.4 for a certain kind of social isolate, a “semi-isolate.” These are characters who had no social contacts through housing or mentoring and no economic exchanges, but were members of a guild — so they had contact with other characters in the guild even though exchange and collaborations over housing or mentoring did not develop from the affiliation. Figure 3.6A shows character level plotted by number of nonredundant contacts. There is a bump up over “0” on the horizontal axis, which is the positive effect held constant by the control for semi-isolated characters in Table 3.4. There is also a bump in achievement over the largest networks, networks of two dozen or more nonredundant characters. Large networks contribute to the network effect, but are not essential. I get the results reported in Table 3.4 if I re-estimate the models excluding the high achievements of characters with the largest networks (24 or more nonredundant contacts).
Controls

Player demography is a negligible control. The data are reports from players when they signed up for their EQ2 account, so the reports are to be studied with caution. It is fortunate that the data play a minor role in the prediction. Achievement has no association with player age. Men are slightly more likely to reach higher character levels (Table 3.4). Achievement has no association with region. Most players on the study-population server lived in the US (88.2%). Players from outside the US wanted to play with friends in the US, or they were entering to find new challenges. Either way, non-US players were slightly more likely to be network brokers (5.1 versus 4.4 nonredundant social contacts on average for non-US versus US players), and slightly more likely to reach higher character levels (Table 3.4). I tested for a coastal advantage within the US. The east and west coasts were combined in a dummy variable added to Model 8. In the combined social and economic networks model, the coastal variable makes a small addition and the American control remains a small decrement. I also estimated Models 8 with controls for character gender and race, but neither affected the predictions. Female characters were no more or less likely to achieve, and achievement was not appreciably higher or lower for good or evil characters relative to neutral.

Experience is an important control. I use four variables to control for differences in experience. Two measure player experience: player time inworld (measured in 24 hour days), and the number of characters in which the player was active. The other two controls measure player experience with the character whose achievement is being predicted: player time spent in the character since it was created (measured in 24 hour days), and proportion of the player’s total time inworld that has been spent in the character. The results in Table 3.4 show that the more time a person spends inworld, especially in the achieving character, the higher the person’s achievement with the character. The most predictive experience variables are days spent in the achieving character (t-tests of 20 and 16 in Models 8), followed by number of different characters a person has played (t-tests of 15, 13, and 11 in Models 8).
I hasten to note that time alone is not sufficient. Level is not an outcome fixed by the game software to certain amounts of time inworld or certain kinds of social networks. Individuals vary widely in the time spent reaching higher levels, and their networks vary widely at each level. Experienced players can develop a character more quickly, but there are players in low character levels who have spent a lot of time inworld. At the other extreme, there are confirmed instances of “gold farmers,” that is, players who repeatedly develop characters or property as quickly as possible for resale (Taylor, 2006:130 ff.), but the instances are rare.\textsuperscript{20} With respect to networks, difficult quests require collaboration between complementary kinds of characters, so character heterogeneity around more experienced players could be viewed as a network requirement built into the game software (e.g., see Taylor, 2006:39ff., on “the necessity of social networks” in EQ2). Nevertheless, networks vary widely within character levels, so although more experienced players on average have more diverse social contacts, it is a tendency, not a necessity. In fact, Shen, Monge, and Williams (2012) control for character diversity when they estimate the brokerage-achievement association in EQ2. They too use effective size to measure access to structural holes. They also compute a measure of contact diversity that is low when a character draws all contacts from the same character class and high for characters connected equally with contacts in each of the four character classes. The contact diversity measure is associated with achievement, but holding it constant, the achievement association with effective size remains strong (Shen, et al., 2012:14).

**Detail on Second Life Achievement**

Activity in Second Life is less scripted than in EQ2. Interests can vary widely. Newbie avatars can be distinguished from long-term residents (Boostrom, 2008), but there is no obvious progression from lower to higher levels. By the same token, the lack of an integrating goal makes Second Life more dependent on the infrastructure that users create for one another. Residents depend on someone to provide the infrastructure

\textsuperscript{20}During the observation period, Sony banned 0.43% of characters for being gold-farmer characters (Ahmad et al., 2009). Roy et al. (2012) estimate that an equal number of the remaining characters are the undetected work of gold farmers.
that makes Second Life an interesting place to spend time. In this, Second Life is less a game than it is a social movement or a collaborative community.

Brokerage and Achievement

Who provides the infrastructure that sustains the community and makes it attractive to new and continuing residents? Rainie and Wellman (2012: Chp. 8) describe examples of these infrastructure leaders and label them “networked creators.” Fleming and Waguespack (2007) show that the people who emerge as work-group creators and leaders in open-source software communities tend to be people who have broad networks that reach into separate groups of potential participants. As Fleming and Waguespack found network brokers more likely to emerge as leaders, as Bavelas and Leavitt found brokers more likely to emerge as leaders in successful groups (Figure 2.6), I expect network brokers in Second Life to emerge as the creators and leaders of successful groups.

I measure such achievement in four ways: the number of groups a person founded (each group has a resident registered as its founder), whether the person’s groups are open to the public (versus invitation only), whether the person’s groups survive (groups with less than two members are deactivated by Linden Lab), and the extent to which the person is successful in crafting groups such that they attract a large number of members (as Soda et al., 2004, measure broker-predicted television show achievement by the number of people drawn to a television show). If network brokers inworld have the information advantages attributed to brokers in the real world, then the four inworld achievement indicators should increase with inworld access to structural holes.21

21 It would be attractive to distinguish theoretical dimensions of achievement with respect to founding groups inworld, as Kraut and Resnick (2011) define critical design issues in creating a thriving online community. Kraut and Resnick are concerned with online communities in general, but the issues they discuss apply to founding a thriving group in a virtual world like Second Life: founding on a topic with rich inventory of discussion content, attracting and socializing new members, encouraging commitment, encouraging contribution, and regulating behavior. These are all network issues addressed by the vitality of brokerage and the reputational governance of closure, all issues in which access to structural holes can be an advantage. For the purposes of this chapter, I group the indicators of founding successful groups as alternative measures of a general dimension of achievement.
That is what the first row of Table 3.6 shows. Multiple models are presented to show the brokerage association with achievement measured in different ways. In each model, the linear association with achievement in the first row is the first or second strongest effect (second only to the tendency for high achievers to have extensive experience inworld). The first three models in Table 3.6 predict action. The second three predict action success. The final model, Model 15, summarizes across the previous six models. The summary is a canonical correlation model in which the Table 3.6 predictors are used to predict a standardized linear composite of all six achievement indicators. There is one dimension of covariation between the predictors and achievement (.58 canonical correlation for Model 15 versus a next-strongest correlation of .14). The Model 15 canonical correlation variable constructed from the six achievement indicators is the summary achievement variable for Second Life in Figure 3.5.

The linear and dampening network effects displayed in Figure 3.5 are evident in the first two rows of Table 3.6. Network brokers are more likely to found a group (Model 9), to found a group open to the public (versus a closed group open by invitation only, Model 10), and to found a group that survives (Model 11). Network brokers founded a larger number of groups (Model 12), and a larger number of their groups survive (Model 13). These founder variables increase linearly with number of nonredundant friends, then slow when a person has too many disconnected friends. Figure 3.6B shows the zero-order associations. People quickly saw opportunities to found groups. The odds of founding increase sharply with a person’s initial handful of disconnected friends. Number of foundings, and number of founded groups still active at the time of the data download, show slower increases.

There is also an increasing positive effect of effective size. Once a group is founded, additional nonredundant friends beyond an initial core have an increasing positive association with group membership. The structural-holes effect is decreasing positive on successfully founding groups, but increasing positive on growing the groups founded. Figure 3.6C shows the zero-order association. Number of members increases slowly with the first few nonredundant friends, then increases more quickly.
Thus, there is a positive, rather than negative, effect in the second row for Model 14. Membership in a person’s most successful group is a good indicator of total membership in all the groups the person founded. The largest group a person founded contained about three fourths of the total membership in all her groups (74.6%) and the percentage does not vary with network brokerage (-.03 correlation between percent of members in ego’s largest group and the horizontal axis in Figure 3.6C). When I re-estimate Model 14 to predict total membership in all of a person’s founded groups, I get the same results reported for Model 14: a 42 t-test for the linear effect and a 47 t-test for a positive effect in the second row.

Model 15 is a summary canonical correlation model defined by the strongest network association with achievement, which is the five founding variables, so the summary association in Figure 3.5 shows increasing foundings through the first dozen nonredundant friends, followed by slower, then negative effects from additional nonredundant friends. Table 3.5 shows that the same results are obtained for the alternative network measures of access to structural holes: number of bridge relations, network betweenness, and network constraint.

The brokerage-achievement association does not depend on the inactivity of isolates, the many people who did not found any groups, nor extreme contributions from characters with the largest networks. First, “semi-isolate” in the third row of Table 3.6 has positive associations with achievement. Merely being a member of groups, even if no friendships were established in the groups, holds constant the tendency for such unfriended people to found groups. Beyond the control for semi-isolate, I estimated summary Model 15 excluding the five and a half million people who had no friends (first two rows in Table 3.3). The brokerage-achievement association is strong: 145 t-test for achievement increasing with nonredundant contacts, and -88 for the dampening effect of too many nonredundant contacts. When I re-estimate Model 15 excluding people who never founded groups, the two statistics are 29 and -18 respectively. When I re-estimate the model excluding people with the largest networks (24 or more nonredundant contacts), the test statistics are 384 and -112 respectively.
Controls

The brokerage-achievement association survives controls for kinds of people founding groups. Gender is a negligible factor. Men and women were equally likely to found successful groups. Older people were more likely to found groups, but age is a negligible factor in Table 3.6 relative to the network predictors. The summary achievement variable in Model 15 shows founders most likely to live in North America (.12 and .05 mean scores for the US and Canada respectively), next most likely in Western Europe (-.02 mean score for France, Germany, and the UK, -.05 for the rest of Western Europe), and least likely to live elsewhere (-.09 mean score for South America, -.06 for Asia, and -.09 for anywhere else). Dummy variables in Table 3.6 distinguish North America and Western Europe as regions more likely to contribute founders, but the regional controls are negligible relative to the network variables.

Tourist and personal experience are complementary strong controls. The tourist variable measures the probability that ego was about to exit the virtual world, given the number of days he had spent inworld, whether he was a kind of person prone to exit, and the state of the virtual world when he first entered. Tourists are unlikely to found groups, but the tourist variable only weakly predicts number of groups founded or members attracted (the last four columns in Table 3.6). Once a person founds a group, the founder is not a tourist, leaving the tourist control irrelevant to the number of groups founded or group members attracted. In complement, a person’s days of

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22 If the association with age had been stronger, I would have pursued a nonlinear association. In graphs of the founder variables across age, averages increase with age from year to year until the late 40s then start to decline. Reading across the columns of Table 3.6, age is positively correlated (up to age 50) with achievement, e.g., .98 with the probability of founding a group, .98 with the number of groups founded, and .94 with membership in the largest group founded. After age 50, the same correlations are negative (-.77, -.75, and -.42 respectively). Adding a nonlinear age effect to Table 3.6 does not improve the predictions. For example, adding age squared to Model 9 adds nothing to the prediction already made by the other controls (pseudo R^2 before and after adding age squared is .49). Adding age squared to Model 12 adds nothing (R^2 before and after is .25). The association with age is more subtle than the linear effect in Table 3.6, and substantial in age’s association with exit (see Table A8), but the linear effect in Table 3.6 is sufficient for age’s function as a control variable in the table.

23 Imputation provides tourist scores for 61,988 people missing from Table 3.6 (see footnote 2 in Appendix B). Re-estimating summary Model 15 with the imputed scores yields results almost identical to the ones presented (respectively, 446 and -204 t-tests for the first two rows). The stable results are reassuring, but imputation provides no advantages, so I only use complete observations in Table 3.6.
experience in Second Life strongly increases the likelihood of successfully founding groups, and attracting numerous members to the groups founded.

CONCLUSION

The results from Second Life and Everquest II (EQ2), consistent with network effects in the real world, lead me to conclude that it is reasonable to use the rich network data available in virtual worlds to better understand, and prepare people to engage, the networks that provide advantage in the real world. These are only two virtual worlds, but EQ2 is not untypical of fantasy worlds of creatures and quests, and Second Life is one of the largest open worlds, inhabited by diverse people doing a wide variety of things. Some readers deeply familiar with virtual worlds could find the conclusion obvious, but it is impossible to be sure without running the numbers. My purpose in this chapter has been to secure an evidence chain from brokerage and closure in virtual worlds back to the same mechanisms in real-world networks in real-world organizations. As expected from previous theory and research in the real world, relations embedded in closed networks inworld are more likely to be trusting relations (Figure 3.3). As expected from previous theory and research in the real world, network brokers inworld are more likely to show high achievement and emerge the leaders who provide social infrastructure that makes the virtual world valuable and attractive (Figure 3.5). Brokers reached higher levels of character development in EQ2 and were more likely to found groups in Second Life, groups more likely to survive and attract more people as members. Evidence of the closure-trust association and the brokerage-achievement association is robust to strong controls for context and kinds of people/avatars. Only limited control variables were available here, but they are controls one would like to see, and certain of them — particularly the experience of spending time inworld, social homophily, and the fleeting attachment of tourists — had strong associations with the trust and achievement variables. With the brokerage-closure evidence chain between real and virtual now in place, I feel secure drawing more detailed inferences from the rich data available in virtual worlds.
Three methodological issues came up in the analysis. Network data are readily available in virtual worlds such that it is easy to compute network metrics for large volumes of edge data without pausing to ask what the edges mean to the people connected by them. Software distinguishes categories of relations inworld, but the meaning of the relation categories depends on how people use them. Patterns in the use of inworld labels such as “friend,” “modify objects,” “trustee,” or “visitor” can be used to derive strength-of-connection scores for network analysis. Examples in this chapter are Second Life friendship (Figure A1 and Figure A4 in Appendix A), and EQ2 housing (Figure C1 in Appendix C). Second, time-stamped inworld activity makes it likely that network analysts will have to decide how to aggregate inworld activity recorded in physical time into socially meaningful relationships. Mentoring and exchanging goods in EQ2 are examples in this chapter (Table C4 and Figure C2 in Appendix C, Figure D1 in Appendix D). Third, social boundaries in virtual worlds are more porous than the usual organization boundaries used to define populations in real world studies of network advantage. Being able to distinguish tourists can be a useful control to seal the boundary around a study population. Second Life provides illustration in this paper (Table B2 and Table B3 in Appendix B). Virtual worlds are not unique on this issue. Tourist control variables should be useful in studies of porous populations in the real world, but virtual worlds — and online communities more generally — are especially likely to be porous populations in which people are free to enter and exit, slipping unnoticed across the boundary between real and virtual.

REFERENCES


Shen, Cuihua. 2010. The Patterns, Effects and Evolution of Player Social Networks in Online Gaming Communities. Doctoral Dissertation, School of Communication, University of Southern California.


Figure 3.1: Scenes in **Second Life**  
(February 2008, just after the data download)

- Attend a Meeting or Class
- Shop
- Wander the Earth
- Meet, Engage, and Exchange with Folks
Figure 3.2: EverQuest II Characters
(during the 2006 observation period, descriptions from EQ2.WIKIA.COM)

GOOD: Stout and strong, Dwarves are known for bravery and a sense of honor, though not particularly for their intellect. Mentally sharp and morally virtuous, Froglocks strive to eliminate villainy and corruption. Courageous Halflings are good-natured and friendly, known for their humor. High Elves embody nobility and wisdom, but their stoic nature can be mistaken for arrogance. Wood Elves are pleasant and friendly, but fierce protectors of the woodlands, battling any who would taint the purity of nature.

EVIL: Sinister, cunning, and dangerous, Dark Elves coolly prey on the weak and the ignorant. Calculating and cold, the Iksar are a harsh but disciplined people who delight in cruelty and conquest. Ogres are aggressive brutes whose physical might is matched only by their hunger for power. Ratongas are keenly perceptive and highly intelligent, but tend to be selfish and manipulative. Trolls care only about satisfying their hunger for food and lust for battle, making them fearsome and deadly opponents.

NEUTRAL: Hearty and strong, Barbarians are loyal companions and unforgiving enemies. Erudites eschew their human heritage, seeking arcane knowledge and mystical power. Gnomes make up for their small stature with tenacity and ingenuity. Descended from humans and elves, Half Elves are known for fierce determination and independence. Humans are diverse and adaptable, at once wise, foolish, and brutal. Worshiping spirits of the land, the Kerra’s docile manner can mask the fearsome predators that they are.
Figure 3.3
Closure-Trust Association in the Virtual Worlds

(Dots are average Y scores within intervals of X. Second Life trust is friendship rights granted to contact as predicted in Table 3.1 by Model 2. EQ2 trust is housing rights granted to contact as predicted in Table 3.2 by Model 4 for social relations and Model 5 for economic relations. Standard errors in parentheses are adjusted for autocorrelation between relations from same character using STATA “cluster” option.)
Figure 3.4
Network Closure and Trust

Trust is more likely within a relationship embedded in a closed network.

a Zero refers to a relationship with no mutual contacts in a network of multiple contacts.
b Zero refers to a relationship with no mutual contacts in a network of one contact.
Figure 3.5
Brokerage-Achievement Association in the Virtual Worlds

(Dots are average Y scores within intervals on horizontal axis. EQ2 achievement variable is the predicted character level in Model 8, Tables 3.4 and 3.5. Second Life achievement is the canonical correlation dependent variable in Model 15, Tables 3.5 and 3.6.)
Achievement increases with access to structural holes between nonredundant contacts. Graph A describes EverQuest 2 (EQ2), graphs B and C Second Life.

\(a\) Zero refers to isolates, people with no network as defined in text and no group/guild affiliations.

\(b\) Zero refers to people with no network, but affiliated with groups in Second Life or guilds in EQ2.

**Figure 3.6**

**Detail on Brokerage-Achievement**
<table>
<thead>
<tr>
<th>Closure Variables:</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Mutual Contacts</td>
<td>5.43 (119)</td>
<td>5.17 (104)</td>
</tr>
<tr>
<td>Number of Mutual Contacts Squared</td>
<td>-.29 (-67)</td>
<td>-.28 (-56)</td>
</tr>
<tr>
<td>One-Contact Network</td>
<td>1.40 (18)</td>
<td>2.81 (34)</td>
</tr>
<tr>
<td>Ego’s Network Size</td>
<td>-.13 (-33)</td>
<td>-.13 (-25)</td>
</tr>
<tr>
<td>Contact’s Network Size</td>
<td>.02 (68)</td>
<td>.03 (92)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Homophily Controls:</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ego’s Tourist Score</td>
<td></td>
<td>3.92 (13)</td>
</tr>
<tr>
<td>Friend’s Tourist Score</td>
<td>-9.47 (-33)</td>
<td></td>
</tr>
<tr>
<td>Tourist Dissimilarity ([ego – friend])</td>
<td>-6.24 (-20)</td>
<td></td>
</tr>
<tr>
<td>Ego Player Lives in North America</td>
<td>.60 (5)</td>
<td></td>
</tr>
<tr>
<td>Friend Player Lives in North America</td>
<td>.36 (5)</td>
<td></td>
</tr>
<tr>
<td>Same Geographic Region (five regions)</td>
<td>2.60 (40)</td>
<td></td>
</tr>
<tr>
<td>Ego Player’s Age (years)</td>
<td>.16 (35)</td>
<td></td>
</tr>
<tr>
<td>Friend Player’s Age (years)</td>
<td>.07 (25)</td>
<td></td>
</tr>
<tr>
<td>Age Difference ([ego – friend])</td>
<td>-.20 (-58)</td>
<td></td>
</tr>
<tr>
<td>Ego Player Is Female</td>
<td>4.62 (48)</td>
<td></td>
</tr>
<tr>
<td>Friend Player Is Female</td>
<td>-2.25 (-33)</td>
<td></td>
</tr>
<tr>
<td>Both Female</td>
<td>1.46 (13)</td>
<td></td>
</tr>
</tbody>
</table>

| Intercept [R²]                                   | 53.78 [.10] | 44.59 [.12] |

Note — These regression models predict 100 times the fractional trust variable in Figure A4 in Appendix A. Routine t-test statistics are in parentheses (with standard errors adjusted for correlation between friendships with the same ego resident using STATA’s “cluster” option). Model I is estimated from 2,218,770 relationships involving more than a weak tie (723,635 clusters). Model 2 is estimated from 1,755,736 of those relations (the ones on which complete ego and friend attribute data are available, 655,596 clusters).
### Table 3.2 — Closure-Trust Association in EQ2

<table>
<thead>
<tr>
<th></th>
<th>Model 3 (social)</th>
<th>Model 4 (social)</th>
<th>Model 5 (econ)</th>
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<tbody>
<tr>
<td><strong>Closure Variables:</strong></td>
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<tr>
<td>Number of Mutual Contacts</td>
<td>5.82 (30)</td>
<td>5.23 (30)</td>
<td>1.31 (20)</td>
</tr>
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<td>Number of Mutual Contacts Squared</td>
<td>-.30 (-18)</td>
<td>-.29 (-19)</td>
<td>-.06 (-11)</td>
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<tr>
<td>One-Contact Network</td>
<td>42.86 (78)</td>
<td>35.01 (48)</td>
<td>-.20 (0)</td>
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<td>Ego’s Network Size</td>
<td>.05 (2)</td>
<td>.10 (4)</td>
<td>-.03 (-11)</td>
</tr>
<tr>
<td>Contact’s Network Size</td>
<td>-.13 (-22)</td>
<td>-.03 (-7)</td>
<td>-.03 (-21)</td>
</tr>
<tr>
<td><strong>Homophily Controls:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characters Played by Same Person</td>
<td>34.24 (72)</td>
<td>12.62 (4)</td>
<td></td>
</tr>
<tr>
<td>Ego Player Lives in Confederate South</td>
<td>-.14 (0)</td>
<td>-.15 (-1)</td>
<td></td>
</tr>
<tr>
<td>Contact Player Lives in Confederate South</td>
<td>-.25 (-1)</td>
<td>-.15 (-1)</td>
<td></td>
</tr>
<tr>
<td>Same Geographic Region (eight regions)</td>
<td>6.12 (29)</td>
<td>4.41 (28)</td>
<td></td>
</tr>
<tr>
<td>Ego Player’s Age (years)</td>
<td>.04 (3)</td>
<td>.04 (5)</td>
<td></td>
</tr>
<tr>
<td>Contact Player’s Age (years)</td>
<td>.04 (4)</td>
<td>.04 (7)</td>
<td></td>
</tr>
<tr>
<td>Age Difference (</td>
<td>ego – contact</td>
<td>)</td>
<td>-.15 (-13)</td>
</tr>
<tr>
<td>Ego Player Is Female</td>
<td>3.95 (11)</td>
<td>3.38 (13)</td>
<td></td>
</tr>
<tr>
<td>Contact Player Is Female</td>
<td>4.13 (18)</td>
<td>3.38 (18)</td>
<td></td>
</tr>
<tr>
<td>Both Female</td>
<td>-4.51 (-8)</td>
<td>-.96 (-2)</td>
<td></td>
</tr>
<tr>
<td>Ego Character Race is “Good” (see Figure 3.2)</td>
<td>.95 (3)</td>
<td>.23 (1)</td>
<td></td>
</tr>
<tr>
<td>Contact Character Race is “Good”</td>
<td>.93 (7)</td>
<td>.23 (2)</td>
<td></td>
</tr>
<tr>
<td>Characters Are Same Race</td>
<td>3.53 (15)</td>
<td>2.39 (12)</td>
<td></td>
</tr>
</tbody>
</table>

Note — These regression models predict 100 times the fractional trust variable in Figure C1 in Appendix C. Routine t-test statistics are in parentheses (with standard errors adjusted for correlation between friendships with the same ego character using STATA’s “cluster” option). Mutual contacts can be by housing, direct mentoring, or joint mentoring. Model 3 is estimated from 336,150 social relations (26,442 clusters). Model 4 is estimated from 216,677 of those relations on which complete attribute data are available (16,548 clusters). Model 5 is estimated from 199,118 economic relations on which complete attribute data are available (17,335 clusters).
Table 3.3 — Nonredundant Contacts Indicate a Network that Bridges Structural Holes

<table>
<thead>
<tr>
<th>Effective Size (Number of Nonredundant Friends)</th>
<th>(N)</th>
<th>Network Size</th>
<th>Bridge Relations</th>
<th>Network Betweenness</th>
<th>Network Constraint (x 100)</th>
<th>Groups</th>
</tr>
</thead>
<tbody>
<tr>
<td>None (no groups)</td>
<td>5,091,995</td>
<td>Min</td>
<td>Mean</td>
<td>Max</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>None (in groups)</td>
<td>576,193</td>
<td>0</td>
<td>0.00</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>One</td>
<td>457,651</td>
<td>1</td>
<td>1.14</td>
<td>33</td>
<td>2.48</td>
<td>.06</td>
</tr>
<tr>
<td>Two</td>
<td>110,259</td>
<td>2</td>
<td>2.30</td>
<td>33</td>
<td>1.78</td>
<td>1.32</td>
</tr>
<tr>
<td>Three</td>
<td>48,318</td>
<td>3</td>
<td>3.52</td>
<td>34</td>
<td>2.50</td>
<td>3.78</td>
</tr>
<tr>
<td>Four</td>
<td>26,716</td>
<td>4</td>
<td>4.68</td>
<td>35</td>
<td>3.20</td>
<td>7.38</td>
</tr>
<tr>
<td>Five</td>
<td>17,188</td>
<td>5</td>
<td>5.89</td>
<td>33</td>
<td>3.75</td>
<td>12.15</td>
</tr>
<tr>
<td>Six</td>
<td>11,665</td>
<td>6</td>
<td>7.02</td>
<td>36</td>
<td>4.34</td>
<td>17.90</td>
</tr>
<tr>
<td>Seven - Eight</td>
<td>15,369</td>
<td>7</td>
<td>8.62</td>
<td>35</td>
<td>5.03</td>
<td>27.99</td>
</tr>
<tr>
<td>Nine - Eleven</td>
<td>12,594</td>
<td>9</td>
<td>11.27</td>
<td>41</td>
<td>6.16</td>
<td>49.54</td>
</tr>
<tr>
<td>Twelve - Sixteen</td>
<td>10,107</td>
<td>12</td>
<td>15.34</td>
<td>48</td>
<td>7.73</td>
<td>95.05</td>
</tr>
<tr>
<td>Seventeen or More</td>
<td>13,768</td>
<td>17</td>
<td>38.87</td>
<td>846</td>
<td>16.93</td>
<td>1152.80</td>
</tr>
<tr>
<td>TOTAL</td>
<td>6,391,823</td>
<td>0</td>
<td>3.07</td>
<td>846</td>
<td>2.93</td>
<td>26.06</td>
</tr>
</tbody>
</table>

Note — These results are from Second Life. The last four columns are mean scores within rows. Means in the TOTAL row exclude isolates. Ego’s redundant friends are friends to each other. Size excluding weak ties is a count of anyone with whom ego shared more than “inworld” friendship. A bridge is a friendship in which ego and a contact have no mutual friends beyond weak ties. Network betweenness is the number of pairs of friends between whom ego is the only connection (within ego’s network). Network constraint is a concentration index varying from zero to 100 with the extent to which ego’s network time and energy is concentrated in a single group.
### Table 3.4 — Brokerage-Achievement Association in EQ2

<table>
<thead>
<tr>
<th></th>
<th>Models 6</th>
<th></th>
<th>Models 7</th>
<th></th>
<th>Models 8</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Social</td>
<td>Economic</td>
<td>Social</td>
<td>Economic</td>
<td>Social</td>
<td>Economic</td>
</tr>
<tr>
<td>Effective Size</td>
<td>2.13 (47)</td>
<td>2.04 (47)</td>
<td>1.17 (15)</td>
<td>1.63 (21)</td>
<td>2.66 (41)</td>
<td>2.73 (41)</td>
</tr>
<tr>
<td>Effective Size Squared</td>
<td>-.05 (-31)</td>
<td>-.04 (-22)</td>
<td>-.02 (-9)</td>
<td>-.03 (-10)</td>
<td>-.07 (-29)</td>
<td>-.06 (-25)</td>
</tr>
<tr>
<td>Semi-Isolated</td>
<td>5.34 (9)</td>
<td>7.60 (13)</td>
<td>-3.30 (-2)</td>
<td>1.87 (1)</td>
<td>9.52 (4)</td>
<td>13.74 (6)</td>
</tr>
<tr>
<td>Character Experience (days inworld)</td>
<td>.12 (20)</td>
<td>.07 (12)</td>
<td>.11 (10)</td>
<td>.07 (7)</td>
<td>.20 (20)</td>
<td>.15 (16)</td>
</tr>
<tr>
<td>Percent Player Time in This Character</td>
<td>.24 (48)</td>
<td>.22 (48)</td>
<td>.11 (9)</td>
<td>.08 (7)</td>
<td>.05 (5)</td>
<td>.02 (3)</td>
</tr>
<tr>
<td>Player Experience (days inworld)</td>
<td>.04 (17)</td>
<td>.03 (16)</td>
<td>.03 (4)</td>
<td>.02 (3)</td>
<td>.01 (1)</td>
<td>.00 (0)</td>
</tr>
<tr>
<td>Log Number of Characters played</td>
<td>1.33 (7)</td>
<td>.92 (5)</td>
<td>2.32 (8)</td>
<td>1.29 (5)</td>
<td>3.58 (15)</td>
<td>3.00 (13)</td>
</tr>
<tr>
<td>Player Lives in America</td>
<td>-1.64 (-5)</td>
<td>-1.31 (-5)</td>
<td>-2.31 (-5)</td>
<td>-1.82 (-5)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Player Age (decades)</td>
<td>.01 (1)</td>
<td>.08 (7)</td>
<td>.02 (1)</td>
<td>.10 (6)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Player is Female</td>
<td>-3.59 (-12)</td>
<td>-2.41 (-9)</td>
<td>-3.09 (-7)</td>
<td>-1.57 (-4)</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Intercept</td>
<td>13.46</td>
<td>10.17</td>
<td>27.63</td>
<td>23.85</td>
<td>16.66</td>
<td>15.77</td>
</tr>
<tr>
<td>R²</td>
<td>.67</td>
<td>.71</td>
<td>.41</td>
<td>.54</td>
<td>.58</td>
<td>.63</td>
</tr>
<tr>
<td>Observations</td>
<td>21,536</td>
<td>21,536</td>
<td>6,258</td>
<td>6,258</td>
<td>11,029</td>
<td>11,029</td>
</tr>
</tbody>
</table>

Note — These are OLS regressions predicting character level at the end of the observation period (t-test statistics in parentheses). “Social” is a model in which prediction is based on a character’s social contacts, versus “Economic” in which prediction is based on a character’s economic contacts. Models 6 are estimated with standard errors adjusted for correlation between characters played by the same person (STATA “cluster” option). Models 7 and 8 are estimated excluding all but each player’s primary character. Models 7 and 8 are the same except that self-reported player demographics are deleted in Models 8 (region, age, and gender). Character experience is number of 24-hour periods a person has spent playing this character. Player experience is 24-hour periods the person has spent playing any character in EQ2. Semi-isolated is a character with no social or economic contacts, but in a guild.
## Table 3.5
Similar Results with Other Broker Metrics

<table>
<thead>
<tr>
<th></th>
<th>Social</th>
<th>Economic</th>
<th>Social</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EverQuest II</td>
<td></td>
<td>Second Life</td>
</tr>
<tr>
<td></td>
<td>(n = 11,029)</td>
<td></td>
<td>(n = 5,631,917)</td>
</tr>
<tr>
<td>Number of Bridge Relations</td>
<td>2.37 (40)</td>
<td>1.56 (46)</td>
<td>.0684 (250)</td>
</tr>
<tr>
<td>Bridges Squared</td>
<td>-.04 (-19)</td>
<td>-.02 (-28)</td>
<td>-.0004 (-133)</td>
</tr>
<tr>
<td>Network Betweenness</td>
<td>.55 (36)</td>
<td>.77 (46)</td>
<td>.0352 (239)</td>
</tr>
<tr>
<td>Betweenness Squared</td>
<td>-.01 (-28)</td>
<td>-.01 (-42)</td>
<td>-.0003 (-185)</td>
</tr>
<tr>
<td>Log Network Constraint</td>
<td>-7.32 (-36)</td>
<td>-9.13 (-48)</td>
<td>-.7889 (-481)</td>
</tr>
</tbody>
</table>

Note — The results are an OLS regression coefficient and its routine t-test statistic in parentheses. The EQ2 results are for Model 8 when the row network index here is used in place of the “number of nonredundant contacts” index in Table 3.4. “Betweenness” is divided by its maximum for each network and multiplied by 100 to vary from zero (no access to holes) up to 100 (all of ego’s relations provide monopoly access to holes). The “Social” column contains results obtained with the row index computed from social relations, versus “Economic” for the row index computed from economic relations. The Second Life results are for Model 15 when the row network index here is used in place of the “number of nonredundant contacts” index in Table 3.6. A summary canonical correlation achievement variable is constructed for each of the three estimations in Second Life. The canonical correlations are .55, .57, and .57 respectively for number of bridge relations, network betweenness, and log network constraint (which are about the same as the .57 canonical correlation for nonredundant contacts in Table 3.6).
## Table 3.6 — Brokerage-Achievement Association in Second Life

<table>
<thead>
<tr>
<th></th>
<th>Model 9 Founded a Group</th>
<th>Model 10 Founded an Open Group</th>
<th>Model 11 Any Still Current</th>
<th>Model 12 # Groups Founded</th>
<th>Model 13 # Groups Still Current</th>
<th>Model 14 Size Largest Group</th>
<th>Model 15 Z-Score Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective Size</td>
<td>.45</td>
<td>.43</td>
<td>.50</td>
<td>.05</td>
<td>.05</td>
<td>.54</td>
<td>.24</td>
</tr>
<tr>
<td></td>
<td>(1712)</td>
<td>(132)</td>
<td>(183)</td>
<td>(197)</td>
<td>(299)</td>
<td>(49)</td>
<td>(442)</td>
</tr>
<tr>
<td>Effective Size Squared</td>
<td>-0.02</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.0005</td>
<td>-0.0005</td>
<td>.02</td>
<td>-.01</td>
</tr>
<tr>
<td></td>
<td>(-127)</td>
<td>(-98)</td>
<td>(-139)</td>
<td>(-36)</td>
<td>(-66)</td>
<td>(34)</td>
<td>(-207)</td>
</tr>
<tr>
<td>Semi-Isolated</td>
<td>.58</td>
<td>.52</td>
<td>.50</td>
<td>.02</td>
<td>.01</td>
<td>.11</td>
<td>.10</td>
</tr>
<tr>
<td></td>
<td>(53)</td>
<td>(28)</td>
<td>(37)</td>
<td>(28)</td>
<td>(35)</td>
<td>(5)</td>
<td>(85)</td>
</tr>
<tr>
<td>North American</td>
<td>.96</td>
<td>.61</td>
<td>.61</td>
<td>.02</td>
<td>.01</td>
<td>-.04</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>(754)</td>
<td>(31)</td>
<td>(42)</td>
<td>(50)</td>
<td>(27)</td>
<td>(-2)</td>
<td>(82)</td>
</tr>
<tr>
<td>Western European</td>
<td>.28</td>
<td>.27</td>
<td>.20</td>
<td>.002</td>
<td>.001</td>
<td>.02</td>
<td>.01</td>
</tr>
<tr>
<td></td>
<td>(21)</td>
<td>(14)</td>
<td>(14)</td>
<td>(6)</td>
<td>(5)</td>
<td>(1)</td>
<td>(9)</td>
</tr>
<tr>
<td>Age (decades)</td>
<td>-0.14</td>
<td>-0.19</td>
<td>-0.13</td>
<td>-0.001</td>
<td>0.001</td>
<td>-0.01</td>
<td>0.004</td>
</tr>
<tr>
<td></td>
<td>(-33)</td>
<td>(-29)</td>
<td>(-28)</td>
<td>(-8)</td>
<td>(9)</td>
<td>(-2)</td>
<td>(12)</td>
</tr>
<tr>
<td>Female</td>
<td>-0.30</td>
<td>-0.36</td>
<td>-0.34</td>
<td>-0.015</td>
<td>-0.01</td>
<td>-0.23</td>
<td>-0.03</td>
</tr>
<tr>
<td></td>
<td>(-34)</td>
<td>(-26)</td>
<td>(-40)</td>
<td>(-43)</td>
<td>(-15)</td>
<td>(-15)</td>
<td>(-44)</td>
</tr>
<tr>
<td>Tourist (Appendix B)</td>
<td>-84.67</td>
<td>-89.08</td>
<td>-103.28</td>
<td>0.01</td>
<td>0.01</td>
<td>0.28</td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td>(-113)</td>
<td>(-73)</td>
<td>(-102)</td>
<td>(19)</td>
<td>(35)</td>
<td>(11)</td>
<td>(4)</td>
</tr>
<tr>
<td>Experience (hours inworld)</td>
<td>.11</td>
<td>0.04</td>
<td>0.08</td>
<td>0.05</td>
<td>0.02</td>
<td>0.56</td>
<td>0.11</td>
</tr>
<tr>
<td></td>
<td>(189)</td>
<td>(75)</td>
<td>(150)</td>
<td>(903)</td>
<td>(728)</td>
<td>(237)</td>
<td>(957)</td>
</tr>
<tr>
<td>Entered during Pre-Launch</td>
<td>1.09</td>
<td>0.83</td>
<td>0.02</td>
<td>0.05</td>
<td>-0.001</td>
<td>0.262</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td>(12)</td>
<td>(6)</td>
<td>(0)</td>
<td>(12)</td>
<td>(-0)</td>
<td>(1)</td>
<td>(10)</td>
</tr>
<tr>
<td>Intercept</td>
<td>-3.02</td>
<td>-3.61</td>
<td>-3.03</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.01</td>
<td>-0.16</td>
</tr>
<tr>
<td>R²</td>
<td>.49</td>
<td>.38</td>
<td>.49</td>
<td>.25</td>
<td>.21</td>
<td>.03</td>
<td>.33</td>
</tr>
</tbody>
</table>

Note — First three columns are logit models (pseudo R² in bottom row). The next three columns are OLS regressions. Model 15 is a canonical correlation model predicting the six achievement variables (R² is squared canonical correlation, canonical z-score achievement is plotted in Figure 3.5). Routine test statistics are reported in parentheses (n = 5,631,917). Semi-isolated is a player with no friends, but in a group.