Virtual Worlds as Laboratories

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Abstract

A virtual world is a persistent space where tens, hundreds, thousands, or even millions of users interact with each other and a mediated environment defined as a physical space through rules created by designers and enforced by computer code. Researchers have argued that these characteristics make virtual worlds particularly well suited for conducting parallel experiments to test macro-level social theory. The purpose of this essay is to provide an introduction into virtual worlds research. It is not an exhaustive resource chronicling the history of virtual worlds, but rather an introduction broken into three sections for those wishing to learn more about the past, present, and future directions of the topic. First, it explores what researchers have said about using virtual worlds research and the fields of research where virtual worlds have been used. In doing so, it focuses on research in video games studies and complex systems. Second, it examines cutting-edge work in virtual worlds research, identifying that both academia and the game industry will play a significant role in the success and direction. Third, it identifies six key issues that scholars using virtual worlds research will face as they move forward.

INTRODUCTION

Over the last decade, social scientists have expressed interest in using virtual worlds to study the societies of the real world. The argument follows that virtual worlds can track user behavior in a database, that virtual worlds can be experimentally manipulated and run in parallel for controlled experimentation, and that virtual worlds are inhabited by societies of users. These societies are of interest to researchers because they feature project-based teams, corporations, governments, and economies. In other words, virtual worlds have the same complex social arrangements that you find in the real world, and they afford researchers powerful tools for conducting research.

But what is a virtual world? Bartle (2004), who constructed the first virtual world with Roy Trubshaw, defines one as a persistent online space with physical rules that is shared by many players who can interact with the world and each other. When he adopted this definition, he was comparing massive multiplayer online games such as *Everquest*, *Ultima Online*, *Linage*, and *Multiuser*

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Dungeon to local multiplayer games such as *Half-life, Quake,* and *Mario Kart.* At that time, it was easy to segment environments that were virtual worlds from those that were not. There were some hybrids, such as *Diablo 2,* but they numbered few.

Ask for an example of a virtual world now and the answer might be *World of Warcraft*, *EVE Online*, *Second Life*, *Minecraft*, *Modern Warfare*, *Parallel Kingdoms*, or *League of Legends.* The point being, there are now many online spaces that are clearly virtual worlds (*World of Warcraft*, *EVE Online,* or *Second Life*) and there are also many online spaces that straddle the boundary (*Modern Warfare, Diablo 3, Minecraft*, or *League of Legends)*. Virtual worlds are now more difficult to delineate from nonvirtual worlds. They contain elements that are both persistent and nonpersistent, have a few players upward to millions of players, and have rules that bridge the virtual and the real.

In order to focus on the virtual worlds that have interested social scientists over the last few decades, it is important to have a working definition that limits scope. Environments that fall out of this definition are still interesting and share properties with virtual worlds, some more so than others, but when scholars discuss virtual world experiments, they always possess the following four characteristics:

Virtual Worlds are Persistent and Multiplayer. They are inhabited by a group of users and information about those users continues to exist in a database when those users are not present.

Virtual Worlds Incorporate Space. Whether one-, two-, or three-dimensional users of virtual worlds interact in a digital representation of a physical space. Fantasy football does not have a physical space. *Second Life* does.

Virtual Worlds are Designed. A user can interact with a virtual world through an interface that is defined by rules created by a designer or engineer.

The Rules of a Virtual World are Enforced by Computer Code. What separates a virtual world from a sports league, the television show *Survivor*, or The Stanford Prison Experiment is that they instantiated and enforced by a computer.

Putting all three together into one definition: A virtual world is a persistent space where tens, hundreds, thousands, or even millions of users interact with each other and a mediated environment defined as a physical space through rules created by designers and enforced by computer code.

Each of these characteristics makes a virtual world a valuable tool for studying human society. A persistent world uses a database. The behaviors of every user in the world can be tracked and stored. Using the appropriate tools for analysis and visualization, a researcher can ask questions about individuals, groups segmented by variables of interest, or the entire population. By designing the rules and the physical space, a research can craft an environment that is balanced between abstraction and replication of the real world for the specific question of interest. Finally, computer code allows a virtual world to be tinkered with and copied. The experimental method requires running at least two identical environments in parallel while manipulating only the variable of interest. Virtual worlds are suited for experiments and scholars have compared them to Petri dishes or neighboring island nations (Bradley & Froomkin, 2004; Castronova, 2006). In these examples, each world is constructed with the same rules except for a change in a variable of interest. It is then populated with a random sample of users and the society is tracked over time. If behavior in virtual worlds truly parallels behavior in the real world, then they present a powerful way to study society. It is no wonder that virtual world research has generated interest in fields such as public health, economics, communication, complex systems, law, and public policy.

Like the ghosts of *A Christmas Carol*, this essay explores the past, present, and future of virtual worlds research. The section titled "Foundational Research" introduces the past and explores the foundational research for experimentation with virtual worlds. It shows that researchers working in complex systems, simulation, and agent-based modeling were actually the first to consider the use of virtual worlds for social experimentation. However, it was the video game industry and video game scholars made it possible to conduct experiments with real human beings. The section titled "Cutting-Edge Work" focuses on the present. It explores cutting-edge research in both academia and the game industry, and it introduces studies and tools that will shape the future of virtual worlds research. The section titled "Key Issues" focuses on the key issues moving forward and identifies six issues that researchers crafting virtual worlds for social science research will have to address moving forward.

FOUNDATIONAL RESEARCH

In the early 2000s (decade), researchers studying games and media identified that virtual worlds offered a unique opportunity for conducting controlled experiments on human societies and social groups. They recognized that virtual worlds were designed and instantiated through computer code and that a scientist could manipulate the code to study social behavior in a series of parallel experiments. This was the first time that virtual worlds from the entertainment industry were identified as tools for social scientific research, but it was not the first time that virtual worlds had been used to study social behavior. It is the field of complex systems holds that distinction.

Complex systems are nonlinear systems composed of simpler interworking parts. Ecosystems, beehives, brains, and governments are all complex systems. Each is a collection of individual organisms, bees, neurons, or people interacting to produce emergent behavior. The origins of complex systems research can be traced back a few hundred years to Darwin and Adam Smith, whose theories demonstrate that complexity can arise from a few simple rules. Much of this early work relied on a top-down approach and used the scientific paradigm of reductionism to examine the individual components of the system. This approach, however, was met with limited success because it is difficult to understand the behavior of a beehive by studying the behavior of a single bee. A bottom-up approach was required, but it was not until the creation of the modern computer that scientists were able to build virtual worlds, populate them with autonomous agents, and test hypothesis about the system as a whole, a technique known as *agent-based modeling*.

Perhaps the best-known early work in the agent-based modeling comes from Conway (1970) whose *Game of Life* spawned a variety of "life-like" agents in a virtual world with a few simple behavioral rules. Other early work includes Schelling's agent-based models of segregation, which show how a simple rule regarding tolerance to diversity can lead to highly segregated communities, and Axelrod's (1987) famous evolutionary tournament designed to test the evolutionary success of cooperative and selfish agents playing a repeated *prisoners' dilemma*. From this groundbreaking work, an entire field has emerged. It uses virtual worlds to study complex systems such as food chains, traffic patterns, flocking, local economies, and information transmission.

Although scholars studying virtual worlds for entertainment rarely mention it, research in the field of complex systems and agent-based modeling is important, and the two fields are likely to intersect. As Section titled "Key Issues" of this essay will show, researchers in complex systems have identified and are currently tackling some of the most important obstacles for the study of human society using virtual worlds. That said, there is one important distinction between the two fields. Virtual worlds research proposes using real human societies in virtual worlds to study social behavior, while agent-based modeling uses computerized agents driven by simple rules. Agent-based models have their advantages. They can run iterations of a complex system and examine the behavior of agents across millions of rounds or generations in a manner of seconds. They also have a weakness. The predictions of the model are based on simple agents, not real humans.

The foundational research for using virtual worlds with real human beings as laboratories for social scientific research is largely theoretical and philosophical in nature. Massive multiplayer online virtual worlds have existed since the late 1970s, but the potential of virtual worlds for social research did not become apparent until Castronova (2001, 2003) demonstrated, through the use of econometrics, that virtual economies were similar and connected to the real economy. Afterward, Bradley and Froomkin (2004) picked up on this work and were the first to identify that virtual worlds, with their real economies, were well suited to operate as a test bed for law and policy, especially when the law or policy was too risky or intractable for experimentation in the real world. In 2006, Castronova (2006) performed a case study on two natural experiments that tested game theoretic coordination problems in the online role-playing games *Dark Age of Camelot* and *Everquest*. Since then, Castronova's research has stressed the importance of developing virtual worlds as a scientific apparatus for conducting experiments on societies. He has stated many times that policymakers should invest in virtual worlds as they do in supercolliders, satellites, or other high-tech research tools (Castronova & Falk, 2009; Castronova, Bell, *et al.*, 2008; 2009; Ross, Castronova, & Wagner, 2012).

One of the more famous instances where researchers recognized the power of virtual world research happened by accident. It was triggered by a glitch known as *the Corrupted Blood incident*, which acted like a real virus, spreading through the game *World of Warcraft* killing thousands of players. Citing the glitch as an example, Balicer (2007) proposed that data from virtual worlds could be used to model the spread of infectious disease, and shortly after, Lofgren and Fefferman (2007) demonstrated that the Corrupted Blood incident shared many of the characteristics of real-world epidemics. Later that year, the potential of virtual worlds reached a wider scientific community when Bainbridge (Bainbridge, 2007) published an article in the journal *Science* detailing the work of scholars thus far and championing virtual worlds as the future of social science experimentation.

Most of the foundational research regarding the use of synthetic worlds to study social science has been philosophical in nature; however, there were a few attempts in the early 2000s (decade) to build virtual worlds for researcher purposes. In 2005, Castronova led a team of researchers and developers on a project named *Arden*, a virtual world based on the works of William Shakespeare. According to Castronova *et al.* (2008), *Arden* had two goals, to educate players by immersing them in the work of William Shakespeare and to provide a platform for cross-server economic experimentation. By late 2006, it was apparent that *Arden* would not meet its ambitious long-term goals, so the project was scaled back and Castronova acknowledge that the failure of Arden might serve as a warning of the difficulties of virtual world research (Baker, 2008; Castronova, Cummings, *et al.*, 2009).

In 2008, following his work on *Arden*, Castronova, Ross, and a team of researchers began work on a web-based virtual world named *Greenland* (Ross, 2009). Once again the goal was macroeconomic experimentation, this time specifically focused on the emergence of currency. Construction of the world was completed in January 2009, and a pretest was conducted with 700 participants and 5 servers. Although the game maintained an active player base for 2 months, the targeted economic theories were never tested. Once again the experiment was considered unsuccessful as unexpected expansion and warfare in the game disrupted economic activity (Ross, 2009; Ross & Cornell, 2010).

The most successful examples of research involving online societies can be found in the field of complex systems. In 2006, Salganik, Dodds, and Watts (2006) constructed parallel instances of a music sharing website where they tested social learning theory by comparing the influence of song popularity and song rating on the number of downloads. Although this experiment did not use a virtual world as defined here, it was groundbreaking because it provided a successful example of how to test a hypothesis about macro-level social behavior in parallel online experiments.

Due to the difficulties of virtual world experiments, some researchers have turned to using the large datasets of existing virtual worlds as a basis for comparing real-world behavior to virtual behavior. In 2006, Ducheneaut, Yee, Nickell, and Moore (2006) collected information about the players of *World of Warcraft* using autonomous bots and examined how the design of *World of Warcraft* motivated the behavior of players and social groups. In 2009, another group of researchers started The Virtual World Observatory, which is a multiuniversity research group created to study social behavior using large datasets from popular virtual worlds. The group has published a considerable amount of research, with much of it based on findings generated using a four-terabyte dataset from the virtual world *Everquest* (Virtual Worlds Observatory, n.d.). In addition to performing research, the group also tackled some of the major organizational and access problems that researchers must face when attempting to store and analyze large amounts of data from virtual worlds (Williams, 2010a).

CUTTING-EDGE WORK

Over the past 5 years, some of the momentum behind using industry grade virtual worlds as experimental environments has abated, as a number of projects have demonstrated that building games and virtual worlds for scientific experiments is a considerable challenge. Yet, the momentum continues in two directions. First, the video game industry is interested in the using social science theory, experimentation, and analytics for understanding, predicting, and shaping the behavior of players in online games. Second, academics have scaled back virtual worlds research. Instead of trying to build industry grade worlds populated by thousands of people, they are now using simpler virtual worlds to study the dynamics of small groups.

The most powerful tools for testing macro-level social theory now exist in the game industry. Due to this phenomenon, Castronova, Ross, and Knowels (2013) argue that over the coming decades the major advances in social science will be made by game designers tinkering with online societies and not social scientists in universities. The move toward advanced tools for behavior tracking, analytics, and visualization in the game industry has been swift. Over the past 5 years, companies such as Zynga, Bioware, Electronic Arts, Activision/Blizzard, Riot Games, Valve Software, and CCP Games have gone from having almost no capabilities for analytics to possessing the most advanced tools for studying societies ever created. The Game Developers Conference, the premier forum for discussing the development of games, now regularly features discussions about the best practices for studying, creating, and maintaining economies and social institutions in virtual worlds. Many social scientists also been pulled into this work, as Valve Software, CCP Games, Disney/Playdom, and Riot Games have all recently hired social scientists to conduct research and design online societies.

While the game industry has scaled up the practice of virtual worlds research, researchers in academia have scaled back. Currently, the most successful examples in academia come from researchers using virtual worlds to study small groups on a short-time scale. For example, Dabbish, Kraut, and Patton (2012) recently installed *World of Warcraft* on a private server and used it to study behavior in groups of 5–25 players. Team members of *The Augur Project* at the Carnegie Mellon ETC have used *Amazon's Mechanical Turk* in combination with three of game-like prototypes to study and build predicative models of player behavior (Augur, 2013). Wisdom and Goldstone (2010) recently created a small-scale asynchronous virtual world based around a puzzle game. It allowed players to see information about what past players had done and was used to test social learning theory. In complex systems, Mason and Watts (2012) conducted a series of experiments with simple web-based games to study collaborative problem solving in groups, and Centola (2010) examined how social networks influence the exchange of health information by experimenting with parallel interactive websites. These examples do not exhaust the current research, but they do serve to demonstrate the direction of virtual worlds research in academia.

Finally, researchers continue to work with large-scale datasets. Szell, Lambiotte, and Thurner (2010) examined the structure of social networks in the game *Pardus*, a virtual world claiming over 100,000 active users. While Williams and others have begun to explore the link between behavior and motivation, using surveys linked to behavioral data in virtual worlds such as *League of Legends* and *Everquest 2* (Virtual Worlds Observatory, n.d.), Williams's work has also moved him into the game industry. He recently stared the company *Ninja Metrics* to provide social network analysis and machine learning to game companies (Ninja Metrics, n.d.).

KEY ISSUES

Virtual worlds present an exciting opportunity for researchers looking to study social systems, but the research will require overcoming some key issues. This section identifies the main issues facing researchers studying social systems in virtual worlds. They are *the mapping principle, big data, the attention economy, player synchronization, connecting to mental states, and complex and chaotic systems.*

The Mapping Principle

Williams (2010b) coined "the mapping principle" as a problem for researchers wanting to study virtual worlds. In his article, he argues that using virtual worlds for research is a good idea, but that researchers wishing to pursue it must understand the similarities and differences between real and virtual behavior. Virtual worlds are abstractions of the real world, and thus behavior does not always match one to one. The researchers who aimed to study the spread of epidemics using the Corrupted Blood incident in *World of Warcraft* encountered the mapping principle first hand. They witnessed infected individuals trying to infect others because it was funny or dying was of little consequence.

The mapping principle is not entirely a new problem for experimentalists and follows closely to the problem of maintaining ecological or external validity. When experimental researchers create controlled environments for the study of real-world decision-making, they make choices about abstraction and how costs and incentives match those of the real world. Maintaining external validity can be difficult in even simple experiments. The complexity of virtual worlds and the game design decisions that go into them make constructing virtual worlds for targeted experimentation even more of a challenge (Ross & Cornell, 2010).

Big Data

Another problem that researchers studying virtual worlds must face is storing and analyzing the large, and growing, behavioral datasets of virtual worlds. Storage space is becoming less expensive and storing terabytes of data is no longer a major concern. What is of concern for researchers are the methods for accessing, analyzing, visualizing, and interpreting this data. As the social sciences continue to harness the powers of big data and computation, it is becoming apparent that scholars in the social sciences and the humanities must work more closely with researchers, such as computer scientists, familiar with the techniques and methods required to harness big data.

Attention Economy

Human beings have limited attention. In our mediated world, attention is a valuable commodity and there are millions of experiences competing for this valuable resource, creating what has been termed an *attention economy* (Simon, 1996). Researchers who wish to use virtual worlds for studying social systems will have to compete for attention. Currently, if a scientist needs a few hundred participants to come into the lab for an hour, they attract them with extra credit or money. Depending on the question, a scientist using a virtual world may need more than a few hundred participants and may also need them for a long period of time. A number of research projects have used *Amazon's Mechanical Turk* to attract a few thousand participants and independent research has validated the results of participants using the service (Mason & Suri, 2010). *Mechanical Turk* may present one low-cost method for attracting players, but researchers wishing to attract players without paying them must figure out how to create engaging experiences that can attract the attention of users and maintain ecological validity.

Player Synchronization

The most interesting questions that can be asked using virtual worlds involve societies interacting over time. This presents a coordination problem for any researcher asking these questions using a virtual world because players must all be present in the world at the same time in order to interact with each other. To make matters worse, many virtual worlds suffer from high attrition rates and players dropping out or not playing at the same time can create validity problems for researchers.

One solution is to let players interact asynchronously. Changing the progression of time from continuous to larger discrete units (turns) allows players to enter the virtual world and make strategic decisions at any time during the turn. There are many successful virtual worlds that use asynchronous play, but one concern is that it slows the pace of the game and decreases the number and type of strategic interactions. When a player finishes their turn, they must wait for all of the other players in the game to react, or for the turn timer to expire. Some research questions may not be approachable through asynchronous play; therefore, researchers must explore the limitations created by the difficulties of synchronization.

CONNECTING BEHAVIOR TO MENTAL STATES

Virtual worlds are good at answering questions about behavior because they can track it at a very fine time scale. What they are not good at is connecting behavior to the beliefs and desires. Researchers using virtual worlds and machine learning can make very accurate predictions about the behavior of individuals, but are challenged when explaining why an individual makes a certain decision. To overcome this hurdle, researchers have linked self-report data to behavioral data in order to explore the motivations of players, and game developers have discussed collecting biometric feedback through controllers (Caplan, Williams, & Yee, 2009; Sottek & Warren, 2013; Williams, Consalvo, Caplan, & Yee, 2009; Williams, Yee, & Caplan, 2008). Still, the connection between behavior and beliefs and desires is limited in virtual worlds and a problem that researchers must continue to address.

COMPLEX AND CHAOTIC SYSTEMS

Virtual worlds are complex, they have interworking parts that lead to emergent behavior, and are also chaotic, living on the border of order and randomness. In complex and chaotic systems, small decisions early on can lead to big differences further in time (Miller & Page, 2007). For example, many are familiar with the metaphor that describes how flapping butterfly wings may lead to the formation of a hurricane (Lorenz, 1993). It is an extreme example, but it depicts chaotic systems quite well. As time progresses, societies can have multiple branches. Small fluctuations can equal big changes. What if Gore had won the election instead of Bush? If we run the simulation 100 times with different people in the key roles, would the outcome remain the same every time? Probably not. Scientists who are studying virtual worlds must prepare for uncertainty due to early decisions and differences in populations. They must consider the choices and rules that they design into the game and understand the motivations of players, and they must run multiple occurrences of the same exact world in parallel. Only then can they understand when and why a society takes a different path.

CONCLUSION

Over the last decade, game developers have attempted to build hundreds of virtual worlds and many of them have failed. In order to navigate the difficult of building virtual worlds, the mapping problem, external validity, and the attention economy designers have to carefully combine theory and game design. Unanticipated design decisions or the decisions of a few individuals can lead to very different social outcomes in virtual worlds. This means that researchers who wish to gain the most from virtual worlds must run multiple instances in parallel to establish consistent outcomes and publish the design, method, and results so that other scientists can replicate the experiment and compare their own results. How will researchers publish the design and programing decisions made when constructing virtual worlds? In addition, there is little theory available to those who are building simulations of reality. The best theories of game design, even in serious games, are institutionalized and internalized within a few talented individuals. In order to realize the potential of virtual world research, there must be a shared knowledgebase of the mapping principle and difficulties encountered during along the way. Virtual worlds present a powerful opportunity for social scientists, but the construction and use of these systems may rival in scale and complexity the challenges of building satellites for space exploration or super colliders for physics.

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TRAVIS L. ROSS SHORT BIOGRAPHY

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