Spring 5-2017

Total Immersion: Virtual Reality's Path to Mass Adoption

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A Capstone Project Submitted in Partial Fulfillment of the
Requirements of the Renée Crown University Honors Program at
Syracuse University

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and Renée Crown University Honors
Spring 2017

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Abstract

With the release of devices such as the Oculus Rift, HTC Vive, and Google Daydream in 2016, virtual reality seems poised to take over the tech and media landscape. Professional estimates of the projected popularity of these devices span extremely wide ranges, and many of these predictions fall victim to a self-serving bias. The purpose of this research is to identify the variables that affect the spread of the use of virtual reality, and to analyze how the characteristics of modern virtual reality relate to these variables. The framework used to identify and assess these variables comes from Everett Rogers's seminal *Diffusion of Innovations* theory.

To contextualize modern day VR, the paper include a brief history of the technology and relevant predecesors. It also compares and constrasts the diverse VR offerings on the market today. After analyzing virtual reality through the principles of the Diffusion of Innovations theory, it is clear that many factors are slowing VR's rate of adoption, and that near-future estimates of the spread of the technology should be conservative. Despite this, the benefits of VR as seen through Rogers's lens suggest that the longterm view of the platform is much more optimistic.

Executive Summary

While the term virtual reality ("VR") has existed since the 1960s, technology and media evangelists have a new hope that the potential of this platform is about to be realized. In its most basic sense, virtual reality uses videos or computer graphics in an immersive way in an effort to make users feel as if they are actually "in" the content they are consuming. With the release of devices such as the Oculus Rift, HTC Vive, and Google Daydream in 2016, consumers have never had so many options to experience this medium. This has led to bold predictions about the future growth and popularity of VR; however, many of these forecasts vary widely, and are often guilty of self-serving bias.

The purpose of this research is to first identify the variables that affect the spread of the use of virtual reality. The framework used to identify and assess these variables comes from Everett Rogers's *Diffusion of Innovations* theory. First published in 1962, this literature examines hundreds of innovations to identify patterns and suggest general rules that dictate how populations of people adopt new ideas, techniques, or products. Rogers examines the spread of new musical genres, agricultural techniques, medicine usage, technological devices, and more. Despite their categorical differences, these innovations all follow similar trends as they are adopted by a population.

While the study of virtual reality within the context of the Diffusion of Innovations theory is the cornerstore of this research, this paper includes additional information to contextualize current day adoption of VR. First, the history of virtual reality is traced back to the 1700s, where panoramas attempted to recreate the same immersive media experiences that VR offers today. This survey of VR continues to the first electronic versions of the medium, when innovators like Morton Heilig and Ivan Sutherland created the rudimentary machines that paved

the way for modern day VR. The paper focuses heavily on the virtual reality of the 1990s, which experienced brief popularity before losing relevance. The history of virtual reality in this decade has many parallels to virtual reality today, and offers valuable lessons on how the medium can avoid slipping into irrelevance again. The paper constrasts and compares the different VR offerings currently on the market, and explains some of the technical differences between the variety of content available for these devices.

After establishing virtual reality's long history and its current landscape, the research identifies the key factors that affect the technology's rate of adoption by the general population. These include characterics of the virtual reality devices themselves, the mass media and interpersonal communication around these devices, and the steps in the process individuals go through when deciding whether to adopt or reject virtual reality.

After analyzing virtual reality through the principles of the Diffusion of Innovations theory, it is clear that many factors are slowing VR's rate of adoption, and that near-future estimates of the spread of the technology should be conservative. Despite this, the benefits of VR as seen through Rogers's lens suggest that the longterm view of the platform is much more optimistic.

Acknowldgements

This project would not have been possible without the help and support of my professors and family. I would like to thank Professor Beth Egan for helping me on this Capstone journey by being my advisor. Our weekly chats in your office always left me inspired and eager to continue with the next phase of this project, even as it went through many different iterations.

I would also like to thank my Capstone Reader, Professor Dan Pacheco, whose course on Virtual Reality Storytelling was the inspiration for me to write a capstone on the topic of VR. As someone who had followed VR since high school, to finally have the chance to experience it through your class was an incredible opportunity. Your constant encouragement to experiment made me want to learn more about virtual reality.

Lastly, my parents deserve an immesurable amount of graditute. Ever since helping me read along to *Big Pig on a Dig*, you have always instilled in me the importance of academics. I know that none of my scholarly achievements would have been possible without you, and I'm looking forward to showing you what I'm going to do with the past twenty two years of learning. Thank you for everything.

-Josh

Table of Contents

Chapter 1: Virtual Reality

With the New York Times winning a Cannes Lions Grand Prix for its virtual reality experience "The Displaced" (Nudd, 2016), Facebook's $2 billion acquisition of the VR company Oculus (Wagner, 2016), and a $80 billion market estimate in 2025 by Goldman Sachs (Bellini, 2016), virtual reality demands attention from anyone involved in the world of media. Yet with bulky equipment and a high barrier to entry, this new medium must overcome significant hurdles. Will it explode like the Internet and the smartphone, or be relegated to lists of tech failures, like Google Glass and 3D TVs?

With content creators, investors, marketers, and more interested in the future of virtual reality, the platform's growth and mass adoption is of key concern. Already, there are signs that virtual reality has a noticeably different impact than other forms of media. For example, the United Nations commissioned a series of VR films about Syrian refugees and Liberian Ebola victims, and one of the films "inspired one in six members of the public who viewed it to donate money, twice the average for the UN and UNICEF" (Milling-Smith, 2016). Patrick Milling-Smith, the president of the VR production company Vrse.works, reports that his company's VR experiences "with the softest of calls to action" have garnered a more than 15% response rate, while the average response rate to direct marketing is often less than 1% (Milling-Smith, 2016). Despite these promising statistics, mass adoption of virtual reality requires an enormous set of criteria to be met. Theoretical models and historical media adoption trends can map the evolution of virtual reality, and, more importantly to the audiences referenced above, can predict its future.

Research Purpose

The majority of forecasts predicting the adoption of new media platforms are conducted by consulting firms or in-house research firms within large corporations, and are rarely created by academics or published in open literature (Carey & Elton, p. 63). Often, the firms producing for-profit market forecasting reports fall victim to "self-serving bias" resulting in "overly optimistic forecasts" (Carey & Elton, p. 71). Additionally, these reports often fail to recognize unintended or evolved uses of new media. For example, an early 1980s forecast by McKinsey and Company for AT&T predicted that there would be 900,000 mobile phone users globally by the year 2000. In reality, there were 106 million users in the United States alone by this time. The firm failed to anticipate that the mobile phone would be a device used outside the realm of emergency communications, and ended up costing AT&T billions of dollars with their poor advice (Carey & Elton, p. 71). Today, the applications of virtual reality are already highly varied, ranging from entertainment and education to medical services and military training. While the identification of these multiple uses helps to eliminate surprises, it also adds complexity to the forecasting model. The complicated world of virtual reality has resulted in a massive degree of variance in predictions, with some as optimistic as 20 million virtual reality devices sold this year, and others as low as 300,000 units (Pressman, 2016).

Therefore, the purpose of this research is to determine if the adoption rate of virtual reality should be estimated optimistically or more cautiously. To accomplish this, the technology will be studied within the framework of Everett Rogers's *Diffusion of Innovations* theory. This is the de facto method of adoption-focused research, with more than 6000 research studies and field tests confirming the veracity of this theory (Rogers, p. 1). There are four key areas that Rogers's theory examines: the qualities that make an innovation spread, the communication channels

through which the innovation is shared, the process by which individuals within a population adopt the innovation, and the social systems and population segments in which the innovation is shared (Rogers, p. 10). Analysis of these four focuses of the Diffusion of Innovations theory revealed that while this generation of virtual reality has serious long term potential, expectations of the platform in the near future should be treated more cautiously.

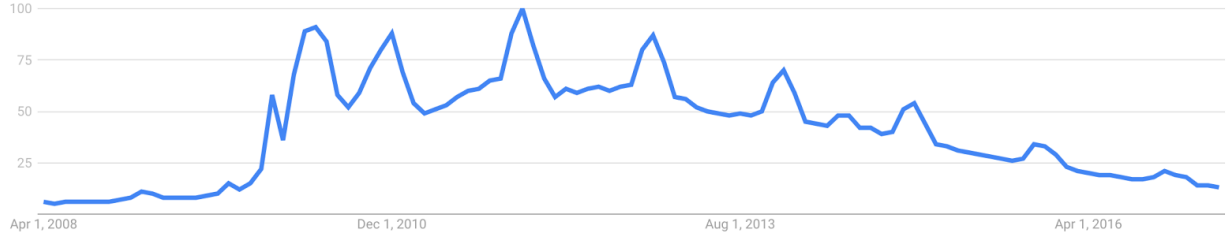
The Stakes: Bad Bets in Tech

For content publishers, advertisers, and device manufacturers, understanding emerging media means more than simply being ahead of the curve: it can be the difference between business success or failure. Even platforms that rapidly capture the attention of the public and news media and appear poised for mass adoption can suddenly spiral into irrelevance. The brief popularity of 3D TVs illustrates how platforms that once received the same excitement that virtual reality enjoys today eventually fell out of touch with consumers.

In 2011, 3D televisions were the star of CES, the Consumer Electronics Show. Leaders in technology describe this annual trade show, started in 1967, as a "gauge of where the industry is headed" and the best place "to learn the latest trends in technology" (Consumer Technology Association, 2016). Developments in 3D screen technology brought significant price reductions to the glasses required to use these televisions, dropping the price of a pair of 3D glasses from around $150 to $30 (Willcox, 2011). At CES 2011, technology giants like Toshiba, LG, and Vizio introduced 3D TVs for general consumers, and content behemoths like ESPN announced the start of 24-hour full-3D channels (Tanaka, 2011). The technological advances that reduced the price of these 3D screens meant that 3D TV was more widely available than ever before, and

support from both hardware manufacturers and content producers positioned 3D TVs for commercial success.

Yet six years later, tech outlets are writing headlines like “Shambling Corpse of 3D TV Finally Falls Down Dead” (Katzmaier, 2017). LG, Sony, Samsung, Vizio, and more have dropped support for 3D TVs or have failed to announce updated models in recent years, and ESPN dropped its 3D channel in 2013. Representatives from both LG and Sony cited a lack of consumer interest in the technology as the reason for halting production of their 3D TVs (Katzmaier, 2017), and an analysis of Google searches for the phrase “3D TV” also suggests a waning interest.



Source: Google Trends (Google, 2017)

The chart above shows relative search interest on Google for the term “3D TV.” A value of 100 shows peak popularity for the term, and all other numbers are in relation to this peak search volume. Searches spike in November and December (holiday gift-buying season), but interest today is at almost the same level it was before 3D TVs took CES 2011 by storm.

The initial heavy support from both hardware and content producers makes the eventual bust of 3D TV a compelling example of the level of intricacy involved in the diffusion of an innovation. Characteristics of the innovation itself, the communications channels and contexts in which the public sees and discusses the innovation, and the actual adoption process are all factors that influence the success of a technological innovation. The research conducted for this project

analyzes this multitude of factors to identify the factors that encourage--and also obstruct--virtual reality's path to mass adoption.

Diffusion of Innovations Theory

In his seminal 1962 book *Diffusion of Innovations,* Everett Rogers outlined the ways that populations adopt innovations of all varieties, from the technological to the agricultural. Rogers is a pioneer in this field: when the first edition of this book was published, there were 405 publications on the topic. In the 1995 fourth edition, that number is almost 4,000 (Rogers, i). Rogers defines innovation as "an idea, practice, or object that is perceived as new by an individual or another unit of adoption" (Rogers, xvii). He specifies that the objective newness of an idea is immaterial, and rather the "perceived newness of the idea for the individual" constitutes innovation (Rogers, p. 11). While the history of experiential media dates back hundreds of years (and virtual reality itself to 1960s), Roger's definition of an innovation limits the scope of this research to virtual reality products that have been available to consumers for only the past few years.

Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social system" (Rogers, 5). Due to the inherent newness of innovation, its diffusion implies two corollaries: a degree of uncertainty and an "alteration in the structure and function of a social system" (Rogers, 6). This paper seeks to identify the uncertainties in the factors that affect virtual reality's rate of adoption in an effort to predict if it will become as commonplace in the United States as innovations like the smartphone and television.

Chapter 2: A Survey of Virtual Reality

The Pre-Digital History of Virtual Reality

While the technology for virtual reality as it is known today has only existed for the past few years, the idea of immersive media dates back centuries. In 1787, Irish painter Robert Barker applied for a patent for the panorama, a large-scale painting produced in a cylindrical exhibition space (Ellis, p. 133-134). The purpose of this style of painting, as described by Barker in his patent, is to "make observers, on whatever situation he may wish they should imagine themselves, feel as if really on the very spot" (Ellis, p. 134). Compare this to the copy found on the website for Oculus Rift, one of the first mainstream virtual reality hardware producers: "Whether you're stepping into your favorite game, watching an immersive VR movie, jumping to a destination on the other side of the world, or just spending time with friends in VR, you'll feel like you're really there" (Oculus, 2016).

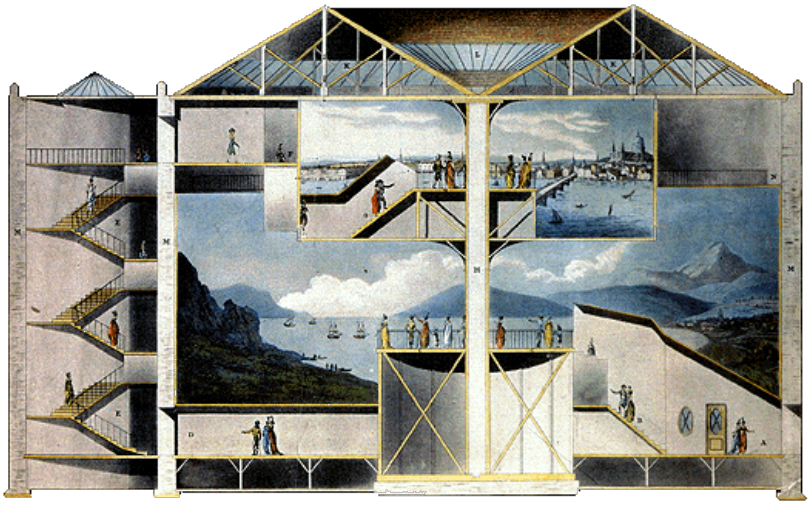


Diagram depicting one of Barker's panoramas[1]

An advertisement for Barker's panorama, placed in a newspaper on March 24, 1788, says that the installation "is not perfectly understood until seen" (Ellis, p. 134). Similarly, virtual reality is frequently described as needing to be tried to be fully understood. When Facebook

acquired Oculus, Mark Zuckerberg, the owner of Facebook, posted, “People who try it say it's different from anything they've ever experienced in their lives” (Zuckerberg, 2016). While the technology has changed, the desire to create media experiences that fully immerse the audience has existed for more than two hundred years.

Popularized in the 1850s, the stereoscope more closely resembles the VR goggles of today. This technology creates three-dimensional images from two flat images, which when taken from slightly different angles and observed through curved lenses, create a sense of depth (Potter, p. 346). This principle, binocular vision, is the same used today with Google Cardboard, a virtual reality device that replaces the stereoscope’s two flat, static images with two different dynamic views produced on the screen of a smartphone. The stereoscope was extremely popular in Victorian homes, in part due to the wide variety of devices. Small, handheld stereoscopes were affordable by most families, while the wealthy often purchased larger, more decorative versions of the device (Potter, p. 347-348). With a large market for content, there was a massive variety of types of images to view. Like today’s digital virtual reality, “the viewing conditions of the stereoscope encouraged viewers to engage in an anticipatory, open-ended, and imaginative fantasy narrative” (Potter, p. 347).

An ornate stereoscope from the 19th century[2]

Like all other media, virtual reality was upended by the invention of the computer. Innovators like Morton Heilig and Ivan Sutherland used digital technologies to bring virtual reality into the digital age, although their creations never exploded into the mainstream in the same way that the stereoscope did.

Pioneers of Modern Virtual Reality

Technological advances have allowed simulated experiences to become even more convincing. Unlike the panorama and the stereoscope, which could only show a still image, electronic devices allowed for more complex and dynamic experiences. An early example of this is Morton Heilig's Sensorama, a device which earned Heilig the title of "The Father of Virtual Reality" (Travel, n.d.). Patented in 1962, the Sensorama is a device that uses 3D video, audio, scent, vibrations, and wind in order to "stimulate the senses of an individual to simulate an actual experience realistically" (Heilig, 1962). In the file for the patent, Heilig describes different use cases for the device, including for military training, practice for laborers using complex machinery, and as an instructional tool for teachers to use in their classrooms (Heilig, 1962). Heilig built a prototype of the Sensorama and created a series of short films for it, with the intention of using it in arcades. Due to the machine's complexity, it was never commercially produced, and even attempts to sell the Sensorama to companies like Ford for showroom purposes fell flat (Turi, 2016).

Heilig's device, while electronic, was entirely mechanical. The development of the computer allowed this type of immersive experience to become even more realistic. In 1965, computer scientist Ivan Sutherland introduced the concept of the *Ultimate Display:* "A room

within which the computer can control the existence of matter" (Sutherland, 1965). Sutherland describes this room in further detail:

> "A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal" (Sutherland, 1965).

With this conceptual framework, Sutherland created the first digital virtual reality headset. In a paper published in a journal for the 1968 American Federation of Information Processing Societies Fall conference, Sutherland describes a "head-mounted three dimensional display" that he created at Harvard University in partnership with the Office of Naval Research and the Department of Defense (Sutherland, 1968). The purpose of this display was to "present the user with a perspective image which changes as he moves" (Sutherland, 1968). In order to track user movements, the device hung from the ceiling, earning it the nickname the Sword of Damocles. This technology was only capable of displaying basic shapes because in 1968, "no available general-purpose computer would be fast enough to become intimately involved in the perspective computations required for dynamic perspective display" (Sutherland, 1968). While the Sword of Damocles did not expand outside the realm of academia, it proved that motion-tracking head mounted displays were possible.

The military's interest in virtual reality continued from the 1960s to the 1990s. In 1997, the Army funded a project through the Institute of Creative Technologies of the University of Southern California to develop Virtual Vietnam, "the first virtual-reality application for PTSD" (Mead, p. 139). By immersing veterans suffering from PTSD into a VR experience similar to the source of their PTSD, the team behind the project hoped to help these soldiers process and learn

to cope with the traumatic events they had experienced. Initial testing showed that the program had potential, but it was never fully implemented for Vietnam veterans (Mead, p. 139).

Since this initial experimentation, the military has used VR in the treatment of PTSD for veterans from conflicts in Iraq and Afghanistan in dozens of treatment sites across the country (Mead, p. 133). Testing has shown that this form of PTSD treatment has an incredibly effective cure rate between 70 and 90 percent (Mead, p. 134). Due to the Department of Defenses's interest in this program, VR therapy has caught the attention "of the larger psychiatric community" (Mead, p. 134).

Comparatively, virtual reality for the purpose of entertainment enjoyed much less success in the 1990s and early 2000s. Initially, prospects for VR in the early 1990s appeared strong. In the fall of 1991, Virtuality, a company producing consumer-ready VR devices, hosted a product showcase in London's Wembley Stadium, showing 2000 attendees the potential of this new medium (Sankin, 2015). Tech magazines praised Virtuality and proclaimed that a revolution in gaming had arrived. In 1996, a virtual reality arcade opened in Times Square and was covered by the New York Times (Martin, 1996). Devices like the 1995 Nintendo Virtual Boy brought VR technology into the home at a cost of $179.95.

Only a year later, the Virtual Boy could be found in bargain bins for $30 or less. Similarly, Virtuality had effectively dissolved by 1997, and the VR arcades sold off their machines (Sankin, 2015). Despite the technology community's initial excitement for virtual reality in the early 1990s, the technology simply had not developed enough to justify the high cost of these devices. Clunky interfaces and poorly rendered graphics left users wanting more, especially as computers and videogame consoles continued to create experiences with increasingly impressive visuals (Sankin, 2015). The actual experience of virtual reality in the

1990s could not meet the hype surrounding it, and disillusioned gamers quickly lost interest. Jonathan Waldern, the founder and CEO of Virtuality, pointed to the Internet as one of the reasons why the expectations of VR ballooned to unattainable levels:

> "It instantly became a fanboy club; we all loved each other" (Sankin, 2015).

Interviewed after the announcement of the Oculus Rift, Waldern offered his thoughts on how virtual reality will enter the mainstream:

> "You don't even need a lot of elaborate environments to really make that take off. What you need is accessibility. And a level of quality that is tolerable" (Sankin, 2015).

While Waldern acknowledges that VR is currently offering the same inflated promises that it did nearly two decades ago, the technology has advanced to a point where the quality is tolerable and mass accessibility is possible. The following section outlines the specific devices that define this current generation of VR.

Current VR Offerings

The virtual reality devices studied in this research were selected because of their generally wide availability to general consumers as of January 2017. Because the purpose of this research is to study mass adoption of VR, devices not readily available to the public were not considered. While each of these products is considered a virtual reality device, vast differences exist between their price and functionality, ranging from 70-sensor systems to a piece of folded cardboard. Each of the six devices studied over the course of this research are described below.

Oculus Rift[3]

Oculus Rift: With a 2011 campaign on the crowdfunding website Kickstarter generating more than $2.4 million dollars, the Oculus Rift led the resurgence in VR that had been dormant since the 1990s (Oculus, 2012). After four years of production and two developer kit versions, the consumer version of the Oculus Rift was released on March 28th, 2016 at a retail price of $599.99 (Rubin, 2016). It requires a high-powered computer to function, and the user typically sits in a chair while using the device.

HTC Vive[4]

HTC Vive: Videogame software company Valve and technology hardware company HTC partnered in 2014 to develop their own virtual reality device, which would later be known as the Vive (Souppouris, 2016). Unlike the Oculus Rift, the HTC Vive uses full-room location tracking, with a pair of base stations set up on opposite sides of a room that track the user as he or she physically moves through the space. This movement is then recreated in the virtual experience,

making it even more immersive. HTC and Valve released the consumer version of the Vive on April 5th, 2016 at a price of $799.

Playstation VR[5]

Playstation VR: Released in October 2016, Playstation VR is Sony's take on a virtual reality headset (Sony Computer Entertainment, 2016). Sold for $399, Playstation VR is powered by a Playstation 4 videogame console, unlike the PC-based Rift and Vive. The screen display in Playstation VR has a smaller field-of-view and lower resolution than those found in the Rift and Vive, but the system is more affordable because the Playstation 4 used to power it is cheaper than the computers necessary to power the Rift and Vive (Leone, 2016).

Samsung Gear VR[6]

Samsung Gear VR: Samsung released a developer version of the Gear VR in 2014 (Oculus VR, 2014), but the product hit store shelves in November 2015 at a retail price of $99 (Oculus VR,

2015). It has since gone through several iterations, with the most recent update released on April 21, 2017 and featuring a price increase up to $129 (Goode, 2017). Unlike the Oculus Rift, HTC Vive, or Playstation VR, Gear VR is completely wireless. A mobile phone inserted into the headset powers the device and provides the screen used for viewing. This makes Samsung Gear VR much more accessible. Currently, the system supports Samsung Galaxy smartphones and the Samsung Note5 smartphone (Samsung, 2017).

Google Daydream[7]

Google Daydream: Released on November 10, 2016, Google Daydream is the VR system most recently introduced to the mass market (Doronichev, 2016). Similar to the Samsung Gear VR, a smartphone inserted into the device provides the digital processing and display screen for the headset. It uses smartphones running the Android operating system, including the Mate 9 Pro, Axon 7, Moto Z, and Google's own Pixel phone (Daydream, 2017). The headset retails for $79.

Google Cardboard[8]

Google Cardboard: Google Cardboard is the most simple and affordable VR platform currently available on the market. As the name implies, Google Cardboard is made of cardboard folded into a headset shape with two curved lenses that create a sense of depth when the user looks through them onto a smartphone inserted into the device. Cardboard was released in 2014, but Google has made the schematics for the device publicly available, allowing any individual or company to produce their own version. Google's motive for developing Cardboard was to make the introduction to virtual reality as widely available as possible (Singh, 2017). It is compatible with any Android or iOS smartphone, and prefabricated versions cost between $10 and $20 (Cardboard, 2017).

These six devices offer an extremely wide perspective on the different types of virtual reality currently available. While devices like the Oculus Rift and HTC Vive offer unparalleled immersion and quality of visual displays, headsets like Samsung Gear VR and Google Daydream offer a virtual reality experience at a fraction of the cost. These differences, and how they impact rate of adoption are discussed in more detail in chapters three, four, and five.

Key Terminology

Similarly to how the word "channel" took on a new meaning with the introduction of the radio or how "bandwidth" became newly important with the development of the Internet, so too have virtual and augmented reality created a new vocabulary. In an article published in Fast Company, Daniel Perlin outlines the basics of this new language. As the UX Director at the highly-awarded advertising agency Droga5, Perlin has years of experience in vocalizing how people interact with technology (Perlin, 2016). He distinguishes between virtual reality and augmented reality, explaining that "augmented reality uses a layer of image upon the uninterrupted images of the real world" (Perlin, 2016). Hardware that supports AR includes the Microsoft Hololens. Virtual reality differs from augmented reality in that while augmented reality relies on showing the real world in real-time, virtual reality completely removes the user from the real world. Perlin makes a distinction between 360 degree video and virtual reality, claiming that the former is not virtual reality because the user cannot control space or time within the experience; he or she is simply a passive observer (Perlin, 2016). For the purposes of this research, virtual reality will be defined as an experience that, through the use of fully immersive screens, removes users from the world around them and places them into another one. Under this definition, 360 degree video is one form of virtual reality (although certainly less engaging than Perlin's version of virtual reality). This paper examines the adoption of VR platforms as a whole, and identifying differences between 360 degree video and more traditional VR content falls outside the scope of this research.

With books, users read; with radio, users listen; with television, users watch. A user in a VR or AR experience "feels" (Perlin, 2016). With its ability to fully immerse users into a new perspective, some researchers have coined VR the "empathy machine" (Alsever, 2015).

Researchers at Stanford University's Virtual Human Interaction Lab have conducted experiments that suggest the empathetic power of VR. For example, subjects who saw a 65-year-old virtual avatar of themselves prompted them to save more for retirement, and "seeing the world through the eyes of a color-blind person will make you more willing to help him or her than if you just imagined it" (Alsever, 2015). Therefore, when discussing VR, commentators must "speak of presence, of worlds, and of experience" (Perlin, 2016). The traditional narrative structure typically found in media is upended by virtual reality, and now feelings, ideas, and environment can become the plot itself.

Chapter 3: Innovation Characteristics and Adoption Rates

While many factors influence an innovation's rate of adoption, none matter more than the innovation itself. If there are fundamental problems with the innovation, no amount of advertising, media coverage, or sales promotions will convince an individual to adopt it. Based on hundreds of case studies analyzing the diffusion of innovations, Rogers identified five characteristics of an innovation that directly affect rate of adoption: relative advantage, compatibility, complexity, trialability, and observability (Rogers, p. 15). This chapter analyzes these five areas within the context of virtual reality.

Relative Advantage

Relative advantage is "the degree to which an innovation is perceived as better than the idea it supersedes," with "better" measured in economic terms, social prestige, convenience, satisfaction, or more (Rogers, p. 15). The larger an innovation's relative advantage, "the more rapid its rate of adoption will be" (Rogers, p. 15). There exists both empirical and anecdotal evidence that reveal virtual reality's relative advantage.

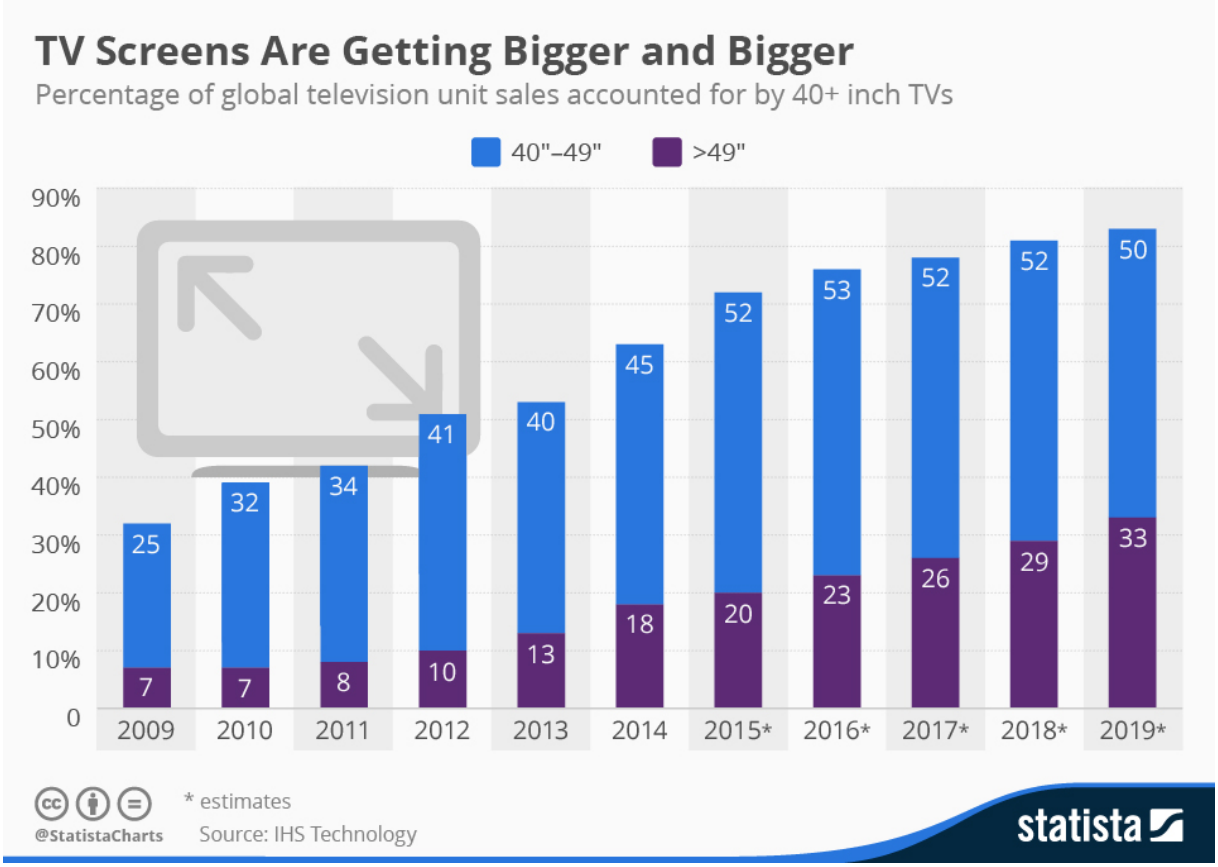
As previously mentioned the Modern Virtual Reality section of Chapter 2, virtual reality has potential as a serious treatment option for sufferers of PTSD. For PTSD patients who were not receptive to any other forms of treatment, the effective cure rate for VR treatment was between 70 and 90 percent (Mead, p. 134). In April 2016, a surgery conducted at the Royal London Hospital was streamed live over virtual reality, allowing medical students to see the procedure from a firsthand point of view without the need to be physically in the room (Weller, 2016). Research conducted at the University of Gothenburg in 2015 posited that within an educational setting, VR has the benefit of eliminating distractions and completely immersing

students into the material they are studying. For visual exercises, such as comparing the size of planets, children had a better comprehension of scale when completing these lessons with the help of virtual reality (Hussein & Natterdal, 2015). In job training that is hazardous or expensive, VR can be a satisfactory alternative.

All of these examples of relative advantage stem from the fact that the virtual reality is a totally immersive medium. Anecdotally, it is this immersion that makes virtual reality an unparalleled media experience. As previously mentioned in Chapter 2, Mark Zuckerberg posted that virtual reality is "different from anything [people] have ever experienced in their lives" before paying $2 billion to acquire Oculus (Zuckerberg, 2015). Time magazine has called the medium "transcendent" (Stein, 2015); Wired, "magic" (Rubin, 2016); The Washington Post, "completely amazing" (Tsukayama, 2016). The vocabulary of VR described in Chapter 2 affirms that this innovation is a completely new medium. In no other form of media do users purely "feel" or "experience." The sense of presence that comes with virtual reality gives it a relative advantage in terms of immersion over all other forms of media. According to the Diffusion of Innovations theory, this advantage ultimately encourages adoption.

Compatibility

Compatibility is "the degree to which an innovation is perceived as being consistent with the existing values, past experiences, and needs of potential adopters" (Rogers, p. 15). While modern virtual reality itself is too new to have a shared culture of existing values, identifying trends in electronic entertainment in general can help to see if VR adheres to an existing set of values. The total immersion of the medium has both benefits and drawbacks. The figure below identifies TV sales data since 2009.



Source: Statista (Richter, 2015)

This shift toward larger screens, while reflective of lowering costs, suggests that television users are looking for more immersive and gaze-filling experiences. In a 2015 study, even when year-to-date US sales of televisions were down 3 percent, sales of televisions larger than 50 inches were up 10 percent (Halzack, 2015). Virtual reality delivers the immersive experience that media consumers crave; however, it may be immersive to the point of isolation. According to the Consumer Technology Association, half of online Americans use another device, such as a smartphone or tablet, while watching video content, with a whopping 88 percent of Americans 18-35 engaging in this behavior (Cassagnol, 2016). Donning a virtual reality headset requires the user to give up this "second screen" experience, which could ultimately violate expected norms in electronic entertainment. This inconsistency with norms negatively affects rate of adoption.

Complexity

Complexity is "the degree of difficulty to which an innovation is perceived as difficult to understand and use" (Rogers, p. 16). Again, the isolation associated with strapping a headset over one's eyes often imparts a sense of helplessness, and the unprecedented level of immersion means that the user interface is entirely unfamiliar. This is reinforced by a 2013 paper in the journal for the Association of Computing Machinery that studied different versions of user input to "walk" in a virtual space. Wearing the same virtual reality headsets, different groups using either gamepad joysticks or directionally-sensing headsets "exhibited difficulties" traveling along a virtual path. Even more surprisingly, even frequent computer game players, who are accustomed to this style of controller, spent more than one third of their time in the experience stationary (Ruddle, 2013). Virtual reality on mobile devices, which uses devices that most consumers are already familiar with, may prove to have less complexity.

Trialability

Trialability is "the degree to which an innovation may be experimented with on a limited basis," with trial reducing uncertainty prior to adoption (Rogers, p. 16). At present, there are relatively few trial opportunities for virtual reality. Oculus Rift, HTC Vive, Playstation VR, and Samsung Gear VR offer demos in retail spaces, but the number of individuals these demos can reach is minimal.

As with the complexity criterium, virtual reality on mobile devices may serve as a gateway to richer VR experiences. There have been widespread campaigns to increase trial of platforms like Samsung Gear VR and Google Cardboard. Samsung has run many promotions giving away free Gear VR headsets to recent purchasers of a Gear VR compatible phone, such as:

-A promotion from February 23, 2016 to March 18, 2016 giving away up to 300,000 Gear VRs

-A Fathers Day 2016 promotion giving away up to 600,000 Gear VRs

-A Black Friday 2016 promotion giving away up to 100,000 Gear VRs (Samsung, 2016)

Based on these promotions alone, it is possible for one million Samsung Gear VRs to be in use. Additionally, the New York Times, over two distribution waves, has given away 1.3 million Google Cardboard headsets to its physical and digital subscribers in conjunction with its foray into producing stories in 360 degree video (Rhoades Ha, 2016). It is important to note that Rogers's definition of trialability references experimentation on a "limited basis." In the instance of these giveaways, this limited basis is not time-based, as the recipients own these devices. Using Roger's definition of innovation as an "idea or practice," if virtual reality as a medium is the innovation instead of the hardware devices themselves, then the smaller, more "limited" experiences in terms of VR capability offered by Gear VR and Google Cardboard constitute trial, even if the individual owns these devices.

Primary research conducted in London also revealed that trial of virtual reality in public places can occur outside the context of an in-store demo. Since June 2015, the Natural History Museum in South Kensington, London has offered multiple iterations of a VR experience that uses Samsung Gear VR headsets. The first experience, known as *First Life*, immersed users into an ancient undersea world narrated by celebrated naturalist Sir David Attenborough. The follow-up took museum-goers to the Great Barrier Reef. Speaking of *First Life*, Museum Director Sir Michael Dixon said, "We know virtual reality can transport us to impossible places, and this is a compelling example of where technology can really change the way we experience museums and their collections" (Natural History Museum, 2015). While the primary purpose of using virtual

reality in this way is more in-line with the education goals of the museum than a tech demo, it certainly may be many individuals' first exposure to the medium. A similar instance is an attraction titled *Virtually Dead*, a zombie-themed interactive theater experience with a VR component using the HTC Vive (Walton, 2016). Experiences like these give individuals the opportunity to try virtual reality at a much lower economic cost than buying the device; however, the availability of such opportunities is limited outside of major cities.

Observability

Observability is "the degree to which results of an innovation are visible to others" (Rogers, p. 16). In the fourth edition of *Diffusion of Innovations*, Rogers uses the example of solar panel adopters in California, who are often found in neighborhood clusters (Rogers, p. 16). The high visibility of innovations like these increases rate of adoption, as individuals' doubt is reduced when seeing their peers using them (Rogers, p. 16). Rogers acknowledges that innovations like the home computer are "relatively less observable, and thus diffuse more slowly" (Rogers, p. 16). Similarly, virtual reality headsets are typically used within the home, and therefore lack visibility.

The technological diffusion scholars John Carey and Martin C.J. Elton acknowledge a characteristic similar to observability which they call a "stunning innovation…the Holy Grail in new media adoption" (Carey & Elton, p. 55). These innovations "dazzle" through their "creativity, user interface design, and appealing content" (Carey & Elton, p. 55). They cite Apple's release of the iPod in 2001 as an example of a stunning innovation. Updated versions of the device were "designed explicitly to be worn like clothing," with the iconic white earbuds boldly branding iPod users in public (Carey & Elton, p. 55). With yearly updates to smartphones,

smartwatches, laptops, and more, tech has become its own fashion statement. The bulky, privately used VR headsets are incompatible with this trend of technology as fashion.

Chapter 4: Communication Channels

Communication, through both mass media and interpersonal channels, is inherent to the diffusion of innovations. Rogers describes four key components of communications:

1. An innovation
2. An individual or entity with knowledge of the innovation
3. An individual or entity without knowledge of the innovation
4. Communication channels connecting the two units (Rogers, p. 18)

Digital media has highly fragmented the mass communications landscape. In Rogers's model, this affects not only the communications channels used, but even the communicating entities themselves.

Virtual Reality exists in two different forms in the mass media. Because the devices in this study are consumer-facing mass market electronics, the companies that manufacture them spend money to advertise. Secondly, the novelty of this new technology has inspired media coverage from a wide variety of outlets. Within the context of the Diffusion of InnovationsTheory, these advertisers or writers are the entity with knowledge of the innovation. Readers without knowledge of the specific VR platform mentioned in communication channel are the entity *without* knowledge of the innovation. Based on the wide variety of VR platforms and types of experiences available (as previously mentioned in Chapter 2), a general knowledge of Virtual Reality is not enough to consider a person familiar with the specific innovation. Rogers tells us that it does not matter if an idea is not "objectively new;" what matters is the perceived newness of the idea by the individual (Rogers, p. 11). "If the idea seems new to the individual, it is an innovation" (Rogers, p. 11). A person who has used Google Cardboard would

have almost no understanding of the mechanics of the HTC Vive; therefore, these are considered separate (though related) innovations.

Mass Media: Advertising

Because the early versions of this new generation of mass market virtual reality platforms devices were meant for developers, advertising them was unnecessary. With consumer versions of the Oculus Rift, HTC Vive, Playstation VR, and Google Daydream released to the public in 2016, the companies behind these products have only started advertising them in the past year. Samsung Gear VR is the exception, with paid promotional activity starting in 2015.

Advertising Spend for Virtual Reality Devices 2016* *Unless otherwise noted		
Samsung Gear VR (2015)	$4,514,100.00	Network TV, Cable TV, Spot TV, Internet Display
Samsung Gear VR	$17,147,000.00	Network TV, Cable TV, Spot TV, Internet Display
Playstation VR	$3,999,200.00	Network TV, Cable TV, Spot TV, Internet Display
HTC Vive	$15,500.00	Internet Display
Oculus Rift	$6,000.00	Internet Display
Google Daydream	$3,600.00	Internet Display

Source: AdSpender (AdSpender, 2017)

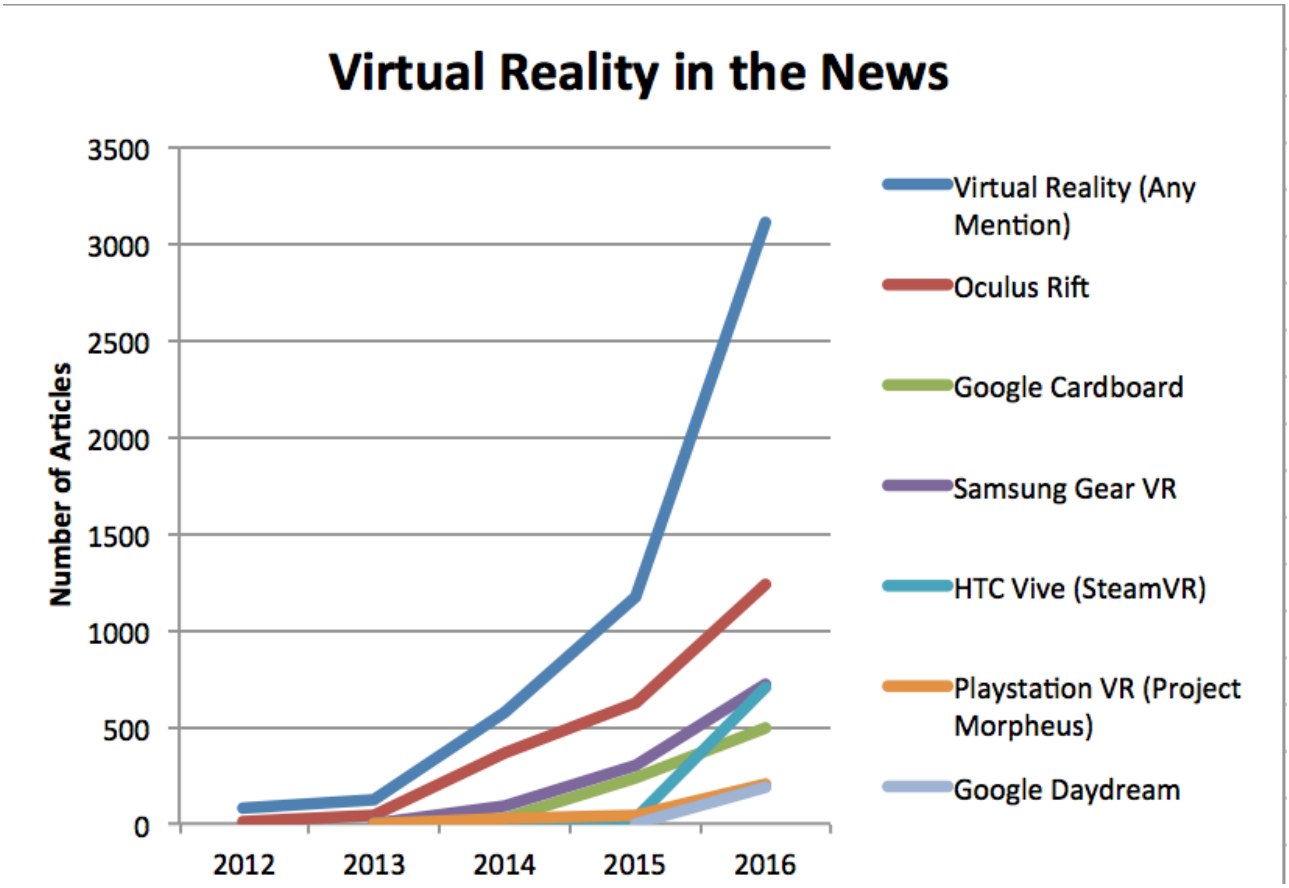
From 2015 to 2016, Samsung's spend on advertising nearly tripled. With most modern-day VR devices hitting store shelves in 2016, this increased competition may explain Samsung's interest in spending more. Still, these numbers are relatively small. For comparison, in the first full fiscal year after the release of the first iPhone, Apple spent $97.5 million on advertising for the device (Fiegerman, 2012). In the same year, Microsoft spent a massive $400 million advertising its Windows smartphones (Fiegerman, 2012).

While most of these VR companies are smaller than behemoths like Apple and Microsoft, their immensely smaller advertising spends may not be purely due to budget constraints. In a 2016 interview with the Financial Times, Palmer Luckey, the CEO of Oculus, stated that the early iterations of its VR devices will appeal "disproportionately" to gamers and other niche groups (Bradshaw & Ahmed, 2016). By focusing on this small group of early adopters, Oculus and companies like them have no need for their advertising to reach the entirety of the population. While messaging to the entire population will increase general awareness faster and ultimately speed up rate of adoption, this strategy may be short-sighted. In an analysis on the first year of modern generation VR headsets, the MIT Technology Review asserts that, "By limiting advertising, headset makers are attempting to manage hype and focus on the smartest way to increase adoption" **(**Brewster, 2016). Virtual reality is currently best suited for gamers, and advertising this innovation to members outside of this group before the hardware and content are ready may ultimately lead to the same rejection of VR that occurred in the 1990s, but on a larger scale. While VR's limited appearance in paid media may affect rate of adoption in the short term, it is a strategy that takes into account the platform's limitations in the hope of eventually becoming relelvant to more than gamers.

Mass Media: News Coverage

The novelty of virtual reality has attracted news coverage from a variety of platforms and sources. As more devices become available to consumers, the more media coverage virtual reality receives. Using the article database LexisNexis, the number of articles about VR and specific VR platforms can be calculated, taking into account both print and online magazines,

newspapers, industry journals, blogs, and other news sources. The graph below shows the result of this research.



Source: LexisNexis (LexisNexis, 2017)

The rapid increase in stories about VR indicates that interest in the platform is not waning. Furthermore, the coverage which new devices receive suggests that VR is a subject that people are actively following. For example, compare the number of stories written about Oculus Rift when it was first announced to that of the Google Daydream the year it was announced. In 2012, when the Oculus Rift Kickstarter was announced, there were only 6 articles written about it. Even after the release of the Rift's first Developer Kit in 2013, there were a meager 45 stories. Comparatively, when the Google Daydream was announced and released in 2016, there were 190 articles that referenced it (LexisNexis, 2017). This increase in initial coverage suggests that

VR has a higher profile now than it did in 2012. The more exposure an individual has to coverage of an innovation, the more likely he or she is to adopt it.

Interpersonal Communication

Even more effective in the diffusion of innovations than advertising or stories in mass media is interpersonal communication. This form of communication is key in establishing a critical mass of people who use the innovation (Rogers, p. 12). This maxim holds true in the world of advertising, with a Nielsen study revealing that 92% of people believe family and friends "over all forms of advertising," and 64% of marketing executives saying they believe word of mouth is the most effective form of marketing (Whitler, 2014). Rogers identifies two forms of interpersonal communication: homophily and heterophily (Rogers, p. 18). In homophilous interpersonal communication, the people communicating are similar to each other and are typically of the same social group, while heterophilous communication occurs between people different from one another (Rogers, p. 19). Rogers asserts that homophily is more effective in the diffusion of innovations because individuals communicate with similar coded language and social mores; however, he acknowledges that "one of the most distinctive problems in the diffusion of innovations is that the participants are usually quite heterophilous" (Rogers, p. 19).

Facebook, the owner of Oculus, has indirectly acknowledged this phenomenon. In a Facebook post announcing the company's acquisition of Oculus, CEO Mark Zuckerberg states that in its first stage, the Rift is meant primarily for gamers (Zuckerberg, 2014). This thinking reflects the VR devices of the 1990s, which were meant almost exclusively for videogames. With more historical ties to VR and with current innovations catering to them, it makes sense that

gamers are more aware than the general public of virtual reality. A 2016 study conducted by the Entertainment Software Association found that 55% of the "most frequent" gamers were aware of virtual reality (Entertainment Software Association, 2016). Comparatively, a study conducted by Horizon Media found that just 33% of the general public has an unaided awareness of the medium (Lobaczewski, 2016). The same study also found that 93% of the online conversation surrounding virtual reality occurred within the context of gaming, further reinforcing the concept that diffusion of innovations happens more quickly through homophily than heterophily. Until content creators start making VR experiences that appeal to more than just gamers, the innovation will not achieve mass adoption.

Chapter 5: The Innovation-Decision Process

The innovation-decision process is a process by which individuals seek and process information in order to "reduce uncertainty about the advantages and disadvantages of the innovation" (Rogers, p. 14). Rogers identifies five main stages of the innovation-decision process: Knowledge, Persuasion, Decision, Implementation, and Confirmation (Rogers, p. 162). Different groups of adopters move through each stage at different rates, but all experience a similar journey on the path to eventual adoption.

Knowledge

Rogers defines the knowledge stage as the period of time when an individual is "exposed to an innovation's existence and gains some understanding of how it functions" (Rogers, p. 162). As discussed earlier, 33% of the general, internet-using public has unaided awareness of virtual reality (Lobaczewski, 2016). Some innovation diffusion scholars claim that the knowledge stage is passive, as individuals are unable to seek out information about something he or she does not know exists (Rogers, p. 162). Yet others believe that knowledge of innovations comes as a result of an individual's "interests, needs, and existing attitudes," a tendency known as "selective exposure" (Rogers, p. 162). Individuals are also susceptible to selective perception such that even when they are exposed to innovation, they may not notice it if it is irrelevant to their immediate needs or desires. For example, a farmer in Iowa could "drive past a hundred miles of hybrid corn" without seeing the innovation (Rogers, p. 164).

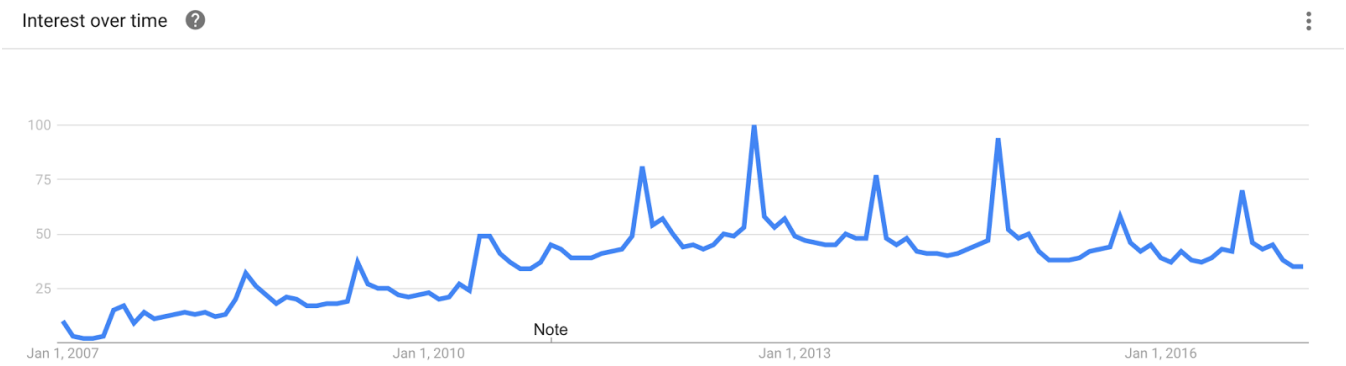
Virtual reality has enjoyed such widespread media coverage that even individuals in a passive knowledge stage can have exposure. While Chapter 4 describes the increase of news stories about VR over time, it is critical to note that the technology is not just covered in blogs and tech journals, but also the mainstream media. According to LexisNexis, The New York

Times mentioned virtual reality in 359 articles in 2016 alone. The online versions of CNN and The Washington Post featured 52 and 109 stories, respectively, that included the subject. On TV, VR was mentioned in 41 different CNN segments and 6 Fox News segments in 2016 (LexisNexis, 2017). This mainstream media coverage means that individuals can become aware of VR even if they remain passive news consumers in the knowledge stage of the innovation-decision process.

Trends in internet searches also suggest that some individuals are more active in the knowledge stage. The graph below shows relative search volume on Google for terms related to virtual reality from 2012 to March 2017 in the United States.

Source: Google Trends (Google, 2017)

The rising number of searches for VR since 2012 shows that individuals are seeking out knowledge of this innovation. The large spike in searches occurred in December 2016, suggesting that many people sought out information on virtual reality during the holiday season. This seasonality may not bode well for mass adoption of VR. Compare the graph above to a graph tracking relative search volume for the iPhone from its reveal in 2007 to March 2017.

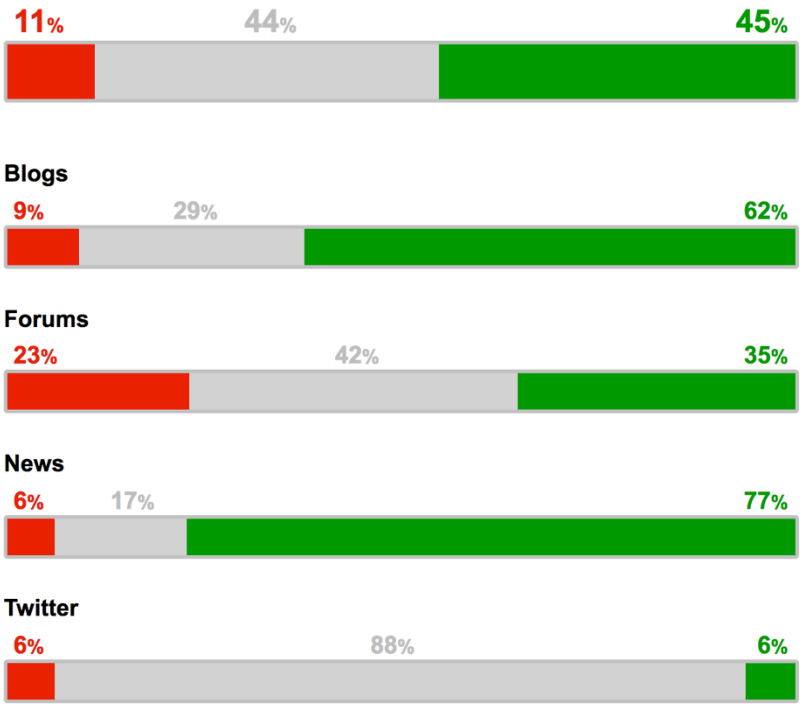


Source: Google Trends (Google, 2017)

In this graph, spikes in search volume correspond with Apple keynote addresses announcing new iPhone versions, not holiday purchases (Apple, 2017). While Apple currently ranks as the second most valuable brand in the world and its product updates are expected to be of wide interest (Farber, 2017), manufacturers of virtual reality headsets have so far failed to achieve a similar level of knowledge-seeking from the general public.

Persuasion

After learning about an innovation, individuals form a "favorable or unfavorable attitude" toward it during the persuasion stage (Rogers, p. 169). This stage of the innovation-decision process is a "vicarious trial," with individuals weighing the costs and benefits of the innovation and forecasting if it is worth incorporating into their lives. As with the knowledge stage, individuals will progress through the persuasion stage in their own way, but there are general trends that can be identified by using the social listening platform Sysomos. The data below shows sentiment negative, neutral, and positive sentiment for the terms "virtual reality" or "VR" for the past year (Sysomos, 2017).



Source: Sysomos (Sysomos, 2017)

These statistics illustrate the differences between different groups in the persuasion stage on the innovation-decision process. Generally, more authoritative sources, like news outlets and blogs, have a more favorable view of VR than more personal sources like Twitter and online forums. The social listening conducted by Horizon Media found that 10% of negative online posts about VR were critical of the high prices of headsets (Lobaczewski, 2016). Rogers acknowledges that social reinforcement plays an integral part in the persuasion stage, as inherent doubt is a product of unfamiliarity for most individuals (Rogers, p. 168). With only one third of individuals aware of VR, this social reinforcement is not yet readily available. While VR has enjoyed increased coverage in the mass media, Rogers points out that mass media messages are “too general” to provide meaningful confirmation to individuals (Rogers, p. 168).

Decision

Between the persuasion and decision stage is the "KAP-gap," which is the rift between knowledge and attitude, and practice (Rogers, p. 169). Simply put, individuals may think positively of an innovation, but other factors may prevent them from actually using it. Innovation diffusion scholars have identified income as the most important demographic in adoption (Carey & Elton, p. 337), and this assertion holds true within the context of VR. Even Palmer Luckey, the CEO of Oculus, acknowledged in 2015 that the price of virtual reality headsets would need a massive price reduction before the platform would reach mass adoption (Bradshaw & Ahemd, 2016).

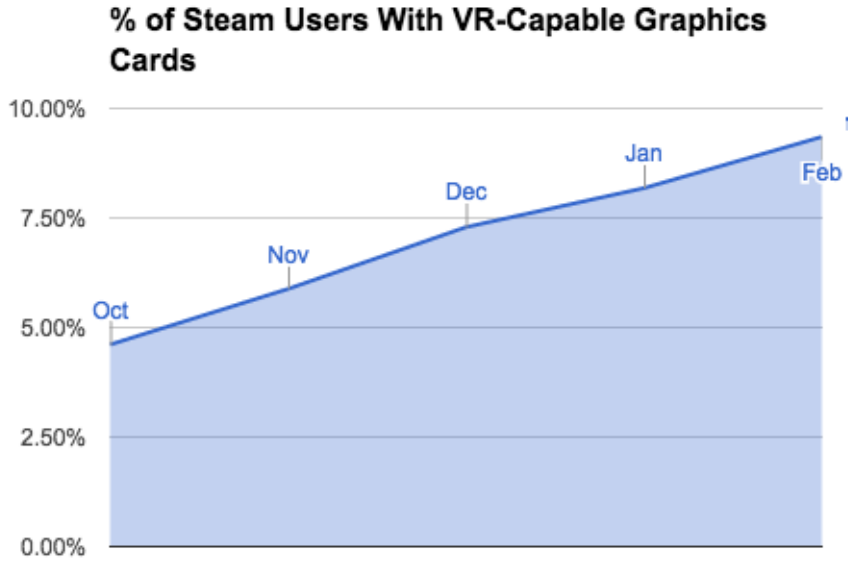
The chart below, from Carey & Elton, shows the cost of different innovations in terms of average weeks of the median household income in the US in that year. The chart has been updated to reflect the combined cost of the computer-based VR headsets available today and a computer with the recommended specifications to run these headsets.

Cost in Terms of Average Weeks of Median Household Income, United States								
Year	Radio Set	B&W TV	Color TV	VCR	CD	DVD	Oculus Rift	HTC Vive
1929	1.8							
1930								
1935								
1940								
1945								
1947		5.3						
1950		3.3						
1955		1.8	6.6					
1960			4.1					
1965			3.1					
1970			1.9					
1975				6.2				
1980				3.3				
1983				1.4	1.8			
1985				1.1	0.7			
1989					0.4			
1993					0.2			
1997						0.8		
1999						0.3		
2001						0.2		
2003						0.1		
2016							1.45	2.11

Source: Carey & Elton, United States Census Bureau (United States Census Bureau, 2017)

This chart shows that it is common for the first iteration of innovations to cost more than an entire week's worth of pay. In accordance with Moore's law and the past ninety years of trends, the price of virtual reality headsets should decrease in the future. Out of people who had intended to purchase a VR device in 2016, 64% cited price as the reason why they ultimately did not (Bazilian, 2017). While expectations about the rate of adoption of VR should be tempered while prices remain high, this statistic suggests that adoption may drastically increase as prices decrease.

The cost of a VR-capable computer was included in the headset cost in the chart above because so few individuals have machines capable of powering these devices. Steam is a computer-based videogame distribution and online multiplayer service, and in 2015, reported that it had 125 million active users worldwide (Paget, 2017). From these 125 million people, Steam collects and publishes information on the hardware used by these gamers. For computer videogamers, who require more advanced and powerful machine than regular computer users, less than 10% of Steam users had the minimum computing power necessary to power the Oculus Rift or HTC Vive (Steam, 2017). While this number has consistently increased since October 2016, it is expected that much fewer typical computer users have the hardware necessary to power PC-based VR.



Source: Steam Hardware & Software Survey (Steam, 2017)

Fortunately, Playstation VR and mobile VR are alternatives to expensive and hardware-intensive PC-based VR. In the early stages of this generation of virtual reality, these more affordable devices are imperative to the initial adoption of VR. While these headsets are less immersive than their PC counterparts (discussed in more detail in Chapter 2 - Current VR Offerings), adopters of Playstation and mobile VR have still reported high amounts of satisfaction (discussed in more detail in Chapter 5 - Confirmation). The wider accessibility of these types of headsets is critical to a steady rate of adoption of virtual reality.

Implementation

In the Implementation Stage, the Innovation-Decision Process changes from a "strictly mental exercise" to a demonstration of behavior (Rogers, p. 172). This is the stage in which an individual actually uses the innovation. He or she made the choice to adopt the innovation in the preceding stage, but certain obstacles can obstruct the process as it enters the Implementation stage. For example, product shortages could prevent an individual from adopting an innovation,

even if he or she has decided to adopt it (Rogers, p. 173). Shortages in critical components delayed shipments of both the HTC Vive and Oculus Rift (Jennings, 2016), leaving purchasers frustrated (Evangelho, 2016).

Notably, there is distinction between implementation and adoption. Even though the individual decides to use the innovation in the Implementation Stage, there still exists "a certain degree of uncertainty about the expected consequences of the innovation" (Rogers, p. 173). Simply because an individual purchases or begins using an innovation does not guarantee adoption. Instead, adoption occurs when "the new idea becomes an institutionalized and regularized part of the adopter's ongoing operations" (Rogers, p. 173). At this point, the Implementation Stage ends.

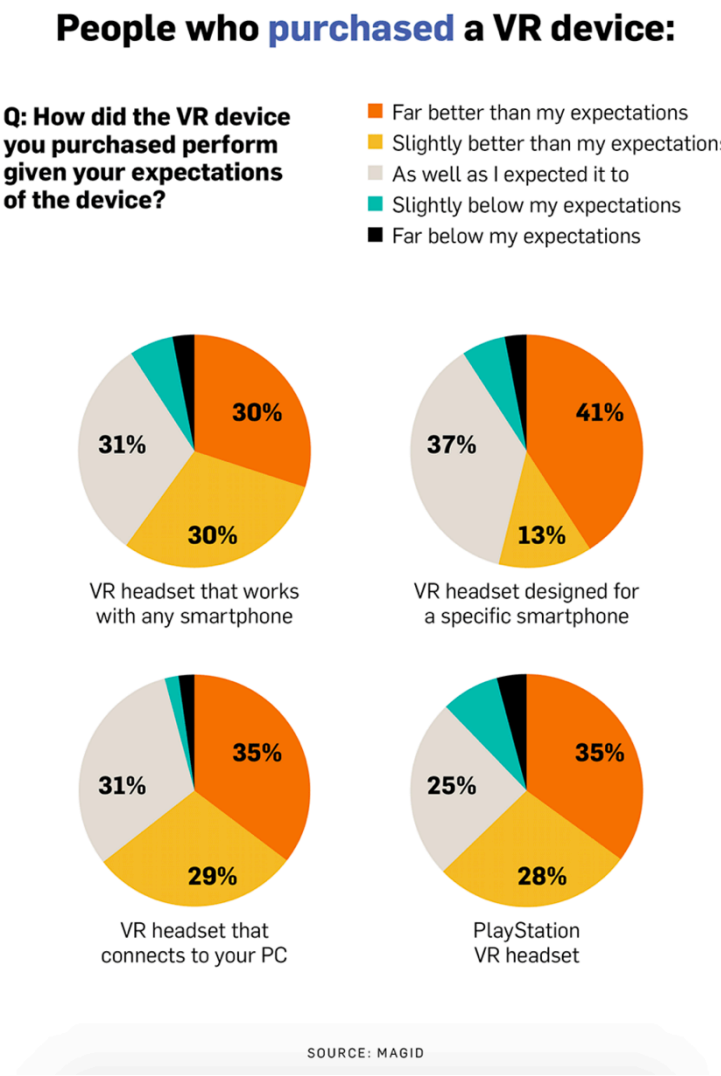
Confirmation

The Innovation-Decision Process does not conclude with the adoption or rejection of an innovation. In the Confirmation Stage, an individual seeks reinforcement that he or she made the right decision to adopt or reject an innovation (Rogers, p. 181). Even after initially adopting an innovation, an individual may choose to later reject it in a process known as discontinuance (Rogers, p. 182). Rogers identifies two types of discontinuance: *replacement* and *disenchantment.* Replacement discontinuance is common: iPods replaced the Walkman, and USB thumb drives replaced CDs and floppy disks. In disenchantment discontinuance, an individual rejects an innovation due to "dissatisfaction with its performance" (Rogers, p. 182).

Early adopters of virtual reality have no possible way of engaging in replacement discontinuance during the Confirmation Stage. Many of these devices are little more than one year old, and a distinct, superseding improvement is yet to be seen. While HTC and Oculus have hinted at upcoming improvements and hardware updates to their VR headsets, improvements to

this already existing hardware are highly unlikely to be viewed as innovations using Rogers's definition, which states that the object must be "perceived as new" (Rogers, xvii). Changes in the near future for the virtual reality devices currently at market are more likely to be seen as improvements rather than entirely new innovations.

At this nascent stage of virtual reality, disenchantment is the much more likely form of discontinuance to occur. When consumer-grade virtual reality devices hit store shelves in the early 1990s, the inflated expectations surrounding the medium caused the disenchantment that led to early adopters' desertion of the technology by the end of the decade. However, early research into the current generation of VR headsets suggests that disenchantment only affects a small number of early adopters. Research group Magid surveyed 2000 people in December 2016 and January 2017 to assess public opinion on virtual reality, and spoke specifically to current owners of VR equipment to assess their level of satisfaction with it (Bazilian, 2017). The overwhelming majority of users of all types of VR available agreed that their device has performed at or above their expectations (Magid, 2017).



Source: Magid, Adweek (Bazilian, 2017)

These results suggest that VR owners are largely happy with their purchases, no matter the level of immersion offered by their devices. Critically, only 5% of PC VR users reported disappointment with the platform. With the Oculus Rift and HTC Vive offering the most immersive, complete virtual reality experience on store shelves today, this suggests that as mobile VR catches up to PC VR in terms of quality, even more users will be satisfied with these devices. This is a critical difference from the brief VR boom of the 1990s.

Chapter 6: The Path to Mass Adoption

Obstacles

Despite the excitement surrounding virtual reality and the unprecedented levels of technical achievement in the devices available today, analyzing the key influences on rate of adoption reveal a wide variety of obstacles between VR and mass adoption. One of the most important of these obstacles is price. The devices that produce the most convincing and immersive virtual reality experiences cost hundreds of dollars. While cheaper alternatives exist, the comparatively low quality of these devices does not reflect the true potential of virtual reality technology.

Additionally, donning an isolating headset is incompatible with current trends in media consumption. Virtual reality requires users to reject the norm of multiscreen viewing and devote their full attention to the platform, to the point of social isolation. Isolation is a massive obstacle for VR. Because the content is experienced through a headset, those outside of the experience have very little opportunity to try or observe the innovation. Trial and observability have a high impact on rate of adoption, and the in-home, private use of VR makes it extremely difficult for the tech to spread across different social groups. Typically, early adopters of an innovation are more educated and more wealthy than later adopters (Rogers, p. 269). While the current cost of VR is prohibitive, a price decrease may still have little impact on mass adoption if would-be later adopters have no opportunity to see and learn about the innovation.

Opportunities

Despite the challenges that currently inhibit virtual reality's rate of adoption, many of the problems that caused the virtual reality bust of the 1990s no longer exist in today's VR offerings.

As indicated in Chapter 5, most purchasers of virtual reality devices in the past year are satisfied with the technology, and feel that it met their expectations. Unlike in the 1990s, the technology behind these headsets is able to support virtual reality's bold promise of transporting its users to other worlds. While most of these current users are interested in the gaming capabilities of the platform, a massive increase in news coverage means that even those outside of this group of early adopters are able to reach the Awareness stage of the Innovation-Decision Process.

While VR is still far from mass adoption, the companies behind it no longer exist on the fringe. Support from tech behemoths like Facebook, Samsung, and Google gives virtual reality the chance to be treated like an investment in the future. Palmer Luckey, the CEO of Oculus and arguable leader of this virtual reality's renaissance, has said that it will likely be ten years before a majority of the population adopts the technology (Bradshaw & Ahmed, 2017). It will take time for tech prices to decrease and for more universal applications of the platform to be discovered and perfected, but the premise originally offered by Sutherland's *Ultimate Display* is almost attainable.

Conclusion

Just as they were during the VR buzz of the 1990s, current claims and predictions for virtual reality are incredibly bold, and often biased. The universal academic standard for the assessment of adoption, Roger Everett's Diffusion of Innovation theory, creates a model by which to impartially consider the different factors that affect how mainstream virtual reality will truly become. The different attributes of VR technology itself, the communication surrounding it, and the process in which individuals decide to adopt it all either positively or negatively affect rate of adoption. In the case of VR, these different attributes are often at ends with each other.

The platform has an immense relative advantage over other technologies, but it comes at a high cost and at the expense of conventional media habits.

Despite these obstacles, virtual reality is special. Tech fads come and go, but the promise of VR is unlike that of any other medium: instead of reading, listening, playing, or watching, users of virtual reality are *experiencing*. Since the panoramas of the eighteenth century, humans have craved a medium that transports them to other worlds without the help of the imagination. If costs decrease, content stays relevant and interesting, and the technology continues to improve, a dream two hundred years in the making may be realized in our lifetimes.

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