

A Survey of Addictive Software Design

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The average smartphone owner checks their phone more than 150 times per day. As of 2015, 62% of smartphone users had used their phone to look up information about a health condition, while 57% had used their phone to do online banking. Mobile platforms have become the dominant medium of human-computer interaction. So how have these devices established themselves as our go to connection to the Internet?

The answer lies in addictive design. Software designers have become well versed in creating software that captivates us at a primal level. In this article, we survey addictive software design strategies, their bases in psychology, and their applications in popular software products. We offer a novel taxonomy to better categorize these addictive design strategies. Additionally, we explore a study conducted at the California Polytechnic State University at San Luis Obispo that illustrates the efficacy of one of the addictive design strategies.

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1 INTRODUCTION

As Software becomes an integral part of the human experience, Software designers compete for the attention of users. This competition has prompted the emergence of several user retention strategies that apply psychological principles to software design. In this paper, we will refer to these strategies collectively as "addictive software design."

Before exploring addictive software design, we must define and outline topics that elucidate the importance of the subject. Once we've established this importance, we will explore popular addictive design strategies. After covering each of these strategies, we will examine the foundations of those strategies in psychology. Then we will present successful applications of these strategies in popular applications. Finally, we will offer our novel taxonomy to better categorize addictive design strategies.

2 BACKGROUND

In this section, we will briefly define and outline topics related to addictive software design. These definitions are meant to provide context for the addictive software design strategies in later sections.

2.1 Human-Computer Interaction

Human-computer Interaction (HCI) is a field that arose in the 1980's as a specialty area in computer science embracing cognitive science and human factors engineering. Today, it is a collection of semi-autonomous fields in human-centered informatics. The field grew in prominence with the rise of personal computers, as the demographic of computer users transitioned from technology professionals to everyday people. [4] Today, Human-computer Interaction remains relevant with the ubiquity of mobile devices. For our purposes, Human-Computer Interaction is the academic topic within Computer Science under which addictive software design falls.

2.2 Psychology

Psychology is the scientific study of how people behave, think and feel. As a science, psychology applies the scientific method to study psychological phenomena. [18] Psychology is the field which provides meaningful scientific explanations to addictive software design strategies.

2.3 Mobile Platforms

Mobile platforms are smart phones and tablets that run software, typically connected to the Internet. They are the dominant medium of Human-Computer Interaction today. As of 2016, 67% of digital time is spent on mobile platforms. [21] This time is increasingly focused in a small subset of apps. Smartphone users spent 45% of their app time on their top app and 73% of their app time on their top three apps. Tablet users spent 87% of their app time on their top three apps. The apps most popular with these users are typically published by Facebook, Google, Snapchat, Amazon, and a few other large publishers. [21] As the dominant medium of Human-Computer Interaction, mobile platforms are the most important platform on which to study addictive software design strategies.

2.4 Internet Addiction

Internet addiction is "a compulsive-impulsive spectrum disorder that involves online and/or offline computer usage and consists of at least three subtypes: excessive gaming, sexual preoccupations, and e-mail/text messaging." The symptoms of each variation of this disorder include excessive use, withdrawal when the computer is inaccessible, tolerance and negative repercussions (including lying, poor achievement, social isolation and fatigue. Some countries, such as China and South Korea, consider Internet addiction one of their most serious public health concerns. [1] Internet Addiction illustrates the real consequences of implementing addictive design strategies.

3 ADDICTIVE SOFTWARE DESIGN STRATEGIES

In the following section, we will explore many of the most popular strategies of addictive design outlined by researchers, bestselling authors, and prominent designers. We will attempt to ground each design strategy with a corresponding psychological study that highlights its efficacy. This list is not exhaustive.

3.1 Variable Rewards

A reward is "something given or received in return or recompense for service, merit, hardship, etc." [16] The brain responds positively to rewards. Rewards become variable rewards when they are given randomly and unpredictably. Variable rewards produce more of the neurotransmitter dopamine than regular rewards. [8] Outside of software design, the method of intermittent variable rewards is used most prominently by slot machines. However, mobile applications have begun to take advantage of this effect through the utilization of notifications and other processes. By intensifying the dopamine surges received by their users, software designers are making their products addictive. [2]

3.1.1 Psychological Study: The Skinner Box.

The psychology of rewards has been studied extensively, especially with regards to the neurotransmitter dopamine. The psychological study most closely tied to intermittent variable rewards involves the "Skinner Box," in which pigeons and rats were conditioned to pull a lever when prompted by a light. Researchers found that dopamine levels in these pigeons and rats surged when they were expecting a reward. These effects were multiplied when treats were rewarded at random; adding variability increased the frequency of the pigeons' completing the intended action. [9]

3.2 Social Reciprocity

Social reciprocity is a "mutual exchange" that is social in nature. [16] We are vulnerable to needing to reciprocate others social gestures. [10] This is illustrated by common etiquette like responding to emails or accepting connection requests. Additionally, as inherently social animals, human beings receive chemical satisfaction when they receive social gratification, such as likes. [9] The highly social components of many popular mobile applications contribute to their addictive properties.

3.2.1 Psychological Study: The Power of Reciprocity.

An experiment conducted by Andres Diekmann of the Swiss Federal Institute of Technology explores the power of reciprocity. The experiment involved two groups of test subjects, all anonymous to each other. Subjects from the first group were given 10 tokens worth real money with the option to share some proportion of their tokens with a member of the other group. Later, subjects from the second group were given 10 tokens with the option to share their tokens. Members of the second group reciprocated the gift they'd received almost half the time, and only 10% of the second group did not share their tokens at all. This behavior is not rational, and illustrates the social power reciprocity has on human beings. [5]

3.3 Infinite Scrolling

Infinite scrolling is the idea of loading content on a single page instead of spreading it across a series of pages. [11] It creates an interface through which consuming media is enabled by continuing to scroll, instead of flipping to a new page. This strategy is utilized by many mobile applications. Because there is virtually no end to the materials we can consume via infinite scrolling, we are vulnerable to consuming much more than we would normally without realizing it. This results in users spending much more time on applications than intended.

3.3.1 Psychological Study: The Bottomless Bowl.

Infinite scrolling taps into a psychological phenomena illustrated by the "Bottomless Bowl" study. In 2005, Cornell professor Brian Wansink demonstrated that you can trick people into eating more soup by giving them a bottomless bowl. When their soup refills, people will consume 73% more without even recognizing greater feelings of satiation. [10] These findings are consistent with the notion that the amount of food on a plate or bowl increases intake because it influences consumption norms. [3] This suggests that the time sucking power of infinite feeds is derived from their power to normalize uninhibited scrolling.

3.4 The Illusion of Choice

Just as infinite feeds have the power to normalize uninhibited scrolling, Software Designers have the power to control user choices through the layout of their applications. While an application like Yelp appears to empower the users with reviews of nearby restaurants, it's really controlling the limited number of venues users are exposed to. [10] This illusion of choice can keep users engaged for longer, as dissatisfaction with each choice results in the user spending more time browsing alternatives within the application. However, limiting choices the user is exposed to keeps them acting on those options more diligently. [12]

3.4.1 Psychological Study: Decision Making.

In an experiment undertaken by Stanford's Mark R. Lepper and Columbia's Sheena S. Iyengar, two separate displays of jams were laid out. One display had 24 different types of jams, while the other had only 6 different types. Of the 242 customers who passed by the extensive display, 60% stopped at the booth with the extensive display while only 40% stopped at the booth with the

limited display. However, only 3% of people who stopped at the extensive display purchased jam while 30% of people who stopped at the limited display bought jam. [12] This is just one of many studies that illustrates the power of limiting choices: while people may be attracted by a large variety of options, they are more likely to act when given fewer choices.

3.5 User Investment

Human beings irrationally project more value on objects they're involved in building or creating. Many applications take advantage of this phenomena by giving users power to curate their own social media profiles. This is supported by the "Ikea effect," wherein consumers were shown to be willing to pay more money for furniture they'd contributed in creating than for pre-built furniture. [9]

Additionally, investing time, data or social capital into a platform causes users to spend more time on that platform. This illustrates the importance of first-to-market principles, as once users have accumulated followers on one platform, they are less likely to leave that platform even if a marginally better alternative with the same functionality arises. [9]

3.5.1 Psychological Study: The IKEA Effect.

Named after the popular build-it-yourself furniture chain, the "IKEA effect" refers to the increased value consumers place in something they've had a hand in creating. This phenomena is well documented in a Harvard Business School study titled "The IKEA effect: When Labor Leads to Love." When crafting an IKEA storage box, test subjects were willing to spend over 60% more money for the box they'd built than for a similar box built by somebody else. The effect was exacerbated when subjects were bidding on Origami pieces. This psychological principle has been used in many other applications besides furniture, from instant cake mixes (which became much more popular after consumers were instructed to add an egg) to Build-A-Bear stores. [15]

3.6 Gamification

Closely tied to variable rewards, "gamification" is defined in the tech industry as the process of using game mechanics to reward the completion of tasks. [22] Academically, "gamification" has been defined as "a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes." [14] Experts recommend implementing rewards in small, frequent bits so that the user of an app feels a sense of achievement. They also recommend "sharing loops" that integrate rewards with the users social network by allowing the user to share their accomplishments. [22]

3.6.1 Psychological Study: Gamification.

A review of 24 gamification studies found that gamification has a positive impact on the effectiveness of the core service of the platform being gamified. In particular, every study focused on education or learning platforms found a positive effect. In this review, the most commonly implemented gamified elements across the many studies were points, leaderboards, and badges. [14]

4 APPLICATIONS

This section will cover the applications of these addictive design strategies, particularly with regards to some of the most popular mobile apps available. For reference, the four most downloaded iOS apps of all time are (in order) Facebook, Facebook Messenger, Youtube, and Instagram. [6] Other popular apps we'll look at include Twitter, Uber (the driver version), and LinkedIn.

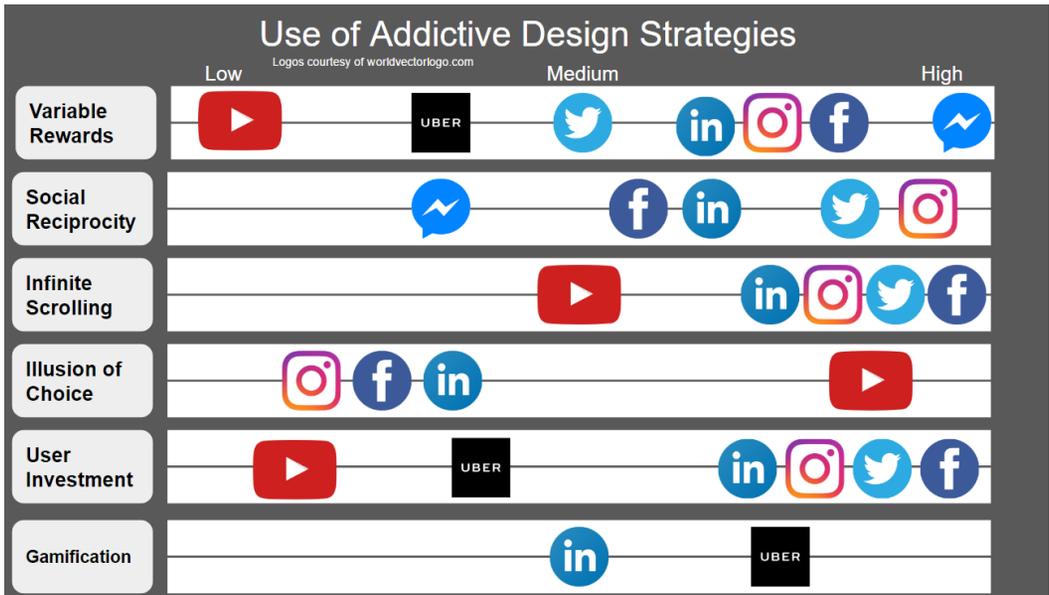


Fig. 1. An illustration of the use of addictive design strategies in popular phone apps

4.1 Variable Rewards

Intermittent variable rewards are used most often in the form of notifications. The Facebook Messenger app relies on notifications and pop ups to alert the user to new messages. The pop ups used by Messenger are some of the most unique of all the major apps, as they appear as bubbles that the user can move around their screen.

The Facebook app utilizes variable rewards in providing notifications for likes, friend requests, and many other activities. Instagram sends notifications for direct messages, when a users' friend posts for the first time in a while, or when somebody likes a users' photo. LinkedIn utilizes notifications similarly to notify users of connection requests, messages and potential job opportunities. Twitter will send users notifications when they are messaged or mentioned. Uber will send drivers notifications when a rider is available to be picked up. And the YouTube app sends notifications when a channel the user subscribes to has posted a new video.

Outside of notifications, Facebook and Instagram are particularly adept platforms at engaging users with "likes." Because a "like" must be given by another user, its delivery is random and satisfying. This is similarly true of "favorites" and "retweets" on Twitter. [9]

4.2 Social Reciprocity

Social reciprocity is either a feature or an emergent property in many social media apps. Apps like Instagram and Twitter have a social etiquette that demands "following back" somebody who has followed you, and the liking and favoriting features can instill a sense of obligation in users to do the same back. Facebook and LinkedIn require friend and connection requests to be accepted before a friendship is made official. And Facebook Messenger messages are shown as "read" to the sending party when opened, motivating users to respond. As these examples illustrate, social reciprocity isn't always an explicit feature. Sometimes it's an unintended consequence of an apps design.

4.3 Infinite Scrolling

Infinite scrolling is most prominently used by Facebook, both on the mobile app as well as the desktop version. It was launched in 2011 at the same time as Facebook Timelines, shortly before Facebook's IPO. [17] The type of infinite scrolling used by Facebook is called "lazy load," because it loads more results as you near the bottom of the page. [13] Before Facebook implemented it, "lazy loading" was used by Twitter and Instagram, and is now used by LinkedIn as well.

YouTube has a different variation on infinite scrolling. While YouTube's search results are paginated (perhaps a result of their ties to Google), they have an autoplay feature which continues to produce related videos to the first one watched manually. Though not explicitly "infinite scrolling," the autoplay feature is a sound example of the same underlying concept of unending content.

4.4 The Illusion of Choice

Most mobile app interfaces use this strategy to direct users between the pages of the apps. What gives these apps the illusion of choice is the way they present a limited set of options as if it were extensive. The YouTube app is particularly adept at this: by presenting the homepage with videos they expect a user to like alongside a search bar, users are given the impression that they can find videos of whatever they want. However, YouTube is meaningfully effecting the content users consume by way of their suggestions and the order of search results.

The illusion of choice is presented effectively in apps like LinkedIn, Facebook and Instagram as well. The results that show up on the main pages of each of these apps appear to be unsorted, chronological posts from all of your friends. However, LinkedIn and Facebook are deliberately tailoring the content that makes it to the top of a users page. And Instagram has recently implemented a similar version of tailored content by showing posts they think you'd like before other posts that are more recent.

Before any of these mobile apps existed, this strategy was being utilized masterfully by Google. While users believe they're searching the full web, Google controls the algorithm that dictates their results. The autocomplete feature of Google (and the similar autocomplete feature used by YouTube) has a powerful effect on the searches users make, yet certain phrases are often blacklisted from those autocomplete lists. For example, typing "crooked hill" on Google will autocomplete with suggestions for restaurants or street names. Typing the same phrase on Bing will autocomplete as "crooked hillary" first - a result that doesn't even appear amongst Google's autocomplete suggestions. [7]

4.5 User Investment

User Investment is often attained through followers, friends and connections. Take Twitter: its core functionality is so easy to recreate that it's been cloned by over 250 other sites. However, Twitter remains dominant in terms of users and valuation. [20] This can be tied to user investment. Twitter users aren't likely to abandon the site for other platforms because they've invested time and energy in gaining followers on their existing account. Even beyond followers, Twitter users have spent time and energy crafting all of the tweets that show up in their history when their profile is examined. [9]

This same notion of user investment is utilized by many other software giants. Instagram uses followers while storing user memories in the form of photos or videos. LinkedIn, as the dominant professional social network, offers access to potential job opportunities through users "connections." Facebook uses friends in addition to their customized Timelines, which store posts as diverse as text, images, and videos. YouTube shows users subscriptions alongside saved videos and videos they've posted. The most successful software apps make it difficult to leave because of the time and energy users invest in them.

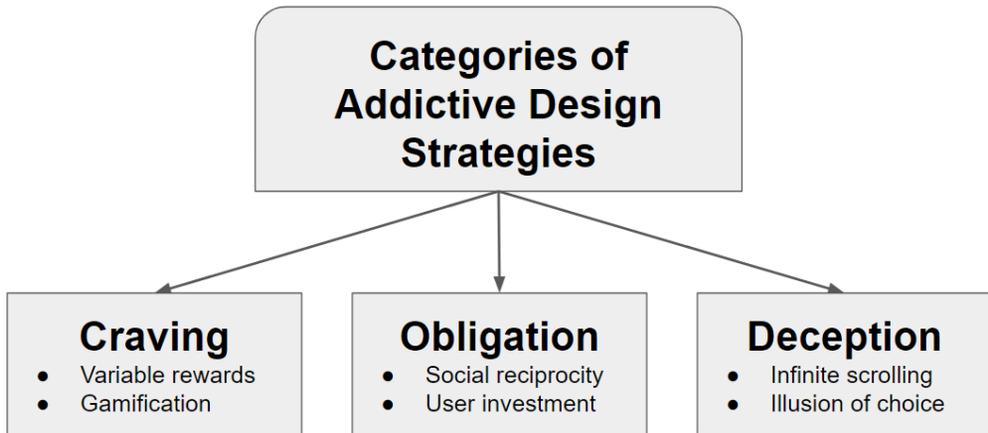


Fig. 2. An illustration of our addictive design taxonomy

Facebook has pioneered another form of user investment through their ubiquity on other platforms. Many sites and apps, such as Tinder, Farmville, and GroupMe, allow users to sign up using their Facebook profiles. By making themselves the middle man between users and other apps, Facebook has made it even more difficult for their users to leave.

4.6 Gamification

Uber has historically had issues with retaining drivers. Recently, to counter this retention issue, the Uber app for drivers has been gamified. To keep drivers on the road for a longer period of time each day, Uber sets arbitrary earnings goals that provide achievements when satisfied. They've also started to queue up the next ride for drivers before they've even finished the one they're currently on. [19]

Gamification is exploited more subtly in other platforms. LinkedIn plots the number of people who have viewed your profile alongside goals and suggestions about how to increase your visibility to employers. Health apps, such as MyFitnessPal, set caloric and exercise goals based on your past information. And Snapchat rewards users for "streaks," or days in a row that users have exchanged Snaps. All of these examples gamify processes that are seemingly unrelated to games because gamification taps into the human desire for achievement.

5 CATEGORIZATIONS

In this section, we will create novel categorizations for each the addictive design strategies we've explored. These categorizations are intended to encompass every addictive design strategy presented in this paper in addition to any addictive design strategies implemented by others in the future. These categorizations are rooted in the psychological weaknesses each strategy takes advantage of.

5.1 Craving

Strategies that fall under the "Craving" category take advantage of the physical, chemical response human beings have to desired types of stimuli. Most often the outcome of these strategies manifest in the form of a dopamine rush. For example, intermittent variable rewards such as message alerts and notifications give users a dopamine rush. [10] Similarly, gamified processes such as

achievements can give users a dopamine rush when they are completed. [19] When a user checks their phone expecting a notification, alert, or achievement and they do not receive one, they are illustrating a powerful desire for something, or a "craving." [16]

5.2 Obligation

Strategies that fall under the "Obligation" category take advantage of the human desire for comfort. Human beings naturally seek stability and reassurance from other humans, and addictive design strategies in this category satiate these needs. [10] For example, social reciprocity strategies maintain and uphold existing social norms by validating friendships or inciting correspondence. Similarly, user investment strategies hook users by getting them so used to a platform that leaving that platform would entail leaving friends, family, and a familiar interface. When a user responds to a message or follows back a friend, they are attempting to fulfill an act to which they feel morally bound, or an "obligation." [16]

5.3 Deception

Strategies that fall under the "Deception" category take advantage of human gullibility. This typically entails manipulating a user into doing something they wouldn't normally want to do through the design of an interface. For example, interfaces that utilize infinite scrolling subtly coerce users into spending more time on an app than they intend to. Similarly, giving users an illusion of choice in an app menu while severely constricting their actions to what you want them to do does not always fulfill their desired goals with the app. Each of these strategies gives a mistaken impression to the user, or "deceives" the user. [16]

6 FINAL REMARKS

The well known design strategies outlined in this paper are used by all of the most popular apps on our phones. These software products don't just dominate the market; they dominate our free time. In the future, we anticipate new addictive design strategies to proliferate. Although the specific nature of these strategies may vary, we expect the reason for their effectiveness to remain the same: they take advantage of properties of human psychology. We hope that the categories outlined in this paper increase public understanding of this underlying psychology. Furthermore, we hope this understanding enables fun and responsible software design.

7 APPENDIX

7.1 Experiment: Facebook Scrolling

In this experiment, students were told to download two Google Chrome extensions (add ons to the Google Chrome web browser). One of these extensions ("timeStats") was designed to measure the time they spent on various websites. The other extension ("Stop Scrolling Facebook") was designed to stop the user every 5 minutes to ask if they wanted to continue scrolling on Facebook. The measure of users desire to spend time on Facebook was the difference between the time they spent on Facebook in one week with the "Stop Scrolling Facebook" extension minus the time they spent on Facebook in one week without the "Stop Scrolling Facebook" extension.

7.1.1 Procedure. Students were split into two even groups. The first group was instructed to download both the "timeStats" and "Stop Scrolling Facebook" extensions, while the second group was instructed to only download the "timeStats" extension. After one week, researchers reached out to each group and instructed them on how to report their weekly Facebook activity. The results from each group were recorded (measured to the nearest minute). At the same time, researchers

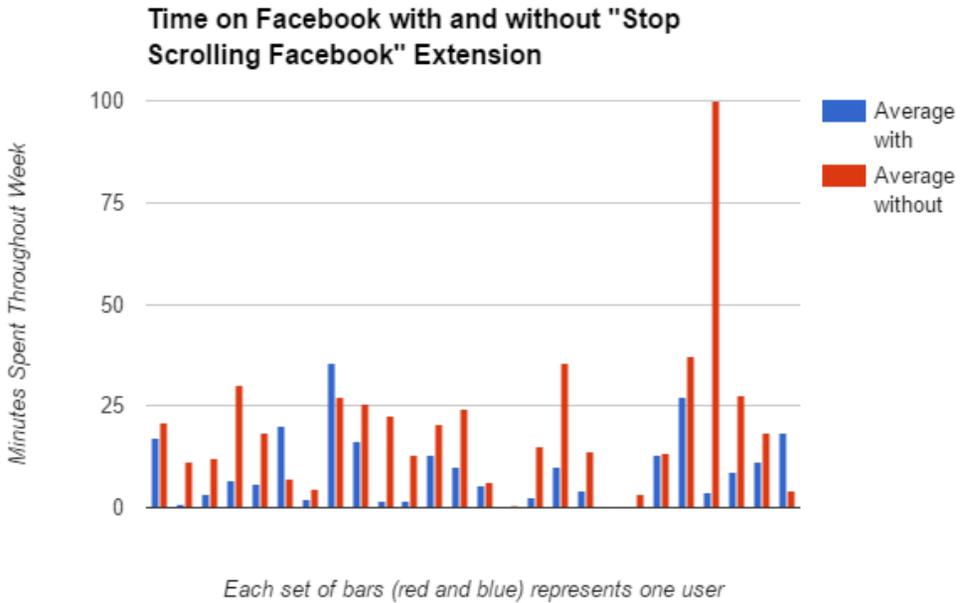


Fig. 3. Results of the Facebook Infinite Scrolling Experiment

instructed the first group to uninstall the "Stop Scrolling Facebook" extension and instructed the second group to install the "Stop Scrolling Facebook" extension. After one more week had passed, researchers reached out again and recorded weekly Facebook activity from each group.

7.1.2 Results. Students spent an average of 10.5 minutes more per week on Facebook without the "Stop Scrolling Facebook" extension than they did with that same extension. The median difference between time spent on Facebook with the extension and without the extension was 9.0 minutes. These differences are significant as students spent an average of only 9.2 minutes on Facebook with the extension vs spending 19.7 minutes on Facebook without the extension - more than twice as long. Further, only 3 students spent more time on Facebook with the "Stop Scrolling Facebook" extension; 21 students spent less time on Facebook with the extension.

7.1.3 Discussion. This experiment was limited by its restriction to tracking Facebook through a browser. When speaking with the students, most admitted that the majority of their Facebook use was conducted through Facebook's mobile apps ("Facebook" and "Facebook Messenger"). However, the difference between time spent on Facebook with and without the "Stop Scrolling Facebook" extension installed is still notable. These results illustrate that users spend more time scrolling the news feed on Facebook than they intend to.

7.1.4 Relevance. This experiment directly tests the efficacy of the "Infinite Scrolling" addictive design strategy outlined in this survey. Its results support the idea that users are deceived into spending more time on a platform with infinite scrolling.

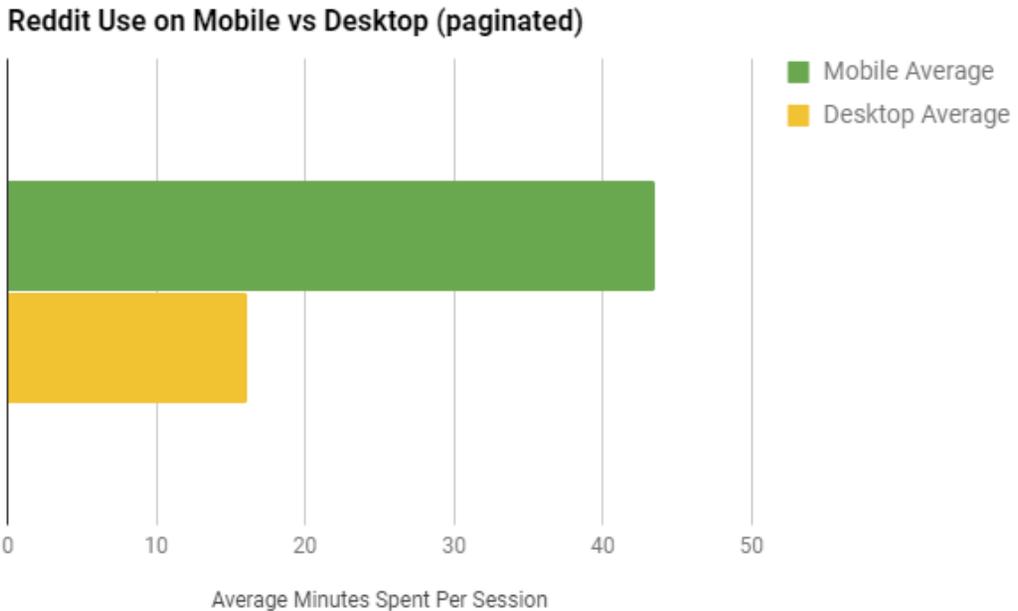


Fig. 4. Results of the Reddit Pagination Experiment

7.2 Experiment: Reddit Pagination

In this experiment, experienced Reddit users were asked to time themselves for two single sessions of Reddit use (where a session is defined as one uninterrupted period of browsing). They were asked to report one session using the Reddit Mobile application (which utilizes bottomless scrolling) and a second session using Reddit via a web browser (which utilizes pagination).

7.2.1 Procedure. Potential test subjects were polled about their Reddit use. First, subjects were asked if they'd used Reddit before. Next, subjects were asked if they had access to the Reddit Mobile application and a browser. After vetting these potential subjects, each subject was asked to self-time and partake in one session of Reddit using the Reddit Mobile application and another session of Reddit using the browser version of Reddit. Subjects were asked to partake in each session on a different day, to avoid seeing the same posts on different days.

7.2.2 Results. Every single test subject spent more time on the Reddit Mobile application than on the browser version of Reddit. Users spent an average of 43.6 minutes on the Reddit Mobile application while they spent an average of 16.1 minutes on the browser version. These averages are very similar to the medians, where users spent a median of 37 minutes on the Reddit Mobile application compared to 15 minutes on the browser version. Qualitative feedback consisted of user comments about which application they felt more or less immersed in, with almost every respondent reporting feeling less immersed on the browser version of Reddit.

7.2.3 Discussion. While this experiment was meant to illustrate the efficacy of bottomless scrolling, these results should be taken with a grain of salt. Because of the nature of the Reddit Mobile application, users almost all used the application on a mobile device while they used the browser version of Reddit on a desktop or laptop device. So while results appear to show that

bottomless scrolling is much more effective, they may just suggest that mobile devices are more compelling mediums for media consumption. Further, the vetting of test subjects (by which we required subjects to be Reddit users with access to both versions of Reddit) severely limited our sample size to a group of 7 people, which is not statistically significant.

7.2.4 Relevance. This experiment is also meant to test the effectiveness of the "Infinite Scrolling" addictive design strategy. As mentioned in the discussion, its results indicate that either infinite scrolling is effective at increasing time spent on an application, users spend more time during sessions on their phone, or some combination of both.

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