

**The Ethics of Addictive App Design: Determining Accountability and Prevention Strategies
for Dangerous App Designs**

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On my honor as a University Student, I have neither given nor received unauthorized aid on this
assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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Introduction

On average, each member of the estimated 2.71 billion smartphone user population checks their phone over 150 times a day (Neyman, 2017; Montag, 2019). As smartphone overuse and addiction proliferates globally, it is essential to critically evaluate the potential consequences, causes of addiction, and ethical boundaries surrounding the growth and development of smartphones and their applications (apps). App developers increase addiction by utilizing unregulated design techniques rooted in psychology to maximize user time spent with the app open. These techniques include infinite scrolling, social reciprocity, and user investment (Neyman, 2017). Each of these techniques provide stimulus to the user that signify a successful completion of a task or social interaction, which trigger dopamine releases through one of three reward pathways (Haynes, 2018). App addiction is both physically and mentally harmful to users as research shows it can contribute to eye strain, spinal pain, exhaustion, anxiety, and depression (Paek, 2017). Despite the harmful impacts, the only barrier protecting users from addictive designs is app developer self-regulation, such as the removal of the viral app “Flappy Bird” by the designer on the grounds of it becoming too addictive for users (Nguyen, 2014). The theory of Technological Momentum is being applied to examine how technological influence and societal demands feed into each other to create an environment where these dangerous designs can thrive. In order to create a safer digital world for future generations, the following question must be addressed: What ethical points of accountability can be found in the new gray area of malicious app design to protect users?

Methods

Historical Case Studies and Policy Analysis methods are utilized to analyze the social and political structures that allow addictive smartphone apps to thrive. The Historical Case Study focuses on comparing the journeys of two addictive apps that found massive success in the technology industry, Flappy Bird and Candy Crush. The development, release, and management of these games are evaluated to determine what ethical boundaries are set by the creators and how those boundaries impact their success. As there is currently no active regulation on addictive app design, the Historical Case Study is centered around the idea of self-regulation. Political regulatory approaches are explored separately through the Policy Analysis. The Policy Analysis is completed by gathering data on past attempts towards regulatory measures. As the U.S. has no successful, existing precedent in this area, app regulation in other countries as well as general technology regulation trends in the U.S. are studied. The policy data is organized geographically as well as chronologically in order to provide necessary context surrounding the regulation and identify any trends.

The Psychology and Regulation of Addictive Design

Addictive app design is reliant on the dopamine rushes that certain features give to users (Wright, 2018). On the user experience side of app design, dopamine rushes are created through usage of infinite scrolling, social reciprocity, and user investment (Neyman, 2017). Firstly, infinite scrolling is utilized by putting all the desired content on one page that can be continuously scrolled through rather than spreading the content over a series of pages. The psychology that supports this technique is illustrated by the “Bottomless Bowl” study in which

professor Brian Wansink proved that people would eat 73% more soup if they are given a bottomless bowl because they lose the visual cue of an empty bowl (Wansink, 2005; Neyman, 2017). Secondly, social reciprocity is the instinct to respond to others in social situations driven by societal convention and courtesy. Allowing users to interact on apps in the form of liking, commenting, or following creates a feeling of obligation to reciprocate the received interactions (Neyman, 2017). Thirdly, user investment involves allowing the user to build something such as a profile. This idea utilizes the “Ikea effect”, which proved that customers were willing to pay more for furniture if they were able to be involved in the assembly (Neyman, 2017). These three all fall under the umbrella of user experience; however, user interface design is also utilized in order to make apps more addictive. The primary tool of addictive user interface design lies in the usage of color (Wright, 2018). Bright colors and warm tones keep users more engaged and entertained. A study of one hundred sixty-one undergraduate students showed that activating the grayscale setting on their phones reduced screen time by 37.9 minutes per day (Holte, 2020).

The neurological effects of these addictive features mimic those seen during the usage of hard drugs, like cocaine (Wright, 2018). The argument that users cannot be addicted to smartphones because addiction requires physical withdrawal symptoms, often associated with hard drugs, has been highly contested. Addiction to a substance is physically different from addiction to a behavior or activity, however smartphone withdrawal symptoms have been discovered.

Withdrawal symptoms of regular smartphone users include increased anxiety, heart rate, and blood pressure (Clayton, 2015). Disbelief in and misunderstanding of smartphone addiction has slowed the progress of creating meaningful legislation to regulate tech companies.

Dangerous app design techniques are currently entirely self-regulated by tech companies who are financially incentivized to increase user screen time. In recent years, there has been an

increase in concern about this lack of regulation and effort to create legislation to protect smartphone users. In 2019, Missouri governor Josh Hawley introduced a bill to ban infinite scrolling and auto play as well as automatically limit time spent on an individual app to 30 minutes a day. This bill did not gain widespread support as it was seen as an attack on “Big Tech” and not everyone believes that smartphone addiction is real (Stewart, 2019). The same year an Italian politician, Vittoria Casa, submitted a bill to require classes on the dangers of smartphone addiction in schools, introduce “re-education” in health care centers, and attempt to monitor excessive smartphone usage (Hamilton, 2019). Casa’s bill did not gain support for the same reasons as Hawley’s. Despite these initial failures, regulation is anticipated to gain more widespread support in action in the coming years of 2022 and beyond (Lima, 2022).

Technological Momentum and Smartphone Apps

The STS framework to support this analysis is Technological Momentum. Technological Momentum will allow for accurate analysis of the current state of society’s engagement with smartphone apps, which currently lies between Social Construction of Technology (SCOT) and Technological Determinism (Hughes, 1994). The early stages of professional app development followed the SCOT framework as apps were designed to meet consumer desires and needs (Klein, 2002). As smartphone app addiction steadily increased, a societal reliance on this technology was created. App technology is still influenced by societal and cultural standards but has clearly shown that it can influence those standards as well. As the system continues to age, it will lean towards Technological Determinism and society may lose control over this potentially dangerous creation (Smith, 1994). The Technological Momentum framework is effectively utilized in the Socioeconomic Impacts of Autonomous Vehicles by Christopher Fitzpatrick (Fitzpatrick, 2020). While discussing Autonomous Vehicles (AV), Fitzpatrick elaborates on the

combination of SCOT and Technological Determinism that produces the Technological Momentum framework and the benefits of viewing technological problems as time dependent. The Technological Momentum framework is particularly useful when analyzing technologies that are in a distinct growth period, such as AVs and Smartphone Apps. The primary critique for Technological Momentum is that it is too broad a framework and lacks precision. This critique is due to the fact that there is a wide spectrum of interactions between technology and society. This weakness will be accounted for by identifying and calling out societal shifts of smartphone app usage on the spectrum of Technological Momentum.

Research Overview

The current state of society's engagement with smartphone apps is categorized as Technological Momentum, seated between SCOT and Technological Determinism (Hughes, 1994). As app technology continues to develop and find new ways to keep users hyper engaged, the influence it has over society is growing larger. The manner in which society engages with smartphone apps is gradually moving towards a state of Technological Determinism. Thus far, society has been relying on tech companies to self-regulate the ethical bounds of their products. Given this freedom, tech companies have exemplified how self-regulation is not a sustainable or reliable form of protection for smartphone users. Consumers need to be provided with the necessary tools to continue to shape technology as it shapes them. Regulation needs to occur in two main phases of app production: development and management. In the development phase, addictive design techniques must be further researched and restricted through legislation. Developers often learn and utilize addictive techniques without fully understanding the impact or implications of the designs. Establishing a repository of known harmful techniques will limit unintended damage and creating restrictions will prevent malicious design. In the management

phase, corporations need avenues to be held accountable for the impact of their active product designs regardless of alleged intent. As new addictive design techniques continue to be discovered, regulatory measures must be able to quickly adapt to provide effective protection to consumers. To achieve this end, management regulation must provide an opportunity to target the symptoms of addiction rather than attempt to predict future causes.

Case Studies: Flappy Bird and Candy Crush

Flappy Bird was a viral sensation for smartphone users, reaching over 50 million downloads within the nine months it was available for download in the app store (Yarow, 2014). The simple yet addictive game challenges the user to navigate a bird through a course of green tubes by tapping on the screen. Flappy Bird was coded in less than a week by Vietnamese Indie Developer, Dong Nguyen, and was released in the app store for over six months before finding widespread success (Mauldin, 2017; Nguyen, 2014). The app reached peak popularity in January of 2014, at which time Nguyen was making nearly \$50,000 every day from Flappy Bird revenue alone. However, Nguyen made the decision to remove the app from the app store in February of 2014. Nguyen cited guilt as the primary reason for taking Flappy Bird down, saying, “I couldn’t sleep” (Nguyen, 2014). The game was initially designed to be played as a method for relaxation when the user had free time, but Nguyen observed that the app was becoming harmful and addictive to players. Other apps designed by Nguyen remain in the App Store as the creator does not perceive them as having the same harmful impact. However, Nguyen has stated that if he observes the same addictive effects Flappy Bird generated, he will also remove his other apps from the store as well (Nguyen, 2014).

Multiple psychological components contributed to the addictive nature of Flappy Bird. The Flappy Bird case study focuses on specific UI and UX components rather than overall game and strategy design, which is another notable contributing factor. Flappy Bird utilizes a retro, pixelated aesthetic filled with bright greens and yellow. The usage of bright colors and warm tones has been proven to increase user engagement and entertainment (Holte, 2020). In addition to the aesthetic choices, the method of engagement is intrinsically addictive. The game stores the user's high score but does not involve a trackable progression through levels. The lack of visual cues to signify relative completion or time investment allows Flappy Bird to utilize the same “Bottomless Bowl” psychological principle applied in infinite scrolling (Wansink, 2005, Neyman 2017). Given the limited resources and time frame utilized to develop Flappy Bird, it is unlikely that Nguyen applied these principles intentionally.

The Candy Crush Saga was launched in 2012 and found immediate success as the most downloaded app in 2013 (Tripathi, 2020). The creator of Candy Crush, King Digital Entertainment Company, employs over 2,000 people and develops a wide variety of interactive mobile games (“*King digital entertainment*”, 2022). The addictive nature of King’s game was explored in a 2013 survey of 1,000 users in which “32 percent ignored friends or family to play the game; 28 percent played during work; 10 percent got into arguments with significant others over their play time; and 30 percent admitted they were addicted.” (Fruhlinger, 2019). At the time this survey was conducted, Candy Crush was generating \$800,000 every day for King (Smith, 2014). King has not addressed any addiction concerns to the public but has consistently added new features and levels to Candy Crush, continuing the app's growth. Reports in 2019 indicate that Candy Crush overall users spend an average of \$4.2 million on the game every day, leading to an estimated \$200 million quarterly revenue (Fruhlinger, 2019).



Figure 1

Candy Crush Map and Gameplay Screens

The two primary user interaction screens in Candy Crush are the map screen and the gameplay screen in Figure 1 (Lofté, 2013). The gameplay screen is where the user interaction occurs and how the game progresses. The map screen tracks user progress and allows the user to navigate throughout different levels. Both of these screens are brightly colored, contributing to increased user engagement (Holte, 2020). The design of the map page integrates multiple psychological app design components. The levels on the map are connected by a road which originates and ends out of the user's view. The user will continue to progress up the road as more levels are completed. However, the progress made by the player is no longer visible as the completion marks are moved off the page in order to create space for new levels revealed along

the road. The “Bottomless Bowl” effect is utilized by the lack of clear start and end destination visual cues on the map to signify an appropriate stop time (Wansink, 2005). The map also ties in the User Investment principle by providing a physical manifestation of the player's progress that can be “built” over time (Neyman, 2017). These three principles combine to make the app design addictive for many users. Given the resources available to King Digital Entertainment Company, it is unlikely that Candy Crush was designed without prior knowledge and understanding of these design principles.

Flappy Bird and Candy Crush provide an effective comparison in self-regulation approaches as both apps reached extreme popularity along close timelines and by using similar addictive app design techniques. Despite these similarities, Flappy Bird is gone forever, and Candy Crush continues to grow. Three main distinctions must be made in analyzing how these cases reached their outcome: Design Resources, Workplace Pressures, and Economic Impact. Beginning with Design Resources, Flappy Bird was designed by a single developer in less than a week (Mauldin, 2017). Whereas Candy Crush resulted from six different teams, comprising half of the employees at King Digital Entertainment Company, working through the app research and design process with an end goal of generating profit (Handley, 2020). The availability of technological and human resources decreases the likelihood of misunderstanding specific design techniques and their potential impacts in the development stage. The difference in development team sizes also contributes to the impact of Workplace Pressures. King Digital Entertainment Company invested a large portion of the company to explore Facebook games and viewed success in the game development project as integral to the company's survival (Handley, 2020). The pressure to deliver new content and progress towards the company end goal would fall upon the employees at King Digital Entertainment Company. As an independent developer, Dong

Nguyen would not receive the same negative impacts from slowed production and would have more control over the direction of development. Finally, the removal of Candy Crush from the app store would have a significantly different Economic Impact than the removal of Flappy Bird. Candy Crush titles generate 85% of the overall revenue for King Digital Entertainment Company, which currently employs over 2,000 people (Williams, 2019). While Nguyen decreased his personal income by removing Flappy Bird from the app store, the magnitude of the Economic Impact of his decision is significantly smaller.

Independent app developers typically operate under more optimal conditions than corporations to prevent and remediate malicious app design. However, it is becoming increasingly difficult for independent developers to succeed in the current market (Duncan, 2014). The current method of self-regulation lacks the necessary systemic reliability and sustainability to combat the negative impacts of smartphone app addiction. As such, progress towards legislation regulating addictive app design must be accelerated. Legislation can function as a necessary tool for society to shape the development of app technology.

Policy Analysis

Some 56% of Americans believe that tech companies should incur more government regulation and this support is trending towards further growth, especially among liberal democrats (Vogels, 2021). Experts predict that 2022 will be a watershed year for technology regulation in the United States (Lima, 2022). However, there are many areas for regulation and the U.S. is not currently focusing on addictive app design as a top priority. The U.S. tends to follow EU trends of technological regulation (Gold, 2021). As such, progress towards

technology regulation in the United States has primarily focused on antitrust measures, content moderation, privacy, and artificial intelligence.

There have been two unsuccessful, major legislative attempts in the addictive app design space as discussed in *The Psychology and Regulation of Addictive App Design*. Neither of these bills gained widespread support as they were seen as an attack on “Big Tech” and there was a general lack of belief in and understanding of smartphone addiction. It is unlikely that future legislation will face these barriers in the same magnitude as bipartisan support for technological regulation grows (Vogels, 2021). The first attempt towards a bipartisan bill regulating addictive app design in this new wave of legislation was introduced in California by Buffy Wicks (Democrat) and Jordan Cunningham (Republican). The Social Media Platform Duty to Children Act would allow parents to sue social media companies for damages that have been incurred on their children by addictive apps (Social Media Platform Duty to Children Act, 2022). For example, parents could sue for the cost of a psychiatrist to treat their child (Deighton, 2022). Unlike the failed Missouri bill introduced by Hawley, the Social Media Platform Duty to Children Act has bipartisan sponsorship and does not limit the actions of corporations, but rather provides a source of accountability. While this access to accountability is necessary, the proposed structure puts the onus of seeking out remediation on the consumer rather than the content developer or a regulatory body.

Limitations and Future Directions

The research conducted in the above case study and policy analysis is limited by several factors. The case study is limited by the amount of information corporations and individuals are willing to share with the public concerning the app development process. Comparison of the

development processes of Flappy Bird and Candy Crush would have been enriched by a deeper understanding of the steps and associated timeline. Additionally, ability to view user research and trial results would allow for a better understanding of the developer's intent. The policy analysis performed was limited by timing as a new wave of technological regulations will be rolling out in the coming year of 2022. The content of these regulations and the manner in which they are received will set a new standard and shape how the United States views regulatory measures. As there is no existing successful regulation in the field of addictive app design, assumptions about the requirements and impacts of a passing bill were made.

The anticipated influx of technological legislation would provide very useful information and guidance in continuing research on accountability for addictive design practices. Tracking trends in the specific design principles and app types the successful legislation attempts to address could produce a better understanding of where legislation is needed and well received. In addition to further policy analysis, research could be continued into how the gamification of everyday apps impacts smartphone addiction. While many UI/UX and psychological principles were addressed in this paper, the psychology and study of game addiction was left out to allow for greater focus on app design. However, as more app developers are incorporating gamification into non-game apps it is likely that some of the principles of addictive game design and addictive app design will converge.

Conclusion

Accountability for technology companies must be established through legislation in both the development and management phases of app production in order to protect consumers from both known and undiscovered addictive design techniques. Design intent is challenging to

identify and prove, and thus should not be the singular focus of regulation. Rather, regulation should target specific known techniques as well as symptoms of addiction. Government regulation is necessary as the structure of corporate systems and the typical app development process is not conducive to ethical self-regulation. Incorporation of addictive design techniques, that are often used without consumer consent or understanding, are creating an imbalance between society and technology that must be addressed in order to protect users from further harm.

References

- Clayton, R. B., Leshner, G., & Almond, A. (2015). The extended iself: The impact of iphone separation on cognition, emotion, and physiology. *Journal of Computer-Mediated Communication*, 20(2), 119–135. <https://doi.org/10.1111/jcc4.12109>
- Deighton, K. (2022). *California bill aims to make tech firms liable for social-media addiction in children*. Wall Street Journal. <https://www.wsj.com/articles/california-bill-aims-to-make-tech-firms-liable-for-social-media-addiction-in-children-11647382786>
- Duncan, G. (2014). *Can indie app developers compete with corporate giants?* Digital Trends. <https://www.digitaltrends.com/mobile/can-indie-developers-still-make/>
- Fitzpatrick, C., Seabrook, Bryn (advisor), & Garner, Gavin (advisor) (2020). Design and Construction of a Ferrofluid Kinetic Art Clock; Socioeconomic Impacts of Autonomous Vehicles. Charlottesville, VA: University of Virginia, School of Engineering and Applied Science, BS (Bachelor of Science), 2020. Retrieved from <https://doi.org/10.18130/v3-y0ez-qe67>
- Fruhlinger, J. (2019, February 10). *Candy crush addiction is real—And can lead to destructive results* Observer. <https://observer.com/2019/02/candy-crush-addiction-real-problem/>
- Gold, A. (2021). *How the U.S. is taking cues from Europe on tech policy*. Axios. <https://www.axios.com/us-europe-tech-policy-margrethe-vestager-bf52369d-8083-4cc8-ac93-e6632e7159c1.html>
- Hamilton, I. A. (2019). *Italy wants to treat phone addicts like drug addicts and send teens to rehab*. Business Insider. <https://www.businessinsider.com/italian-mp-introduces-bill-to-curb-phone-addiction-in-teens-2019-7>
- Handley, L. (2020). How candy crush saga’s riccardo zacconi became a gaming king. *CNBC*.

<https://www.cnbc.com/riccardo-zacconi-hitting-the-sweet-spot/>

Haynes, T. (2018). Dopamine, Smartphones & You: A battle for your time. *Science in the News*.

<https://sitn.hms.harvard.edu/flash/2018/dopamine-smartphones-battle-time/>

Holte, A. J., & Ferraro, F. R. (2020). True colors: Grayscale setting reduces screen time in college students. *The Social Science Journal*, 0(0), 1–17.

<https://doi.org/10.1080/03623319.2020.1737461>

Hughes, T. P. *Technological Momentum*. (1994). Cambridge, Massachusetts. London, England. The MIT Press.

Klein, H. K., & Kleinman, D. L. (2002). The Social Construction of Technology: Structural Considerations. *Science, Technology, & Human Values*, 27(1), 28-52.

<https://doi.org/10.1177/016224390202700102>

“King digital entertainment company profile: Acquisition & investors” / *pitchbook*. (2022).

Retrieved March 20, 2022, from <https://pitchbook.com/profiles/company/54278-47>

Lima, C. (2022). *Analysis | Why 2022 could be a ‘watershed year’ for tech regulation*.

Washington Post. <https://www.washingtonpost.com/politics/2022/01/03/why-2022-could-be-watershed-year-tech-regulation/>

Lofte, L. (2013). *Candy Crush Saga: It’s Bejeweled for ruining your life*. iMore.

<https://www.imore.com/candy-crush-saga-iphone-review>

Mauldin, J. (2017) *The real story behind why flappy bird was deleted(Probably)*. Salient PR.

<https://salientpr.com/blog/therealstorybehindwhyflappybirdwasdeleted>

- Montag, C., Lachmann, B., Herrlich, M., & Zweig, K. (2019). Addictive features of social media/messenger platforms and freemium games against the background of psychological and economic theories. *International Journal of Environmental Research and Public Health*, 16(14), 2612. <https://doi.org/10.3390/ijerph16142612>
- Neyman, C. (2017). A survey of addictive software design. *Computer Science and Software Engineering*. <https://digitalcommons.calpoly.edu/cscsp/111>
- Nguyen, L. A. (2014). *Exclusive: Flappy bird creator dong nguyen says app “gone forever” because it was “an addictive product.”* Forbes. <https://www.forbes.com/sites/lananhnguyen/2014/02/11/exclusive-flappy-bird-creator-dong-nguyen-says-app-gone-forever-because-it-was-an-addictive-product/>
- Paek, K. S. (2017). A convergence study the association between addictive smart phone use, dry eye syndrome, upper extremity pain and depression among college students. *Journal of the Korea Convergence Society*, 8(1), 61–69. <https://doi.org/10.15207/JKCS.2017.8.1.061>
- Smith, D. (2014, April 1). *This is what Candy Crush Saga does to your brain.* The Guardian. <https://www.theguardian.com/science/blog/2014/apr/01/candy-crush-saga-app-brain>
- Smith, M.R. (1994). Technological Determinism in American Culture. *Does Technology Drive History?: The Dilemma of Technological Determinism*. (pp. 1-17). Cambridge, Massachusetts. London, England. The MIT Press.
- Social Media Platform Duty to Children Act, no. 2408, 2022 Reg. Sess. (California 2022) <https://www.sandiego.edu/cai/advocacy/legislation/ab2408.php>
- Stewart, E. (2019). Josh Hawley’s bill to limit your Twitter time to 30 minutes a day, explained. Vox. <https://www.vox.com/recode/2019/7/31/20748732/josh-hawley-smart-act-social-media-addiction>

Tripathi, Y. (2020). *Candy Crush is from which country? Know who the founder is and more.*

Republic World. <https://www.republicworld.com/technology-news/apps/candy-crush-is-from-which-country-know-who-the-founder-is-and-more.html>

Vogels, E. A. (2021, July 20). *56% of Americans support more regulation of major technology*

companies. Pew Research Center. <https://www.pewresearch.org/fact-tank/2021/07/20/56-of-americans-support-more-regulation-of-major-technology-companies/>

Wansink, B., Painter, J. E., & North, J. (2005). Bottomless bowls: Why visual cues of portion

size may influence intake**. *Obesity Research*, 13(1), 93–100.

<https://doi.org/10.1038/oby.2005.12>

Williams, K. (2019, November). *King's candy crush soda saga surpasses \$2 billion in player*

spending. SensorTower. <https://sensortower.com/blog/candy-crush-soda-saga-two-billion-revenue>

Wright, A. (2018). Smartphones: Delivering Your Daily Dose of Dopamine in a Convenient,

Pocket-Sized Package! Alaska Pacific University.

<https://turnagain.alaskapacific.edu/smartphones-delivering-your-daily-dose-of-dopamine-in-a-convenient-pocket-sized-package/>

Yarow, J. (2014). *That goofy, addictive flappy bird game is doing \$50,000 in sales per day.*

Business Insider. <https://www.businessinsider.com/flappy-bird-is-doing-50000-in-revenue-per-day-2014-2>