

Combatting the Ever-Growing Societal Issue of Smartphone Addiction

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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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ABSTRACT

This technical project will involve developing a proof of concept solution to curb smartphone addiction, a prevalent issue continually growing in today's society. Smartphone addiction continues to rise at an alarming rate year by year, and is the cause of educational, emotional, and health related stress and concerns. While current attempts to solve this problem exist, they fall short in terms of emphasizing determination and support in the sense that the users themselves are the only ones who can solve their own addiction. This proof of concept will take the form of a Google Chrome Extension to tackle the problem of website addiction. It will monitor the time a user spends on different websites, and provide informative notifications to users based on their website usage and behavior. For example, if a user has been on a website for a long period of time, a pop up notification will be issued to raise the user's awareness. This extension will also reward users for weekly improvements in their addiction using positive and negative reinforcement in the form of reimbursing the user with money they will have initially deposited to hold themselves accountable. Users will be able to edit and set preferences to help the user customize and personalize their journey to limit and ultimately stop their website addiction, which is a small aspect existing within the overarching problem of smartphone addiction. Provided features will be personalizable for the user will be time limits for particular websites, frequency of pop-up notifications, and more. This proof of concept aims to provide a more personal and supportive solution for users to help themselves curb and eventually eliminate their addiction, while additionally improving upon existing solutions to bring more attention to this alarming, fast-growing societal issue.

INTRODUCTION

Quite possibly one of the most influential, impactful, and innovative creations of the century is the smartphone. As of 2019, 81% of Americans owned a smartphone [Mitchell et al. 2021]. Regardless of race, gender, income, education, or community, the percentage of people in the world altogether who own a smartphone is incredibly high and ever-increasing. With ownership percentages of these devices increasing by the year, the addictive ability through new features and capabilities seems to increase as well. From social media usage such as Instagram or Facebook to educational usage such as Quizlet or YouTube, today's smartphones exhibit a vast array of features to the point where individuals in today's society have all of his or her needs encapsulated into one personal item: their phone.

Applications such as AppDetox, Flipd, and Moment are current applications that aim to combat this addiction. While they offer helpful services such as allowing users to set "rules" on how long they can spend on specific applications alongside reports on daily activity, their engineers seem to have fallen short in terms of not providing personalized, and encouraging features and not emphasizing problem recognition and acceptance as being two extremely important initial steps [Tengyuen 2020]. The current approaches to solving the overall problem of smartphone addiction

are effective only if the users utilizing them have bought into actively attempting to curb their addiction. These solutions prove to be ineffective because they do not promote determinism, perseverance, and encouragement in the realm of making the user trust the process of change. This is seen in terms of the features included within current solutions - as these features solely tackle the general outstanding issues, while giving users too much power with various loopholes to get out of sticking with a recovery plan. For example, this is evident through the personalizable rules that users can make, with no additional encouragement or help in the form of useful tips or rewards for staying off of their smartphones. The negligence of engineers via their current attempts to curb the addiction to provide the fulfilled solutions that support the enforcement of accountability for users who are addicted can and will lead to a large chance of relapses and continued spread of smartphone addiction.

Current solutions such as Apple's Screen Time, additionally seem to be half-heartedly engineered solutions that do not seem to be innovating with an eye for the benefit of society. Arguably, if Apple engineered a strong phone addiction combatant, iPhone sales would plummet, which seems to be a reason for concern amongst technological giants that are producing and selling smartphones.

In listing these various concerns and neglections in the realm of combating smartphone addiction, it is evident that if an optimal and genuinely helpful solution is not found soon, the true value of our natural communicative abilities as humans could be lost. Familial relationships will continue to deteriorate, as this addiction will only grow. As the dependence upon smartphones persists, anxiety increases as the availability of our minds to fully concentrate on vital tasks, called Working-Memory Capacity, decreases tremendously [Carr 2017]. A new and improved solution to this problem is necessary - one that not only provides personable features for users to feel comfortable, but additionally ensures accountability and encouragement in solving a core addiction issue in today's society.

BACKGROUND

This project will aim to research and analyze features that will improve upon existing solutions by providing a proof of concept of a tool that includes features that are missing. By introducing such features in the form of a proof of concept, we hope to investigate the feasibility and viability of our proposed solution before testing the user-friendliness and effectiveness of these additional features for the future. Once research has been conducted with positive results, the goal will then be to incorporate these missing features into any existing current solutions to provide a fulfilling and whole-hearted tool to aid users to combat their smartphone addiction.

The technologies that will be utilized in the future to actually build up a Google Chrome Extension include HTML, JavaScript, and CSS.

RELATED WORK

AppDetox, considered the best anti-smartphone addiction application currently in app stores, provides features such as setting rules for oneself in terms of how long you can be on a specific app for a day, usage time reports, and rulebreaks [Tengyuen 2020]. The clear approach by its developers here was to provide unique features that allow the users to personalize their limitation factors, while “punishing” users for breaking the rules they have set for themselves. While AppDetox provides helpful features, it does not help the user on a personal level to promote their success and encourage determinism to continue the journey to stop being addicted. This flaw can also be seen in FlipD, another leading application in combating this type of addiction. Combating smartphone addiction cannot be achieved without implementing a feature that promotes encouragement, accountability, and responsibility. Without such a feature, the user could easily fall back into their regular routines of checking their phone every five minutes, feeling anxious when they do not have their phone on their person, or other similar signs of clear addiction to their cellular device.

Another existing solution worthy of mention is Apple’s “Screen Time” which was developed and released in 2018. This application solidified smartphone addiction as a prevalent issue because it brought the technology giant Apple to release an application to make users more aware of how they were using their smartphones. Seeing as they released Screen Time as a way of acknowledging the surge of iPhone addiction, users began to note its strengths and benefits. While Screen Time introduced various helpful tools such as setting limitations, parental controls, and weekly notifications, many users pointed to the value of the overall application being lost due to lack of integrating features that tackled promoting self-awareness and self-responsibility to users [Bogost 2019].

Providing downtime limitations and self-set “bed-time” capabilities alongside very detailed weekly reports on usage that come out every Sunday, Apple looked to help users “make more informed decisions” while utilizing their device [Bogost 2019]. At the same time, the application allows users to ignore time limits, while also providing inconveniences in the realm of poorly timed weekly reports. Another source suggests that major complaints had to do with the ability to distinguish between “mindless” and “relevant” activities along with the incapability of the application to provide long-term behavioral statistics [Iryna 2019]. A paramount factor to solving this issue of addiction has to do with allowing the user to acknowledge and realize they are addicted, because by helping addicts to accept and understand their situation, they have already overcome the most difficult battle [Discovery Place 2016]. It can be concluded that Apple has provided an operational, but incomplete smartphone anti-addiction application. With the goal of bringing light to the situation, but clearly not overreaching to the point of losing business, Apple has established a network that has provided users with various capabilities to *monitor* their addiction, but not to *combat* and ultimately solve it.

One feature that will be researched has to do with the functionality of controlling notifications from outside applications through one centralized application. Users will be able to set time ranges in which certain applications’ notification will not be allowed to be

pushed through. Users will also be provided notifications of encouragement, including useful tips on other healthy activities that should be done (like drinking water, exercising, etc.) alongside a daily progress report explaining how they, hopefully, are spending less time on their phones. Apple’s “Screen Time” feature is missing exactly this. While pushing notifications about usage statistics and the ability to set limits are nice to have, the engineers behind this feature neglected to take it any further in terms of bringing to attention signs of addiction and how to stop poor routine tendencies [Apple Inc. 2020].

An existing application that implements a feature that has been overlooked in a majority of other contemporary solutions is called Flora, which is a study-focus application that seeks to limit distractions on one’s phone while studying. When this application is used, a timer can be set and a dollar limit can be set such that every time the user attempts to utilize their phone during this set time they must pay \$X in order to gain access. This is a form of negative reinforcement - a concept of a feature that is very useful and helpful when dealing with issues of addiction. Another literature review cites three determinants for addictive smartphone usage: mood regulation, convenience, and instant gratification. The above example of Flora’s feature falls under the category of mood regulation, which according to the literature review is a form of negative reinforcement due to the nature of charging the user money to access his or her own phone. The review cites this as an effective strategy to combat many addictive behaviors, by causing “flow,” which can be seen depicted in the diagram below [Zhang et al. 2014].

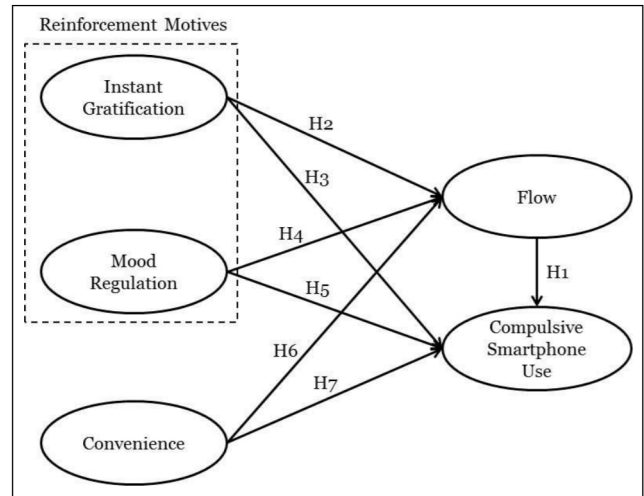


Figure 1: Positive & Negative Reinforcement Flow via the 3 Determinants of Addictive Behavior. Diagram made by a Literature Review Research Paper called, *Compulsive Smartphone Use: The Roles of Flow, Reinforcement Motives, and Convenience* and cited in References [Zhang et al. 2014].

SYSTEM DESIGN

Here, we outline and delineate the various system design components that would exist in the form of a Google Chrome Extension serving as a proof of concept. In describing the technologies, concepts, and components within this idea we will also outline the relationships and interactions between them. The Google support page describing how to go about developing and implementing a Google Chrome extension was utilized to attain a better understanding of how to design this system [Google 2018].

1.1 SYSTEM FEATURES

There will be various features incorporated into the design of this future system, most notably:

- User Preferences (money deposit, time limit set)
- Notifications (Pop-ups)
- Analytics/Reports

User Preferences:

This component of the system will be what the user first sees as they download the extension, and will be modifiable in the options page of the extension. It will consist of standard individual information including name, monetary information, weekly time limit setting, user email and whether the user is considered a student or an adult. A very interesting design decision here is ensuring that the user will need to choose whether they are a student or an adult to help the program delineate “study/work hours” that will not be counted against them in the time limit they set for themselves for free usage of the internet. This is important because depending on the user, their “Free-time” usage hours of a web browser would differ. This component will directly connect to the overall database storing each user’s information.

Notification System:

The notification system will be built utilizing Google Chrome’s chrome.notification API. The API will allow the extension to produce the pop-up notifications for a user based on their current usage time, the amount of money remaining to be made at the end of the week, and a reminder to review and contribute to their end-of-week report. Notifications will be triggered based on spikes in usage and to alert a user of their remaining “Free-time”.

Analytics/Report:

At the end of every week (Sunday night), each user will be emailed a personalized Google Survey Form filled with information for how they performed with their website behavior and usage statistics for the week that will give the user a chance to justify how they improved or regressed in their journey to combat this addiction. Their response will then be stored back into the database linked to their other user information and can be viewed at any time to track progress. Some of the statistics that will be collected include overall time spent on the internet during “Free-time hours,” money deposited to begin the week, money lost/retained by the end of the week, and the justification provided by the user via the form.

1.2 SYSTEM ARCHITECTURE

The system architecture for the extension can be divided into four elements, as shown in Figure 2:

- Manifest
- Background Script
- Options Page
- Data Storage

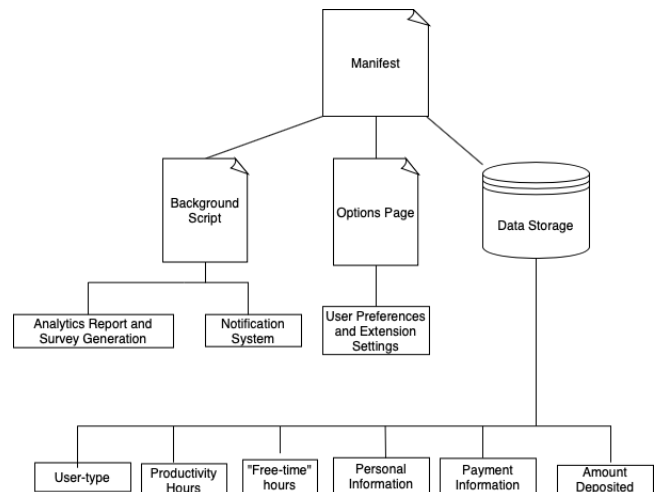


Figure 2: Diagram for System Architecture of Proposed Proof of Concept for Google Chrome Extension

Manifest:

The extension will utilize a Manifest v3 file to outline information needed by the browser to integrate the extension, such as the title and version of the extension. The manifest will define the icon for our extension and define the default landing page when the icon is clicked in the browser. The schema for the database keeping track of user data and information will also be defined within this file. The background script and options page utilized by the extension will be included to ensure the proper functionality of the extension.

Background Script:

The background script will provide the event-handler functionality for our extension. Within the background script, we will define event listeners based on the user’s browser actions and current date and time in relation to the week and productivity hours. The background script will wait until the defined events occur, and define the pop-up notifications that correspond to each event.

The background script will define listeners for each of these events:

- Beginning of each week
- User has not deposited money
- End of the day has been reached
- User goes over set time limit
- End of the week has been reached
- Survey submitted
- User preferences updates

At the beginning of each week, the user will receive a pop-up notification to let them know to deposit funds for the week. If funds

are not provided on the first day of the week, the user will receive a notification once a day each day afterwards notifying them to deposit funds. Once the funds are deposited, the background script will update the database based on the amount of money the user provided.

At the end of the defined hours of productivity based on user preferences, the user will receive a pop-up notification describing the amount of "Free-time" available for use. In the event that a user goes over their set time limit, the user will be provided a pop-up notification notifying them that they have exceeded their defined limit. They will also be notified that deductions to the amount of money deposited at the beginning of the week will now begin.

At the end of each week, defined as Sunday evening, the background script will generate the analytics report based on the user's internet usage for the week, and send the survey regarding their usage to the email listed in their personal information. The report will be generated using data stored within the database throughout the week. The extension will alert the user that the survey has been sent via a pop-up notification. Once the survey has been submitted, the background script will store the information from the user's responses into the database and alert the user that the responses were received successfully.

When a user updates their preferences, the extension will update the user's stored preferences in the database. The background script will handle adjusting the remaining time for the week (if the user adjusts their preferences during an active week), remaining funds for the week, and other fields affected by the update.

Options Page:

The options page will allow the user to modify the settings of the extension by defining the adjustable features.

The options page will provide the user the ability to adjust the functionality of the extension within these aspects:

- User credentials
- "Free-time" hours
- User-type
- Payment information
- Amount deposited

The User credentials option will allow the user to modify their personal information, including their first and last name, and the email address the user would like the end of the week report sent to.

The "Free-time" hours option will allow the user to set the amount of hours they allow themselves to spend on the internet outside of productivity hours.

The User-type option allows the user to choose whether they are a student, providing them productivity hours from 9am-9pm, or they are an adult, providing them productivity hours from 9am-5pm.

The Payment information option will allow the user to modify or update their payment information.

The Amount deposited option will allow the user to modify the amount of money they deposit for the week. If funds are deposited and the week has begun, funds may not be adjusted.

Data Storage:

The method of data storage will follow the schema and information defined in the manifest file. Google Chrome's chrome.storage will be integrated in order to maintain the user data within the extension throughout browsing sessions. The database will be modified by the event listeners within the background script. The database will be used to store the user's personal information, as well as information about the amount of "Free-time" they have remaining for the week, the amount of money they are still able to earn based on the remaining funds from the weekly deposit, and payment information for deposits.

1.3 SYSTEM UI

The extension's UI will be accessible through the Google Chrome browser in the form of an icon. Once the icon for the browser is clicked, the default page for the extension defined in the manifest file will be displayed on the user's screen.

The default page will be a small window that provides information to the user about their current status within the extension. The page will also display the amount of money remaining from the weekly deposit, and the amount of "Free-time" the user has remaining for the week. Depending on the time of day the extension is accessed, the window will have different views. When the extension is accessed within the productivity time window defined by the user's preferences, the page will display the amount of time remaining within their productivity hours. Outside of these hours, the page will place emphasis on displaying the amount of "Free-time" remaining and also display the current balance of the weekly deposit. If the user has no remaining "Free-time", the page will display the current balance of the weekly deposit, and the amount of money that has been lost during the current browsing session. The current balance will be decremented periodically based on the amount of time that the user exceeds their "Free-time" limit by.

The default page will also provide the user buttons to access their user preferences and extension settings. When the user preferences and extension settings button on the default page is clicked, the user will be taken to the Google Chrome extensions webpage of the browser. The page will display the user's current preferences and settings. The window will provide buttons for the user to modify the different options defined by the options page. Once these options are modified and submitted by the user, the background script will ensure the information is updated in the database.

When pop-up notifications that are triggered by the events listed in the background script occur, the user will be provided a pop-up window notifying them of the event. The pop-up notification window will display the name of the notification, as well as its

description. The notification will remain displayed until the user clicks on the button to acknowledge the alert.

In order to close the extension window displayed by clicking on the extension's icon within the browser window, the user will need to re-click the icon, or click the button designated for closing the window.

PROCEDURE

Here, we provide a general description of how the extension will function. The extension will be downloadable via the Google Chrome Extension store. The program will focus on user website behavior and usage on a weekly basis rather than a daily basis to help provide longevity in the user's use of the program. Upon downloading the extension, the user will select if he or she is an adult working in the workforce or a student - this is important in deciding what hours of each day within the week will not be counted against the user for time spent on websites due to working hours (adults 9am-5pm and students 9am-9pm). Upon this choice, users will then be prompted to choose a time limit for the amount of hours they want to have for "free usage of the internet" (which hopefully will be decreasing from week to week) for the entire week. Alongside this, users will need to deposit an amount of money into the extension. This money will be rewarded back to the user, should they stay at or below the time limit they have set for themselves at the end of the week. Should the user exceed this time limit, a percentage of the deposited money will be subtracted for every 0.5 hour that exceeds the set time limit. This ensures the user stays accountable for him or herself, as it is his or her own money that will be lost should they not adhere to the rules they have set for themselves. This will be the main feature for the extension.

Alongside this, there will additionally be justification reports that are released on a weekly basis at the end of the week. The user has the ability to justify to him or herself here why they relapsed or improved in their website usage and behavior over the previous week, while also being able to view various analytics. These will be saved for users to go over whenever they would like. Over the course of the week there will also be daily updates at the end of each day to notify users of their remaining allotted time for the rest of the week.

RESULTS

As this project investigates the feasibility and viability of a proof of concept to solve the overarching problem of smartphone addiction, we will further expound on results by researching and analyzing other studies in how they tested their products.

Firstly, we will cover a review of an application from the user's side. In one review of the application Forest, a user tested the product by intimately reviewing and tracking the progression feature of the application. The number one thing that users of anti smartphone addiction applications seem to care about and view the most is the progression/tracker tool that shows users if they are improving or not. Forest is an anti smartphone addiction application whose tracker tool is a forest. The forest withers and dies out the longer the user is on their phone, but grows and flourishes every time the user puts their phone down. In his review of this

application, William Wan cited the visual recession of the forest enlightened him to the severity of his problem via a dying forest, which prompted him to accept his problem at a higher level and self-reflect [Wan 2019]. This can be seen as a sign that the application works to some extent. Therefore, this review delineated the fact that the effectiveness of the progression/tracker feature of the Chrome extension will be a big determinant of its success in combating smartphone addiction.

In the scope of a company testing their own anti-smartphone addiction application, AppDetox's creators published a scholarly article outlining their project, their cause, how they tested their project, and more. In testing AppDetox, they noted using the Flurry Framework. This framework allowed them to keep track of gender data, rule data (such as how many rules were made, how many were broken), and much more. This is a framework that could be utilized in our case further down the road when the proof of concept in the form of a Google Chrome Extension evolves into a full application. A key extrapolation they were able to make using data collected from thousands of users was that the usage of the smartphone has clearly shifted away from generic cell phone functionality, such as calling, and more towards "always connected internet devices." Another analysis they found was that out of the 11,000 rules users made, these rules were broken 79,000 times [Löchtefeld et al., 2013]. It is evident Flurry is a useful framework in tracking this information, and will definitely be involved in some capacity in the future as this project evolves.

The difficulty in testing a Chrome Extension is the fact that they are embedded extensions onto the Google web browser itself, rather than being a separate file that can be tested [Bose 2020]. As a solution to testing the extension as a whole, Selenium exists as a testing framework that allows users to automate use cases and test the pages, functionalities, and features of a given extension. This is a useful open source framework that will be used in the future upon development of the extension to properly test various test cases. Upon doing this, we as developers can easily run varying test cases optimized to testing efficiency in the realm of combatting smartphone addiction, which will then enable us to analyze statistics and identify potential bugs and issues with the extension as a whole, thus validating the feasibility and viability of the missing features we have isolated.

CONCLUSIONS

We designed a proof of concept for a system to meet the need of a solution to the ever-growing societal issue of smartphone addiction. While knowingly or unknowingly, individuals in society today have increasingly grown dependent on their phones to accomplish nearly every possible daily task. Smartphones have indeed revolutionized the way we automate, communicate, and conduct our daily lives, however with a reliance on such a device we risk losing natural communication with our peers and loved ones, while additionally losing focus on important aspects of life, whether that be studying for a test or simply paying attention to a speaker.

In analyzing the viability and feasibility of creating a proof of concept for a solution to his problem in the form of a Google Chrome extension, it can be concluded that it is feasible and extremely beneficial to spreading awareness of this problematic topic, while also filling the holes that existing solutions have in

their attempts to curb smartphone addiction. By including features such as a justification survey and positive and negative reinforcement-oriented personalizations, users will be able to understand the fact that the road to recovery with addiction is one that is personal, with self-accountability being one of the most important aspects of the journey. By incorporating these features first into an extension, and extensively testing it via various use cases and human groups, the Selenium framework will allow for in-depth data analytics to iron out any final bugs, ultimately paving the way for improvements on existing technologies. As a whole, this project and the analysis and research done behind it has further proven the importance of this problem, shed light on the neglected aspects of the problem, and has proven the overall viability and feasibility of this proof of concept to help solve the problem.

FUTURE WORK

With extended time to work on the system, our implementation could be extended to provide other capabilities to its users. The extension could include a money management feature that allows the user to set a goal amount of money saved through the use of the extension. The money that is reimbursed to the user at the end of each week would remain in the extension until the target amount is reached. The extension would display the running total for each week, providing the user information on the amount of money they have been able to save towards their goal and throughout their time of using the extension.

Another major thing that could be done following intensive testing and a show of positive results and analysis would be to build this proof of concept out into a full-scale application. This would allow for us to make a more immediate impact on society with the problem of smartphones as we would launch to the general audience of smartphone users via the Apple and Android application stores.

REFERENCES

- [1] Amy Mitchell, Lee Rainie, Aaron Smith, Monica Anderson, and Katerina Matsa. 2021. Demographics of Mobile Device Ownership and Adoption in the United States. (April 2021). Retrieved April 20, 2021 from <https://www.pewresearch.org/internet/fact-sheet/mobile/>
- [2] Ngan Tengyuen. 2020. 9 Apps to Curb Smartphone Addiction And Boost Productivity. (May 2020). Retrieved November 23, 2020 from GeckoandFly.com
- [3] Nicholas Carr. 2017. How smartphones hijack our minds. (November 2017). Retrieved April 20, 2021 from <http://www.roughlytype.com/?p=8248>
- [4] Ian Bogost. 2019. I Tried to Limit My Screen Time. (September 2019). Retrieved April 20, 2021 from <https://www.theatlantic.com/technology/archive/2019/09/why-apple-screen-time-mostly-makes-things-worse/597397/>
- [5] Iryna. 2019. Apple Screen Time Tracker – The Good and The Bad. (September 2019). Retrieved April 20, 2021 from <https://www.sedentarybehaviour.org/2019/10/09/apple-screen-time-tracker-the-good-and-the-bad/>
- [6] Discovery Place. 2016. 12 Step Recovery: Step 1, Part 1- Admission, Surrender & Acceptance. (September 2016). Retrieved April 20, 2021 from <https://discoveryplace.info/12-step-recovery-step-1-part-1-admission-surrender-acceptance/>
- [7] Apple Inc. 2021. Use Screen Time on your iPhone, iPad, or iPod touch. (March 2021). Retrieved April 20, 2021 from <https://support.apple.com/en-us/HT208982>
- [8] Kem Zhang, Chongyang Chen, Sesia Zhao, and Matthew Lee. 2014. Compulsive Smartphone Use: The Roles of Flow, Reinforcement Motives, and Convenience. *Compulsive Smartphone Use* (January 2014). DOI:<http://dx.doi.org/10.1523/eneuro.0268-17.2017.t1-7>
- [9] William Wan. 2019. I had a bit of an app addiction. Until these apps saved me. (March 2019). Retrieved April 20, 2021 from <https://www.washingtonpost.com/news/to-your-health/wp/2018/06/29/i-had-a-bit-of-an-app-addiction-until-these-apps-saved-me/>
- [10] Shreya Bose. 2020. How to test Chrome extensions in Selenium. (March 2020). Retrieved April 20, 2021 from <https://www.browserstack.com/guide/test-chrome-extensions-in-selenium>
- [11] Markus Löchtefeld, Matthias Böhmer, and Lyubomir Ganev. 2013. AppDetox. Proceedings of the 12th International Conference on Mobile and Ubiquitous Multimedia - MUM '13 (December 2013). DOI:<http://dx.doi.org/10.1145/2541831.2541870>
- [12] Google. 2018. Architecture overview. (June 2018). Retrieved April 20, 2021 from <https://developer.chrome.com/docs/extensions/mv3/architecture-overview/>