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Attention-Preserving Technology

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Abstract

Smartphone overuse and internet addiction is strongly correlated with a sharp rise in mental health problems, reduced productivity and increased suicide rates. The applications responsible leverage techniques from behavioural science to appeal to our base human natures, causing us to form unconscious habits which lead to increased usage. This greatly detracts from an individual's productivity and ability to focus on difficult tasks.

Many attempts have been made to develop technologies which help individuals reduce these effects in the form of well-being apps. The most effective well-being apps aim to use the same techniques from behavioural science used to hook users to reverse their own effects. However, even these applications are outclassed by their opposites, which are developed by billion-dollar corporations with endless funding and developer man-hours. This project seeks to continue the work of one such well-being app, closing the gap in product quality and feature offerings by leveraging recent advancements in application development methods.

On top of enhancing the original product and its applications in behavioural rehabilitation with new features, the resulting work facilitates developer on-boarding, reduces development time and implements analytical methods for developers to quantitatively assess how effective new features are at helping users improve their focus and productivity.

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- My tight support circle of friends, whom without the guidance of I would have been lost in trying to navigate the process of building such an ambitious product within the short time span of 6 months.

Dedication

This work is dedicated to all my fellow procrastinators who set out on a a productive day only to lose time to an unplanned YouTube binge. It happens to us all, and we owe it to ourselves to be aware of how the subtle ministrations of powerful organisations are designed to influence our lifestyles for their profit.

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Introduction

1.1 Motivation

1.1.1 Problem Statement

Internet addiction is not a new phenomenon. There is adequate scientific literature suggesting that the popularity and overuse of the smartphone and its applications may be the single largest change correlated to a rise in suicide, mental health problems and lower life satisfaction [1]. While many negative effects arise out of the overuse of devices and social media, in this report a particular focus is given to the negative effects it has on the individual's attention capacity, motivation and focus.

1.1.2 User attention as a commodity

Social media and gaming applications (henceforth abbreviated as "apps") generate profits by retaining the attention of a user. Social media apps might monetize this by generating advertising revenue off of a user's screen time, or offer the user additional premium features requiring an in-app transaction to unlock.

Gaming apps have evolved to follow this model of monetizing continued user engagement: games in the early 2000's delivered a full product on an upfront purchase, seeking to deliver an experience that would encourage users to buy a sequel, but modern games now attempt to monetize continued user playtime by offering "microtransactions" in the form of in-game cosmetics or bonuses on top of the base game purchase.

As of June 2020, of the 5 companies to have ever been valued over a trillion dollars, 4 of them are technology companies that profit off of user engagement with their products: Apple ($1568b), Microsoft($1505b), Amazon($1337b) and Google($953b), leaving the winning business models of the decade before such a+s Walmart($337b) and Johnson & Johnson($366b) in the dust [2]. Even Facebook($629b), whose business revenues are almost purely from monetizing user attention, easily doubles the value of the winning business models of the past.

Twitter (a social media company whose revenue comes primarily from advertising) even goes so far as toting the metric of "monetizable daily active users" (mDAU) in investor press conferences [3], referring to users which the company may show ads to. Investors of such business models focus so heavily on such metrics that, despite beating traditional financial health indicators (such as earnings estimates) by a sound margin in the third fiscal quarter of 2020, Twitter lost 20% of its stock value in a single day simply on the announcement that they had only gained 1 million new users instead of the projected 9 million [4] [3].

Therefore, the new hot commodity of the 21st century is no longer gold, silver or oil, but user attention. The attention, engagement and growth of an app's user base is so lucrative for these companies that they have completely changed how their business models are evaluated and priced.

1.1.3 Consequences of addictive app design

Social media and gaming apps are therefore carefully designed with behavioural scientists to be highly addictive, aiming to capture the user's attention and keep them coming back to interact with the application. This is loosely referred to in the industry as a user's level of "engagement"

within the application. To increase and retain user engagement, techniques best described as "addictive software design" [5] are employed, including but not limited to:

- Variable rewards, as in gambling slot machines, maintaining an element of unpredictable positive reinforcement that keeps users coming back for more [5].
- "Bottomless" content with infinitely scrolling lists, experimentally proven to increase consumption [5].
- Ease of use and consistent user-interface elements across apps, allowing users to conveniently feel a sense of familarity when accessing their apps across all platforms (PC, smartphone, tablets and wearables).
-

Such mechanisms are deliberately crafted to appeal to the primitive parts of the brain responsible for unconscious habitual compliance (the limbic system), rather than those associated with rational, forward and deliberate thought (the prefrontal cortex). What this results in is a subtle shift in the tendencies of an individual to prefer comfortable compliance over exercising motivated choice.

This is already a strong tendency for humans, but the subtle habit formation that apps ingrain into our lifestyles further reinforce this tendency to a point which can be extremely destructive.

With the onset of COVID-19 and the rise of the remote workplace, the line between work and play has grown even more vague and the screen time of individuals is higher than ever []. Smartphones and computers are key pieces of technology that are essential for connectivity and productivity in the age of remote work. The devices themselves do not pose a problem, but the access they give users to the attention-grabbing applications they contain have significant effects on the individual's ability to remain focused at work.

The exercise of willpower alone, while possibly yielding some results in the short term, is not the solution to the problem.

1.1.4 Present solutions

Therefore, many efforts have been made in the fields of neuroscience and psychology to raise awareness of the dangers of digital addiction. Similar addiction-based problems such as gambling and drug use may employ a "cold-turkey" approach, but depriving a modern worker of a smartphone and computer almost completely robs them of function in today's digital age. One approach to remedy device overuse is, paradoxically, the use of so-called well-being apps, which each attempt to address problems caused by internet addiction and overuse.

There are many more well-explored examples of insidious software design and behavioural manipulation to exacerbate internet overuse [6], but the arguments proposed so far sufficiently motivate the creation of a solution that does not require the complete abstinence of smart-device usage.

Many examples of so-called well-being apps have been made, in a paradoxical attempt to design apps that would enhance users' productivity or state of mental health. However, [6] highlights that the such apps do not employ the same behavioural "hooks" that social media and gaming apps use. They often yield a short period of initial use, propelled by motivation, and then fall out of favour of their users within a few months.

Therefore, the work previously done in [6] proposes the concept of attention-preserving technology, which leverages the same behavioural science and software engineering techniques from addictive apps to help users stop using them and reverse their detrimental effects. The authors also produced a proof-of-concept: a well-being app called Sage. In summary, their work uses the development of Sage to highlight the failings of the well-being apps that came before it, proposing a set of design principles for future effective attention-preserving app design.

The Sage application helps users regain their focus and productivity through task and time-tracking features. However, given the short development time, it currently exists only as a minimal Android application with limited functionality. Despite this, an initial round of evaluation on the alpha release yielded positive reviews from testers, claiming that it improved their awareness of their own productivity and that they would continue using the application.

1.2 Objectives

The work documented in this report thus seeks to extend Sage with the following objectives:

- Engineering objective: Re-implementing the code base with methods that would be more suitable for lean development teams to continue their work, as well as adding infrastructure for quantifiable measurement of how well the application achieves its objective.
- Paradoxical social objective: Since Sage did not get a lot of development time and only implemented basic features, this project seeks to further explore how to further leverage the technologies and methods that cause the problem of digital addiction to reverse the problem.
- Application objective: Creating a product that may prove useful in prevention and rehabilitation of attention deterioration as a result of device overuse. This could even see use as a commercial product for companies wanting to help their employees improve their focus at work.

In summary, this run of the project aims to improve the current implementation of Sage. The application will be made available to a much larger user base by re-implementing the code base using cross-platform development frameworks. The user interface is then to be given a complete overhaul to improve the smoothness of the user experience and increase user engagement. More features will be proposed and implemented. Finally, an attempt will be made to create and implement quantitative evaluation methodologies that allow the product team to identify which features are most effective at helping users improve productivity and reduce screen time.

Chapter 2

Background

2.1 Biology Primer

To develop an app to fix the problem of attention deficiency, a short exploration into the mechanics of attention preservation is necessary. Within this scope, the conscious human processes new input primarily with three different parts of the brain: the limbic system, the prefrontal cortex and the parietal lobe. These can be respectively understood as the "chimp", "human" and "computer".

2.1.1 The Limbic System

The Limbic System carries out many functions that are considered "primal urges". Emotional responses to food, smell, social cognition, emotional memory (fight-or-flight responses to remembered stimuli), sexual behaviour and most importantly for this context, addiction and motivation [7]. All these functions can be summarised and grouped by one common concern: self and species preservation. The limbic system (henceforth referred to as the "chimp"), is adept at remembering emotional responses to previously experienced situations and inducing the optimal resopnse for self-preservation, should it find itself in a similar one. However, with respect to self-control and achieving one's long term goals, this may be undesirable. The stress

and emotional drain often experienced by an individual trying to solve a difficult problem gets registered as a "threat". When an individual is subsequently faced with the choice of working or procrastinating, their inner chimp finds itself in a simulated "fight or flight" situation. Social media apps and games are placed in a perfect position to offer the escapism the chimp requires to enact it's "flight" response, as they provide an easily accessible alternative to the "threat" of having to do work.

2.1.2 The Prefrontal Cortex

The Prefrontal Cortex (PFC) is the part of the brain largely associated with conscious thought and rational self-control. Many studies in self-regulation have shown that the limbic system and prefrontal context often have large amounts of correlated activity in fMRI scans. The prevailing theory is therefore that the PFC and the limbic system are often at odds, and a variety of factors determine which emerges victorious in controlling the individual's course of action[**?**].

2.1.3 The Parietal Lobe

2.2 Self-regulatory Failure

Resisting the urge to check one's phone or play video games is a prime modern example of self-regulatory failure that reflects much in common with addiction-like behaviour in dieters, smokers and substance abusers. App-fueled procrastination may not be as lethal as substance abuse or obesity, but there nonetheless exists a very slippery slope into internet addiction that may ensnare the average person. Heatherton and Wagner elaborate in [8] that there are a few common causes for self-regulatory failure: negative moods, lapse-activated consumption, cue exposure and self-regulatory resource depletion.

2.2.1 Resource Depletion & the Strength Model of Self-Control

Baumeister and Heatherton [9] initially proposed in 1996 that conscious self-control against one's impulses draws from a global resource pool that depletes as one uses it further. Since then, many studies have been conducted to support this hypothesis. It has been shown that it is possible for individuals to increase this self-regulatory ability [**?**], but the strength model by construction dictates that it is possible to exhaust one's self-control and require a way to "replenish" it. Each individual may have different emotional responses stored by their "chimp", therefore creating a large variance in individuals' ability to stay focused on a task.

This suggests that as long as a distracting alternate stimulus is present, self-regulatory failure is not a question of "if", but "when". For traditional office work settings, this effect is slightly ameliorated by the social norms enforced by the office culture. However, for a person working from home, the distraction unfortunately exists on the same device that enables productivity and there is no one else around to keep the chimp in check.

2.2.2 Cue Exposure

A cue in this context is defined as a piece of sensory stimulus which has an association to a certain consumption-related behaviour. The smell of food for a dieter, the sight of a beer for a heavy drinker. Cues have been shown to increase cravings, draw attention and increase likelihood of consumption [10]. Furthermore, multiple studies have shown that individuals are often unaware of how cues affect them on a conscious level[11], and so it becomes difficult for a struggling individual to pinpoint what it is exactly that causes their self-control to lapse.

¡¡¡¡¡¡¡ HEAD The first example of addictive software engineering is the push-notification, one of the core tools of user-experience (UX) design. The premise seems simple: software engineers needed a way of bringing a user's attention to key information. This is not a "new" phenomenon, as pagers and message alerts have been around for as long as phones have existed. However, the graphical interface of the smartphone takes this to a new level. The modern push notification engages many senses: a kinetic vibration, an audio alert and a visual alert window.

Both Android and iOS have robust application programming interfaces (APIs) that enable developers to exercise a very high level of control over how their app sends and handles notifications [?]. In the example of a social media message from a friend, this allows for extremely alluring design: an avatar of the friend and a short preview of the incoming message. Users are even empowered to make the experience of receiving a notification as enjoyable for themselves as possible. Facebook Messenger allows users to set nicknames for their friends. Most phones allow users to set specific alert sounds on a per-contact basis, allowing a user to know from audio perception alone who they are receiving a message from. A very common use case of this feature is setting a custom sound to differentiate messages comign from one's spouse, close friends or romantic interests. These features play on the natural human tendency to develop social relationships, as it is evolutionarily built-in to our "chimps" as an action that greatly enhances survival in the wild [?].

Cue exposure need not even be as explicit as a push notification. The experience of using a social media app or playing a game is extremely pleasurable. Beautiful colour palettes, high-resolution artwork and buttery-smooth animations are a staple in successful apps. All these factors enable the "chimp" to register a positive emotional response to act of phone use. Therefore, the very presence of the phone is a form of cue exposure that constantly forces the user to exercise self-restraint.

2.2.3 Lapse-activated Consumption

A 1975 study showed that the consumption of a small amount of an addictive substance (in this case, a milkshake on a test audience of dieters) paradoxically caused dieters to consume more food afterwards, in contrast to the control group of non-dieters who ate less [12]. The exact reason as to why this phenomenon occurs is not fully clear, but the implications of its existence are. Picking up one's phone for a short break from work can often snowball into a longer-than-intended session of scrolling social media. Playing "just one round" of a game often ends up being anything but. We will explore in later sections what mechanisms are in place that potentially cause such activities to be so difficult to quit.

2.2.4 Motivation and Persistence

Having explored all the ways in which self-control can fail due to how strong our in-built tendencies are, perhaps then there is a way in which we may use these natural tendencies to our advantage.

2.3 Addictive Design: Social Media Apps

Social media offers novelty at every turn, with variable rewards

2.4 Addictive Design: Gaming

Gaming, on the other hand, are capable of offering a dense, fast-paced, highly engaging experience.

A successful well-being app therefore has to not only help the user form healthy habits that help them avoid self-regulation pitfalls, but offer new "hooks" to help to keep their inner chimp on their side. =======

2.5 User Experience Design

The most critical aspect of any app is the user experience. Therefore, this section will briefly outline a few key goals that this project seeks to achieve in the re-implementation of the existing application.

2.5.1 Problem Statement

When faced with a difficult task, keeping and maintaining one's focus on solving the problem is extremely daunting. There are many factors that determine the extent to which a person

will succeed at this, and while some may be geneticically-attributed, there are many external factors within one's control that can be changed to improve one's focus. However, as we now know, the many distractions that are embedded into our lives now are very adept at drawing our attention back to them and away from the tasks that we may instead wish to focus on.

Therefore, in order to create an effective solution that helps the user actively make choices to keep distractions away, the application must succeed at

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2.6 The Existing Sage Application

2.6.1 Functional overview

After granting the app permissions for notification access in an onboarding sequence, the app starts up and offers its core functionality: a task list. Users may create and edit tasks. Each task may be recurring daily, and may block notifications. Users may then at any time start working on a task, triggering a running timer which may block all incoming notifications while active. A task can be completed, or returned to any time later with a break. All this activity is stored within the client and can be displayed to the user through graphs as a form of feedback on their productivity.

While this is an admirable starting effort, there are many potential points of improvement from a user-experience perspective.

2.6.2 Limiting issues

There are several issues and limiting features with the current implementation of Sage.

- The notification blocking feature is faulty. Certain edge cases allow notifications to still slip through.

- Currently implemented as an Android app, no extensibility to iOS, desktop or mobile web users.
- Completely local: no data backups or export, no online cloud synchronisation.

2.7 Project (Re-)specification

Modern individuals are unable to focus and stay productive for a multitude of reasons. This project seeks to solve that problem by creating a user experience that leverages the concepts explored so far, such that less deliberate exercise of self-discipline is necessary for the user to remain on-task.

Proposing a re-implementation software project naturally begs the following questions: - What advantages will the effort yield, and is it worth the effort? - Will it perform as before, or are there be any compromises as a result of the move?

As such, some initial research had to be conducted to address the concerns. Studying the existing codebase and Android developer documentation

As in any other software engineering problem, the first step is to gather an initial list of requirements that will form the specification of what the final product must achieve.

The re-implementation of the Sage application thus should fulfill the following set of requirements in its MVP:

Functional Requirements

- Re-implement the full feature set of the existing application.
- Fix notification blocking functionality with the use of *Do not Disturb* mode, instead of the current implementation.
- Add online cloud storage and synchronisation of user data.

Non-functional Requirements

- Must be performant without excessive jank, jitter or loading delay.
- In the event of a crash, the application should recover gracefully and inform the user of any inconsistencies in their data caused by the crash (interrupting a focus period, etc).

2.8 Implementation Plan

2.8.1 Iterative Software Development

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