Reducing Smartphone Interaction Using the Principles of Persuasive Technology

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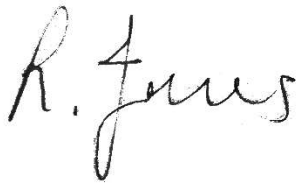

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Submitted by: Ryan Jones

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Declaration

This dissertation is submitted to the University of Bath in accordance with the requirements of the degree of Computer Science in the Department of Computer Science. No portion of the work in this dissertation has been submitted in support of an application for any other degree or qualification of this or any other university or institution of learning. Except where specifically acknowledged, it is the work of the author.

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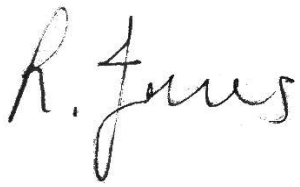

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Abstract

This project aimed to propose as system that tackles problematic smartphone usage by implementing the principles of persuasive technology. The process of changing habits and behaviors was modeled around the transtheoretical model of behavior change (TMM) in an attempt to identify the most appropriate persuasive techniques for the system. The final system was compared against an application that aims to reduce smartphone usage by limiting the functionality of the smartphone, by recording the change in phone usage statistics and attitudes and beliefs surrounding smartphone usage after using one of the application behavior change applications for a period of 5 days. The evaluation identified that both persuasion and limiting functionality are effective methods for reducing smartphone usage.

Contents

1.Introduction

1.1. Smartphone and Social Media Addiction

Problematic smartphone usage stems from a behavioural or psychological dependence on cell phones is described as the usage of mobile devices leading to addictive behaviours such as diminished impulse control (Pivetta, et al., 2019).

Out of the wide range of smartphone applications social media consumes the majority of the time that users spend on their smartphones (Clement, 2018). Inevitably, there have been concerns around problematic social media usage leading to social media addiction being considered for the DSM-5; however neither it nor smartphone addiction are included in any psychological journals (van den Eijnden, et al., 2016). Griffiths and Kuss suggest that smartphones are not an addictive medium, however, they enable engagement in potentially addictive activities such as social media usage (Kuss & Griffiths, 2017).

A study in the United States showed that smartphone users interact with their smartphone within 15 minutes of waking up with 79% of them have their phone near them for 22 hours of the day (Levitas, 2016).

1.2. Negative Impact of the Addictions

Loss of productivity can be attributed to smartphone use with a moderate positive relationship between hours lost at work due to smartphone usage and smartphone addiction (Duke & Montag, 2017). Participants of a study commissioned by Kaspersky Lab were shown to be 26% more productive when their mobile phones were removed from the room than when the phones were in the participants pockets (Kaspersky, 2016).

High smartphone usage has been linked with a variety of effects on both a user's physical and mental health; headaches, impaired memory and concentration, fatigue, dizziness and disturbed can be caused by increasing smartphone usage (Al-khlaiwi & Sultan, 2004).

Although the overuse of digital media can have negative impacts, underuse can also be detrimental to mental health with a quadratic relationship between digital media usage and depression (Reid Chassiakos, et al., 2016); this indicates that there is a certain level of smartphone usage that is beneficial, higher or lower usage than this may increase levels of depression.

1.3. Possible Causes for Overusing

Addictive user experience techniques are present in social media applications, these are used in a way that can invoke unhealthy habits in users; for example the idea of variable reward is prevalent in both social media and gambling, being used by slot machines to keep users engaged (Kruger, 2018). Nir Eyal's Hook model builds on the idea of variable rewards adding 3 additional stages for creating habit forming user experiences; the internal and external triggers that encourage the user to interact with the product, a simple action that is performed in anticipation of a reward, and an investment into the product that encourages the user to return (Eyal, 2019). It is believed that these stages in the hook model are linked to the reward pathways in the brain responsible for releasing dopamine (Haynes, 2018).

Fear of missing out may contribute to high social media engagement (Buglass, et al., 2017) whilst playing an important role in the development of maladaptive mobile phone use (Oberst, et al., 2017). FOMO is defined as "anxiety that an exciting or interesting event may currently be happening elsewhere, often aroused by posts seen on social media."

The relationship between daily stress and social media usage has shown that sites such as Facebook are often used as a source of social support, particularly in cases where users have limited social support

offline. Users may form addictive tendencies as social media proves to be an effective coping strategy for stress (Brailovskaia, et al., 2019).

1.4. Current solutions

There are a selection of applications that provide solutions to problematic smartphone usage, most of these focus on either showing the usage statistics to identify applications that occupy the majority of the user's time, or blocking applications or functionality that users have identified as being problematic. An example of this is the app Offtime (mINdCUBEd, 2020) which splits its functionality into two categories activity overview that provides insights into digital habits, and activity regulation which disables or blocks features during the so-called "OFFTIME".

Forest is an alternative solution which allows users to set timers during which it discourages smartphone activity through the use of persuasive techniques. Through both personal use and reviews on the google play store it is evident that the application has had success in encouraging users to limit phone usage (Seekrtech, 2020). Although the application only focuses on discouraging smartphone usage for short periods of time, it does highlight the effectiveness of persuasive strategies reducing smartphone usage instead of simply blocking the undesired functionality.

1.5. Stakeholders

As mentioned above I am limited in the diversity of stakeholders, this will mostly impact the design and evaluation stages as I will have a narrower set of views and ideas. Having most of the stakeholders aged between 20 and 25 may not have a large impact on the system and its evaluation as 18-25 year olds show higher smartphone and social media usage than other age groups, however, 0-17 year olds have been shown to have the highest usage statistics (Andone, et al., 2016); because of this, I should aim to involve smartphone users aged 16 and 17 throughout my project.

As part of my initial requirements gathering and evaluation I will try to reach a diverse population through the use of a variety of communication devices, for example the use of questionnaires for eliciting requirements will allow me to reach a wider range of people. As I am developing my system for Android, this may limit the potential users; however this should only impact the users that can evaluate my system.

During the design and development I will hold weekly meetings to discuss my progress. As it is unlikely that I will be able to organise a face to face meeting with everybody I will interact with stakeholders in the most appropriate way possible, this could be in the form of instant messaging, a phone call, or a meeting in person.

Throughout my project I will have weekly meetings with my supervisor to discuss my progress and the direction that would be most suitable for my project.

1.6. High Level requirements

1.7. Functional

- The system should focus on limiting a user's smartphone usage.
- It should not restrict access to functionality on the smartphone.
- Should encourage a healthy relationship between users and their smartphones.

1.7.1. Non Functional

- Should run on the Android operating system.
- Should comply with privacy laws such as GDPR.

1.8. Project Plan

1.8.1. Objectives

This project is due for the 1st of May 2020, work will be split into 6 sections:

- Literature review
- Initial requirements gathering
- Design
- Development
- Evaluation of System
- Dissertation

An MVP for the system should be completed by the 17th February 2020 to show in the demonstration of progress.

1.9. Literature review

Before beginning the development of the system, I will first need to gain a wider understanding of the subject area; I plan to do this through a literature review where I aim to summarise and critique information sources relating to my project; the literature areas I intend to evaluate include, but are not limited to, problematic smartphone and social media usage, addictive UX, and persuasive technology. I also have a series of questions that I aim to answer during this section of my project to further focus my research:

- How are habits and addictions formed?
- How effective are the current solutions at reducing smartphone usage?
- Are there any metrics for monitoring smartphone usage and addiction?
- How effective is persuasive technology at breaking 'bad' habits and forming 'good' habits?

Investigating these areas will direct tentative hypotheses and provide me with a clear way to measure my progress and the effectiveness of my final system. It will guide the requirements gathering section of my project by providing a clear problem that I wish to solve and possibly provide ideas for requirements or stakeholder questions.

1.10. Design

The three areas of design that will need to be considered during this stage are the system architecture, user experience and test design. I will aim to ensure regular stakeholder engagement through the use of agile methodologies; work will be split into weekly sprints including a demonstration of progress to encourage feedback from stakeholders.

When designing the system architecture I will need to consider the overall organization of the system, along with data structures and possible interfaces. I plan to split the development work into epics, stories and subtasks in order to simplify large tasks into a more manageable form; this will also make the process of estimating the complexity of the work simpler as it is represented as a defined task instead of a large project.

I will use a variety of techniques when designing the user experience, ranging from simple sketches to gain quick feedback about an idea, to high fidelity designs using tools like Figma (figma, 2020) to simulate how the end product will look.

The creation of test cases during the design phase will promote test driven development, this style of development has been shown to reduce bugs and provides clear acceptance criteria for tasks (Jeffries & Melnik, 2007).

1.11. Development

Good design will reduce the complexity of the development process; it allows me to implement a well-defined feature by working on a series of small tasks with clear acceptance criteria. As I intend to use test driven development I will begin by implementing the test cases designed for a task, then I will focus on developing the feature to satisfy the tests.

I expect the design and development stages to take 12 weeks, I have taken into consideration that this section of work will span across my January exams meaning that a large percentage of my time will be focused on revising.

1.12. Evaluation of my system

Using the metrics researched during my literature review I will evaluate how effective my system is managing problematic smartphone usage. It is likely that user testing will require a substantial amount of time to allow changes in habits to appear in the results; considering this I have allocated 6 weeks to evaluate my system, however during this time I will be able to work on other parts of the project as I will likely be waiting while users test the system.

1.13. Dissertation

During each stage of the project I will aim to document any work relevant to the dissertation, this will reduce the work required to when writing my final dissertation. I have allocated 7 weeks to do this at the end of the project, a large section of this will be in parallel with the evaluation section as I will have time when waiting for users to test my system.

1.14. Risks

Although I have been able to take into account any coursework for my first semester, I have less knowledge about the work required for my second semester of study, I have therefore overestimated sections that occur in the second semester to compensate for this.

I have also attempted to overestimate each section leaving some spare time should an unforeseen problem such as illness occur, I can leverage this time along with the 2 weeks spare at the end of my project in the event that I overrun on a given task.

I will ensure that I keep backups of my project on a cloud service to ensure that work is not lost should my computer break. I intend to use Google Drive for written pieces of work and Git for source code.

1.15. Gantt chart

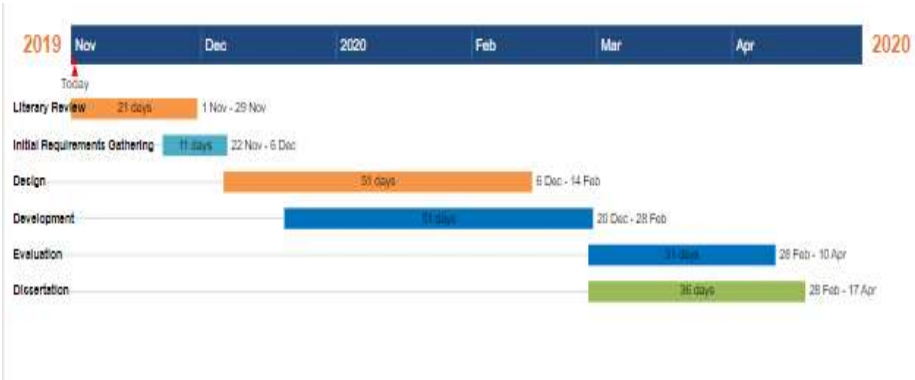

Figure 1 - Project Gantt Chart

1.16. Ethics

Any user testing must be conducted in an ethical manner and adhere to both the Nuremberg code and the University of Bath department of computer science ethics checklist, all volunteers will be over the age of 16 and provide voluntary consent before participating. As it is likely that tests will be performed

on the user's smartphone, there must be care taken to ensure that no damage is done to the devices as a result of the tests.

1.17. Required Resources

For the development of my system I will use Android Studio as my primary IDE for working with android applications. I chose this as it is a free development environment and I have prior experience with other JetBrains tools.

I will need literature surrounding problematic smartphone usage, addictions and habits, and persuasive technology. The University of Bath provides access to a variety of resources that are accessible through the internet and the library. Conferences such as CHI and PERSUASIVE will help in finding relevant papers.

Users will be required to test current solutions of my final system, these will need to own Android smartphones and will preferably be from a diverse range of backgrounds.

2.Literature Review

This section will aim to review the surrounding literature to identify answers to the following questions raised in the proposal:

- How are habits and addictions formed?
- How effective are the current solutions at reducing smartphone usage?
- Are there any metrics for monitoring smartphone usage and addiction?
- How effective is persuasive technology at breaking 'bad' habits and forming 'good' habits?

2.1. Habit

Habits are a fixed way of thinking, willing, or feeling acquired through previous repetition of a mental experience (Andrews, 1903). Once formed, behavioural habits often require little to no thought to perform (Encyclopædia Britannica, 2014). The sequences of actions undertaken in a habit are often triggered by a cue, these cues are stable elements that exist within the performance context of a behaviour. Although the behaviours that form habits are often acted with the intention of achieving a goal such as eating to reduce hunger, habits are undertaken independently of any goal or intention, because of this it can be considered that habits shift the performance of a behaviour from goal dependence to context dependence (Wood & Mazar, 2018). Habitual behaviours can be more efficient requiring less mental effort allowing them to be performed in conjunction with other tasks with a lower decrease in speed and/or accuracy. Habits often occur without conscious awareness and are partly represented in nondeclarative memory making it difficult to access the cues and action; this could lead to difficulty in identifying subtle habits such as habitually checking your smartphone for messages.

2.2. Behavioural Addictions

Addictions are commonly described as being physically and mentally dependent on a particular substance or activity (Lexico, 2020). Addictions can be categorized into two groups, behavioural addictions and substance addictions; although both are very similar, individuals with behavioural addictions have an addiction to the feeling produced by an action rather than a substance, behavioural addictions frequently occur when whenever a habit changes into an obligation (Salman Alavi, et al., 2012). There are seven features that can identify an addiction (Griffiths, 1996):

Salience - when the activity becomes the most important activity in the person's life and dominates their thinking.

Euphoria - the subjective experience that people report as a consequence of engaging in the particular activity.

Tolerance - This is a process whereby increasing amounts of the particular activity are required to achieve the former effects.

Withdrawal symptoms - These are unpleasant feeling states and/or physical effects which occur when the particular activity is discontinued or suddenly reduced.

Conflict - This refers to conflicts between the addict and those around them or from within the individual themselves which are concerned with the particular activity. Continual choosing of short-term pleasure and relief leads to disregard of adverse consequences and long-term damage.

Relapse and reinstatement - This is the tendency for repeated reversions to earlier patterns of the particular activity to recur.

All of these are evident in gambling addictions which is widely considered to be a prototypical behavioural addiction (Robbins & Clark, 2015).

2.3. Problematic smartphone usage

Although problematic smartphone usage has not been formally considered to be an addiction in journals such as the DSM-5, it does share similarities with recognised behavioural addictions and has been stamped as an addiction within mainstream media (Cellan-Jones, 2018; Hurley, 2019; Katwala, 2019). Panova & Carbonell discusses the excessive use and lack of impulse control surrounding smartphone usage with usage that could be considered to match the salience characteristic of behavioural addictions (Panova & Carbonell, 2018), it is also easy to find parallels between withdrawal symptoms and the effects of nomophobia explored by (Yildirim & Correia, 2015).

2.4. Methods of behaviour change

There are a variety of theories describing the process of behaviour change, these can be used to aid building positive habits and combating addictions, many of these could be applied to the process of modifying attitudes and behaviours towards smartphone addiction; the models outlined by (Forest Research, 2012) and condensed into **Figure 2** are each suited to differing scenarios, therefore it is imperative that the correct model is selected for this project.

Description of theory	Common usages
The Theory of Planned Behaviour & Theory of Reasoned Action The intention is itself an outcome of the combination of attitudes towards a behaviour, including the positive or negative evaluation of the behaviour and its expected outcomes, and subjective norms, which are the social pressures exerted on an individual resulting from their perceptions of what others think they should do and their inclination to comply with these.	The TPB is suited to predicting behaviour and retrospective analysis of behaviour and has been particularly widely used in relation to health.
The Health Belief Model Behaviour is determined by a number of beliefs about threats to an individual's well-being and the effectiveness and outcomes of particular actions or behaviours.	Although designed and developed in the healthcare context, the HBM has been applied to the analysis of other types of behaviour and is most suited to explaining or predicting patterns of behaviour.
Stages of Change (Transtheoretical Model TMM) This sub-divides individuals between five categories that represent different milestones, along a continuum of behaviour change. These stages are precontemplation, contemplation, preparation, action, and maintenance.	Is more popular amongst practitioners than researchers, as its constructs and concepts are not particularly well defined, but it provides methods of moving user along the stages thus providing a plan for encouraging behaviour change.

Figure 2 - Processes of behaviour change

Based on this the transtheoretical model is likely to be the ideal basis for behaviour change in this system as it has been previously been applied to a encourage behaviours in a wide range of subject areas

(Prochaska, et al., 2001). It should provide a clear path to guide individuals suffering from smartphone addiction along.

2.5. Transtheoretical model of behaviour change

As mentioned in figure 1, the transtheoretical model of behaviour change (TTM) splits the formation of habits into five stages of change, the model then provides strategies of change that can be implemented in to progress an individual onto the next stage (Prochaska, et al., 2015).

2.6. Stages and strategies of change

2.6.1. Precontemplation

At this stage individuals are usually informed or unmotivated to change their behaviour. The individual will not take action within the next 6 months. The recommended strategies to progress to contemplation include:

Consciousness raising - Finding and learning new facts, ideas, and tips that support the healthy behaviour change.

Dramatic relief - Experiencing the negative emotions (fear, anxiety, worry) that go along with unhealthy behavioural risks.

Environmental reevaluation - Realizing the negative impact of the unhealthy behaviour or the positive impact of the healthy behaviour on one's proximal social and/or physical environment.

2.7. Contemplation

Individuals at the contemplation stage are aware of their behaviours and the benefits of changing, however they are also aware of the negative aspects of altering their behaviour. At this stage individuals intend to change within the next six months. Self-reevaluation is the main strategy that would aid in progressing onto the preparation stage, this is the process of realizing that the behaviour change is an important part of one's identity as a person.

2.8. Preparation

At this stage individuals have a plan and intend to take action within the next 30 days, generally they have already made some significant action within the past year. Self-liberation is the key strategy at this stage as the individual should make a firm commitment to change.

2.9. Action

The individual has made a modification to their lifestyle within the last six months; not all modifications are considered actions at this stage, the individual has to attain a criterion that has been agreed to be sufficient.

2.10. Maintenance

Individuals at this stage have made a behaviour and maintained it for over six months. This stage is focused on preventing the individual from relapsing and offers the following strategies:

Counterconditioning - Substitution of healthier alternative behaviours and cognitions for the unhealthy behaviour.

Helping relationships - Seeking and using social support for behaviour change.

Reinforcement management - Increasing the rewards for the behaviour change and decreasing the rewards of the unhealthy behaviour.

Stimulus control - Removing reminders or cues to engage in the behaviour and adding cues or reminders to engage in the behaviour.

I conducted a series of interviews which targeting the views that smartphone users had towards their devices. Mapping the interviewee's response onto the TTM showed that the majority of users were situated between the precontemplation and preparation stages, with the largest population in the contemplation stage; these users showed that they had an understanding of the effects of smartphone overuse, however they had not acted to reduce their usage.

2.11. Implementing TMM within technology

It can be difficult to create a concrete implementation of the strategies for change due to their vague descriptions, this is especially apparent when creating technology that utilises the model to change behaviour. However there are parallels between the strategies provided by the TMM and the persuasive technology techniques (PT) introduced by (Fogg, 2003, pp. 31-59).

Fogg he describes seven persuasive technology tools which can be incorporated into a system to encourage users to change their attitudes and behaviours, these have been expanded to include a wide range of additional techniques.

Where some of these techniques map between the two theories, for example the concept of reinforcement (referred to as conditioning by Fogg) both use the concept of positive reinforcement to encourage a behaviour; others persuasive techniques would fit well into the transtheoretical model to act as strategies for change.

Both the transtheoretical model strategies for change and the persuasive techniques take inspiration from the behaviour change techniques, **FIGURE 3** helps to identify related elements in the TMM and the persuasive techniques gathered by (Oinas-Kukkonen & Harjumaa, 2008), by relating them to a range of behaviour change techniques identified by (Mardsen, 2016).

Behaviour change technique	Related stages and strategies for change (TTM)	Related persuasive tools (PT)
Feedback and monitoring Monitoring an individual's behaviour, this could be self-monitored by the individual or monitored by an external party, feedback can then be given based on the results of the monitoring process.	**Environmental revaluation** An individual can understand the impact a behaviour through the use of monitoring. **Self-revaluation** Much like environmental reevaluation, monitoring provide better insight into why the behaviour change is important.	**Self-monitoring** Allowing an individual to monitor their own performance. **Surveillance** An individual's behaviour is monitored by a third party. **Praise** Feedback through praise can help motivate individuals continue to progress to achieve their goals.

		Suggestion Feedback through fitting suggestion will have greater persuasive power.
Social support Providing individuals with practical, emotional and unspecified support. Through this individuals gain praise, rewards and advice that will help them in achieving their goal.	**Social liberation** Realizing the social norms and changing in the direction of the healthy behaviour. These social norms could be identified through a social support group. **Helping relationships** Seeking positive social support to help in achieving the healthy behaviour change. **Environmental reevaluation** Realizing the negative impact of the unhealthy behaviour or positive impact of a healthy behaviour based on the individual's social environment.	**Social role** **Cooperation** A system can use an individual's natural natural drive to cooperate to motivate behaviour change. Individuals could do this by providing advice and sharing knowledge. **Recognition** Praise through public recognition and can motivate an individual to make a behaviour change.
Shaping knowledge Helping an individual gain a better understanding of the behaviour by offering information about how to perform a behaviour, antecedents, the causes of the negative behaviour, and how to test their behaviours.	**Consciousness raising** Finding out about the facts and ideas that will aid in changing an individual's behaviour. **Precontemplation stage** This stage encompasses the idea that the individual has no knowledge about their negative behaviour or need for positive idea, and therefore knowledge shaping is required to progress onto the next stage of the transtheoretical model.	**Expertise** Providing an individual with information showing knowledge, experience, and competence. **Authority** The use of authority can increase persuasiveness; individuals are more likely to accept information that is provided by an expert or authority in the field.

		Verifiability Individuals are more likely to accept knowledge if they are provided with a means of verifying the information.
Natural consequences Informing individuals of the consequences of changing their behaviour.	**Dramatic relief** Experiencing the negative emotions that are related to the negative behaviour.	**Simulation** Providing simulations that can persuade by allowing an individual to observe the effects of changing their behaviour.
Comparison of behaviour Allowing the individual to see the effects of changing the behaviour, this could be through a demonstration, social comparison, or providing relevant information.	**Consciousness raising** An individual can gain more information about the behaviour by observing examples of it in practice.	**Simulation** Allowing an individual to view the intended behaviour. Social comparison An individual is able to view the effects of the desired behaviour on others.
Associations Encouraging an individual to perform a behaviour using associations, this could using cues for initiation, or conditioning to encourage or discourage a behaviour.	**Reinforcement management** Increasing the rewards for the positive behaviour to associate it more positively. Decreasing the rewards for negative the negative behaviour to associate it more negatively. **Stimulus control** Adding cues for healthy behaviours and removing cues for unhealthy behaviours.	**Conditioning** Positive or negative reinforcement to associate a behaviour more positively or negatively. **Reminders** Reminders can cue a behaviour if used at an opportune moment.
Repetition and substitution	**Counterconditioning**	**Rehearsal**

Forming habits around positive behaviours through repetition and removing negative habits by substituting them with less harmful ones.	Substituting negative behaviours with healthier alternatives.	Allowing an individual to practice a behaviour, this can allow them to repeat the actions helping to build a habit.
Comparison of outcomes Helping the individual compare the possible outcomes of a behaviour, this could be through a reliable source, listing pros and cons, or comparative imaging.	**Consciousness raising** Individuals can gain a better understanding of the behaviour by comparing the outcomes of the different behaviours.	**Simulation** Simulation can provide insight into the different outcomes of a behaviour.
Reward and threat Providing incentives to perform a positive action and different for negative behaviours. This could be through social or material rewards and incentives.	**Helping relationships** Can provide social rewards following positive behaviour change. **Reinforcement management** Increasing rewards for positive actions and reducing them for negative actions.	**Rewards** Rewards can promote positive behaviour change by providing an incentive for healthy actions. **Recognition** Some individuals could view recognition as a social reward gained by performing positive behaviours.
Antecedents Changing the environment to encourage positive behaviours or discourage negative behaviours.	**Helping relationships** By changing the social environment, an individual can be surrounded by others that can encourage positive behaviours. **Stimulus control** An individual can change their environment to remove stimuli that promote the negative behaviours.	**Reduction** By reducing the complexity of a behaviour an individual can make it easier to perform. **Competition and collaboration** Creating a social environment that encourages working with or against others can encourage the completion of a behaviour.

Figure 3- Linking TMM to persuasive techniques

Both theories are also heavily influenced by the universal persuasive techniques introduced by Caildini to guide decision making (Cialdini, 2001). Some of these techniques such as authority and liking have been adopted by persuasive technology and have formed their own persuasive technology techniques. Many of these persuasive principles are likely to affect the overall success of the TMM:

Authority - This has been added as its own PT technique and is important during any form of consciousness raising in the TMM; individuals respond more positively to information that is provided by an authority, therefore consciousness raising through a reputable source will increase the likelihood of a behaviour change.

Consistency - Individuals are more receptive to familiar situations. Systems that incorporate a familiar feel by incorporating a real-word feel are more persuasive. The TMM aims to alter the behaviours of individuals that often prefer consistency making them resistant to change; because of this it recommends that individuals set realistic goals, this could be interpreted as maintaining as much consistency in an individual's life whilst changing a behaviour.

Consensus - Individuals often look at the actions of others to determine their own; the importance of these social interactions is important in both the TMM and PT. TMM encourages helping relationships to encourage an individual to maintain a behaviour change. These helping relationships are further explored in PT which offers a selection of tools ranging from social learning to competition and collaboration.

Liking - Individuals often respond better to things that they know, like or trust. This has been incorporated into its own PT technique that encourages that systems are attractive and easy to use. Applying this to TTM, a liked source providing information for consciousness raising or cues for stimulating a behaviour will be more effective than one that is not liked.

Tailoring is a persuasive technique that plays an important role in the transtheoretical model. This technique considers that systems that are tailored towards a user's needs or interests are more persuasive. When considering tailoring in the context of the TMM, it has been shown that programs that tailor the experience to the individual's stage in model perform better (Pro-Change, 2016). Tailoring is therefore important in the context of this project, the interview results can be used to identify features that would be most effective at influencing smartphone user's behaviour. It is also imperative that the system is tailored towards each individual user, if the system is able to gauge which stage of the TMM user is at, possibly through the use of a short questionnaire, it will be able to adapt to provide more suitable solutions; by doing this will not only offer a more effective system, but also increase a user's confidence towards the behaviour change program.

2.11.1. Precontemplation

Providing suggestions that are verifiable and have come from an authority or expert will help users gain an understanding of their smartphone habits. This information could include the benefits of reducing their smartphone usage, or the risks involved with increased usage.

Simulation is another technique that would be suitable at this stage, there is no reasonable way to implement this within an application.

2.11.2. Contemplation

Allowing users to monitor their smartphone usage will give them the opportunity to evaluate their habits and decide whether changing smartphone behaviours would provide a positive impact on their lives.

Suggesting appropriate changes based on the findings of the monitoring process could further encourage the user to make a positive behaviour change towards their smartphone usage.

2.11.3. Preparation

To encourage users to continue from this stage, the system should implement social techniques such as social comparison, this could be implemented using leaderboards allowing users to compare their progress against each other.

3.Sprints and Design Thinking

3.1. Agile

Choosing an agile methodology for this project allows for maximum stakeholder engagement with flexibility in the design process, while still reducing risk by ensuring more reliable schedule and delivery estimates. The agile manifesto outlines four principles (Beck, et al., 2001):

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

It aims to encourage an iterative approach to development with work being completed in small cycles that can be demonstrated to stakeholders allowing for continuous review and input; the impact of requested changes is minimized as these sections of work are small (Jon, 2019). Flexibility is encouraged not only due to the dynamic nature of requirements, but also in the use of tools and processes as these should be allowed to change to better improve a team's efficiency; this process sometimes manifests in an iterative manner such as by implementing team retrospectives where processes are reviewed and improvements are suggested where necessary (Derby & Larsen, 2006). This flexibility often leads the practical implementations of agile to vary from team to team as it is adapted to best suit how the members prefer to operate.

Using an agile approach to development has a variety of advantages in the context of this project, none more so than the continuous communication with stakeholders. Rapid acquisition of knowledge around the subject area is imperative to the success of this project, due to my limited personal knowledge of psychology and smartphone usage behaviours prior to this project engaging with customers regularly will ensure that the system targets the most appropriate problems for dealing with problematic smartphone usage.

3.1.1. Implementations of Agile

There are a variety of approaches to an agile methodology, one of the most popular is SCRUM which defines a framework for development. It works into Sprints which are boxes of time in which the team commits to completing a series of tasks, each Sprint contains four types of ceremony (Scrum.org, 2020):

Sprint planning occurs at the start of the sprint and usually involves selecting the tasks for the sprint off of a product backlog.

Sprint review is a meeting usually involving the product owner and development team that gives an opportunity to describe what work was completed and to elicit feedback.

Sprint retrospective allows the team to iteratively improve by providing an opportunity to evaluate what went well and address any issues faced within the Sprint.

Daily standup allows the team to synchronize activities and plan the tasks they expect to accomplish in the next 24 hours.

However, with the flexible nature of agile methodologies these meetings are often adapted with some teams adding new meetings and removing redundant ones where appropriate.

Although SCRUM has been shown to be highly effective in a variety of environments (Scaled Agile, 2020; Malaivaiyavur, 2014; Raju, 2014; Scrum@Scale, 2020) it is most effective when implemented within a team of around seven members, teams that are too small tend to struggle to complete enough tasks within the sprint and it reduces the collective resources that aid in collaboration; this problem is further magnified when considering teams consisting of a single developer, such as in this project, as

many of the ceremonies are aimed at improving team cohesion and organization, making the development process feel bloated with unnecessary tasks.

Kanban is a leaner approach that can be effective with smaller teams, it focuses on visualizing work onto a board which in its simplest form has three sections: To Do, Doing and Done. Although this methodology outlines daily meetings and delivery reviews (Kanbanize, 2020), these meetings are not as well defined into a full methodology and resemble ideas closer to recommendations than actionable procedures, this can make implementing an effective version of Kanban difficult (Majowska, 2015).

3.1.2. Implementation for this project

The Sprint methodology outlined in Knapps book of the same name emerged as a good fit for this project (Knapp, et al., 2016), it focuses on a practical method that has a closer resemblance to a set of instructions rather than the principles and recommendations outlined by other implementations of agile. It naturally lends itself to the rapid prototyping of a new product by starting with a large long term goal then splitting it into smaller testable tasks. The original methodology outlines a five day working week in which a team can identify, solve and test a problem; each day in this week has a clear goal within the sprint.

Monday - Identify the problem that the sprint will focus on solving, this produces a testable goal that can be evaluated at the end of the sprint.

Tuesday - Describe solutions to the problem, it encourages the team to create as many solutions as possible.

Wednesday - Decide on one solution and create a clear plan on how this can be implemented into a testable prototype.

Thursday - Create a testable prototype.

Friday - Interact with stakeholders and test the prototype against the goal defined on Monday.

This not only gives a framework for an agile process that encourages stakeholder engagement along with an iterative approach to design, it also helps encourage Test Driven Development on a higher level by ensuring that a testable goal is created at the start of a sprint and evaluated at the end of it, as well as facilitating the design thinking methodology by splitting the five stages across the days of the week:

Monday - Empathize and define

Tuesday - Ideate

Wednesday - Ideate and prototype

Thursday - Prototype

Friday - Test

In practice implementing this methodology over a single week will not be feasible due to the limited man hours available, instead this process will be extended over two to three weeks to provide enough time to fully design, implement and test a prototype.

3.2. Design thinking

Design thinking is a human-centered strategy for design and development, it aims to identify and solve problems through high customer engagement (designthinking.ideo.com, 2018). The process is split into five stages (TEO & Dam, 2020):

Empathise - Engaging with users you can yield a deeper understanding of who you are designing for, this gives an insight into their needs, thoughts, emotions and motivations.

Define - Producing a meaningful and actionable problem statement often based on the knowledge gained during the empathise stage. These problem statements should be human-centered, and broad enough for creative freedom but narrow enough to be manageable.

Ideate - Generate ideas that aim to solve the defined problem statement by encouraging creativity and innovation.

Prototype - Creating an early, inexpensive and scaled down version of the product in order to reveal problems in the current design. It gives an opportunity to test the practicality of the design.

Test - Evaluate the solutions implemented within the current design in order to examine if it solves the issues defined within the problem statement. It also provides end users with an opportunity to give feedback that not only aid in empathy, but also helps define new problems and create new ideas.

This process naturally lends itself to being implemented within an agile methodology with many of its principles aligning with those outlined in the agile manifesto (Beck, et al., 2001); both emphasise the importance of customer engagement, and both take an iterative approach to design. Implementing this methodology within the development of this project was relatively simple as a result of the chosen agile methodology, however some changes were made in comparison to some conventional implementations of design thinking. Design thinking is often implemented in the form of workshops, these often focus on gathering relevant stakeholders and conducting the whole process within one session (Stevens, 2019); while this extended period of stakeholder engagement is beneficial as it gives opportunity for a larger group, or in some cases multiple sub-groups, to work through a problems and iteratively improve their designs which often fosters more innovation (Morrow, 2018), implementing these on a regular basis is not feasible as expecting to regularly gather a group for a minimum of two hours each sprint would be challenging. By splitting the design thinking process over a week, and involving users using shorter but more focused meetings the pressure of organising workshops was reduced and stakeholders were more open to attending the shorter meetings more regularly.

4.Stakeholder interaction

4.1. Interviews

Interviews will be used throughout this project as they are a helpful tool to gain a deep insight into a subject area by allowing participants to describe their beliefs and feelings about a topic (Evidence Base, 2006). The process of opportunistic interviewing allows interviews to divert to different topics and towards interesting ideas, this is extremely helpful when attempting to empathise with users in subject areas where prior knowledge is limited as the predefined questions may miss important topics (Lazar, et al., 2017).

These will be conducted either face to face, or over an instant messaging platform, Slack or Facebook messenger (Slack, 2020; Facebook Messenger, 2020). While face to face interviews are preferred as they have been shown to elicit more thoughtful and accurate responses (Gubrium, et al., 2001), the messaging platforms are a helpful alternative when requiring a quick and efficient conversation, for example when clarifying small questions about a topic.

4.2. Focus Groups

While more challenging to organise and conduct than interviews as multiple participants must be managed at a single time, focus groups can elicit a wider range of opinions in a shortened space of time. These will be especially helpful during ideation and design phases as they users to develop ideas together often resulting in more developed suggestions (Lazar, et al., 2017). The focus groups used within this project will generally be small (from three to seven) as my limited experience conducting this form of stakeholder interaction may make working with larger groups impractical.

Much like interviews, focus groups will be conducted both in person and using instant messaging, the later form will help to alleviate some difficulty when attempting to organise meetings as they do not require multiple participants to gather at a single location and also allow conversations to be read and continued at a later times should participants not be available at the initial meeting time.

4.3. Questionnaires

These will rarely be used to interact with stakeholders as they have been argued to be inadequate for understanding behaviours and emotions and their rigid nature make eliciting meaningful and in depth responses difficult (Institute of Lifelong Learning, 2009). They will however be used prior to interviews to gain a basic understanding for the topic and help to identify helpful lines of questioning.

5.Version Control

5.1. Introduction

Version control systems (VCS) help to manage revisions of source code helping teams to control changes over time. It keeps track of modifications allowing the comparison of different versions or the reversion to a previous version when a problem arises (Atlassian Bitbucket, 2020). While its potential to aid in collaboration by allowing multiple software engineers to work simultaneously on a project plays an important role when working as part of a team, version control still has a variety of benefits for a lone developer. Firstly the distributed solutions, such as Git, provide a remote backup of work reducing the impact of data loss and hardware failure (Git-Tower, 2020). Having access to previous versions of source code and the ability to compare or revert changes allows more freedom to experiment while programming (Miller, 2020).

5.2. Git Introduction

There are a variety of reasons why Git has become the leading solution for version control (Synopsys, 2020); in this context of this project its unrivalled speed for committing or accessing history, along with is flexibility in allowing workflows that are suited to the team and not imposed by the VCS are key features that prompted its selection (Günther, 2017). Its actions functionality makes automating workflow processes simpler and reducing the overhead required for continuous integration and deployment, the processes of ensuring code is regularly updated to master and ensuring that the master branch is deployable at any point respectively (Codeship, 2020), by allowing branches to be automatically tested and deployed.

5.3. Git Workflow

While ensuring that a clear workflow when using VCS is important when working in a team to reduce the number of integration bugs introduced when working simultaneously, it still provides value when working on a project as a solo developer as it reduces the risk of bugs making it into the final product and provides access a deployable system even if a new feature is in development.

There are a variety of predefined workflows that are suited to different environments and release cycles. Gitflow creates an extra branch off of master for development, this development branch stages all of the changes made within a release cycle, when the software is to be released this branch can be merged into master (Atlassian Bitbucket, 2020). This introduces an extra layer of protection against integration bugs as the development branch will be identical to the product that will be released meaning that any tests can be run before merging to master. However, features take longer to reach master as they have to travel through development and release branches first, this can make continuous deployment difficult which is why this methodology is more appropriate for systems that work on a release cycle where a new version containing multiple new features is released all together.

GitHub flow is a more suitable workflow for this project due to its simple yet effective method of managing workflow; it allows new features to be quickly developed and deployed, while still providing the master branch with a layer of protection (GitHub Guides, 2017). Creating feature branches off master and merging changes back into master when the feature has been implemented allows for the continuous delivery of software outlined in the agile principles (Beck, et al., 2001), this also reduces the overhead as only one pull request is required for each new feature. This method still offers security against integration bugs by allowing the pull request code to be tested, this is a combination of the code in master and the feature branch, it is therefore imperative that pull requests pass all tests before being merged into the master branch.

GitHub allows actions to be added to allow automation of some tasks within this workflow, using these the building and testing processes can be performed on any pull request ensuring all code going to the master branch is correct, and the software can be automatically released when a new feature is introduced into master.

6.Programming Framework

Within the first Sprint of this project stakeholders identified that a mobile application would be the most appropriate implementation for the system; therefore a framework for developing Android application must be found.

Java is often considered to be the official language of native android development due to it being directly supported through the Android SDK (Zipcode, 2016), this provides easy access to many pre-written packages that allow the use of functionality within the device (Android - Java, 2020); for this project gaining access to the users application usage statistics is vital, the android.app.usage package can retrieve this information. Kotlin was also introduced as an alternative to Java (Android - Kotlin, 2020), although its compilation time is often slower it allows for more concise code which often leads to fewer bugs (Hiral, 2018).

The Android's Native Development Kit (NDK) allows applications to be developed in C or C++ resulting in an increase in performance (Android - NDK, 2019). While this is beneficial for games or physics simulations, its use is unlikely to result in a significant difference for this project, especially when considering the improvements in performance of other languages for android development (Son & Lee, 2011).

Despite their cost on performance, cross-platform mobile development frameworks have significantly increased in popularity in recent years (Sullivan, 2018; Google Trends, 2020). The key feature of these frameworks is the ability to condense Android and IOS development into a single codebase and in doing so drastically reduce the cost of development through code reuse; while the scope of this project extends only to Android users, the potential to reach IOS devices could provide opportunity to widen the range of users available in the evaluation phase (Manchanda, 2019). Native cross-platform solutions aim to allow developers to write code once that is then translated into the respective code for each operating system in an attempt to allow identical code between Android and IOS while maintaining a respectable level of performance (ElHady, 2020); there are three popular choices in this category: Flutter, React Native and Xamarin. While Microsoft's Xamarin allows up to 96% of code to be reused, its slightly worse performance and more limited documentation and backing from the community make it a less viable choice when compared to the other two solutions (Merixstudio, 2019). There are valid arguments for both Flutter and React Native, and the two frameworks offer nearly identical performance (ElHady, 2019), the choice to use Flutter was only swayed by the slightly better testing support and wider range of UI components (Jagtap, 2018). Despite being a relatively young language Flutter has vast amounts of documentation due to the great deal of support from both Google and its rapidly increasing user base. Flutter also provides access to native Java or Kotlin (and objective C and Swift for IOS) code through

the use of the platform channels, this allows access to any packages such as the aforementioned android.app.usage.

7.Testing

7.1. Testing Principles

Test driven development (TDD) is a style of programming that aims to improve code quality by writing production code to some predefined unit test. Robert Martin condenses the process into three laws (Martin, 2007):

- You may not write production code unless you have first written a failing unit test.
- You may not write more of a unit test than is sufficient to fail.
- You may not write more production code than is sufficient to make the failing unit test pass.

This produces a loop beginning with writing unit tests that fail, then writing just enough production code to make the tests pass, this process is then repeated. A refactor phase can be added to this process to tidy production code, as a developer you are also protected against introducing new bugs when making these changes as the code will no longer satisfy the unit tests (Koutifaris, 2018). TDD allows confidence in the work being produced, it ensures that the changes being made are not resulting in regressions in other parts of the system, and inspires the confidence to refactor code in order to combat the common issue of software entropy (Martin, 2014). It also has many parallels with the principles outlined by the agile manifesto, such as its rapid feedback and customer-centric characteristics, and is often considered as a necessity when working with such methodologies (benlinders.com, 2017).

It is clear that TDD plays an important role in developing reliable software, and it is considered unprofessional to not use it (Martin, 2014), however it can be expanded through the use of behaviour driven development (BDD). BDD focuses on clearly identifying the scenarios or behaviours the code should have and then proceeding to write code to satisfy those behaviours. It complements TDD by providing a specification that helps define how the testing process can be applied to the project; BDD requires you to find the steps the user will go through, TDD then involves writing tests to ensure that these behaviours have been properly implemented into production code (Milecia, 2019). By combining these it further encourages the user-centric approach as the behaviours are determined by interacting with users, the tests are modelled around the behaviours and the production code is written to satisfy these tests; this further compounds the Agile model of software development (Beck, et al., 2001).

7.2. Testing Process

7.2.1. Sprint Test

At the highest level, testing the proposed solution to the sprint goal that the development process is moving in the correct direction. A goal is defined on the first day of the sprint along with tests to evaluate the goal, the tests are then conducted on the final day of the sprint; these are often customer focused and involve stakeholders interacting with the product and giving feedback. While this process in itself is not TDD, having tests that involve user's directly and evaluate the efficacy of the system on each iteration helps to encourage customer collaboration that is not only encouraged by the Agile methodology but also helps to empathise when considering a design thinking approach to design.

7.2.2. Implementation of BDD

Once a solution to the sprint goal has been decided, the behaviour of the feature can be defined. The Domain Specific Language Gherkin is used to define user stories, its simple Given, When, Then approach to defining behaviour gives structure to user stories while abstracting complexity allowing non-technical stakeholders to evaluate and give valuable insight.

Gherkin stories are written within feature files; while each class within the code could be written as a full Gherkin feature, electing to only use feature files for system level behaviours, helps to remove unnecessary boilerplate code when writing unit tests. BDD will still be used to define the behaviour of the class prior to writing tests, however this will be within the test file itself as comments.

Feature files start by naming the feature and giving a brief description this high level overview of what the feature aims to achieve. Each user story can then be described as a scenario, a scenario should only represent one behaviour (Automation Panda, 2019). Each scenario is broken into steps which are each prefixed by a Given, And, When or Then keyword, these help define what the step is aiming to achieve (Cucumber, 2019):

Given - Used to describe the initial context of the system, sets the scene for the scenario and puts the system in a known state.

When - Used to describe an event or action.

Then - Used to describe the expected output or result.

And - Used succeeding a Given or Then to append another step.

The keyword And should not follow a When keyword, as multiple When steps are often a sign that a scenario can be split into multiple smaller scenarios (Cucumber, 2019). A background scenario can be defined to extract repeated Given steps that are being repeated in each scenario, a common example is navigating to a page (Relish, 2016).

When writing scenarios there exists a fine line between providing enough detail to sufficiently describe and evaluate a feature, yet still not restricting future change to the product through the inclusion of incidental details; an effective way to create useful scenarios is by using the BRIEF principles (Rose, 2019):

Business language - Using language from the business domain helps when conversing with stakeholders.

Real data - Using concrete, real data helps to expose boundary conditions and underlying assumptions early in the development process.

Intention revealing - Should reveal the intent of what the actors in the scenario are trying to achieve and avoid describing the mechanics of how they will achieve it.

Essential - Should only illustrate how a rule should behave, any parts that do not directly contribute should be removed. Any scenarios that do not add to the reader's understanding of the expected behaviour should also be removed.

Focused - Should be focused on a single rule.

Brief - Restrict scenarios to five lines or fewer.

In addition to using these rules, using consistent phrases throughout all features will reduce ambiguity; a common example is whether to use first-person or third-person when writing steps. First-person will be used throughout this project due to personal preference as from past experience stakeholders have found it easier to empathise when reading scenarios as if they are performing the action, however there is a strong case for using third-person (Automation Panda, 2017) largely due to the possible ambiguity around user permissions, such as whether a user is an administrator; this is less of a concern in this project as there will only be one user type, nevertheless the addition of supplementary Given steps to clear ambiguity will be considered in such cases.

7.2.3. Eliciting features

Wednesday in the sprint is allocated to deciding which solution should be prototyped, this process can involve creating a storyboard for the solution to outline its behaviour making it easier to prototype. While it is possible to create a detailed storyboard that explains every behaviour fully, using example-mapping may allow for an increased level of stakeholder engagement when defining functionality. This group based process starts by outlining the user story, the stakeholders can then ask questions about the story, and these questions are answered in the form of rules, and for each rule a set of examples are defined. This process helps to empathise with the user's needs as the development team along with external stakeholders, whether it is actual customers or a customer facing employee, are able to converse to build desired behaviours. This process results in rules and examples are easy to translate into Gherkin features (Simbhoedatpanday, 2015; Wynne, 2015).

7.2.4. Advantages of Gherkin

These Gherkin files have a variety of applications within this project. Firstly they provide a very high level description of how the feature should behave written in domain specific language, they are useful when conversing with stakeholders and attempting to understand whether developers are understanding the desired behaviour correctly.

The BDD features also serve as documentation, both in the role of requirements by clearly defining the expected behaviour of the system, but also for simply describing a feature to any interested parties, this aligns well with the agile methodology which discourages lengthy documentation in favour of creating working code through high customer engagement (Beck, et al., 2001); this process of creating condensed, multi-functional documentation helps to streamline the development process.

While these scenarios will be used to help when designing the structure of unit tests when using TDD, they themselves can be used during system testing to ensure that all desired behaviours have been implemented.

7.2.5. System Testing

Gherkin files are often used as a part of a larger framework known as Cucumber which aids in BDD by allowing user stories written in Gherkin to be linked to executable code to perform the test. Doing this would allow the system level behaviour within this project to be written as automated system tests (Software Testing Help, 2020); while this does allow have a completely automated build, test and release process that can identify regressions faster, for a system of this size the benefits of writing automated system tests may be outweighed by the time taken to implement these tests. Instead, the Gherkin user stories can be used to manually evaluate the feature.

To aid in the process of system testing, the feature files will be structured as closely to the page structure as possible; this ensures that all similar features are collected together, for example any features relating to the home page can be found within the home system testing directory.

7.2.6. Unit Testing

While unit tests will not directly use Gherkin feature files, the process of writing tests will begin by defining the behaviours expected from the production code; this can be achieved by commenting behaviours using the Given, When, Then format, then writing the tests to satisfy these behaviours (Keogh, 2017). This not only provides structure when writing unit tests, but it also acts as documentation for developers trying to understand the behaviour of a piece of code. Clarity is key when writing tests, Martin suggests the Build-Operate-Check pattern for writing code as it allows other developers to easily interpret what the test is trying to achieve (Martin, 2009), notice that this pattern closely resembles the Given, When, Then paradigm that is to be used within this project.

When considering the clarity of unit tests, allowing more repetition of code may improve readability. While DRY code is important when writing production code (The Valuable Dev, 2018), it can lead to

less clear tests; allowing duplication of code in some cases, such as for loops may be beneficial (Lynch, 2018).

Following the F.I.R.S.T principles when writing unit tests encourages cleaner tests that result in more stable production code (Gupta, 2016; Martin, 2009):

Fast - Tests should run quickly, this allows them to be run more frequently.

Independent - Tests should not depend on each other, this allows tests to be run independently.

Repeatable - Test should be repeatable in any environment.

Self-validating - Tests should result in a boolean output.

Timely - Tests should not take long to write.

8.Sprints

8.1. Introduction

This section will document the sprints undertaken during the development of the system, these sprints follow the methodologies outlined in previous sections.

8.2. Sprint 1 – Stakeholder Engagement

8.2.1. Motivation

This first sprint diverted slightly from the conventional sprints outlined for this project, while most sprints focus on developing a prototype that can be implemented within the final product, it instead aimed to help empathise with end users and understand what they require from the system.

8.2.2. Defining a Goal

There were a variety of areas that needed to be addressed to fully understand the potential users of this system. The first of which is to understand their relationships with their smartphones, this resulted in two research questions:

RQ1 - How do users interact with their smartphones?

RQ2 - What attitudes and beliefs do users have towards their smartphones?

RQ1 focused on the empirical data relating to smartphone usage, understanding this may highlight features that will be of greater benefit to end users.

Attitudes and beliefs have a large impact on behaviour with behaviour change models outlining the importance of consciousness raising to change beliefs towards a behaviour (Rimer, et al., 2015), understanding these will help define better strategies for change which can be translated into features within the system.

As well as answering these two research questions, an additional goal of identifying what kind of system users believe would be most appropriate for reducing smartphone usage and defining a possible roadmap for this project will help to create goals within future sprints. There are a variety of different platforms that may be beneficial for reducing smartphone usage ranging from support groups to a phone application, this sprint should find which of these would be best suited for end users. The roadmap can then outline possible features that users think would be beneficial, it can identify possible questions or problems that can be tackled by the system, and finally it should outline features that should be avoided when designing the system.

8.2.3. RQ1: How do users interact with their smartphones?

To answer this research question it is important to understand the metrics that best outline how users interact with their smartphones and which of these indicate problematic smartphone usage. Based on the surrounding literature (Cheng, et al., 2019; Tossel, et al., 2020) the key metrics for understanding smartphone behaviours are:

- The total time spent on a mobile device
- The number of applications opened in a period of time
- The locations that have the highest usage (e.g work or home)
- The number of notifications in a period of time
- The frequency to which they respond to notifications
- The times of day the smartphone is being used (focusing mostly on late at night)
- The number of times the mobile device is unlocked in a period of time

Using a combination of published research and measuring the statistics of a selection of potential users should give a solid overview of this topic.

8.2.4. RQ2: What attitudes and beliefs do users have towards their smartphones?

There are a variety of questionnaires that can provide insight into how users perceive their smartphone usage:

- Transtheoretical model of behaviour change (Prochaska & Velicer, 1997)
- The smartphone addiction scale (Kwon, et al., 2013)
- Self-efficacy scale (Toscos, et al., 2006)

In addition using a semi-structured interview will allow the exploration of areas that cannot be covered in detail by questionnaires, it can also provide a chance to explore any unusual responses to the surveys.

8.2.5. Identifying the appropriate platform

Behaviour change programs can take a variety of forms and it is important to understand which of these is most appropriate for reducing smartphone usage.

Support groups have been shown to be effective at changing a wide range of behaviours from losing weight to quitting alcohol (Weightwatchers, 2020; Alcoholics Anonymous, 2020). Support groups help individuals share information and stories which help to build positive behaviours (David, 2015).

Software has been used to implement behaviour change models such as the transtheoretical model. Some of these systems are quite basic and simply generate a report to send to participants periodically (Johnson, et al., 2008), however others use a fully-fledged application to provide constant feedback (Fitocracy, 2020).

To better understand which platform will be most appropriate for users, a selection of questions surrounding these systems should be added during interviews.

8.2.6. Identifying the Roadmap

There are a variety of persuasive techniques that can be incorporated into the system, however these should be tailored towards the needs of the users, understanding the stage of change that individuals are on the transtheoretical model may aid in the selection of these techniques.

Interviews and group meetings should be conducted to better understand the features most appropriate to users, these should discuss possible features that users want along with ones that should not be implemented within the final system. Using alternate approaches to reducing smartphone usage may help generate ideas for this solution, this could include reviewing the efficacy of applications such as Stay Focused (Stay Focused, 2020).

Based on these findings a clear path for future sprints can be formed by identifying key features.

8.2.7. Stakeholder Interaction methodology

This process will be split into three sections:

Initial meetings - To empathise with stakeholders

Research - To find solutions and based on the initial meeting

Ideation meeting - To present research findings and produce appropriate features

8.2.7.1. Initial meetings

Individual meetings will allow a more in depth conversation into an individual's smartphone usage behaviour.

These will begin by asking participants to complete a transtheoretical model questionnaire aimed at understanding where they are situated in the stages of change; the questionnaire will be formed by adapting questionnaires used for smoking, drugs and alcohol addictions (UMBC, 2015).

A semi-structured interview that will aim to understand each user's beliefs and attitudes towards their smartphone usage and attempting to change their behaviours. The structure of this will be intentionally loose in an attempt to explore areas that the participant believes are important in more detail.

App Usage (App Usage, 2020) will be used to measure:

- App usage time per day
- Number of applications opened per day
- Time of day that the phone is being used
- Number of times the phone is unlocked per day

Locations were omitted as participants may be uncomfortable measuring these and recording notifications was impractical as there are no available systems that record this.

Finally the participants will be requested to install Stay Focused and use it until the second meeting, this meeting will take place minimum of 24 hours after the participants have installed the application.

8.2.7.2. Research

While participants are evaluating the alternative solution, the results of the transtheoretical model questionnaire can be evaluated to identify where in the stages of change participants are and also suggest the persuasive techniques that would be most effective for changing their smartphone behaviours.

8.2.7.3. Second meeting

This will be conducted as a group meeting to gather all participants to discuss the ideas for this project. Using a group meeting as opposed to individual interviews will allow participants to share and expand on each other's ideas. During this meeting the participants will be asked to discuss what they liked and disliked about Stay Focused, they will also be provided with the average results of the tanstheoretical model questionnaires, the average was used as to not single out individual results that could embarrass participants, along with the suggested persuasive features that could be implemented within this project.

8.2.8. Results

8.2.8.1. Initial interviews

These meetings were conducted with six university students aged between 20 and 23.

The initial interview identified that participants found their smartphones to be a useful tool that when used responsibly helps them to socialise with friends and can even make them more productive by providing access to the internet and other resources. However, there are occasions where participants experienced self-perceived overuse which resulted in negative consequences, the most common of which is decreased productivity when attempting to concentrate on tasks such as university work, with all participants mentioning this issue during the interview process.

Five of the six participants have developed strategies for managing their smartphone usage, however many of these were similar and focused on reducing their smartphone usage for short periods of time. Three of participants reported physically restricting access to their mobile device by turning it off locking it inside of a draw, while another explains that using the Forest application (Seekrtech, 2020) which encourages users to not interact with their device for a set period of time using persuasive techniques such as reinforcement and competition. However, all four of these participants reported an urge to reach for their mobile device while using these methods, which indicates that while these do allow individuals to reduce their smartphone usage for a period of time, they do not tackle the underlying urge to use their smartphone. Although problematic smartphone usage may not seem significant as these coping strategies work while the device is restricted, participants did report

difficulty when initiating these strategies, stating that they would often spend too much time on their device before putting it away and concentrating on their desired task.

The final and seemingly most successful solution was found by the self-described "digital minimalist" who mentioned that the issue of problematic smartphone usage was not due to lack of methods for reducing it, and instead results from a lack of motivation. He identified a variety of techniques that help to manage smartphone usage:

- Using a simplistic greyscale user interface for the device
- Turning off notifications
- Using a small phone screen
- Removing social media applications and instead using the web application
- Moving application icons around on the home screen
- Asking why you are using a specific application, for example "I am using Facebook to reply to messages"

These all aim to remove the addictive nature of smartphone usage by breaking the unconscious habits that are formed when using these devices; he identified that smartphone applications could be designed have addictive qualities as companies earn money by drawing the users attention for as long as possible, summarizing this concept by stating that the "biggest fear of capitalism is sleep", a statement that closely resembles Netflix CEO Reed Hastings statements that sleep is the streaming service's biggest competitor (Sulleyman, 2017). He understands that his methods for reducing smartphone usage will not be effective for everyone, however he explained that this was not due to the methods themselves stating "in principle they should work for everyone but the people using them are not always committed, people need a motivation to do things, in my case I understand the value of time and I do not want to waste it scrolling through social media, but for a lot of people that is not enough", he then explained that there would be more benefit in providing a system that could motivate users to stop using their phones instead of performing the act of restricting it.

8.2.8.2. Phone Usage Statistics

The recorded data did provide useful insight into the smartphone behaviours of the participants. The average usage time was 3 hours and 50 minutes results ranging between 2 hours and 30 minutes and 5 hours. The average number of applications opened per day was 34 with results ranging between 15 and 60. On average the number of times each participant unlocks their phone per day was 43 with results ranging between 12 and 73. Users with the highest usage statistic also tended to spend disproportionately more time using their phones late at night (between 10pm and 3am). For all of these the "digital minimalist" recorded the lowest results indicating that his methods are effective.

As the number of phone unlocks was higher on average than the number of application opens it indicates that users are unlocking their phones without opening an application, this maybe to check notifications or a subconscious habit; however this was not the case for the digital minimalist who, based on the statistics, uses his phone with more purpose, this could link back to his technique of asking himself why he using his device.

8.2.8.3. Transtheoretical Model and Persuasive Techniques

Based on the questionnaire the participants were situated between contemplation and maintenance, while this is a wide range the results of the survey and the interview did show that participants have attempted to reduce their smartphone usage with varying success, they often tried to do this when attempting to concentrate on other tasks such as when revising for exams.

Based on these results self-monitoring, suggestion, social competition and cooperation, and reinforcement are likely to be the most effective persuasive techniques outlined in the literature review.

8.2.8.4. Group Meeting

8.2.8.4.1. Discussion about the most appropriate platform

Choosing the platform for the system was a relatively brief discussion, all participants agreed that having a system that was on the phone would be the most helpful. They mentioned that having a phone application would make the system more accessible meaning that they would be more likely to participate. However, they did raise concerns about whether an application could cause an increase in phone usage if implemented carelessly, for instance if there are too many notifications, this issue was revisited when considering using suggestion as a persuasive technique later in the session.

8.2.8.4.2. Stay Focused

Participants found this application to be effective in reducing their smartphone usage, however they did find that it was too intrusive and became irritating after using it for an extended period of time. When asked if users would continue using this application most responded negatively with only two participants considering using it in the future. This could point towards the hypothesis raised by the digital minimalist in his initial interview, as it indicates that motivation could be the limiting factor when reducing smartphone usage.

8.2.8.4.3. Features to avoid

The platform discussion and use of Stay Focused raised two features that should be avoided in the development of this system. The first of which is notifications, participants found these to be irritating when used incorrectly, agreeing that the only helpful use of notifications are for messaging and social media interactions, with five of the six participants opting to disable notifications that are simply trying to get the user to open the application. Even after the persuasive technique of suggestion was explained, outlining that notifications would be used at opportune times, for example when you have been scrolling through social media for an extended period of time, participants were still sceptical about their use within this project.

Blocking functionality within the phone should also be avoided as this was the main concern raised when using Stay Focused. Participants identified that while this works in the short term and is helpful when concentrating on a task without their phone, it felt too restrictive when using it for extended periods of time, stating that it seemed more like a quick fix than a long term solution for problematic smartphone usage. They also recognised that this functionality would be redundant in new systems as there are a variety of similar solutions for reducing smartphone usage, from specific applications to simply turning your phone off, however these do not seem to tackle the underlying problems that cause problematic smartphone use.

8.2.8.4.4. Features to include

Before discussing specific features that would provide value to this application, there was a short discussion regarding what participants believed caused problematic smartphone usage. This was heavily influenced by the digital minimalist's view that motivation was the missing link that would allow users to control their smartphone usage, all participants agreed with this, with some members relating this back to their experiences using Stay Focused; one concern was that the digital minimalist was a strong figure in the group, this may have restricted other participants from sharing their views, this may have been a result of the relatively inexperienced interviewing style, specifically an understanding of when to intervene to gain the opinions of other members. Although this may have led to less overall ideas, the hypothesis that motivation is a key factor in reducing smartphone usage has merit, and it was used as a foundation for identifying possible features.

The participants identified that self-monitoring would be an integral feature within this project, however they expressed that simply listing usage times and numbers of apps used per day, similar to other solutions (Stay Focused, 2020; App Usage, 2020; Apple, 2020), can be confusing; to resolve this issue they proposed an abstract representation alongside the raw statistics, suggesting a variety of ideas

including a simple message, such as “You’re doing well” or “You might want to give it a break”, or a single score that can be easily tracked.

Competition was another popular feature with participants, the topic of leaderboards and gamification was raised early in the discussion, even before the results of the transtheoretical model were explained and the persuasive techniques of social competition and cooperation were introduced.

Finally, participants responded positively to the persuasive technique of reinforcement and being rewarded or punished based on their phone usage, they identified that this could be helpful to further motivate them to control their smartphone behaviour.

8.2.8.5. Roadmap

The roadmap towards the minimum viable product based on interactions with users:

1. Identifying the statistics that will be measured within the application to evaluate smartphone usage.
2. Finding an abstract representation of the smartphone usage statistics.
3. Representing the statistics and abstract representation to allow for self-monitoring
4. Implementing reinforcement within the system to reward and punish users based on their smartphone behaviours.
5. Introduce a feature that allows competition between users.

This roadmap is subject to change, however it will provide a guide for subsequent sprints.

8.3. Sprint 2 - Identifying Statistics

8.3.1. Motivation

This sprint will aim to find the statistics that best represent a user’s smartphone usage behaviour, these statistics will act as the foundation of the application as all features will need to understand how the user is interacting with their device in order to provide meaningful functionality.

8.3.2. Sprint Goal

There are a wide range of potential statistics that could be monitored, however many of these may not be applicable to this project, the statistics identified within this sprint must:

- Be implementable within the Flutter framework
- Accurately measure smartphone usage
- Not intrude into users lives, such that users are uncomfortable providing access to them

The goal of this sprint is to establish a list of statistics that cover the wide breadth of user behaviour while still conforming to the rules mentioned above.

8.3.3. Possible Solutions

8.3.3.1. Total screen time

Measuring the total time the user’s phone screen is turned on is expected to be the most accurate indication of the total usage time; however this does not factor if the screen is on but the phone is left idle, this should be considered when using this value for calculations.

8.3.3.2. Total number of applications opened

Measuring the number of times applications have been opened will give an alternative view of smartphone usage, this will help to give an indication of how long applications are being used for and if the user switches between applications regularly.

8.3.3.3. Total number of unlocks

This is useful for understanding how many times a user reaches for their phone, along with the average length of sessions when coupled with total screen time.

8.3.3.4. Total number of times the screen is turned on
A very similar statistic to the number of unlocks, however this could also show the number of times a user checks for notifications, this habitual behaviour can break concentration.

8.3.3.5. Total number of notifications received
This may identify the cause of the issue rather than show problematic smartphone usage. High numbers of notifications may result in higher smartphone usage as the purpose of these notifications is to encourage users to use the application that the notification originated from.

8.3.3.6. Which applications are being used
In addition to identifying the applications that consume the largest proportion of the user's attention, it may also indicate if the usage is problematic, for instance a user may not consider their high smartphone usage negative if it is primarily on productivity or learning applications.

8.3.3.7. Times of day that the phone is in use
Using mobile devices late at night has been linked with loss of sleep and insomnia (Fossum, et al., 2013), and there is a positive correlation between problematic social media usage and late night sessions (Cheng, et al., 2019), therefore monitoring the times of day that users are active on their devices may help to highlight negative behaviours.

Showing users when they are most likely to use their smartphones may allow them to actively concentrate on not using their devices in those time periods.

8.3.3.8. Locations where the phone is being used
Much like the showing users the times of day that have the highest usage, showing locations that users are most prone to smartphone usage could show trends in their behaviours; for example, it could show that users have a higher usage at work than at home indicating that they are using their phone to procrastinate.

8.3.4. Evaluation of Solutions
Each of the identified statistics was evaluated against the capabilities of the Flutter framework, they were ranked in three categories:

Easy to implement - Will be implemented unless users object recording it

Difficult to implement - Will be implemented if it is believed to be a necessity within the application

Cannot be implemented - Cannot be implemented within this project (Note: some of these can be implemented but they are not practical within the scope of this project)

A focus group was conducted to identify which of the implementable statistics should be included within the system.

8.3.4.1. Not Used
The focus group discussed that having too many statistics could cause confusion, this conversation was very similar to one within Sprint 1 where participants wanted an abstract version of the statistics.

The metrics that were not included:

Total number of unlocks - This would be difficult to implement, and did not add enough value to be a viable feature as its results can be interpreted from the total number of applications opened.

Total number of times the screen is turned on - This was omitted for the same reasons as the total number of unlocks

Total number of notifications received - Not only did this fall into the cannot be implemented, but users did not feel like this would add much value to the system as it does not directly show phone usage

Locations where the phone is being used - Users were uncomfortable having their locations constantly recorded, also this feature would likely require an always on approach to recording data which would drain phone battery.

8.3.4.2. Used

There four selected statistics:

- Total screen time
- Total number of applications opened
- Which applications are being used
- Times of day that the phone is in use

When discussing how these statistics should be implemented the focus group concluded the applications used and times of day should scale the other statistics instead of being explicitly recorded. They identified that there are times of day and applications where they intend to discourage phone usage more than others, for example allowing users to double the recorded statistics for a specific application would discourage use of that app.

8.4. Sprint 3 – Abstract Version of Statistics

8.4.1. Motivation

8.4.1.1. Participants in the focus group in Sprint 1 discussed finding it difficult to interpret the different statistics surrounding smartphone usage, they requested a single value that encompasses all of the statistics into a single place.

8.4.2. Sprint Goal

This sprint aims to identify a representation for this abstract statistic and find an algorithm for calculating it based on an individual's smartphone usage. The required behaviours of this feature are summarised within **APPENDIX A**.

User tests will be conducted to test the outcome of this sprint, these will be split into two sections:

- Comparing the abstract value against the users actual usage statistics
- An informal interview to evaluate are able to correctly interpret the abstract value

8.4.3. Possible solutions

8.4.3.1. Numerical Value or Message

In the focus group conducted in sprint 1, participants offered two implementations of this abstract representation of the statistics, as a number or as a message. After further considering how a message would be implemented, it was found that this would require numerical calculations to select the correct string, this process lends itself to a single score that can be used to determine overall smartphone usage similar to the idea of simply using a number; as a consequence of this, the numerical representation of statistics was chosen as the primary solution as it satisfies the targets of this sprint while allowing still messages to be implemented at a later date.

8.4.3.2. Methods of Measuring Score

The score could be calculated in two different ways, a cumulative score where users are awarded for positive behaviours by increasing its value, or a subtractive score where users are punished for negative behaviour by decreasing its value.

8.4.3.2.1. Cumulative Score

The main advantage of this method is that it allows the score to persist forever, slowly increasing when users are not using their smartphone. This allows the score to act as a currency or experience points providing further incentive to develop healthy smartphone usage behaviours. Over time its effects of this strategy may diminish as the score increases as positive actions will be perceived to have less

influence on the overall score; for example when the score is 50 earning 10 points in a 20% increase, whereas this earning 10 points when your score is 500 only results in a 2% increase.

This may also be slightly more difficult to calculate as it requires the measurement of the time that users are not on their device, this could be done by calculating the percentage of time that the device is in use, and the rate of application opens (number of applications opened / time), then relating these to a numeric score, however the subtractive method of calculating a score may be more intuitive.

8.4.3.2.2. Subtractive Score

This method lends itself to measuring usage over a period of time such over the course of a day, this allows the score to decrease over the day giving a clear representation of that day's phone usage. This method of resetting statistics every day could be used by the cumulative scores, however as the score is increasing from zero in this scenario it may be difficult to interpret what the score represents; this problem does not exist within the subtractive method as scores are decreasing from a set value, for example counting down from 100, this gives a starting point that scores can be measured relative to.

Using score as currency or experience points can still be incorporated into this solution simply by recording the daily scores.

Discussions with stakeholders concluded that 100 should be the starting score, this is a round number that is closely associated with percentages allowing it to be easily interpreted by end users.

8.4.3.2.3. Handling Multiple Statistics

The subtractive method seems to be the more appropriate method of measuring score, however there are multiple ways of interpreting the multiple statistics for measuring phone usage statistics to form a single score.

Method 1. Weigh the statistics such that they are usable within the same for example 1 application open = 1 point and 1 hour of use = 10 point. While this method is simple to implement when using two statistics, the process of adding new statistics in the future can be difficult as the points awarded for each action are dependent on the scores of other actions.

Method 2. Split the 100 points between the statistics, for example 50 points for total screen time and 50 points total number of applications opened, allowing score calculations for each statistic to be independent of all other statistics. An additional benefit of this is that it allows statistics to be weighted differently should one be deemed more important, for example assigning 70 points to total screen time and 30 point to total number of applications opened.

Method 2 is more appropriate for this project as it allows statistics to be analysed independently allowing for a more versatile approach to analysing the statistics.

8.4.3.2.4. Calculating Scores for Each Statistic

Using method 2 each statistic can be evaluated individually, the simplest method for doing this would be to hard code the scoring system such that actions have a predefined score, for example 1 hour of screen time is equal to 10 points.

A more sophisticated method would be to compare the individual's statistic against the statistics of all other users and then using the percentile rank as the score, this would result in the user receiving 80 points if her usage statistics are lower than 80% of all users. While this scoring system is likely to be more accurate as it uses real time data instead of relying on hardcoded and potentially outdated estimates, it would require a large number of users to implement this effectively and therefore it would not be practical to use within this project.

8.4.3.3. Chosen Solution

- Subtractive design with the score starting at 100 that is reset every day

- Assigns 50 points (50%) to total screen time and 50 points (50%) total number of applications opened
- Uses a hard coded scoring system for each statistic

The hard coded scoring system was produced using the phone usage statistics gather within Sprint 1:

Total screen time:

- If the time is less than 2 hours and 30 minutes, 0 points are deducted from the total screen time score
- Every 1.5 minutes after 2 hours and 30 minutes results in the loss of 1 point

Total number of applications opened

- If the number of applications opened is less than 10, 0 points are deducted
- Every application open after 10 application opens results in the loss of 2 points

8.4.3.3.1. Example

8.4.3.3.1.1. Total screen time = 3 hours

3 hours results in a total screen time score of 80
This results in a total score of: 80*0.5 = 40

8.4.3.3.1.2. Total number of applications opened = 20

20 application opens results in a total number of applications opened score of 60
This results in a total score of: 60*0.5 = 30

8.4.3.3.1.3. Total score

Total number of applications opened score + total screen time score
= 40 + 30
= 70 points out of 100

8.4.4. Prototype

Prototyping this solution will be done by manually calculating the scores based on measured application usage statistics, similar to the example above. The statistics will be gathered using App Usage (App Usage, 2020).

8.4.5. Testing

The scoring system satisfies all acceptance tests **APPENDIX A** and was shown to be effective through testing with 4 participants, one participant with high levels of smartphone usage, two with moderate smartphone usage and one with low smartphone usage.

8.4.5.1. Comparison of Abstract Value and Statistics

8.4.5.1.1. Participant 1 (High usage)

Total screen time: 4 hours and 43 minutes
Total number of applications opened: 47
Score: 18.7

8.4.5.1.2. Participant 2 (Moderate usage)

Total screen time: 3 hours and 5 minutes
Total number of applications opened: 31
Score: 67.35

8.4.5.1.3. Participant 3 (Moderate usage)

Total screen time: 3 hours and 45 minutes
Total number of applications opened: 29
Score: 56

8.4.5.1.4. Participant 5 (Low usage)

Total screen time: 2 hours 12 minutes
Total number of applications opened: 13
Score: 97

8.4.5.2. Informal Interview

Participants understood what their individual score signifies. The persuasive effect of this score for reducing smartphone usage was striking, without being directed towards this line of conversation two of the four participants mentioned that they would consider reducing their smartphone usage after being presented with their results.

8.5. Sprint 4 – Scaling By Time and Application

8.5.1. Motivation

In Sprint 2 users suggested that the times of day and applications should be used to alter other statistics instead of simply using them as standalone stats, this feature will aim to encourage or dissuade the use of the smartphone during set time periods or for certain applications.

8.5.2. Sprint Goal

Although the overall concept of scaling statistics based on application and time of day was covered within sprint 2, there were some details which were overlooked:

Q1 - Which statistics should be scaled?

Q2 - Are these applications and times of day set by users, or predefined?

A focus group was gathered to answer these two questions. In response to question 1, the group decided that all recorded statistics should be scaled, including the overall score; users identified that scaling the score will have a larger impact on user behaviour as this is the easiest method of viewing their daily performance, however they did identify that the system should explicitly state that the selected applications and time will scale score to reduce ambiguity.

The focus group clearly stated that users should choose the applications and times of day that will be used to scale their score and statistics. They identified that this would give a more personal experience, allowing users to target times of day and applications that they are most concerned about; this also implements a level of tailoring, the principle in which systems "will be more persuasive if it is tailored to the individual's needs" (Fogg, 2003).

Considering the outcome of the focus group, acceptance criteria for this sprint were produced in the form two of Gherkin features: scaling statistics by time of day and scaling statistics by application **APPENDIX B**.

8.5.3. Possible Solutions

During the focus group conducted when identifying the sprint goal, user identified that having control of which applications and times of day would scale statistics would allow for a more personal and tailored experience; however, this raises the questions of how much control the users should be given, users can either be given full control to scale times of day and applications as they see fit by setting their own multipliers, or users can be restricted to halving or doubling statistics for chosen applications and times of day.

8.5.3.1. Setting Custom Multipliers

While this approach may allow for a more customizable experience it may introduce an unnecessary layer of complexity.

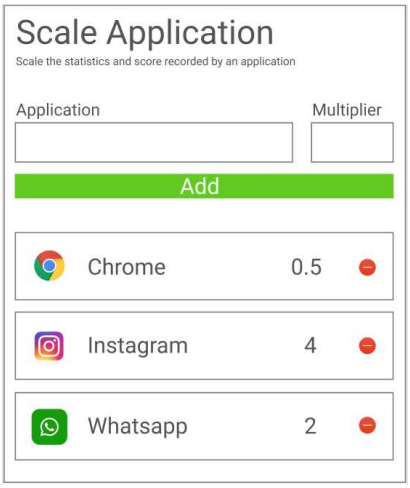

Figure 4 – Custom multiplier design

8.5.3.2. Restricted Design

This is a more verbose method allowing users to pick their 'good' and 'bad' applications, however they do not have the fine grained customization that the custom multipliers method provides as it only allows statistics to be doubled or halved.

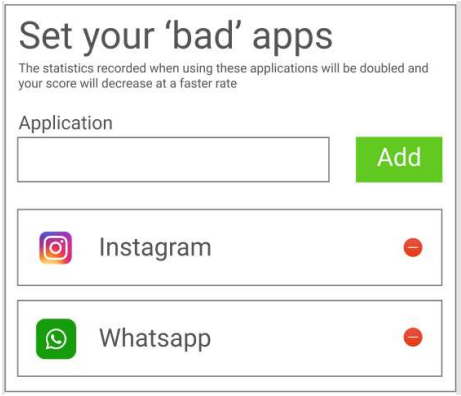

Figure 5 - Restricted design bad application selector

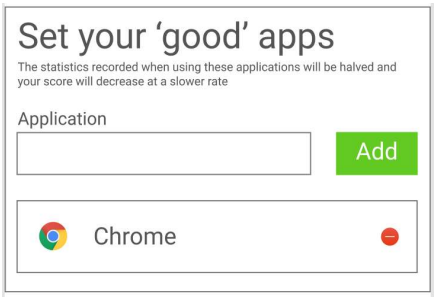

Figure 6 - Restricted design good application selector

8.5.4. Testing

As both of these designs satisfy the acceptance criteria, both were presented to stakeholders to gain feedback on which would be most appropriate for this project. While all stakeholders found the simpler 'good' or 'bad' implementations more intuitive, they did like the extra range of options provided by the multiplier approach. They concluded that the multiplier design should be used within the project, however the message "scale the statistics and score recorded by an application" should be extended to further explain how the multiplier effects the recorded statistics; the more verbose message "**Assigning a multiplier to an application will scale the recorded statistics and score for that app**, for example

assigning Instagram a modifier of 2 will double the total screen time and number of opens recorded when using Instagram, this will also cause your score to decrease faster. **Modifiers can be set to fractions** for example 0.5 will halve your recorded statistics." While this may take longer to read, stakeholder agreed that having the option to customize scales outweighed the slight impact on usability.

8.6. Sprint 5 – Self-Monitoring

8.6.1. Motivation

Self-monitoring is a persuasive technique that is ubiquitous across applications that aim to reduce smartphone usage (Apple, 2020; App Usage, 2020; Stay Focused, 2020), allowing users to evaluate their performance helps to raise consciousness and change attitudes and beliefs towards behaviour by reflecting on previous actions (Epstein, et al., 2008).

8.6.2. Sprint Goal

The goal of this sprint is to identify an effective way to implement self-monitoring into the system, this will require the identification of the information necessary for self-monitoring and then the production of a design that incorporates this information. As it is unclear what information needs to be presented to the user the only defined scenario at this stage is: The user has access to enough information to self-monitor their phone usage **APPENDIX C**.

To test the outcome of this sprint, users will be presented with the self-monitoring feature and asked to complete a questionnaire to evaluate their understanding of the phone usage presented by the feature **APPENDIX D**; although this questionnaire is simple, its intended purpose is to guide a subsequent interview that will aim to get feedback and identify possible changes that should be implemented.

8.6.3. Possible Solution

Self-monitoring is often facilitated through the use of a dashboard in most applications that aim to reduce smartphone usage; although in previous sprints users have identified that the statistics shown in these other applications can become overwhelming and difficult to interpret, there may be some implementing this method of representing statistics to provide users with a more fine grained understanding of their phone usage.

The process of designing the dashboard began with a short focus group to identify which statistics should be represented within this section. The group members were aware of the score functionality [and identified that the components of this should be displayed (Total screen time and total number of applications opened) as it will highlight where the user can improve to increase their daily scores. When asked whether the score should feature within this section, participants identified that it should be omitted from the statistics dashboard and relocated somewhere obvious within the application such as on the home page; stating that it may get overlooked if it is buried away within the statistics. Instead of a single score statistic the group approved a score comparison section, allowing users to compare their overall usage to previous days. Heuristics have been shown to be more effective than statistics at changing the behaviour of individuals experiencing low self-control (Reinhardt & Hurtienne, 2019), Reinhardt and Hurtienne identified two types of heuristic:

Social proof: For example "9/10 people use their mobile device less than you"

Scarcity: For example "There's are only 5 hours left until you go to bed, don't waste them on your phone"

Participants of the focus group responded well to the principle of heuristics originally intending to implement both social proof and scarcity into a single section of the dashboard; however, the group could not decide on a set of statements that could incorporate scarcity effectively, instead settling for the following social proof statements:

- "Well done! You use your phone less than 96% of people"

- "Congratulations! You use your phone less than 76% of people”
- "56% of people use their phone less than you"
- "You use your phone more than 74% of people"
- "You phone usage is higher than 95% of people"

Following the focus group, scenarios were added to the self-monitoring feature to account for the required statistics **APPENDIX C**.

8.6.4. Prototype

The basic framework for the application was implemented by this point in development, allowing new pages to be easily added. As the overall structure of the dashboard is unlikely to change drastically based on feedback, and due to the simplicity of designing user interfaces within the Flutter framework, this feature was implemented directly into the application during the prototyping phase. As a large proportion of the application was still in development, screenshots were taken of the final design and sent to the participants, allowing the user tests to be run without requiring the install of an unfinished application. The screenshots were taken for three user groups:

- High usage user (**APPENDIX E)**
- Average usage user (**APPENDIX F**)
- Low usage user (**FIGURE 7**)

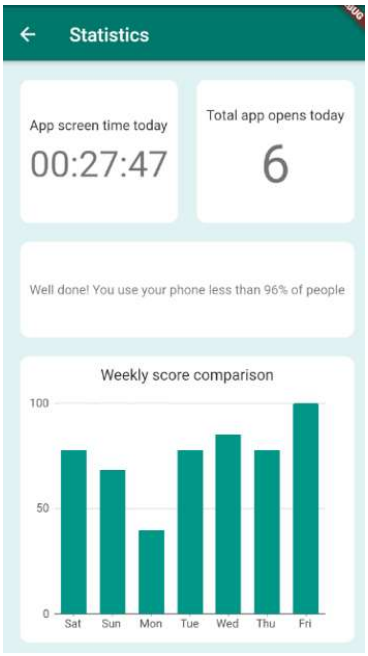

Figure 7 - Low usage user statistics page

8.6.5. Testing

User testing was conducted on using six participants, two for each screenshot. The results of the questionnaire (**APPENDIX D)** were positive with all participants correctly identifying their assigned user type. Question 3 raised some concerns as participants requested more information for understanding how to reduce their usage statistics can be improved, while they identified that they can easily see if they are spending too much time on their phone, or if they are regularly checking applications, they were unsure which applications this was referring to. Based on this feedback, an additional behaviour was added to the gherkin file: The user can view their daily application usage breakdown; this behaviour was implemented using a pie chart comparing the usage time of each application.

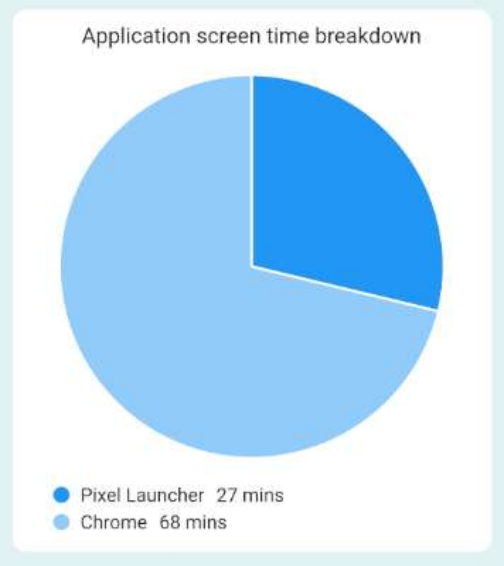

Figure 8 - Application screen time breakdown

8.7. Sprint 6 - Reinforcement

8.7.1. Motivation

In sprint 1, motivation was identified as a key cause of problematic smartphone usage, providing a feature that incorporates reinforcement either to reward positive behaviours, or to punish negative behaviours can aid in increasing motivation.

8.7.2. Sprint Goal

This sprint aims to identify a method of implementing reinforcement for reducing smartphone usage, by rewarding positive behaviours and punishing negative behaviours. The premise for this feature is relatively simple, resulting in a gherkin feature file only consisting of two expected behaviours, "the user is rewarded for positive behaviours" and "the user is punished for negative behaviours" **APPENDIX F**. As reinforcement is a persuasive technique that may take time to fully effect user behaviour, it is impractical to attempt to fully test the change in a user's smartphone usage as a result of this feature within a sprint. Instead the testing process will focus on the user's initial attitudes and feelings towards the feature, these will be gathered through a series of interviews.

8.7.3. Possible Solutions

Positive reinforcement can be implemented through rewards such as virtual trophies, altering media items such as user avatars, or even simple messages of praise (Oinas-Kukkonen & Harjumaa, 2009), similarly messages have been used to establish negative reinforcement by "nagging" users to perform a desired action (Kirman, et al., 2010).

To identify the most appropriate implementation of this feature a focus group was conducted for the purpose of answering two questions:

Q1: What behaviour(s) will this feature be reinforcing?

Q2: How will it be represented within the application?

8.7.4. Response to Question 1

Participants were united in choosing maintaining a high score as the behaviour that should be reinforced, the score is a representation of overall phone usage and while it has no real meaning it does evaluate how well a user has performed in a day.

8.7.5. Reponses to Question 2

Once the behaviour had been selected, the participants then identified methods of implementing reinforcement for encouraging users to maintain a high score during a simple brainstorming session.

8.7.5.1. Currency or Experience Points

Implementing a currency or experience system can be used to promote behaviours, it is a form of gamification common across applications (Seekrtech, 2020; tasktopia.io, 2020; habitica, 2020). These applications often provide restricted content that users have to buy or unlock by levelling up, it is often most impactful when used to augment other features within an application that are easily customised, for example allowing users to plant different types of tree in the Forest application (Seekrtech, 2020); at the current stage of development, therefore this feature is unlikely to be practical as the customisable areas of this project are limited.

8.7.5.2. Messages of Praise or Constructive Criticism

Praise has been shown to be an effective method of persuasion (Orji, et al., 2014), incorporating it into simple messages further motivates users to promote their smartphone usage. Using positive and negative messages to influence behaviour was an approach used by Kirman, et al. to promote environmentally friendly behaviours (Kirman, et al., 2010). Although this would be simple to implement within this system, participants of the focus group identified that it may be too basic and provides very similar functionality to the heuristic included within the statistics dashboard.

8.7.5.3. A Visual Representation of the Score

A popular idea within the focus group was to include a visual representation of the score that aims to cause an emotional connection between the users and their score. The idea was originally proposed as a virtual animal that you would take care of by increasing your score, this was likened to a Tamagotchi (tamagotchi, 2020), and would aim to evoke an emotional reaction towards the creature as you attempt to help it grow. The group were asked to generate ideas for alternate visual representation of the score resulting in the following list:

An animal: Can be happy and healthy or unhappy and sick.

A smiley face: Can be happy or sad

A flower: Can be thriving or dying

An athlete: Can be lazy or fit

A battery: Can be full or empty

A meditating person: Can be calm or manic

While this focus group agreed that a visual representation of the score would be their preferred method of implementing reinforcement, they could not agree on which specific metaphors would be most appropriate, arguing that each of the ideas had merit, with some representing the score most effectively, and others invoicing a greater emotional response.

8.7.6. Selecting a Visualisation

Mood boards were created for each of the metaphors identified within the initial focus group, these aimed to aid in the selection of a visualisation by providing an overview of how it might look (**FIGURE 9**, **APPENDIX H-L**).

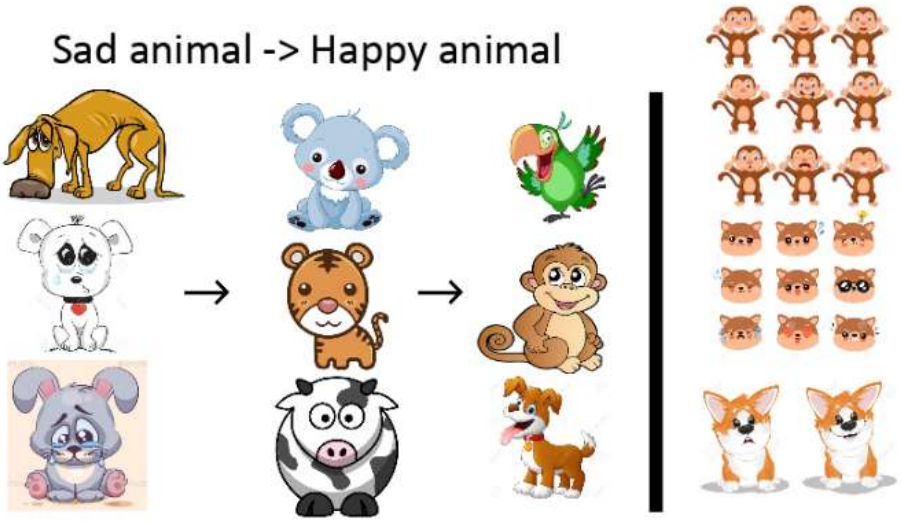

Figure 9 - Mood board for the animal visualisation

These mood boards were presented to a group of end user who were asked to rank the metaphors in three categories, from 1 (best) to 6 (worst):

Emotional response: How well the design evokes an emotional attachment to help encourage users to reduce their smartphone usage.

Simplicity: How easy the design would be to implement, a complex design implemented poorly would likely result in a diminished emotional response when compared with a simpler but more refined implementation.

Representation of score: Whether the users can easily identify their level of smartphone usage; as the score is a value between 0 and 100, having a design that clearly represents for each point would help with this.

Although the flower was rarely ranked first, its consistency across all three categories lead to it being the most obvious choice for this feature. However, if this project was less limited by time the animal may have been the most effective design as it is likely to invoke the greatest emotional response from users **Appendix M**.

8.7.7. Prototype

A simplistic mock-up was used to outline how the visualisation would look, three scores were depicted: 0 point (Sad), 50 points (Medium) and 100 points (Happy). Participants of the testing stage were made aware that this was a very early design and were requested to provide possible design ideas that could be implemented, they were also made aware that the final product would be animated to represent all 100 score points.

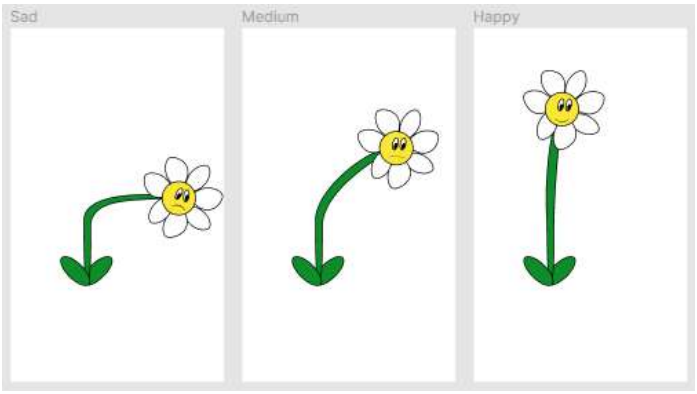

Figure 10 - Simplistic for flower visualisation

8.7.8. Testing

The design satisfies both behaviours defined in the gherkin feature file **APPENDIX G**, negative behaviours (when the user's score is low) results in a sad and lifeless flower, positive behaviours result (when the user's score is high) in a happy and thriving flower.

The interview conducted to evaluate the feature were also largely positive, with participants stating that they can easily see how well they have performed and feel like this would encourage them to reduce their smartphone usage. They did identify that the final version should better implement colours, proposing that low scores could be represented with a duller, greyed depiction of the flower which moves towards a brighter and vibrant colour when the score increases.

8.8. Sprint 7 – Competition

8.8.1. Motivation

Competition was the final persuasive technique requested by stakeholders, it is a strategy in which users are able compare their performance against the performance of other users, and has been successful at promoting behaviour change in a variety of domains (Orji, 2016).

8.8.2. Sprint Goal

This sprint will aim to implement competition within the system, this will require the identification of a comparable statistic, along with selecting an appropriate implementation. As this feature is relatively simple there is only one required behaviour: The user is able to compare their performance against the performance of other users **APPENDIX N**. Like other persuasive features within this application, evaluating the effectiveness of this technique is not viable as it will take time to affect user behaviour, however this feature will be presented to users to receive feedback.

8.8.3. Possible Solutions

Similar to the reinforcement feature the score is an obvious choice for implementing competition, it is a single value that provides an effective overview of a user's smartphone usage.

Leaderboards are a hugely popular implementation of competition within applications, they are a form of gamification that is common across a variety of applications (Seekrtech, 2020; keepthescore, 2020). It is an obvious choice for this application as it provides the expected behaviour required for this feature within a format that users will be familiar with.

8.8.4. Prototype

Much like the statistics dashboard this feature was implemented directly into the application. For the minimum viable product of the system it was implemented with mocked data that simulates other users, firstly this was simpler to implement and had a similar outcome to fully implementing the feature, it also ensures that there are enough users on the leaderboard for users to compete against; much like using percentile rank method of calculating score identified in Sprint 3, as there will be a limited number

of users for this project it is impractical to implement features that are reliant on having multiple users on the application at the same time.

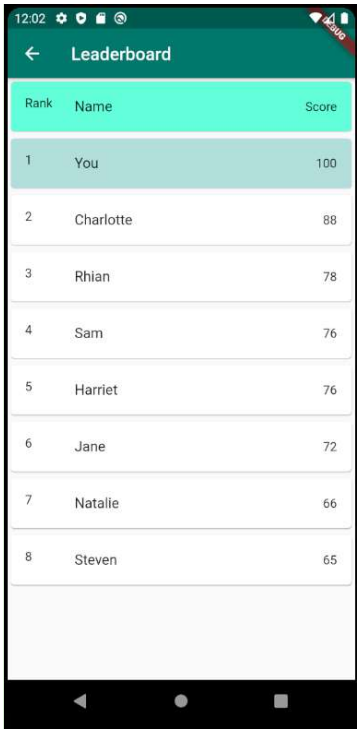

Figure 11 - Leaderboard prototype

8.9. Testing

User feedback did not raise any major criticism with this feature, and satisfies acceptance criteria outlined in the gherkin feature file **APPENDIX N**.

9.Usability Testing

9.1. Motivation

Usability testing helps foster better user experience by identifying problem areas within a product (Williams, 2019); liking is an effective persuasive technique (Cialdini, 2001), identifying and eliminating problems that users identify within the system will lead to a more likeable and persuasive design.

While an informal implementation of testing usability using interviews to critique designs has been utilized by previous sprints, a conventional approach to this usability testing should be implemented to evaluate the entire system and ensure that features are equally usable when not tested in isolation.

9.2. Methodology

9.2.1. Heuristic Walkthrough

Heuristic walkthrough splits the usability test into two passes, the first focuses on a task orientated evaluation and the second pass is a free-form evaluation.

9.2.1.1. First Pass

The first pass closely resembles a cognitive walkthrough by providing a series of tasks for the participant to perform; while these tasks can be performed in any order, the priority given to each task should guide the participant's selection. During this section the user's actions will be ranked between 1 and 3 for each task; 1 signifies that the user completed the task using optimum pathway, 2 signifies that the user completed the task using an alternate pathway, and 3 signifies that the user did not complete the task. In addition to this ranking system observations will be recorded.

9.2.1.2. Second Pass

In this section participants are able to explore any aspects of the system, the knowledge gained during the first pass should guide their actions. By adapting Nielson's ten usability heuristics (Nielsen, 1994) into simplistic questions targeted towards an average user of the application **APPENDIX O** (Note - some heuristics were omitted as the process of translating them into questions involving this application proved to be impractical), this second pass can mimic a heuristic evaluation of the system; while this is not a complete substitute for a full heuristic evaluation involving an expert user with in depth knowledge of the Nielson heuristics, it mitigates the overall impact of not have access to such an individual.

9.2.1.3. Rationale for using heuristic walkthroughs

This form of walkthrough was chosen as it has been shown to identify significantly more problems than cognitive walkthroughs, and results in fewer false positives than heuristic evaluations (Sears, 1997).

9.2.2. Effects of COVID-19

The ethical implications of coronavirus and the social distancing guidelines meant that conducting face to face usability tests with individuals that I did not have regular contact with, such as housemates, would not be possible.

9.2.2.1. Remote usability testing

One solution to this would be to conduct remote usability testing, this allows moderators and participants to be located in different locations while the system is being tested. This process usually involves the use of conferencing software such as Zoom or Skype (Kalwani, 2020; Microsoft, 2020; Zoom, 2020), however while these allow computer screens to be shared to allow virtual observations of participant behaviour during the test, this functionality is not supported on mobile devices making them ineffective for testing applications; even if the smartphone screens could be shared, this form of usability testing can lead to difficulty when supporting participants that have encountered bugs (Logan, 2014).

9.2.2.2. Face to face user testing with housemates

Usability tests will instead be conducted using my two flatmates, due to our living situation we already have regular contact meaning that quarantine will not be broken to perform these tests. While it is recommended that five participants are used usability tests, with the highest cost benefit for using different numbers of heuristic evaluators situated at 4.4 users, the use of two testers results in between 25% and 80% of usability defects being identified (Nielsen & Landauer, 1993); this percentage is dependent on the properties of the application, the methods used and the skills of the heuristic evaluators.

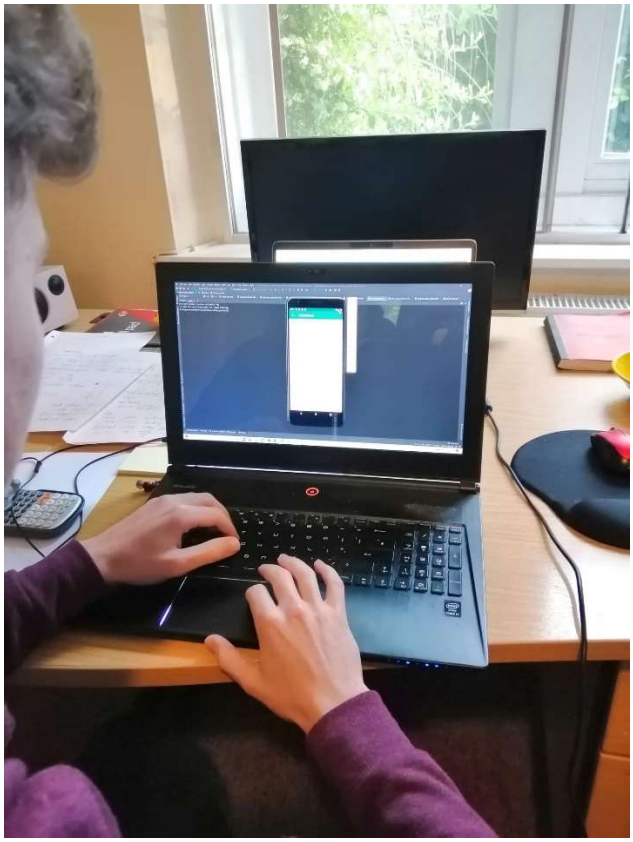

Figure 12 - Flatmate participating in usability test

9.3. Results

The results of usability testing were largely positive, participants completed all tasks within the cognitive walkthrough section (pass 1). The heuristic evaluation (pass 2) also provided useful insight, however the questions may need refinement should this methodology be implemented in the future as participants found some to be too vague; this problem was easily solved by adding extra prompts where necessary, for example during the question “can you identify areas of the application that you are familiar with, whether form the real world, or other applications?” participants needed clarification of what is meant by an area. Usability testing identified two problems within the system:

1. There was limited documentation surrounding the score
2. Selecting a scaled application or time period was too technical

9.3.1. Explanation of the score in the home page

This problem was identified during the second pass of one of the tests, the participant responded to the question “are there any areas of the application that need further documentation or help?” by explaining that although the overall concept of the score is clear, the system does not explain how the score is created, this information would help users to identify how to improve future scores.

9.3.2. Simplify settings

During the cognitive walkthrough section of both usability tests, participants had difficulty understanding the multiplier used for scaling applications or times of day. They explained that although the documentation is thorough, the overall feature is unnecessarily complex and does not show a clear distinction between the times of day and applications that result in smartphone usage that is negatively impacting the user's life, and the times of day and applications that user is not concerned about.

10. Application Summary

10.1. Home Page

The home page incorporates the score along with its visual representation.

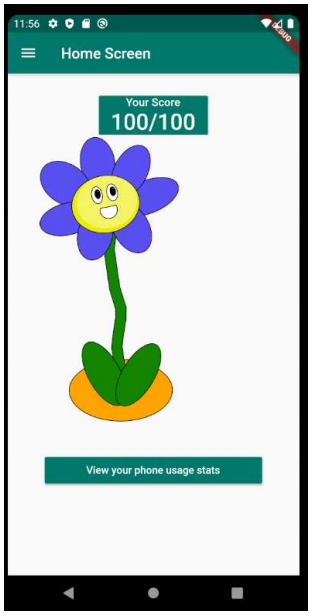

Figure 13 - Home page

Based on the results of the usability test which identified that there was no documentation surrounding the scoring system within the app, an additional popup was implemented to provide more information.

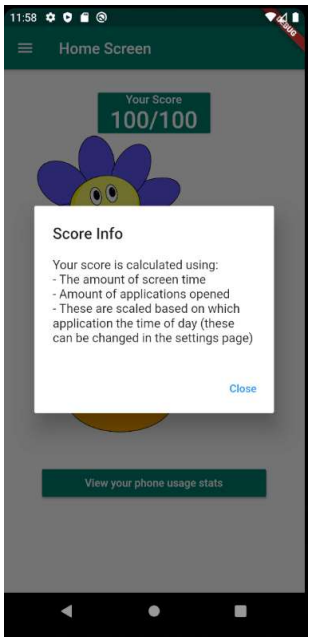

Figure 14 - Score description

10.2. Leaderboard page

The leaderboard page remained the same as the prototype within sprint 7.

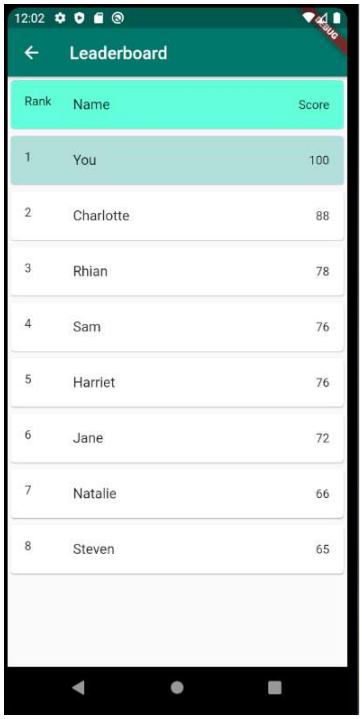

Figure 15 - Leaderboard Page

10.3. Settings Page

This page implements the scale time period and scale application functionality. Following the results of the usability testing which identified that the multiplies was unnecessarily complex [Link to section], the scaling features adopted the simple good and bad design proposed in sprint 4 [LINK TO SECTION

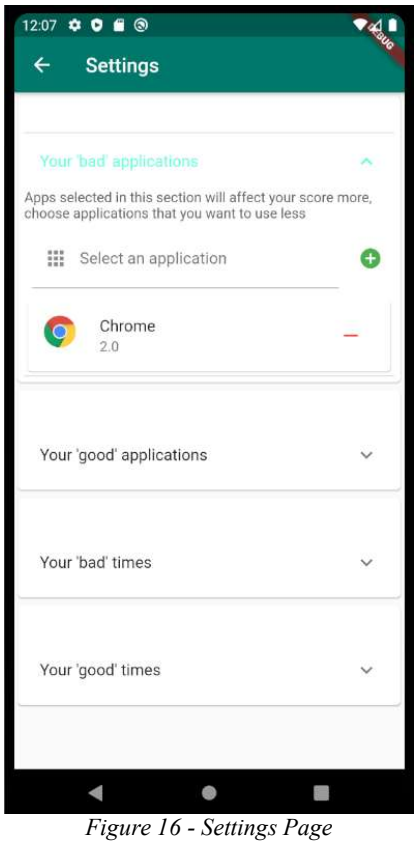

Figure 16 - Settings Page

10.4. Statistics page

This page remained unchanged following sprint 5.

Figure 17 - Statjstjcs Page

11. Experiment Design

11.1. Introduction

The purpose of the evaluation of this system is twofold. On the one hand, it aims to provide a comparison with other applications that aim to solve the issue of problematic smartphone usage through non-persuasive methods. On the other hand it aims to assess the impact of the persuasive techniques used on mobile phone usage.

Testing persuasive systems can be a notoriously difficult task, as an individual's intentions may not always align with their behaviours. There have been a variety of approaches taken to evaluate systems that aim to persuade user behaviour, some focus solely on the behaviour change prompted by a given system (Reinhardt & Hurtienne, 2019), whereas others implement questionnaires, interviews and domain specific tests aimed at monitoring the change in an individual's beliefs and intentions (Grimes, et al., 2010; Li & Chatterjee, 2010). Research testing the efficacy of implementations of the Transtheoretical Model in different domains often take a similar approach of using metrics and questionnaires to gauge the individuals stage of change within the model (Marcus, et al., 1992; Peterson & Aldana, 1999; Sarkin, et al., 2001), Park & Gweon show that a five-item questionnaire can be used to show an individual's position within the TMM when trying to reduce their smartphone usage (Park & Gweon, 2015).

11.2. Logging metrics

There are a variety of metrics that could be logged to identify problematic smartphone usage, the most obvious two are the *total time spent on the mobile device* and the *number of applications opened in a period of time*. Both of these are suggested to double when an individual is experiencing problematic smartphone usage (Tossel, et al., 2015). There may also be value in monitoring the *number of notifications* and the *frequency to which the subjects respond to these notifications* as individuals experiencing problematic social media usage were found to receive 27.4% more notifications and respond to these more regularly (Cheng, et al., 2019); this study also identifies that individuals experiencing problematic social media usage tend to use the platforms late at night, therefore *time of use* could provide useful insight into the effectiveness of smartphone reducing systems.

When measuring the smartphone usage Wilcockson, et al. suggest that a minimum of 5 days is required to fully understand a user's behaviour, and that measuring the frequency of phone usage may provide a better understanding of habitual behaviour (Wilcockson, et al., 2018).

Caution must be taken when requesting users to self-report their smartphone usage as they have a tendency to overestimate their statistics (Deng, et al., 2018), it is therefore important that these recordings are not directly compared to their actual usage times; however, they may still allow users to categorised into heavy and light users, also comparing self-reported usage times before and after the test may give an insight into the consciousness raising and self-monitoring capabilities of a system.

11.3. Attitudes and beliefs

Attitudes and beliefs play an important role in the changing of behaviours (Ford-Martin, 2020) with persuasive technology often focusing on changing attitudes alongside behaviours (Oinas-Kukkonen & Harjumaa, 2008). It is important that changes in these attitudes are measured alongside any variations in behaviour. It is recommended that three steps are taken when forming a new measure for attitudes (AECT, 2001):

1. Identify the construct being measured.
2. Find and evaluate existing measures of the construct.
3. Construct an attitude measure.

In the case of this study the constructs being measured are the user's attitudes regarding smartphone misuse, their attitudes towards their own smartphone usage and whether they aim to reduce their usage time.

The Smartphone Addiction Scale (SAS) has been shown to provide useful insight when identifying individuals prone to problematic smartphone usage (Kwon, et al., 2013). The shortened version of this scale SAS-SV is more applicable to this project as it does not require the participant to answer 33 questions, instead consisting of a 4-point Likert scale with 10 questions (Kwon, et al., 2013).

Self-efficacy is often linked with behaviour change (Holloway & Watson, 2002), even with some persuasive technology techniques aiming to increase in it (Toscos, et al., 2006); measuring levels of self-efficacy can provide an understanding of an individual's expectancies of performing, or in this case abstaining from performing, a given behaviour. The self-efficacy scale implemented by Sherer, et al. provides a general measurement of self-efficacy designed to be adapted to different domains (Sherer, et al., 1982); and has been shown to be an effective measure in areas such as reducing smoking when combined with the TMM (DiClemente, et al., 1985). Gökçearslan, et al. identifies an indirect link between general self-efficacy and smartphone addiction and proposes a set of questions to reproduce this phenomenon; the study also identified that an individual with high levels of self-regulation will be less likely to experience smartphone addiction and offers a questions to identify self-regulation levels (Gökçearslan, et al., 2016).

The quantity of statements used in questionnaires should be carefully considered as too many questions can lead to answers veering towards the middle ground (Johnston, 1997). Pre-test measurements must also approached with caution as they can potentially introduce contaminating effects (Li & Chatterjee, 2010), for instance there is the possibility that asking subjects about their smartphone usage before the experiment could introduce a level of unintended consciousness raising; this may have been shown by Cheng, et al found that subjects that viewed articles relating problematic social media usage were twice as likely to report having a problem regarding their social media usage (Cheng, et al., 2019).

As well as using these predefined scales, simply looking at *which system the user preferred* may be an indicator of which could be more successful in the long term. Not only do subjects have a higher chance of eliciting a positive response to systems they like (Cialdini, 2001), but they are also more inclined to continue to use a system that they enjoyed using.

11.1. Qualitative investigation

This evaluation may also be a good opportunity to gain insight into how subjects perceived the system proposed within this project and provide feedback on further work and possible implements. The user feedback thus far has been based upon short periods of use or user testing to evaluate the usability of the application, this has not provided an opportunity for users to fully experience how the persuasive techniques over sufficient lengths of time for them to impact behaviour.

11.2. Methodology

11.2.1. Pre-Test Measurement: Setting the Baseline

Prior to the test, the subject's average daily screen time and number of phone unlocks will be recorded through the use of App Usage (App Usage, 2020), this will provide a baseline of their usage statistics; they will be asked to delete this application after recording these statistics. Subjects will also be requested to complete a questionnaire (**APPENDIX P)** consisting of questions relating from the SAS-SV, self-efficacy scale and self-regulation scale (Jerusalem & Schwarzer, 2005; Kwon, et al., 2013; Gökçearslan, et al., 2016). Finally participants will be asked if they currently use any systems that aid in reducing their smartphone usage.

11.2.2. Study Conditions

Based on the information gathered within the pre-measurement the subjects will be split into two groups, these will be selected such that the individuals with problematic smartphone usage are equally distributed groups. One group will use the system proposed in this project, the other will use Stay Focused (Stay Focused, 2020).

11.2.3. Usage of the systems

The subjects in each group will be asked to install one of the two applications, there will be no requirements on how they should be set up; this will both simulate usage in the real world, and also compound the effect of any tailoring employed by the applications as they will be customized to the subjects individual needs. The subjects will use their designated application for 5 consecutive days, again there will be new requirements on how they should use them.

11.2.4. Post-task measurements

Following their use of the applications the subjects will be asked to reinstall App Usage (App Usage, 2020) which allows the recoding screen time and phone unlock for each day of the test. The participant will then be asked to complete the same questionnaire used in the pre-measurements, two additional questions will be used to assess which application participants preferred using.

Finally a semi-structured interview will be conducted on the group the applications proposed in this project to identify possible features that they believe would be beneficial to implement in the future.

11.3. Effects of COVID-19

Due COVID-19 the methodology of this experiment proposed above varies from the idea implementation.

Firstly the subjects used within the experiment will be friends and family members as there will be limited access to new participants; this raises the issue of bias towards the system proposed as part of this project, to reduce the impact of this neither group will have knowledge of whether they are using the application proposed as part of this project or the external application it is being compared against. The original method aimed was to use flyers on the University of Bath campus, this would gain unbiased participants that are within the age range mentioned in the constraints of this study. Using flyers may have also yielded more participants thus a higher proportion of users with problematic smartphone usage.

A larger issue introduced by COVID-19 is the lack of contact available with participants. The original method involved requesting access to the individuals phone during the pre-measurement phase to install App Usage and record their average usage data, as users will now be required to complete this process it introduces the possibility of consciousness raising that is not a result of the application being tested.

11.4. Expectations for Results

- The application proposed as part of this system will have a greater impact on beliefs as Stay Focused aims to restricting behaviour rather than change attitudes surrounding a topic.
- Stay Focused to be more effective at the start of the test, and it reducing in effectiveness over time as find its functionality irritating.
- Higher self-efficacy leading to higher behaviour change.

12. Results

12.1.1. Introduction

This section will focus on analysing the results collected through the evaluation of the proposed system. As alluded to in the evaluation methodology COVID-19 restricted the recruitment of participants, the research group consisted of 6 participants aged between 20 and 25 (μ=22, σ=1.53), with 4:2 gender split between male:female. All participants within this study were either friends or family, however the measures for mitigating any biases caused as a result of this identified in the evaluation methodology were implemented during this study.

As this project does not aim to follow a full experimental design, along with the issues raised as a result of the small and possibly biased population sample, caution should be taken when making conclusions based on the following results, they may, however, indicate towards possible trends in smartphone usage that can support existing studies or guide further research.

This experiment aimed to compare and evaluate the efficacy of two applications that target problematic smartphone usage that use contrasting approaches for changing user behaviour; the application proposed within this project aims to use persuasive techniques to encourage users to reduce their smartphone usage, whereas Stay Focused (Stay Focused, 2020) limits usage time by restricting functionality, for example blocking problematic applications.

12.2. Pre-test recordings

12.2.1. Overview of pre-test recordings

The pre-test aimed to identify a baseline for each participant's smartphone usage statistics by recording their average daily usage time and average number of application opens, along their beliefs and attitudes around this topic through the use of smartphone addiction scale, self-efficacy and self-regulation scales (**APPENDIX Q, APPENDIX R**).

The average usage times of the sample ranged between 172 minutes and 342 minutes per day (μ=246 minutes, σ=51.93 minutes), and the average number of applications opened per day ranged between 24 and 81 (μ=50, σ=19).

The questionnaire used a 5-point Likert scale for SAS-SV, self-efficacy and self-regulation. For the SAS-SV users reported average scores ranging between 1.78 and 4.11 (μ=3.02, σ=0.76), the self-efficacy scale recorded average scores between 2.5 and 4.6 (μ=3.46, σ=0.70), and the self-regulation scale recorded average scores between 1.8 and 4.4 (μ=3.1, σ=0.77) [**APPENDIX S**].

12.2.2. Comparison of pre-test results

The pre-test results indicated towards a negative correlation between smartphone usage statistics and self-regulation (**FIGURE 18 and 19**), this supports Gökçearslan, et al's findings that individuals with higher self-regulation skills show lower addictive smartphone behaviours (Gökçearslan, et al., 2016). This hypothesis is further supported by the negative correlation between self-regulation and the SAS-SV (**FIGURE 20**).

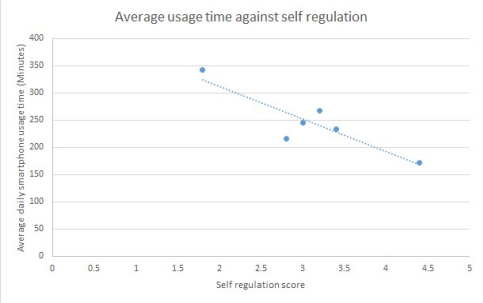

Figure 18 - Average usage time against self-regulation

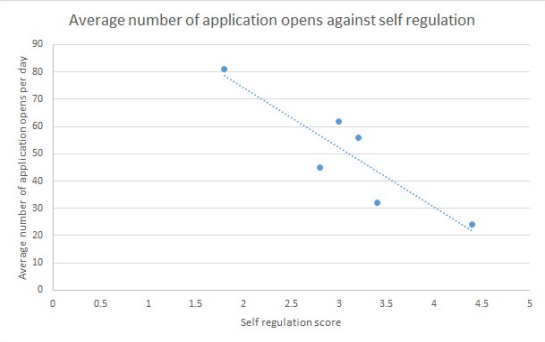

Figure 19 - Average number of application opens against self-regulation

Figure 20 - SAS-SV against self-regulation

There appeared to be no discernible relationship between self-efficacy and any of the other results gathered during the pre-test, this may indicate self-efficacy having little to no effect on problematic smartphone usage.

Finally the positive correlation between the participant's average smartphone usage statistics and their average SAS-SV scores (**FIGURE 21 AND 22**) may indicate the effectiveness of the SAS-SV as a predictor of smartphone addiction.

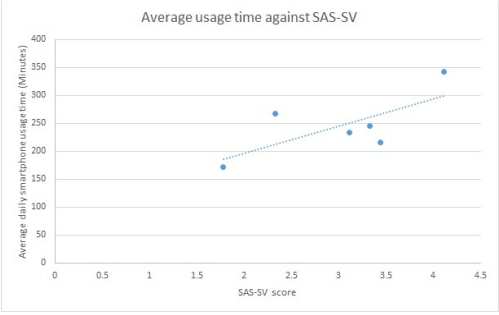

Figure 21 - Average usage time against SAS-SV

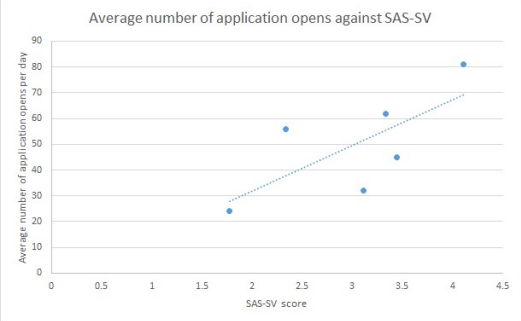

Figure 22 - Average number of application opens against SAS-SV

12.2.3. Discussion about pre-test findings

While these results indicate a relationship between smartphone usage, self-regulation, and the SAS-SV as a method of identifying problematic smartphone usage, there is still some variation within these result possibly highlighting that there are a wide range of factors that contribute to problematic smartphone usage; studies have associated problematic smartphone usage with depression, anxiety and stress (Elhai, et al., 2017).

12.3. Comparing the two applications

12.3.1. Overview of the groups

Participants were randomly assigned into two groups:

Group 1 - This group will use the stay focused app

Group 2 - This group will use the application proposed in this project

The average pre-test data for both of these groups were similar, except for the SAS-SV mean which was higher in the group 2, however group 1 had a significantly higher standard deviation across all recorded data (**APPENDIX T)**.

12.3.2. Usage statistics differences

Comparing the difference between the average total screen time recorded in the pre-test and the average total screen time of the 5 days that participants were using the smartphone reducing applications may indicate if the solutions were effective at reducing smartphone usage. Stay Focused appeared to be more successful at reducing screen time with all participants experiencing a reduction in average daily screen time (**FIGURE 23**), this may indicate towards the expectations that Stay Focused would be a more effective application at reducing smartphone usage in the short term. This comparison may also indicate that the application used by group 2 was ineffective at reducing smartphone usage as one user significantly increased their screen time by 44.4 minutes per day while using the app; however, this participant's results may have been skewed by a single day in which they recorded over double their average usage time (APPENDIX U), this was later found during post-test interview to be a result of a long session of watching Netflix, omitting this day results in an average daily screen time of 195 minutes for this participant during the 5 days, a decrease of 21 minutes compared to their average screen time prior to using the application.

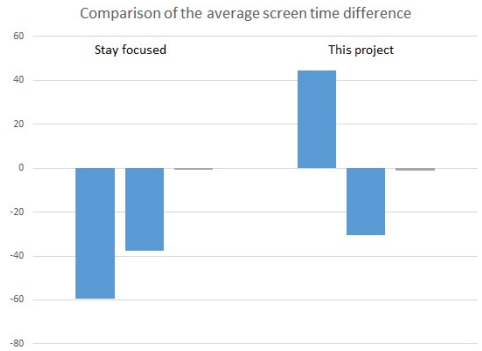

Figure 23 - Comparison of the reduction in average screen time

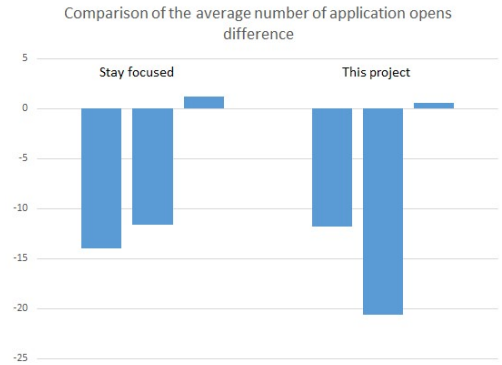

Figure 24 - Comparison of the reduction in average number of application opens

A similar comparison of the total number of application opens yielded homogeneous results, with both applications reducing the number of application opens per day significantly for ⅔ of the participants.

Both groups contained an individual that did not respond to the application, showing little to no change in their smartphone usage behaviour, the possible reasons for these users not showing signs of behaviour change was addressed during the interview stage.

12.3.3. Daily statistics

Analysing the daily scores over the course of the 5 days may indicate which application will have the greatest long term success, we would expect these long term applications to either maintain a constant level of lower smartphone usage or to continue to reduce smartphone usage over time, in contrast short term solutions may begin to lose effectiveness possibly resulting in users returning to their previous behaviours. It is worth noting that this may not provide an accurate forecast for long term behaviour change as it would be naive to estimate that the process of changing habits, which has been shown to take on average 66 days to change (Lally, et al., 2009), could be estimated within 5 days, however this is more likely to show if users will persist with using the application over an extended period of time.

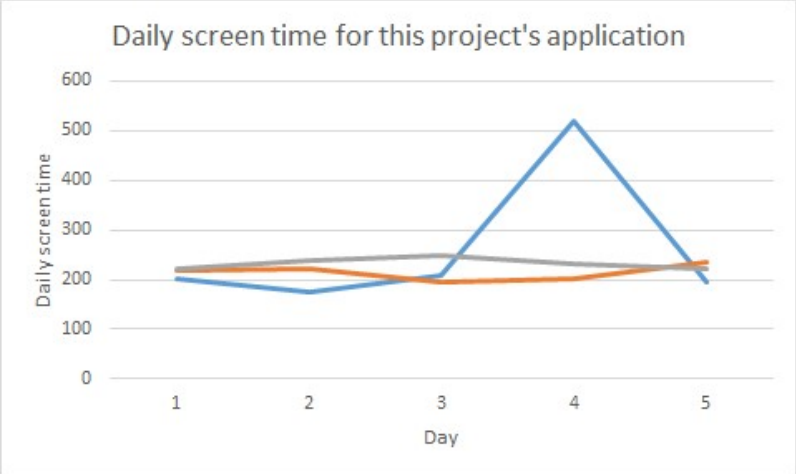

Figure 25 - Daily screen time for this project's application over the 5 days

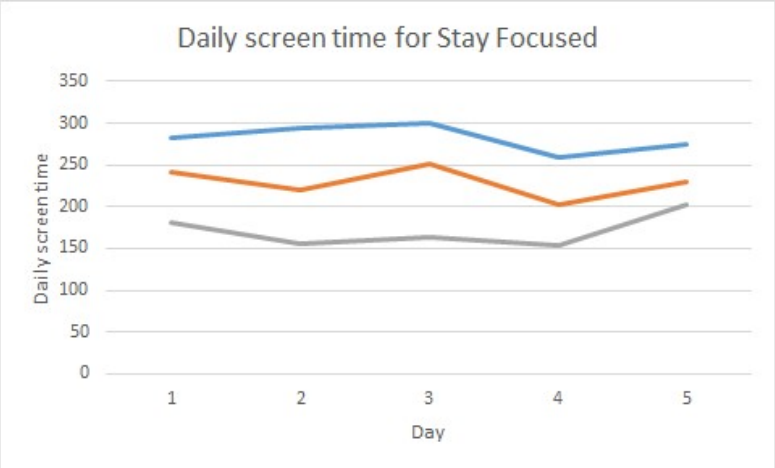

Figure 26 - Daily screen time for Stay Focused over the 5 days

Omitting the previously mentioned day in which in which a participant recorded a significant increase in mobile phone usage, the participants in group 2 maintained constant levels of smartphone usage (**FIGURE 25)** indicating that the application created as part of this project may be effective in the long term problematic smartphone usage. Participants using the Stay Focused application performed consistently (**FIGURE 26**); the slight upturn in usage times for all participants on the last day may raise concern, especially when coupled with results of interview in which users stated that they would prefer to use the app when attempting to reduce usage for short periods of tim2, however it is likely that this slight increase in usage is a coincidence caused by the low sample size.

12.3.4. Post-test Questionnaire

The expectation that higher self-efficacy would result in an increased behaviour change was incorrect, in fact self-efficacy showed little to no relationship with problematic smartphone usage or behaviour change throughout the experiment; the use of a pilot study may have been helpful to identify this prior to the experiment allowing it to be eliminated from the questionnaire, this could create room for another value to be analysed or would result in a shorter questionnaire that could elicit more accurate responses.

As expected, the group using the application proposed as part of this project showed a vast improvement in their self-regulation scores (**FIGURE 28**). The change in self-regulation varied dramatically between participants in the Stay Focused group (**FIGURE 27**), it is unclear whether this is a result of using the applications, or whether other factors may have impacted these results.

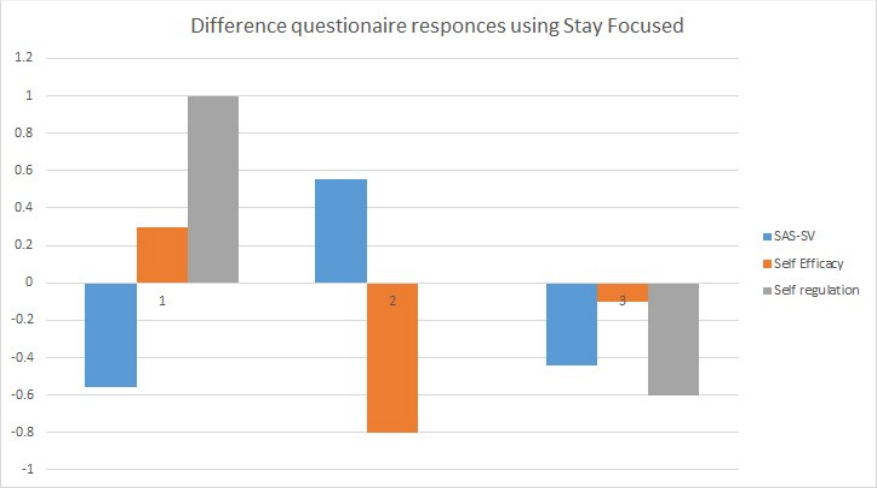

Figure 27 - Difference in questionnaire responses between pre and post test for stay focused

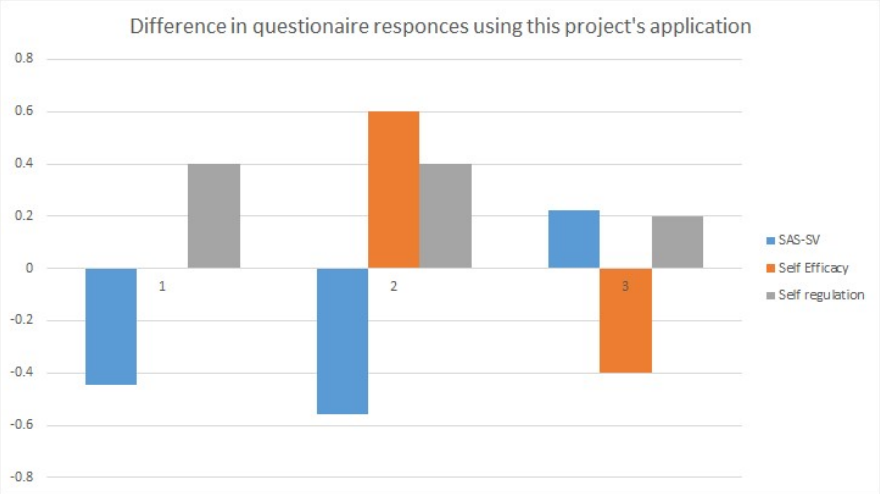

Figure 28 - Difference in questionnaire responses between pre and post test for this project's application

Both applications indicated a reduction in smartphone addiction in 2 out of 3 participants by reducing their SAS-SV scores, while it was unclear what influenced the increase in the participant of group 2, results of an interview with the Stay Focused indicated that the increase in their SAS-SV score could be as a result of consciousness raising, seeing his phone usage statistics help him realise that he is using his smartphone more than he would like.

12.4. Results from interviews

The interviews helped to identify the cause of an anomalous result within the daily usage times of one of the group 1 participants. On day 4 of the experiment their usage time peaked to 521 minutes, when this was raised during the interview the participant explained they had fallen asleep while watching Netflix leading to a single usage session over 7 hours long.

Within both groups there were users that were unresponsive to their respective applications, for group 1 it was not a problem with the application itself, instead the participant's smartphone usage was already too low for the system to have any impact. However in group 2, the participant identified that they forgot to check the application regularly which minimized its overall effectiveness; they identified that the use of notifications may help to remind users to stop using their device.

These interviews also aided in further understanding the usage behaviours of participants. When asked "are there any factors that increased your usage during the 5 days?" all participants identified work or

the act of procrastinating from doing work. One concern was raised around the impact of coronavirus on smartphone usage, identifying that simply being at home when trying to work lead them to reach for their device more often, they mentioned that this was likely because they did not have work colleagues watching them; Fogg identifies the principle of surveillance as a possible persuasive technique in which others observe your behaviour (Fogg, 2003, p. 46), a principle that could be implemented into future applications to reduce smartphone usage.

When asked if they enjoyed using the applications, both groups responded positively. However, 2 of the 3 participants in group 1 responded no when asked if they would continue using it in the future; the consensus in group 1 was that the application would be helpful for short periods of time, for example when trying to revise, however it could become tedious with extended use.

Participants in group 2 identified that there were flaws in the system, for example it is easy to forget about, however they were open to using it in the future.
When asked to choose the most helpful feature participants using Stay focused identified that being able to limit the use of some applications is useful when you are trying to work as you can remove access to the ones that cause distraction. Two participants using the application created in this project chose the score as the most helpful feature, stating that it allowed them to quickly check if they are overusing their phone. The third participant identified the statistics page, specifically application breakdown as the most helpful feature.

When participants in group 2 were asked to identify possible new features for the application, the main response were solutions to notify users of their smartphone usage; notifications were a common example, however one participant identified that the score could be presented on the user's lock screen or home screen as a widget.

12.5. Summary

This study aimed to evaluate the effectiveness of two different solutions to reducing smartphone usage. It identified that in the while short term both systems have merit, their practical applications vary with Stay Focused an effective solution at increasing short term productivity, and the system created in this project aiming to reduce overall smartphone usage by changing behaviour. This difference in methodology between the two systems could indicate the possibility that they can work effectively in conjunction with one and other.

12.6. Limitations

The Hawthorne effect may have impacted the participants actions, under observation individuals have been shown to modify behaviours (McCambridge, et al., 2014), as participants of this study may have modified their smartphone behaviours as they were aware that their usage statistics were being recorded; this may have acted in a similar way to the persuasive technique of supervision.

COVID-19 introduced a variety of problems into the design of this experiment. It made the task of finding participants difficult resulting in a small sample population which limits the validity of inferences made within the study and leads to anomalous results heavily influencing the outcome of the study. The social-distancing guidelines also introduced the possibility of a priming effect as users are requested to record their own smartphone usage before taking part in the study; preferably this process would have been performed by an examiner with the consent of the participant. The isolation caused by social distancing may have impacted the smartphone usage recorded over the 5 day within the study; the average statistic recorded within the pre-test will be largely influenced by pre-isolation behaviours, however there has been fluctuations in smartphone usage, likely as a result of the social-distancing guidelines (Koeze & Popper, 2020).

Finally, 5 days may not have been enough time to allow changes in behaviours to fully manifest, while the results do indicate that the systems are effective at reducing smartphone

usage for the 5 day period, further research should be performed to identify if these systems are capable of fully changing smartphone usage behaviour.

12.7. Extensions

The results of this study identified a range of possible extensions to the application proposed as part of this project, both through analysing the result to determine effective features and from gathering feedback from participants.

12.7.1. Improving the Visibility of the Application

User identified that it is easy to forget about this application, in its current state it requires uses to actively check the application periodically. This issue could be elevated through the use of notifications to warn users that they are spending too much time on their device. During the design phase stakeholders were opposed to such a feature as they believe that it could become irritating, and if this were to be implemented caution would have to be taken to avoid this as smartphone users have been shown to respond negatively if notifications are used inappropriately (Kakehi, 2019). Following Fogg's guidelines for suggestion (Fogg, 2003, pp. 41-43) may aid in the development of this feature as it identifies that timing is important when sending these messages, here are three possible implementations notifications:

- If a user has been using one of their 'bad' applications for a long period of time send "Hey, you've been on Instagram for 20 minutes, why not give it a break"
- If a user is using their phone a 'bad' time period send "It's getting late, why don't you go to bed?"
- If a user's score reaches drops below a certain threshold send "Your plant is dying, why not give your phone a rest"

Participants suggested displaying the user's score on their lock screen as an alternative solution to the problem of visibility, however users may stop noticing this over time due to the habitual nature of smartphone usage.

12.7.2. Tailoring Towards the User

Systems are more persuasive when they are tailored towards an individual (Fogg, 2003, p. 38), including messages tailored towards the users interests, such as "in the time you have been on your phone today, you could have read a chapter of Harry Potter", may help users conceptualise their smartphone usage into a format that they can easily understand.

12.7.3. Refining the Application

Cialdini identifies liking as a persuasive tool that helps to influence behaviour (Cialdini, 2001), refining aspect of the application could therefore lead to a more persuasive experience. This could include speeding up loading times for some pages or implementing micro animations (Mooij-Geble, 2018).

13. Conclusion

This project aimed to propose a system that reduces smartphone usage using the principles of persuasive technology, the final application used a combination of reinforcement, self-monitoring and competition. The effectiveness of the system was compared against an alternate solution for reducing smartphone usage, this not only indicated that both systems are effective at reducing smartphone usage, it also highlighted some trends identified in other studies such as the role of regulation in problematic smartphone use. COVID-19 played a prominent role towards the end of this project, hindering both usability testing and the overall evaluation process. Overall this study suggests the principles of persuasive technology can be applied to reducing problematic smartphone usage, however further research should be performed to fully identify the persuasive techniques that are most effective at reducing problematic smartphone usage.

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Appendix

15. Appendix A

Feature: Abstract statistic - Score
The abstract statistic (later renamed to score) allows users to easily identify if they have be overusing their smartphone by providing an abstracted representation of their usage statistics

Scenario: The score considers the total number of applications opened within its calculation
When my total number of applications opened statistic increases
Then my score should be negatively impacted

Scenario: The score considers the total screen time within its calculation
When my total screen time statistic increases
Then my score should be negatively impacted

Scenario: The score represents the user's high usage statistics
Given I have high smartphone usage statistics
Then my score should indicate that I am overusing my smartphone

Scenario: The score represents the users low usage statistics
Given I have low smartphone usage statistics
Then my score should indicate that I have low smartphone usage

Scenario: The score represents the users moderate usage statistics
Given I have moderate smartphone usage statistics
Then my score should indicate that I have moderate smartphone usage

16. Appendix B

Feature: Scaling statistics by time of day
Allows users to set times of day where the recorded statistics and score are scaled up or down

Scenario: The user can set a time of day that scales up the recorded statistics and score
When I set a scaled time period that scales up recorded statistics
Then the statistics recorded in the set scaled time period are scaled up

Scenario: The user can set a time of day that scales down the recorded statistics and score
When I set a scaled time period that scales down recorded statistics
Then the statistics recorded in the set scaled time period are scaled down

Scenario: The user can remove a time of day that scales up the recorded

```
statistics and score
Given I set a time period to scale up statistics
When I remove the scaled time period
Then the statistics recorded in the set scaled time period are not
scaled up

Scenario: The user can remove a time of day that scales down the
recorded statistics and score
Given I set a time period to scale down statistics
When I remove the scaled time period
Then the statistics recorded in the set scaled time period are not
scaled down

Scenario: The users screen time is scaled up when the phone is used
during a scaled up time
Given I set a time period to scale up statistics
When I use my phone during the scaled time period
Then My recorded screen time is scaled up

Scenario: The users screen time is scaled down when the phone is used
during a scaled down time
Given I set a time period to scale down statistics
When I use my phone during the scaled time period
Then My recorded screen time during the time is scaled down

Scenario: The users number of applications opened are scaled up when the
phone is used during a scaled up time
Given I set a time period to scale up statistics
When I open applications during the scaled time period
Then My recorded number of applications opened during the time period is
scaled up

Scenario: The users number of applications opened are scaled down when
the phone is used during a scaled down time
Given I set a time period to scale down statistics
When I open applications during the scaled time period
Then My recorded number of applications opened during the time period is
scaled down

Scenario: The decrease in the users score is scaled up when the phone is
used during a scaled up time
Given I set a time period to scale up statistics
When I use my phone and open applications during the scaled time period
Then The decrease in my score is scaled up

Scenario: The decrease in the users score is scaled down when the phone
is used during a scaled down time
Given I set a time period to scale down statistics
When I use my phone and open applications during the scaled time period
Then The decrease in my score is scaled down
```

```
Feature: Scaling statistics by application
Allows users to set applications where the recorded statistics and score
are scaled up or down

Scenario: The user can set an application that scales up the recorded
statistics and score
When I set an application that scales up recorded statistics
Then the statistics recorded when using the scaled application are
scaled up

Scenario: The user can set an application that scales down the recorded
statistics and score
When I set an application that scales down recorded statistics
Then the statistics recorded when using the scaled application are
scaled down

Scenario: The user can remove a scaled application that scales up the
recorded statistics and score
Given I set an application that scale up statistics
When I remove the scaled application
Then the statistics recorded when using the scaled application are not
scaled up

Scenario: The user can remove a scaled application that scales down the
recorded statistics and score
Given I set an application that scale down statistics
When I remove the scaled application
Then the statistics recorded when using the scaled application are not
scaled down

Scenario: The users screen time is scaled up when using an application
that is scaled up
Given I set an application to scale up statistics
When I use the scaled application
Then My recorded screen time is scaled up

Scenario: The users screen time is scaled down when using an application
that is scaled down
Given I set an application to scale down statistics
When I use the scaled application
Then My recorded screen time is scaled down

Scenario: The users recorded number of application opens is scaled up
when opening an application that is scaled up
Given I set an application to scale up statistics
When I open the scaled application
Then My recorded number of application opens is scaled up

Scenario: The users recorded number of application opens is scaled down
when opening an application that is scaled down
Given I set an application to scale down statistics
When I open the scaled application
Then My recorded number of application opens is scaled down
```

```
Scenario: The decrease in the users score is scaled up when using a
scale up application
Given I set an application to scale up statistics
When I open and use the scaled application
Then The decrease in my score is scaled up

Scenario: The decrease in the users score is scaled down when using a
scale down application
Given I set an application to scale up statistics
When I open and use the scaled application
Then The decrease in my score is scaled down
```

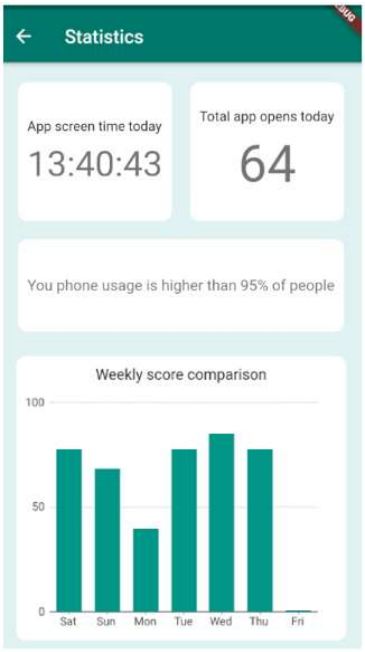
16.1. Appendix C

```
Feature: Self-monitoring
Allows the user to monitor their phone usage statistics

Background:
Given I navigate to the statistics section

Scenario: The user has access to enough information to self-monitor
their phone usage
The statistics section provides enough information about the user's
phone usage to allow them to self-monitor and aid in consciousness
raising
Then I am presented with sufficient phone usage statistics

Scenario: The user can view their daily total phone usage time
The statistics section shows the user the total time that their screen
has been turned in that day
Then I am presented with my daily phone usage time

Scenario: The user can view their daily application opens
The statistics section shows the user the number of applications they
have opened in that day
Then I am presented with my daily application opens

Scenario: The user can view their weekly score comparison
The statistics section compares the user's phone usage score for the
past week
Then I am presented with my weekly score comparison

Scenario: The user is shown a heuristic to based on their usage
statistics
The statistic section provides a heuristic based on the user's statistic
to further persuade them to reduce their smartphone usage
Then I am presented with a heuristic based on my usage statistics

Scenario: The user can view their daily application usage breakdown
The statistics section compares the amount that the user uses each
application in that day
Then I am presented with my daily application breakdown
```

16.2. Appendix D

No	Question	Answer
1	Would you describe the presented smartphone usage as high, medium or low?	
2	What is the most problematic area of the presented smartphone usage?	
3	Does the presented data show areas of your smartphone usage that can be improved?	

16.3. Appendix E

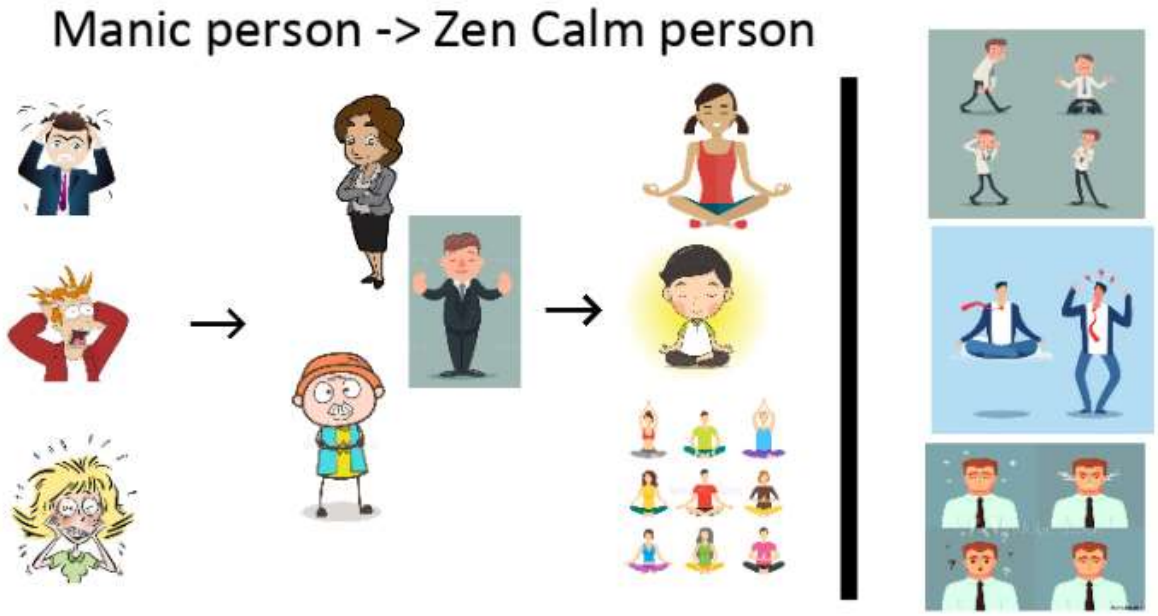


16.4. Appendix F

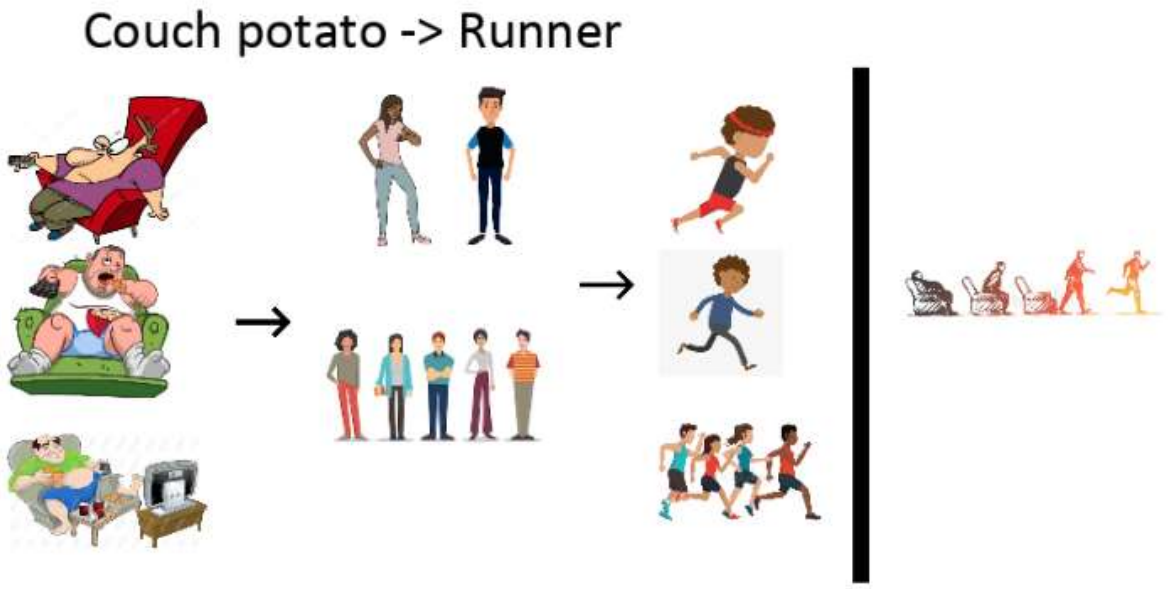
16.5. Appendix G

```
Feature: Reinforcement
This promotes a behaviour through positive or negative reinforcement,
users are rewarded for positive actions, and punished for negative
actions

Scenario: The user is rewarded for positive behaviours
When my smartphone usage is low
Then the application rewards my positive behaviour

Scenario: The user is punished for negative behaviours
Given I my smartphone usage is too high
Then the application punishes my negative behaviour
```

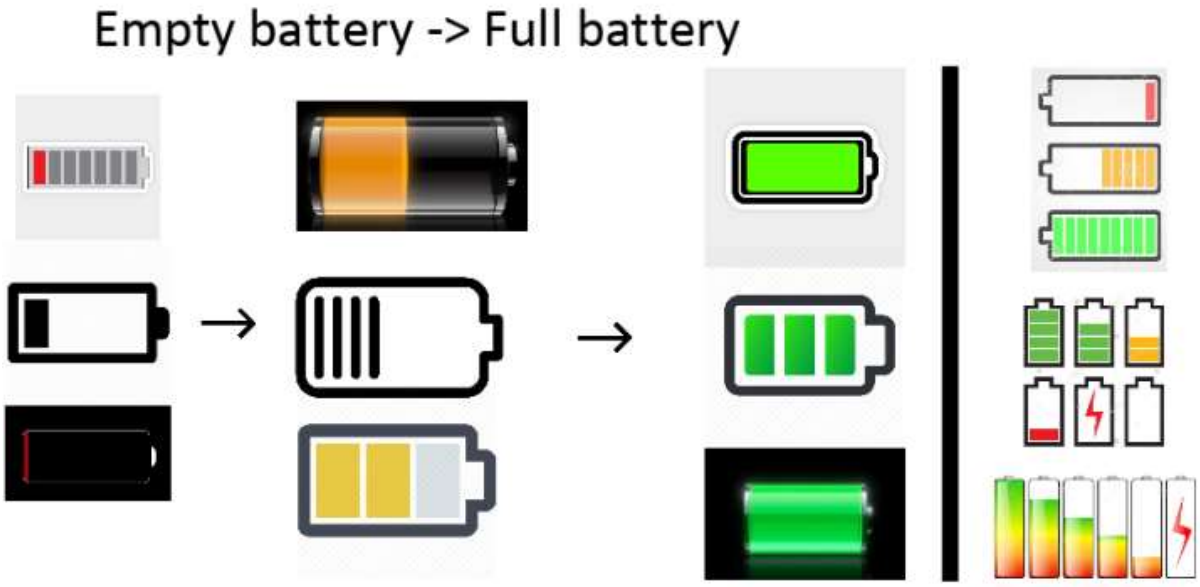
16.6. Appendix H



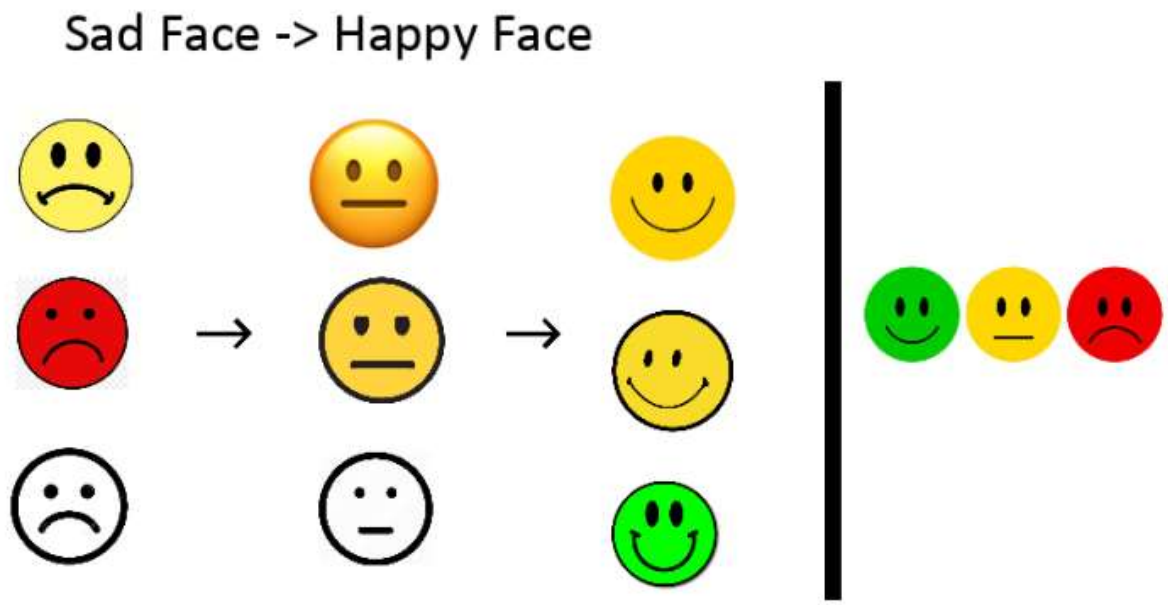
16.7. Appendix I



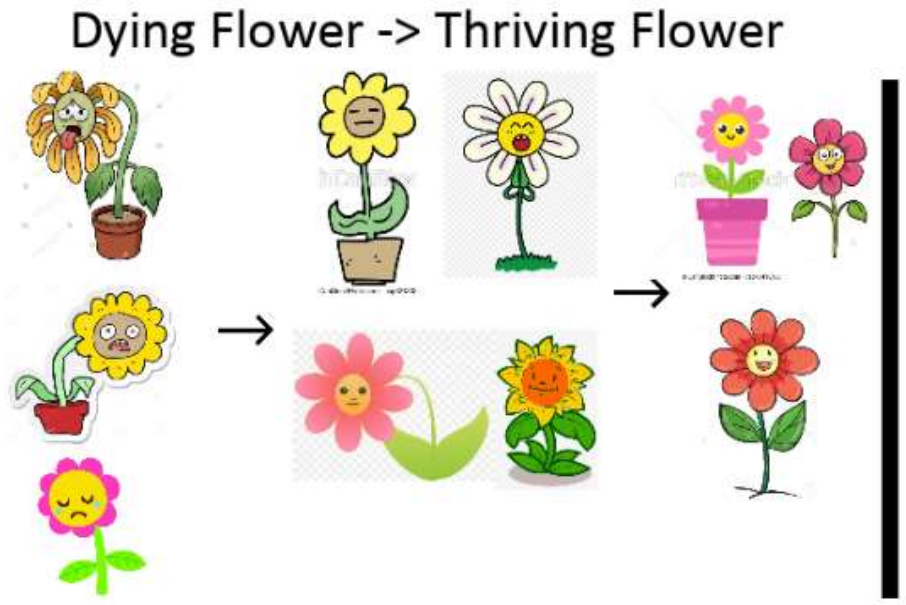
16.8. Appendix J



16.9. Appendix K



16.10. Appendix L



16.11. Appendix M

	Participant	Emotional response	Simplicity	Representation of score	Total
Animal	1	1	4	4	41
	2	1	5	5	
	3	2	5	4	

	4	1	4	5	
Athlete	1	4	5	6	58
	2	5	4	6	
	3	4	4	5	
	4	3	6	6	
Battery	1	6	2	1	38
	2	6	2	1	
	3	6	3	1	
	4	6	2	2	
Flower	1	2	3	2	26
	2	2	3	3	
	3	1	2	2	
	4	2	3	1	
Meditating person	1	3	6	5	57
	2	3	6	4	
	3	5	6	6	
	4	4	5	4	
Smiley face	1	5	1	3	32
	2	4	1	2	
	3	3	1	3	
	4	5	1	3	

16.12. Appendix N

```
Feature: Competition
This allows the user to compete and compare performance again other
users

Scenario: The user is able to compare their performance against the
performance of other users
When I navigate to the competition section
Then my performance is compared with the performance of other users
```

16.13. Appendix O

17. Heuristic walkthrough

17.1. Overview of application

This application aims to use persuasive techniques to help users build a healthier relationship with their smartphone. It does not aim to block or restrict functionality of the mobile device, only encourage the user to alter their usage behaviours.

17.2. Typical user

This application is aimed to be accessible to all smartphone users, however the study conducted as part of this project will be targeting university students aged between 20 and 25.

17.3. Typical tasks

- Viewing their phone usage score
- Viewing the reinforcement visualisation
- Viewing their usage statistics
- Comparing their phone usage score against other users
- Setting a time period that scales their phone usage statistics
- Setting an application that scales their phone usage statistics

17.4. Pass 1 - Tasks

17.4.1. Can you identify where the phone usage score is located

Priority	Pathway	Did user complete action	Observations
1	Navigation drawer -> Home page -> Located at the top of the page	1 - User completed the action using optimum pathway 2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.4.2. Can you identify where the visualisation of your score is located

Priority	Pathway	Did user complete action	Observations

1	Navigation drawer -> Home page -> Located in the center of the page	1 - User completed the action using optimum pathway 2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.4.3. Can you locate the breakdown of your phone usage statistics

Priority	Pathway	Did user complete action	Observations
2	Navigation drawer -> Statistics page	1 - User completed the action using optimum pathway 2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.4.4. Can you compare your phone usage score to other users

Priority	Pathway	Did user complete action	Observations
2	Navigation drawer -> Leaderboard	1 - User completed the action using optimum pathway 2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.4.5. Can add a new time period that scales your usage statistics

Priority	Pathway	Did user complete action	Observations
3	Navigation drawer -> Settings page -> Complete scale time period form -> click okay	1 - User completed the action using optimum pathway	

		2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.4.6. Can add a new application that scales your usage statistics

Priority	Pathway	Did user complete action	Observations
3	Navigation drawer -> Settings page -> Complete scale application form -> click okay	1 - User completed the action using optimum pathway 2 - User completed the action using an alternate pathway 3 - User did not complete the action	

17.5. Pass 2 - Questions:

Heuristics	Questions	Responses
Visibility of system status	Are your usage statistics and score easily accessible? Is it easy to get lost using the application?	
Match between system and the real world	Can you identify areas of the application that you are familiar with, whether from the real world, or other applications?	
User control and freedom	Do you feel restricted into using the application in a specific way, or are you given the option to perform tasks freely?	
Consistency and standards	Is navigation consistent throughout the application? Are features consistently displayed throughout the application?	
Error prevention	Is it easy to make mistakes when using this application?	
Recognition rather than recall	Are you having to memorise how to perform tasks?	

Flexibility and efficiency of use	How easy is it to perform your desired task?	
Aesthetic and minimalist design	Is the design of the application aesthetic? Is the user interface bloated with unnecessary information or objects?	
Help and documentation	Are there any areas of the application that need further documentation or help?	

17.6. Appendix P

No	Question	What is it testing	Strongly disagree	Disagree	Weekly agree	Agree	Strongly agree
1	I miss planned work due to smartphone use	SAS-SV					
2	I have a hard time concentrating due to smartphone use	SAS-SV • Self regulation (reversed)					
3	I feel pain in my wrists or at the back of my neck while using a smartphone	SAS-SV					
4	I can not stand not having my smartphone with me me	SAS-SV					
5	I think about my smartphone when I am not using it	SAS-SV					
6	I will never give up using my smartphone even when my daily life is already greatly affected by it	SAS-SV					
7	I am constantly checking my phone so as to not miss conversations	SAS-SV					

8	I use my phone longer than i had intended	SAS-SV					
9	People around me say that I use my phone too much	SAS-SV					
10	I can always manage to solve difficult problems if I try hard enough	Self-efficacy					
11	If someone opposes me, I can find the means and ways to get what I want	Self-efficacy					
12	It is easy for me to stick to my aims and accomplish my goals	Self-efficacy					
13	I am confident that I could deal efficiently with unexpected events	Self-efficacy					
14	Thanks to my resourcefulness, I know how to handle unforeseen situations	Self-efficacy					
15	I can solve most problems if I invest the necessary effort	Self-efficacy					
16	I can remain calm when facing difficulties because I can rely on my coping abilities	Self-efficacy					
17	When I am confronted with a problem, I can usually find several solutions	Self-efficacy					
18	If I am in trouble, I can usually think of a solution	Self-efficacy					
19	I can usually handle whatever comes my way	Self-efficacy					

20	If I am distracted from an activity. I don't have any problem coming back to the topic quickly	Self-regulation					
21	If an activity arouses my feelings too much. I can calm myself down so that I can continue with the activity soon	Self-regulation					
22	If an activity requires a problem-oriented attitude. I can control my feelings	Self-regulation					
23	I stay focused on my goal and don't allow anything to distract me from my plan of action	Self-regulation					

Appendix Q

No	Question	What is it testing	1	2	3	4	5	6
1	I miss planned work due to smartphone use	SAS-SV	4	2	1	3	2	4
2	I have a hard time concentrating due to smartphone use	SAS-SV Self regulation (reversed)	5	3	2	4	4	4
3	I feel pain in my wrists or at the back of my neck while using a smartphone	SAS-SV	3	1	1	2	2	1
4	I can not stand not having my smartphone with me me	SAS-SV	4	3	1	5	4	3

5	I think about my smartphone when I am not using it	SAS-SV	4	2	2	3	4	4
6	I will never give up using my smartphone even when my daily life is already greatly affected by it	SAS-SV	4	3	2	3	3	2
7	I am constantly checking my phone so as to not miss conversations	SAS-SV	5	4	4	5	4	4
8	I use my phone longer than i had intended	SAS-SV	5	2	2	4	5	5
9	People around me say that I use my phone too much	SAS-SV	3	1	1	2	2	1
10	I can always manage to solve difficult problems if I try hard enough	Self-efficacy	3	5	3	3	2	5
11	If someone opposes me, I can find the means and ways to get what I want	Self-efficacy	3	4	3	3	2	4
12	It is easy for me to stick to my aims and accomplish my goals	Self-efficacy	2	5	3	4	3	4

13	I am confident that I could deal efficiently with unexpected events	Self-efficacy	3	4	3	3	2	4
14	Thanks to my resourcefulness, I know how to handle unforeseen situations	Self-efficacy	3	5	4	4	3	4
15	I can solve most problems if I invest the necessary effort	Self-efficacy	4	5	5	4	4	5
16	I can remain calm when facing difficulties because I can rely on my coping abilities	Self-efficacy	2	4	3	2	2	3
17	When I am confronted with a problem, I can usually find several solutions	Self-efficacy	2	4	3	4	1	3
18	If I am in trouble, I can usually think of a solution	Self-efficacy	3	5	3	4	3	4
19	I can usually handle whatever comes my way	Self-efficacy	3	5	4	4	3	4
20	If I am distracted from an activity. I don't have any problem coming back to the topic quickly	Self-regulation	2	5	5	3	3	3

21	If an activity arouses my feelings too much. I can calm myself down so that I can continue with the activity soon	Self-regulation	2	2	4	3	3	3
22	If an activity requires a problem-oriented attitude. I can control my feelings	Self-regulation	3	3	4	2	3	4
23	I stay focused on my goal and don't allow anything to distract me from my plan of action	Self-regulation	1	3	5	4	4	4
24	I find it easy to concentrate	Self-regulation	1	3	4	2	2	3

17.7. Appendix R

Pre-test statistics		
Participant	Usage time	Application opens
1	342	81
2	267	56
3	172	24
4	216	45
5	245	62
6	234	32

17.8. Appendix S

Pre-test questionnaire						
Participant	1	2	3	4	5	6
SAS-SV	4.111111111	2.333333333	1.777777778	3.444444444	3.333333333	3.111111111
Self-Efficacy	2.8	4.6	3.4	3.5	2.5	4
Self-Regulation	1.8	3.2	4.4	2.8	3	3.4

17.9. Appendix T

		Stay focused	Persuasive system proposed as part of this project
Age	Range	22 - 25	20 - 22
	Mean	23.00	21.00
	Standard deviation	1.41	0.82
SAS-SV	Range	1.78 - 4.11	3.11 - 3.44
	Mean	2.74	3.30
	Standard deviation	1.00	0.14
Self-efficacy	Range	2.8 - 4.6	2.5 - 4
	Mean	3.60	3.33
	Standard deviation	0.75	0.62
Self-regulation	Range	1.8 - 3.2	2.8 - 3.4
	Mean	3.13	3.07
	Standard deviation	1.06	0.25
Average usage time	Range	172 - 342	216 - 245
	Mean	260.33	231.67
	Standard deviation	69.56	11.95
Average number of application opens	Range	24 - 81	32 - 62
	Mean	53.67	46.33
	Standard deviation	23.33	12.28

17.10. Appendix U

		Participant					
		1	2	3	4	5	6
Day 1	Usage time (minutes)	282	241	182	201	217	222
	Applications opened	66	40	29	39	44	29
Day 2	Usage time (minutes)	295	220	155	176	222	240
	Applications opened	75	49	19	28	52	40
Day 3	Usage time (minutes)	301	252	163	210	195	249

	Applications opened	91	55	34	44	40	32
	Usage time (minutes)	260	203	154	521	202	231
Day 4	Applications opened	54	36	17	26	32	35
	Usage time (minutes)	274	230	202	194	236	223
Day 5	Applications opened	49	42	27	29	39	27
	Usage time (minutes)	282.4	229.2	171.2	260.4	214.4	233
Average	Applications opened	67	44.4	25.2	33.2	41.4	32.6