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Raising Awareness of Smartphone Overuse among University Students

A Persuasive Approach using Digital Wellbeing Chatbots

MASTER DISSERTATION

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MASTER IN INFORMATICS ENGINEERING

UNIVERSIDADE da MADEIRA
A Nossa Universidade
www.uma.pt

December | 2020

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ORIENTATION
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A dissertation submitted in partial fulfilment of
the requirements for the degree of Master of Science,
Specialisation Area of Informatics Engineering

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Funchal, December 15, 2020

To my Mother, my Father,
and my Sisters.

Abstract

Smartphone overuse can lead to a series of physical, mental, and social disturbances. This problem is more prevalent among young adults as compared to other demographic groups. Additionally, university students are already undergoing high cognitive loads and stress conditions; therefore, they are more susceptible to smartphone addiction and its derived problems.

Throughout this master's dissertation, we present a novel approach where a conversational mobile agent uses persuasive messages exploring the reflective mind as a way to raise users' awareness of their usage and consequently induce reduction behaviours. We conducted a four-week study with 16 university students undergoing stressful conditions – a pandemic crisis in the course of their semester – and evaluated the impact of the agent on smartphone usage reduction and the perceived usefulness of such approach.

Results show the efficacy of self-tracking in the behaviour change process: 81% of the users reduced their usage time, and all of them mentioned that having a conversational agent alerting about their usage was helpful. Before this experiment, only 68% of the subjects considered such an approach could be useful. In conclusion, users deemed essential to have an engaging conversational agent on their smartphones, in terms of helping them become more aware of usage times.

Keywords: Conversational Agents, Behaviour Change, Smartphone Overuse, Digital Wellbeing

Resumo

O uso excessivo de *smartphones* pode conduzir a uma série de distúrbios físicos, mentais e sociais. Este problema tem uma maior prevalência entre os jovens, quando comparado com outros grupos demográficos. Além disso, e dado que os estudantes do ensino superior passam por elevadas cargas cognitivas e condições de *stress*, estes são, portanto, ainda mais susceptíveis ao vício do *smartphone* – e aos seus problemas derivados.

Nesta dissertação de mestrado, apresentamos uma nova abordagem na qual, através de uma aplicação móvel, um agente conversacional usa mensagens persuasivas que exploram a mente reflexiva do utilizador, com o intuito de aumentar a sua consciência sobre o seu uso do *smartphone* e, consequentemente, induzir comportamentos de redução de utilização. Conduzimos um estudo de quatro semanas com 16 estudantes universitários em condições atípicas – uma crise pandémica ao longo do semestre – e avaliamos o impacto do agente conversacional na redução do uso do *smartphone* e a percepção da utilidade desta abordagem.

Os resultados mostram a eficácia da automonitorização no processo de mudança de comportamento: 81% dos utilizadores reduziram o seu tempo de utilização e todos mencionaram que ter um agente conversacional a alertar sobre o seu uso foi útil. Antes dos testes, apenas 68% dos mesmos considerou que tal abordagem poderia ser útil. Concluindo, os utilizadores consideram essencial ter um agente conversacional nos seus *smartphones*, que os ajude a estarem mais conscientes sobre a sua utilização.

Palavras-chave: Agentes Conversacionais, Mudança Comportamental, Utilização Excessiva do Smartphone, Bem-estar Digital

Acknowledgements

First of all, I would like to thank the University of Madeira for the opportunity to develop this work and for all the knowledge and expertise acquired since the Bachelor's degree until this Master's degree.

I thank my supervisor, Professor Pedro Campos, for accepting the challenge that I proposed and for all the guidance through this work.

To all subjects that participated in this work, without their availability, this work would have never been possible to conclude, here is my acknowledge to them.

My gratitude also goes to my family – Clarisse, João, Ana, Paula, Margarida and Madalena – for all patience and support throughout my academic journey. Without you, this work would never be possible.

I also thank my friends from University of Madeira Students' Union and GDG Madeira: Andreia Nascimento, Diogo Freitas, Fernando Martins, Gonçalo Nuno Martins, and Luís Eduardo Nicolau. Thank you for your support, motivation and guidance through the last times.

Finally, I would like to thank all my course colleagues and to all those who I did not mention previously but contributed to this work.

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List of Acronyms

ADHD	Attention Deficit Hyperactivity Disorder.
AI	Artificial Intelligence.
AIML	Artificial Intelligence Markup Language.
ANOVA	Analysis of Variance.
APA	American Psychiatric Association.
API	Application Programming Interface.
BaaS	Backend as a Service.
CHT	Center for Humane Technology.
CITA	Center for Internet and Technology Addiction.
DSM-5	Diagnostic and Statistical Manual of Mental Disorders: 5^{th} Edition.
FAQ	Frequently Asked Questions.
FOMO	Fear of Missing Out.
GMS	Google Mobile Services.
IDE	Integrated Development Environment.
JSON	JavaScript Object Notation.
ML	Machine Learning.
MSD	Musculoskeletal Disorders.
MVC	Model-View-Controller.
MVP	Model-View-Presenter.
MVVM	Model-View-ViewModel.

NLG	Natural Language Generation.
NLP	Natural Language Processing.
NLTK	Natural Language Toolkit.
NLU	Natural Language Understanding.
OEM	Original Equipment Manufacturer.
OS	Operative System.
RPC	Remote Procedure Call.
RQ	Research Questions.
S-O-R	Stimulus-Organism-Response.
SaaS	Software as a Service.
SAS	Smartphone Addiction Scale.
SDK	Software Development Kit.
SICAD	General Directorate for Intervention on Addictive Behaviours and Dependencies.
SIML	Synthetic Intelligence Markup Language.
WMD	Wireless Mobile Devices.
XML	eXtensible Markup Language.

List of Publications

1. Abreu, C., Campos, P., *Raising Awareness of Smartphone Overuse among University Students: A Persuasive Approach using Digital Wellbeing Chatbots*, 16th International Conference on Persuasive Technologies 2021 – Submitted.

Chapter 1

Introduction

— We are what we repeatedly do. Excellence, therefore, is not an act but a habit.

Will Durant (1885-1981)

Millions and millions of hours are spent every day on Wireless Mobile Devices (WMD), like smartphones or tablets, being considered as indispensable tools in people's daily lives [1–4]. These devices — especially smartphones due to their pocket-size — are carried with us everywhere, since they offer a lot of powerful functionalities that help on a variety of situations, like scheduling a meeting, making an online purchase or a bank transfer, managing the e-mail inbox or getting emergency information. The excessive use of these devices, however, poses the following research question: is the way they are used leading to addiction?

WMD are very recent products on the market. Due to this, the number of existing studies on the negative consequences they may have remains very scarce — even if addiction-related research has been increasing [5]. In this way, it is harder to understand the negative impacts that misuse of the smartphone has on people. However, many researchers already consider smartphone addiction as one of the greatest addictions of the current century [6].

1.1 Problem

Smartphones end up being devices where it is possible to spend time for professional and/or personal reasons. Mobile platforms have become the dominant interface of

human-computer interaction, where, for example, 37% of Americans mostly access the internet from smartphone [7] — this percentage increases to 58% in the 18-29 age group. These devices established themselves as our go-to connection to the internet, using an addictive design. Software designers have become well experienced in creating software that captivates us at a primal level [8].

Since smartphone addiction can, to some extent, generate money, software companies compete for the users' attention. Software designers work on attention retention strategies, applying psychological principles to software design as much as they can [8]. The companies' success can be measured through the time user spend on their products since the greater the number of users, the greater the usage and the time spent by users will be [9]. Facebook and YouTube are examples of the bottomless vortex of content platforms that use infinite scrolling — although YouTube has already implemented some digital wellbeing strategies [10]. In addition to the infinite scrolling, there are a lot of other persuasive techniques intended to successfully grab the users' attention into the smartphone's screen, like push notifications or pull-to-refresh options.

The hidden goal driving the direction of all of the technology developed is the race for our attention and the best way to get that is to know how the mind works. With this, the existing techniques are becoming increasingly sophisticated and efficient. There are a lot of products specifically designed to create addiction, leading companies to place the applications' success at the centre of their focus instead of the user's success – their productivity and focus. Furthermore, there are research centres that study these persuasive techniques to get people attention [11].

Some researchers conclude that users can reach for their smartphones up to one hundred times and spend more than three hours on their devices each day [12–14]. As expected, these numbers are not identical for all age groups. The youth and young people may be more prone to smartphone addiction than older adults [13, 15]. Moreover, some studies suggest that users tend to underestimate the number of hours they spend on average, per day, on their smartphones [12, 16].

The problem becomes even more evident when it is crucial to ensure that young people do not fall into these attention stealing mechanisms since research says that, after the interruption of an activity, humans take around 25 minutes to reach full productivity [17–19]. Some research points out that 95% of university students have smartphones [20], that is a youth group that is submitted to high cognitive loads during periods of study and evaluations. While they are considered one the most

susceptible groups, they have the highest smartphone usage rates [13, 15]. Also, the abnormal use of the smartphone can cause users a series of physical, mental, sleep and social disturbances [6].

It is crucial to clarify that a smartphone without applications would not be handy in the digital world we live in. For that reason it is understandable that people live their lives through their smartphones. However, when talking about people addicted to smartphones, it is understood that these are people who abnormally and excessively use them. Smartphones and their applications are a dangerous digital addiction trigger team, and it is imperative to know, at least, how it is possible to reduce the negative impacts that they can cause on their users.

1.2 Motivation and Research Questions

In July 2020, the market share of the Android Operative System (OS) was around 75%, which means that around three-quarters of mobile applications are Android applications [21]. Even though only 2% of Android applications integrate the Social category, the majority of time spent on the smartphone are on these apps [14, 22, 23]. This could be seen as a sign of productivity if users had a social media management job, as well a sign of nonproductivity if we are talking about, e.g. a student who needs to study for an assessment and is scrolling on social media feeds. Given these scenarios, it can be difficult to evaluate, specifically for each user, if they are spending their time well, since the context of each user is usually not available.

There are a lot of strategies that intend to fight the abnormal use of the smartphone, like blocking, removing or self-tracking smartphone apps [24]. These strategies can be found in a lot of applications, some of them already embedded in the smartphone's OS itself. Recently, Google and Apple implemented digital wellbeing promoting in-apps on their OS. These apps, however, do not use the power of conversational agents to promote digital wellbeing. These agents can be defined by their availability, correctness and impartiality and could be useful to obtain specific usage information and try to optimize the users' smartphone usage, using conscious goals and self-monitoring [25].

In this work, we present a new and subtle approach using conversational agents to the digital wellbeing ecosystem. This novel system is intended to raise self-awareness to higher education students about their smartphone use and mitigate this problem,

since young people are one of the most vulnerable to smartphone overuse [12, 14, 15].

In this context, some Research Questions (RQ) have emerged:

- **RQ1**: Can alerts sent by a conversational agent, triggered by smartphone usage data, mitigate the problem of smartphone overuse?
- **RQ2**: Do users underestimate the total time they spend per day, on average, on their smartphone?
- **RQ3**: Do letting users define an objective/task makes them more likely to accomplish it and to work towards it?
- **RQ4**: Is it beneficial for users' "smartphone behaviour" to have a floating widget always on smartphone's display, making sure that they know how much time they are using the smartphone?

These RQ are intended to be answered through qualitative and quantitative data gathered throughout the study protocol, mainly composed by the collection of smartphone usage data and questionnaires filled out by the subjects.

1.3 Contributions

With the development of this new approach to digital wellbeing, using conversational agents, this work intends to make the following contributions:

1. A mobile app that can collect smartphone usage data and make use of it to manage a conversational agent that aims to increase productivity and stimulate self-awareness of smartphone use;
2. A detailed analysis of some of the most used Android usage-tracking apps, comparing their features with the affected user's cognitive component [24];
3. The creation of a novel system that intends to make users more aware of their use since self-awareness plays an essential role in the behaviour change process [26];
4. The validation of existing research conclusions, like users underestimating how much time they spent on the smartphone [12, 16, 27, 28];

5. An analysis of a set of scientific data, resulting from a study regarding the impact of the developed app on the user-smartphone relationship;
6. The development of a digital wellbeing conversational agent concept that could be adopted and improved on smartphone integrated personal assistants.

With this, the shift from (a) technology that is guided by the time spent to (b) technology that is oriented by the time well spent could be more accessible to the user.

1.4 Document Overview

Besides the Introduction, this dissertation has five more chapters. Throughout Chapter 2, the impact that smartphones have in people's lives, what are the negative impacts of smartphone overuse and what kind of solutions already exist on the market that intends to solve — or to mitigate — this problem will be discussed.

According to what is mentioned in the State of the Art in Chapter 2, the approach that will be used in this research work is described in Chapter 3. Also described are the technologies and tools used, the prototyping model and the architecture of the system.

A description of all the implemented and achieved work is done after describing the approach: the main goal is to mitigate smartphone overuse through conversational agents messages based on their usage data. Also, it uses mainly self-awareness as the primary behaviour change tool. The implemented work can be found throughout Chapter 4.

To validate the work and approach developed in this dissertation, several tests were carried out with students from the University of Madeira, which can be found in Chapter 5. The objective is to understand the impact and influence the proposed application had on smartphone use. For that, the tests, in summary, consisted of two surveys and an analysis of the collected usage data on each user's smartphone, before and after installing the developed application — called TORINGO. The selected tests were proposed according to the RQ drawn from the previous chapters.

The conclusions of the developed tests developed in Chapter 5 and the future work can be found in Chapter 6.

This master thesis was written in British English, and LaTeX was used — under the Overleaf tool — to write it. Regulations and other normative documents from the Portuguese Institute for Quality (PIQ) were considered in this writing work.

Chapter 2

State of the Art

> — It requires self-reflection and the determination to wrest your life back from a device that has been specifically designed to make it difficult to do so.
>
> *Catherine Price* (1978-)

2.1 Wireless Mobile Devices

When wireless technology emerged, nobody could predict that just a couple of decades after, it would enable people to have a pocket-sized gadget with a camera, a GPS, a caller and other tools that at the beginning of this millennium were not yet significantly developed and widely used. Mobile technology evolved so remarkably over the last decades through their wide-reaching effects and by the rapid expansion of mobile phones worldwide [29].

Despite radiophones having been available since the 1920s and handheld radio transceivers since the 1940s, the first handheld cellular mobile phone appeared in 1973, invented by Martin Cooper and John F. Mitchell of Motorola [30]. This mobile phone was costly, bulky, large and used by a limited number of people, making it, at that time, a not comprehensive technology.

In 2007, when the iPhone emerged, Steve Jobs said: "Every once in a while, a revolutionary product comes along that changes everything" [29]. He was right: smartphones changed our lives completely, less than 35 years after the first cellular mobile phone. According to Statista [31], in 2018, there were 2.9 billion smartphone users, representing around 38% of the world's population. At first glance, this

number may seem small, but it is predicted that in 2021, this number will increase to 3.8 billion – representing around 48% of the world's population.

In 2007, only 4% of American adults owned smartphones [32]. Ten years later, 77% of American adults — and 92% of those under 35 years old — own smartphones [32]. Also, penetration is similarly high in most western nations, and even higher in several Middle Eastern and Asian countries. South Korea, for example, has a national smartphone ownership rate of 88%, including 100% of those under 35 [32]. These data illustrate the smartphones' presence in people's lives. In Table 2.1 it is possible to see the evolution of the percentage of smartphone users worldwide [31, 33].

Table 2.1: In four years, the percentage of worldwide smartphone users grew almost 10%, reaching almost half of the worldwide population. * Forecast.

Year	**Total population**	**Smartphone users**	**Percentage**
2016	7.42B	2.5B	34
2017	7.51B	2.7B	36
2018	7.59B	2.9B	38
2019	7.67B	3.2B	42
2020*	7.79B	3.5B	45

Nowadays, mobile technology assumes an extraordinarily indispensable role in the life of their users, due to the possibility of making almost everything at any place. It is possible to consume continuously useful information whenever users want to, with fewer and fewer restrictions. The problem is that users' time is limited, but the information available the smartphones — that can be carried everywhere – can offer is not. Catherine Price, an award-winning science journalist, believes that technology must act as a servant [29]. However, it is acting as a master to users since there are not any imposed smartphone usage restrictions, a decision that is up to each user. Nevertheless, is this a problem or are people not even conscious of that possibility? Are they caring about that? What has changed in just over a decade?

According to neuroscientist Adam Gazzaley and to psychologist Larry Rosen, "human beings seem to exhibit an innate drive to forage for information in much the same way that other animals are driven to forage to food" [29]. That happens because "this 'hunger' is now fed to an extreme degree by modern technological advances that deliver highly accessible information" [29]. People always wanted to

look for new information, and throughout the last decades, there was a growth in the ways to get it.

The newspaper is a source of limited information and readers eventually reach its end. With the telephone, it is possible to contact anyone. However, there were costs accordingly with the call duration, and it was a fixed device. With television, the content is unlimited, but since it is not a mobile technology, people only use it at home or in another leisure place. With radio, even if it is allowed during working hours, it is often used just for listening to music. With the smartphone, there is an unlimited source of information that can be utilised everywhere, since it allows us to have a permanent internet connection. In Figure 2.1 it is possible to compare train users' behaviour in two different centuries. Although people's behaviour looks similar in the two different lifetimes, on the one hand, train users consulted the newspaper as a source of limited daily information; on the other hand, they look at the smartphone as a device that provides unlimited and customized information.

(a) Photo by Stanley Kubrick. (b) Photo by Hugh Han.

Figure 2.1: Train users (a) reading the newspaper in 1946 and (b) focused on their smartphone devices in 2018. These images are separated by a time window of about seven decades.

In this context, since companies' success can be measured by the time spent by their customers using their products, software designers try to engage smartphone users on their products for the longest time possible. Nowadays, psychological principles are more reliable than ever, and they are applied to increase success and as much as they can [11]. Digital communication has been around for longer: the difference is that there are now people who fight for our attention using persuasion techniques, promoting the "attention economy".

2.2 Smartphones as an extension of ourselves

Robert Owen (1771-1858), a pioneer socialist and a social reformer that was born in Wales, envisaged a better world for workers, during the First Industrial Revolution in Britain, when people usually were working around 10 to 16 hours a day, decreasing the daily workload. Then, by 1817, he proposed the goal of the eight-hour day and coined the slogan: "Eight hours' labour, Eight hours' recreation, Eight hours' rest" [34, 35]. Since then, and although there are other concept proposals, the daily routine is usually organized this way. Now, it is essential to understand the impact that smartphone's usage has on the people's quotidian.

Mobile devices were created to be simple and efficient communication tools, but over the last two decades, they shifted towards much more sophisticated devices. Previously, people had one tool for each task: a GPS navigator to find the route to the restaurant we had seen in the internet, a camera to take photos of our family, a web browser to find all the answers to the questions we have, and an MP3 player, to play which music we want to hear in that moment. Nowadays, smartphones are being compared to a Swiss Army Knife: a tool for all functions (see Figure 2.2) [36]. There are thousands of different smartphones in the market, being also the most used and successful tech product, compared with the tablet and the computer [37].

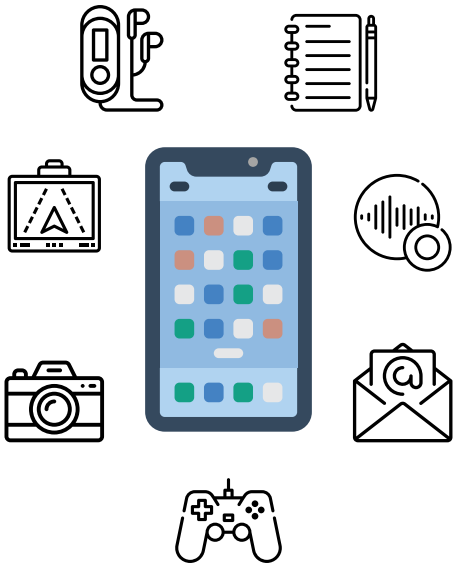


Figure 2.2: The smartphone as a Swiss Army Knife. Icons made by Nikita Golubev, Catkuro, Freepik, and Smashicons from Flaticon.

Nonetheless, if only one tool is needed — or only one task is needed to perform —, the others seem to steal attention from the user: smartphones are designed to

engage users, making them use it more than initially required and end up getting stuck on them. Therefore, it is vital to understand whether the aggregation of all these features is healthy for users or not. In the past, internet connection was only available at people's homes or other specific spots, like cybercafes or schools, nowadays, however, smartphones allow ubiquitous connectivity, allowing people to be constantly online [38].

Nowadays, smartphone users are increasingly shifting from traditional web browsers into using apps as "gateways" to Internet services [39]. According to the Pew Research Center (2015), 30% of American smartphone users say they "frequently" use the maximum amount of Internet data they are allowed to consume as part of their mobile phone plan, and 51% say this happens at least occasionally [40], which indicates the data plan is insufficient for the use given to the smartphone.

The smartphone is used by some users right before going to bed and immediately after waking up, spending dozens of minutes on it on the first and last moments of each day [5]. Also, most people admit that their smartphones are always within easy reach, what may make it so difficult to resist the temptation to glance at it for long periods of time, to check the news, the e-mail, social apps or just about anything else they desire [5, 32, 40].

Some smartphone users report that they never leave home without their phones and some say they "could not live without them", feeling anxious, nervous or worried about being parted with the smartphone for even a single day [3, 32, 40, 41]. Also, people admit checking their smartphones during intimate moments (*e.g.* during intercourse, the shower or on the toilet), working hours and also during other social and family moments (*e.g.* during a meal), being these situations more recurrent in young people — between ages of 10 and 24, according to the World Health Organization [12, 14]. Also, people tend to use smartphones while driving, what could lead to an inattentional blindness since the driver is not paying attention to the road [42].

About smartphone usage, research shows that people can spend more than three hours per day on their smartphones— some studies reported an average of almost 5 hours — and reach for them more than 100 times (or every ten minutes) every day [4, 12–14, 27, 43]. Some studies concluded that notifications are checked mainly within a few minutes of their arrival, regardless of whether the smartphone was in silent mode or otherwise [12, 44, 45]. Research suggests that smartphone users experience phantom vibrations at least occasionally, with these being innocuous

sensations particularly prevalent in users who are very attached to their devices [32]. In Section 2.2.4, it will be discussed the smartphone collateral damages.

Although this overwhelming smartphone usage — possible by the vast quantity of features and tools available on these devices —, smartphones promise to create a surplus of resources, productivity, and time [32, 46, 47]. Now, it is essential to understand if, through the different functionalities available on these devices, users are being rewarded such productivity and time or if these promises fall short in real contexts, since some people use their smartphones during high cognitive periods — like working or studying [12].

2.2.1 Productivity through digital multitasking

People believe humans can think about many things at once. Yet, human brains can only process one thought at a time [48]. What changes between humans is the capacity to switch tasks quickly, and smartphones try to create the illusion that multitasking is possible — that is, processing simultaneously two or more attention-demanding tasks. People's focus can be shifted in milliseconds, but the effort that is needed to jump from one task to another is more critical [49].

Some quick tests have been developed to try to elucidate about the mental switching costs. The following one, by the Potential Project (a group based out of Denmark), exemplifies that in four steps [50]:

1. Take a piece of paper and draw two lines on it;
2. While the stopwatch is counting, write on the first line "I am a great multi-tasker" and then write on the second line the numbers 1 to 20 sequentially;
3. Take another piece of paper and draw two additional lines;
4. Now, repeat the second command but keep switching between the two tasks and track how long you take for its completion. In the first line, write a letter from this sentence "I am a great multitasker" and then write a number on the second line. Continue until both taks are finished.

It is possible to conclude that humans are fast changing their focus, but doing it so many times can harm productivity. Moreover, this is just a simple task, that does not require much effort from human brains, and the time to start in the task was short. Each time human attention switches, cognitive load increases [17, 19].

Furthermore, the kind of tasks performed during periods of study or work are more mentally demanding than writing sequential numbers.

More important than the frequency with which our attention changes, it is the average amount of time these changes take. Several observational studies showed that a typical workday can be highly fragmented: on average, people tend to switch activities every 2-3 minutes and get interrupted more than ten times each day [51–53].

Human's brain activity can be compared to moving a big, massive block: the most challenging part is to start moving it — due to the force of static friction — and then everything becomes easier — due to the force of dynamic friction [29]. Research says we take around 25 minutes to reach full productivity after being interrupted because it takes some a while to stop thinking about something and start thinking about something else [17, 19].

Due to the amount of time needed to reach full productivity, using smartphones during high cognitive periods can be prejudicial, since people have little awareness of the frequency with which they check their phone [12, 16, 27]. In 2012, Oulasvirta *et al.* demonstrated that rapid mobile phone interactions are common, noting that smartphones were used more often throughout the day and are used more in terms of total usage time compared with laptops, during study periods [54].

Although multitasking means performing multiple tasks simultaneously, most activities that require active attention cannot be done simultaneously [55]. For example, it is possible to listen to a podcast and put on pants (it is an unconscious process for most humans), but it is not possible to pay attention to the podcast and talk to someone at the same time. However, when people are driving and texting, people tend to lose situational awareness, what could take up to 30 seconds to get back to a full alert state [56].

Notifications: how and when?

Notifications are a core feature on smartphones since they are the primary way to alert users about a variety of events [45]. There are many ways to alert users of a new notification: using a sound, a vibration, or the LED light, separately or even combinations of these. Besides the fact that smartphones can offer unlimited information and being a mobile device with a mostly permanent internet connection,

it can also steal user focus when a notification arises. Push notifications are widely used, and in Figure 2.3 it is possible to observe an example of them.

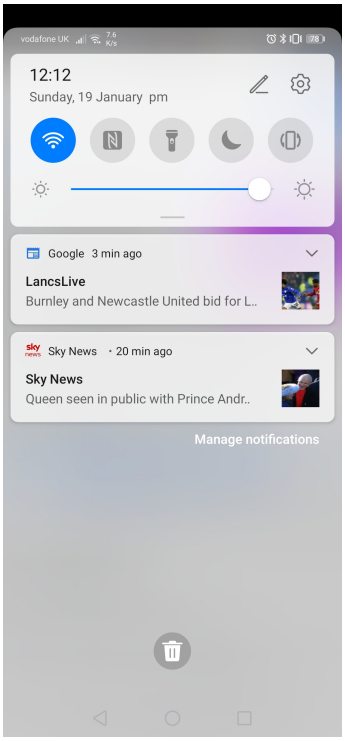


Figure 2.3: Android push notifications with the screen unlocked, which can trigger a sound, a vibration or the blinking of a LED light – or all together – as soon as they arrive.

Notifications are considered as disruptive since they arrive at users' smartphones at random times, however, in contrast, some research found that people suffered no consequences if they arrive at opportune times in between work tasks [12, 57, 58]. The problem is that notifications are widely implemented to get users' attention as soon as they arrive. For that reason, the Center for Humane Technology (CHT), a non-profit organization set up by former Google Design Ethicist Tristan Harris, recommends disabling all notifications that are not sent by people [59].

As previously mentioned before, in Section 2.2, smartphone users can receive more than 100 notifications each day, and people generally check them within a few minutes of arrival, independently if the smartphone was on silent mode or otherwise [32, 44, 45]. One reason that could explain this short check time is the Fear of Missing Out (FOMO) since smartphone users could think that they will receive an important call or message, which was found to be correlated with technological anxiety/dependence [3, 44]. This overwhelming quantity of smartphone checks can be a barrier to

focus and productivity since humans take around 25 minutes to reach full productivity after an interruption [17, 19].

Due to the negative impact that notifications could have on peoples' productivity, some approaches find that reducing interruptions and deferring notifications may work in a professional context [44]. Since asynchronous communication via mobile devices is still on the rise and becoming a more and more critical way of communication for large groups in our societies [44], it is essential to find a new way to alert users without interrupting them.

Technology helps us to do more or less?

Mobile technology — and technology overall — intends to enhance our productivity and be part of our daily problem solver [1, 2, 15]. Although there are multiples examples and studies talking about excessive smartphone use, smartphones intend to create a surplus of resources and productivity [32, 46, 47]. In fact, some research reports that smartphones can improve, for example, psychological wellbeing if they were used to fulfil a need to care for others or supportive communication [14].

A non-addicted user can spend an amount of time on the smartphone in an equal quantity as an addicted user, but the non-addicted user's time is constant, more focused on concrete tasks and less disperse [6]. The relationship that people have with their smartphones defines how the real-life relationships are: if they prioritize the short-screen relationships over them or not.

More importantly than the smartphone total usage time, is the way that it is used and the relationship that the user keeps with it. Researchers reported on previous studies of technological addictions that the excessive and problematic usage depends mainly on function rather than the usage amount: repeated usage for mood adjustment purposes, for example, may form regular usage and lead to addictive behaviours [5, 60].

Smartphones are on peoples' lives for around one decade, and it is vital to stop and think about the risks and effects of the relationship that is established with them, starting to know for what reasons smartphones are used.

2.2.2 Work tool vs Leisure tool

Smartphones can be used for many reasons — practical, subconscious and emotionally deep ones — and in a couple of different contexts — work and/or leisure. Even though it can be used by, for example, a Mobile Quality Assurance as a primary tool to manually debug a mobile application, it can also be used to gossip with friends during the night.

Flow describes a state in which people are fully absorbed by an activity, forgetting about space and time, whilst being very productive. To achieve this state of flow, two pre-requisites are needed [61]:

1. An even match between a person's ability and the difficulty of a given task;
2. Several minutes of full, unbroken concentration.

Taking this into account, the smartphone can have a major influence in achieving the second pre-requisite, since it could distract users to a point where it is not possible, in the short term, to achieve the necessary minutes of full, unbroken concentration. Although people take around 25 minutes to reach full productivity, as discussed in Section 2.2.1, they can check their smartphones every 18 minutes, becoming clear why these devices hinder people from achieving/maintaining undisrupted concentration [61].

According to the Pew Research Center (2015) [40], smartphone owners can use these devices in a wide range of contexts:

- 99% used their smartphone at home;
- 82% used their smartphone in a car or on public transit;
- 69% used their smartphone at work.

However, not all participants in this study were full-time employees: among those who are, fully 91% used their smartphone at work over the study period [40]. People probably tend to find it easier to use the smartphone from their workplace during working hours instead of, for example, sitting at the company sofa watching television, what could be explained by the fact that smartphone can be a leisure and work tool at once. Due to this reason — and to the smartphone ubiquitousness — it is harder to disconnect from work tasks in domestic environments and get a full state of flow.

A link between smartphone overuse and decline of productivity is often hypothesized, but empirical evidence on this subject is limited [61]. Duke *et al.* (2017) found a moderate relationship between smartphone addiction and a self-reported decrease in productivity, because of using smartphones during work hours and the consequent lost work hours for using it [61].

Workplace location and design can also affect productivity. Research has shown the impact of open-plan workspaces on workers' behaviour and performance: notwithstanding to contributing to teamwork and creativity, such distractions as uncontrollable and unwanted noise, the presence of other people and the lack of visual and acoustic privacy (among other ambient conditions) may reduce workers' satisfaction with workspace and, consequently, their performance [62, 63]. According to Ozimek (2020), companies that made the substitution for remote work because of the pandemic crisis, consider that this shift is going better than expected [64]. There are some advantages as:

1. There is no commute;
2. There is a reduction of non-essential meetings;
3. Less distractions than the office.

On the other hand:

1. There are technological issues;
2. There is an increase of distractions at home;
3. There is a reduced team cohesion.

It is important to know if the distractions at home are more harmful than those experienced at office workspace — especially in 2020 with the COVID-19 pandemic crisis, which has dramatically increased remote work and what can accelerate its adoption in the following years [65]. Besides, some of these problems could be mitigated by experience [64]. Duke *et al.* (2017) also mentioned that tendencies towards smartphone addiction and overt checking of the smartphone could result in less productivity both in the workplace and at home [61].

Van Laethem *et al.* (2018) also found that smartphone use after work is not favourable for employee detachment and recovery, regardless of workplace telepressure [66]. Also, Son *et al.* (2018) concluded that work-related smartphone use exacerbates work-leisure conflicts [67]. Moreover, Hilbrecht *et al.* (2013) verified

that their participants' schedules reflected a desire to separate work from other aspects of domestic life rather than to integrate [68]. However, future research is needed in order to conclude if people tend to be more productive and less distracted when spaces and objects — in this case, smartphones — are specifically designed for one kind of context/task: work or leisure. Besides, there is a lack of research about the benefits and harms of having a device used for work and performing leisure activities simultaneously.

"I'm very sceptical of the idea that using my phone excessively harms my wellbeing. I think these risks may be overblown. Just a thought". This is a comment of a person about Google's Digital Wellbeing application. And this is just an example of the way people might have to excuse the smartphone overuse problem. For this reason, it is important to keep mentioning the harms that smartphones can have, avoiding the danger of the single-story introduced by Chimamanda Adichie (2009) during a TED talk [1]. There is not any problem in talking about the smartphone with the unlimited tasks we can do through it, and that is absolutely fantastic, recognizing the potential of it. The problem is the other side of the matter, with the absence of discussion about all the consequences that smartphone overuse can cause.

People will not simply stop using smartphones due to the many and clear benefits they bring to everyday life. It is necessary, however, to discuss which approach should be taken, a careful and well-considered approach, informing users about the risks and effects that overuse of smartphones have on people's lives and that they can consciously make their decisions.

Education and technology

According to De-Sola Gutiérrez *et al.* (2016), the age of smartphone initiation is decreasing, in which Table 2.2 shows a high percentage of children owning WMD [6]. This finding is particularly relevant, accordingly with The American Academy of Pediatrics (2016) [69], because:

- The children who overuse online media are at risk of problematic Internet use;
- The heavy users of video games are at risk of Internet gaming disorder.

Curiously, both of these conditions are in need of further research from Diagnostic and Statistical Manual of Mental Disorders: 5th Edition (DSM-5).

[1] See more at `https://youtu.be/D9Ihs241zeg`

Table 2.2: Share of children owning, at least, one WMD in Portugal (2018) and in the United Kingdom (2019). Data retrieved from Statista and Marktest Telecommunications Barometer.

Country	Age Group	Percentage
Portugal (2018)	10-12	83
	13-17	97
	10-17	94
United Kingdom (2019)	8-11	86
	12-15	97
	5-15	93

In general, media use among adolescents has grown over the last decade, caused by an increase in smartphone use among this age group, in which three-quarters already own smartphones and one-quarter describe themselves as being "constantly online" in the Internet [69].

Since young adults — in the U.S., 92% of them being smartphone owners — rely heavily on smartphones [32], this should also shift our concerns to young students in order to help with, control or tackle this issue [70, 71]. Fu *et al.* (2020) points out in their research that 95% of university students have smartphones [20]. Johnson *et al.* (2016) concluded that smartphones are used for academic purposes by higher education students, like reading, browsing and downloading academic material [72], and Atas *et al.* (2019) reported smartphone use among university students to text and talk with someone, check social media and doing Internet searches, even during classes [71].

Even though smartphones can positively impact their academic performance, *e.g.* through the enhancement of learning skills and preparation and submission of assignments on time [72], it can also harm their performance, depending on how and where smartphones are used [20, 32]. Fu *et al.* (2020) found that smartphone overuse stimulates students' health issues, which could affect their academic performance negatively [20]. In Figure 2.4 it is possible to observe the Stimulus-Organism-Response (S-O-R) framework that articulates the smartphone overuse and the academic performance of students [20].

Using this proposed framework, Fu *et al.* (2020) concluded that insomnia could decrease the sleep time of students, affecting their daytime learning; nomophobia

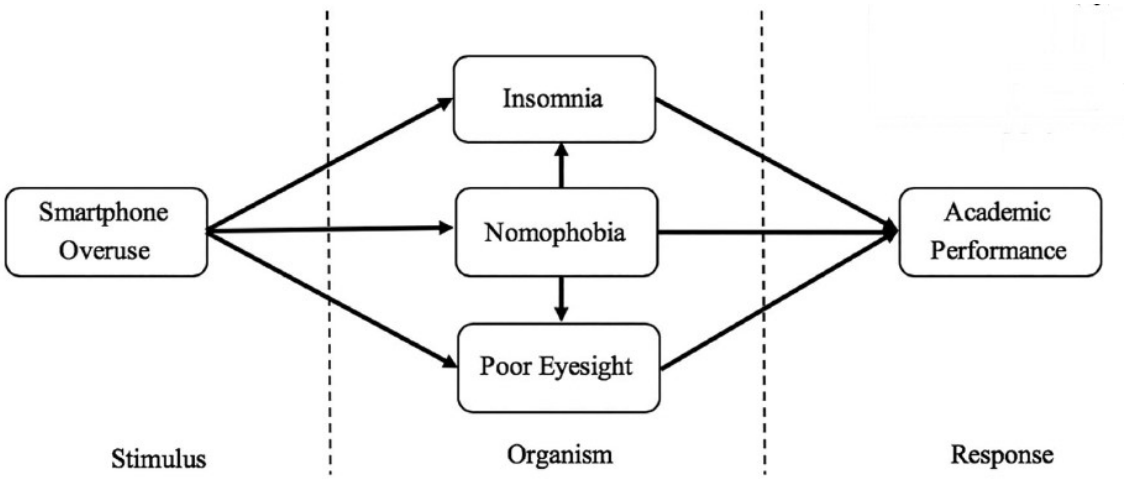


Figure 2.4: S-O-R framework about smartphone overuse and academic performance. Image from Fu *et al.* (2020) [20].

(see more details in Section 2.2.4) can lead to distractions during classes; and poor eyesight can prevent students from effectively gaining knowledge in class [20]. These organisms are all reasons that contribute for a poorer academic performance, which suggests that university teachers may help their students to avoid the negative impact that excessive use of the smartphone can have on their academic performance, through their affected health issues [20].

As discussed in Section 2.2.1, it is easy to understand how smartphones can harm the attention of their users, since — not only, but also — notifications are designed to alert the user of new information as soon as it becomes available. If this happens during high cognitive level activities (mainly in times of study and evaluations), the students' focus and attention may be compromised, increasing cognitive loads each time the users shift their focus from their activity towards their smartphone and back [12]. Lee *et al.* (2014) pointed out that some college students receive only for mobile instant messaging more than 400 notifications per day [5].

Also, a survey conducted by General Directorate for Intervention on Addictive Behaviours and Dependencies (SICAD) in Portugal, during the months on April and May 2020, concluded that, due to the lockdown in the second quarter of this year, the amount of time spent on digital media increased [73]. In Table 2.3 is presented the minimum daily time spent on the Internet on social networks, work, information, communication, games and/or other leisure activities, before and during the lockdown in Portugal.

The majority of the studies that address this problem have focused on the young

Table 2.3: Time spent online before and during the lockdown in Portugal, during April and May 2020. The sample is not representative of the Portuguese population.

Time spent	Before the lockdown	During the lockdown	Difference
Less than 1 hour	7%	4%	-3%
1-2 hours	33%	15%	-18%
3-4 hours	25%	24%	-1%
5-6 hours	17%	24%	+7%
More than 6 hours	18%	33%	+15%

and student populations, where impulsive behaviour and sensation-seeking play an important role in these periods of life [6]. Although the smartphone certainly entails risks for young people and adolescents, problematic consumption indubitably exists in adults as well.

2.2.3 Attention as the most valuable thing

Human beings are naturally distractible since they are always alert, waiting for danger due to the surviving instinct. The human beings' attention can be driven by any stimulus like sounds, vibrations or lights. Smartphones use the same strategies to change the environment and steal the user's attention. Besides, smartphones offer users the opportunity to customize and manipulate the device interface — which makes them intrinsically rewarding — but they also deliver immediate access to other individuals and feature mobile applications — making them also as extrinsically rewarding [14]. Since there is this intrinsic need for humans to search for information, many companies base their products on offering new information.

Social media companies are one of the most significant examples which continually provide new free information, and those that are so profitable make billions of dollars each year, being also one of the categories with the most addictive apps on the market [23]. That profit is reached not because they are concerned about people to share and whom they connect with, but because their users are the products of their service. Ramsay Brown, the co-founder of Dopamine Labs (later known as Boundless Mind), said that users do not pay for Facebook. Still, advertisers pay

for it, mentioning that these products are free because users' eyeballs "are what is being sold there" [74].

The average incremental welfare gain from the Internet between the years 2007 and 2011 is about $159 billion per year, out of which about $106 billion accounts for the consumer surplus from the free digital services on the Internet [75]. Every year, since 2016, more than $500 billion has been spent on global advertising [76], making advertising one of the most profitable businesses worldwide. In Table 2.4, it is possible to see how much money was spent on advertising between 2015 and 2019 in the digital media share (as WMD and computers; TV is not included in this share) [76, 77]. Digital media is the only one that continues to increase its market share and the one that accompanies the growth of worldwide advertising spent.

Table 2.4: Media share on global advertising (in U.S. billions) between 2015 and 2019. In 'Other Media' are included - not only, but also - newspapers, radio, magazines and cinema.

Year	Global Advertising Spent	Digital Share	TV Share	Other Media
2015	$485.17bn	24.6%	42.0%	33.4%
2016	$503.67bn	31.8%	38.3%	29.9%
2017	$521.38bn	35.6%	36.6%	27.8%
2018	$543.71bn	39.0%	34.9%	26.1%
2019	$563.02bn	41.8%	33.6%	24.6%

Since users' attention allows some software companies to sell more and more digital advertising spaces, one of the primary metrics used to measure companies' success is how much attention its users give to their products. Companies are profitable when they sell their advertising to their users. Because of that, companies' motivation is centred on competing for users' attention rather than trying to reduce smartphone owners' usage time and improve their digital wellbeing, since they make money by just distracting their users. These companies are not appealed to avoid that kind of behaviour but instead keep betting on new ways of engagement, that is known as the currency of the "attention economy" [78].

For the companies that are based on the "attention economy", users' attention is their primary interest. Since their products are cost-free, they intend that users pay for them with their attention [75]. Many engineers try to engage their users on their products because the greater the number of users, the greater the number of accesses to their apps will be, resulting in more ingenious opportunities to catch

the attention of their apps' users and monetize their products [9]. In Figure 2.5 it is possible to observe why some companies have users' attention as their primary interest.

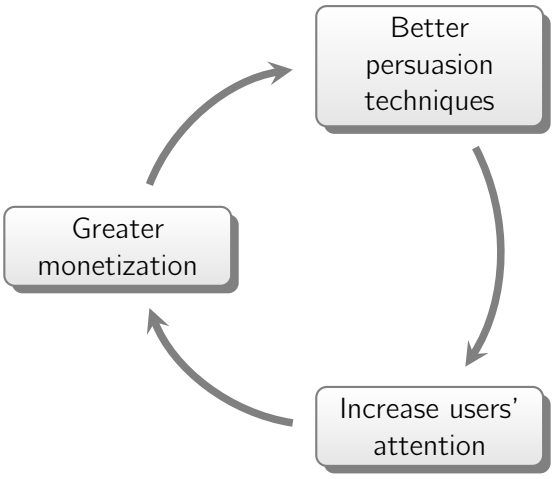


Figure 2.5: Vicious circle for companies that are based on "attention economy".

Throughout recent years, some research centres developed and perfected these techniques, like the Behavior Design Lab (previously called as Persuasive Technology Lab) and the Boundless Mind (previously named as Dopamine Labs), the latter being recently acquired by Thrive Global. Many persuasion techniques intend to maximize users' attention, as push notifications — detailed on Section 2.2.1 —, infinite scrolling and pull-to-refresh [8]. Some of these techniques used on smartphones are also common to slot machines: intermittent variable reward schedules are the psychological mechanism that makes slot machines addictive [79]. Checking social networks for new content — through the pull-to-refresh technique — have the same psychological mechanism than slot machines.

However, besides the effectiveness of these techniques and the fact that many apps are being designed to addict their users, they can cause damage to smartphone owners: for example, push notifications can increase inattention and hyperactivity symptoms [9, 12]. There are also some new approaches for redesigning menu systems for choice-making [2], centred on digital wellbeing. However, these have barely been adopted by tech companies, since their products' success is more important than the users' digital wellbeing [80].

Steve Jobs, when interviewed by the New York Times in 2011, said that he limits how much technology his kids use at home. Also, Microsoft founder Bill Gates and

[2] See some examples at `https://bit.ly/Choicemaking`.

his wife, Melinda Gates, said that none of their kids had phones until they were 14 years old. Also, Mark Zuckerberg wrote an open letter, released in 2017, to his baby daughter to "stop and smell the flowers" — not mentioning Facebook or even the internet [81].

Some technology chief executives strictly limit their children's screen time. As Adam Alter — a professor of marketing at New York University — previously mentioned in an interview they [leaders of software and technology companies] "do not trust themselves or their kids to be able to resist the charms of the very products they are promoting" [81]. Beverly Amico, the Director of Advancement at the Association of Waldorf Schools of North America, says tech leaders send their children to school, in part, because keeping young children away from tech in the classroom cultivates the attributes they like to see among their staff — creative thinking, resourcefulness and perseverance [81], which leads to the conclusion that technology can harm these attributes.

The main problem is that these companies are trying to steal users' attention using manipulative tricks of psychology and using human instincts to continue being profitable. The time we spend paying attention to these products is time we could be using for more profitable or enjoyable and enriching tasks; thus it is time we are never getting back. The decision of using these products must be conscious, avoiding reaching the point of getting unsatisfied with smartphone usage data. Smartphone usage should be decided by the user and not by the device (which is being controlled by third parties).

Awareness of the problem is half the battle.

The (un)existence of digital boundaries

As previously mentioned in Section 2.2.2, smartphones can also be used for many purposes, like for education or works reasons. Nevertheless, how time is spent on smartphones, without disregarding the strain injuries that may occur from overuse of the smartphone, is important to assess. For example, it is possible to use a smartphone to help us learn a new language or travel in a city for the first time without getting lost. The problem is when the content visualised does not contribute to personal growth.

All of the design decisions intend to present content that is interesting for the users, leaving behind the smartphone addiction's hypothesis and making the world more impressive than ever. The problem is, as Tristan Harris mentioned that this interesting content intends to leave users hooked on the screen for long periods, and companies are being experts on this as never before. What is missing in the equation are the boundaries: these strategies intend to hook people on the screen but without any limits. Netflix's CEO said that their biggest competitors are "Facebook, YouTube and sleep". But before this crazy idea to start competing with sleep emerges, companies must understand that human architecture is limited and technology should also start helping to define these boundaries and respecting human lives [11].

Since the level of users' engagement measures the companies' success, there are so many people working on efficient techniques to get their attention as never before. Furthermore, for that reason, people experience a huge need to use the smartphone at all times, breaking annoying and boring moments with it. Some research concludes that people have little awareness of the frequency with which they check their phone, concluding that fast smartphone interactions are usual among users [27, 54]: since smartphone interactions are divided into tiny fractions along the day, people tend to lose control about the number of times they do it [12, 16, 27]. The same does not happen when someone is asked, under normal conditions, how long they slept on the night before, as it is a process that usually happens in a row, it becomes easier to respond, and the answer gets closer to reality.

The smartphone can be pulled out of the pocket any time it is needed. Once again, for that reason, it is easy to lose track of time. People should know where they spend their time, in a consistent way, to maximise their productivity and allow them to make conscious decisions.

Despite only 2% of the Android apps on the market make-up the Social category, some studies point this as the most addictive category among participants, with Communications apps being in second place [14, 22, 23]. One of the reasons that explain why social networks are predominantly used is because they allow people to maintain asynchronous and synchronous contact, being an essential tool in the academic, professional or personal scopes [82]. Also, people can build their social networks, create their online identity/ies and communicate using platforms provided by social media sites and mobile apps [69]. According to some studies, 76% of teenagers use at least one social media site, being more than 70% those that maintain a "social media portfolio" of several selected sites, including Facebook, Twitter,

and Instagram. Mobile apps provide a breadth of functions, such as photo sharing, gaming, and video-chatting [69, 82]. However, this makes it difficult to know if they are being used for productive (*e.g.* in the case of a social media manager) or nonproductive (*e.g.* to gossip with friends) purposes, as previously discussed in Section 2.2.2.

2.2.4 Collateral Damages

As is being mentioned in Section 2.2, people could spend more than 5 hours each day on the smartphone, which represents around 76 days hooked on the screen each year. In addition to these worrying numbers, the different contexts where people use the smartphone are also disturbing. As discussed throughout this Chapter, people tend to use the smartphone in classes, during work, right before getting to sleep and as soon as they wake up. Nevertheless, people also tend to use it while driving [3], during a meal and other social and family moments.

The Pew Research Center (2015) surveyed the necessity of mobile connectivity, and [40]:

- 54% of Americans said that their phone is "not always needed" while for 46% of Americans said it is something they "could not live without";
- 57% of smartphone owners reported feeling "distracted" because of their phone
- 36% reported that their phone made them feel "frustrated".

Smartphone overuse could lead to several injuries. Some studies suggest that the increasingly pervasive digital technology use provokes inattention (due to serving as a readily available source of distraction) and hyperactivity (due to offering a virtually unlimited array of alternative activities), even in people that are not clinically diagnosed with Attention Deficit Hyperactivity Disorder (ADHD) [12]. Also, higher levels of inattention suggest a decrease in productivity and psychological well being.

Hussain *et al.* (2017) found that time spent on the smartphone was positively related to the length of smartphone ownership, narcissism and anxiety, suggesting that increased time spent using a smartphone may lead to problematic use [14]. Andreassen *et al.* (2016) demonstrated a relationship between social media addiction

[3] See more at `https://itspeoplelikeus.com.au/`.

and narcissism [83], while Kandhi *et al.* (2019) reported a significant correlation between smartphone addiction and depression [84]. Excessive smartphone users experienced more depression symptoms, difficulties in the expression of emotion, higher interpersonal anxiety and low self-esteem.

Also, young people are more willing to try out new technology and thus be more prone to problem use [14, 15]. According to Demirci *et al.* (2015) university students with high depression and anxiety scores could be more susceptible to smartphone addiction [85]. As discussed in Section 2.2.2, smartphone overuse stimulates students' health issues, deteriorates the quality of their sleep, of their eyesight and of their time-management skills. Smartphone overuse can also affect their academic performance since sleep plays an essential role in their memory and focus during learning moments [15, 20, 69].

Smartphone abuse is associated with problems of self-esteem, self-concept, and neuroticism of their users [6]. Excessive usage of smartphones reflects its negative impact on users' wellbeing, what could aggravate their social life, their emotions (as anxiety), and even their eating habits [20].

The smartphone can also cause harm, repeated physical, mental, social, work or familial interruptions, and can lead to people preferring digital interactions over personal contact, promoting the virtualization of socialization and damaging social relations [6]. The consistent and repeated glances at the smartphone during social moments created a new neologism called *phubbing*, short term for *phone snubbing*. Smartphones are having a massive impact on the way people — especially teenagers — are interacting, virtualizing their relationships and social connections [29, 86]. De-Sola Gutiérrez *et al.* (2016) reported that some people get some warmth of irritability or feel lost if separated from the phone, and feelings of unease when unable to send or view messages [6].

Smartphone overuse enables behavioural problems and disorders – as depression and anxiety – and poor sleep quality, particularly in adolescents. This fact has become more and more evident in communications media, inspiring new pathologies, such as [6, 20]:

- "Nomophobia" (No-Mobile-Phobia) – a term coined in 2008, represents the fear of not having a mobile phone;
- FOMO – the Fear Of being disconnected or leaving the Internet, and Missing Out opportunities of social interaction;

- "Textaphrenia" and "Ringxiety" – the false sensation of having received a text message or a call, that leads to constantly checking the smartphone. It is suggested that these pathologies can be proved by some research that points out that people attend to new notifications quickly regardless of the alert mode on their phones [44, 45];
- "Textiety" – the anxiety of receiving and responding immediately to text messages.

In addition to behavioural and psychological harms, it can also cause some physical and muscle injuries, such as neck and shoulder issues, blurred vision, and wrist pain [15]. Since smartphones promote the predominant use of the thumb or of only one finger, texting or using the controls can also lead to Musculoskeletal Disorders (MSD), caused by strain injuries using these devices [87]. To prevent these disorders, users must maintain a correct posture, use voice-to-text software and limit the usage time [87].

2.3 Is Smartphone Addiction a reality?

In Section 2.2.4, the negative impacts that smartphone overuse can have were discussed. Among these, some were related to behavioural problems, disorders and poor sleep quality. Also, the FOMO was found to be correlated with technological anxiety/dependence and neuroticism [3]. Anxiety, impaired sleep quality, dependence and limited self-control — particularly when consuming online content — are some of the similar symptoms of substance use disorders that were found in common in some smartphone users [5].

When there is a reference to smartphone addiction, it should be taken into consideration the whole ecosystem, which includes its mobile applications. Some researchers, however, are already using the designation smartphone addiction, referring that it is associated with an increased time on these devices [14].

According to American Psychiatric Association (APA), addiction is "a complex condition, a brain disease that is manifested by compulsive substance use despite harmful consequences" [88]. Besides substances, addiction can also include behaviours: gambling disorder is the only non-substance-related disorder proposed for inclusion with DSM-5 substance-related and addictive disorders [6]. It is interesting to note that smartphones were previously compared to gambling slot machines on

Section 2.2.3. Smartphone addiction, however, was not yet considered by DSM-5 neither for a future consideration — although internet gaming disorder was discussed on DSM-5 with conditions for further study [89].

Some studies point out that there is a consensus about the existence of smartphone addiction, although the delimitation and criteria used vary by researchers [6, 15]. However, since this is a phenomenon that has recently started to be studied, there is a paucity of research on its assessment and, consequently, more studies are needed to produce more reliable instruments, and to demonstrate adequate content as a measure of addiction [15].

Dr David Greenfield, the founder of Center for Internet and Technology Addiction (CITA) and assistant clinical Professor of Psychiatry at the University of Connecticut School of Medicine, compared the smartphone as "a portable dopamine pump", being carried by kids for around one-decade [90]. In 2018, some researchers pointed out that, due to the steady decline over the past decade in drug use by teenagers in the United States of America, it is highly plausible that interactive media is being used as an alternative to drugs, since it fulfils the necessity of sensation seeking through, for example, games and social media [90]. Although it is only a theory, it becomes worrying to consider and compare the use of the smartphone with the consumption of drugs, which could lead us to consider the existence of smartphone addiction.

Simon Sinek, a motivational speaker and a British-born American author, said that "cigarettes are out, social media is in. It is the drug of the twenty-first century (at least people who smoke stand outside together)".

2.3.1 Combating this addiction

Many studies point to the existence of smartphone addiction among users, with this turning into a concern for many people who try to solve – or avoid – the existence and prevalence of this problem. With that in mind, some research centres have been created to study and combat this phenomenon.

Tristan Harris, who spent three years as a Google Design Ethicist, is now the president and the cofounder of the CHT, and intending to help people live more intentionally with their devices, radically reimagining technology for the common good of humanity [59].

CITA was founded by renowned cyberpsychologist Dr David Greenfield, who set out to treat patients, train healthcare professionals on how to diagnose and treat problematic tech use, and sensitize the community in general [60]. The mission of the CITA is to create a new normal concerning our relationship with technology. One of several tests that have been developed is very interesting: Smartphone Compulsion Test. With this one, it is possible to know the relationship people have with their smartphone [4]. However, Harris *et al.* (2020) has mentioned there is a lack of research supporting the theoretical foundation behind some gradings created for smartphone use evaluation [88].

Besides, institutions such as the APA also share this concern, and recently they shared a paper with some recommendations: children ought not to sleep with devices in their bedrooms, including TVs, computers, and smartphones; and should avoid exposure to these devices for 1 hour before bedtime [69].

Many researchers and journalists are terrified about the negative effects that smartphones' overuse can cause. For this reason, a community was created by several institutions with the main goal of "enhancing human relationships through the intentional use and development of technology" [5].

Several authors have already written about this problem, showcasing their concerns:

- Adam Alter, a marketing professor at New York University, the author of a recent book called "Irresistible" talks about technology addiction and the "attention economy";
- Catherine Price, an award-winning science journalist, wrote the book "How To Break Up With Your Phone" that intends to overtake smartphone addiction in thirty days; and
- Jean Twenge, professor of Psychology at San Diego State University, wrote the book titled "iGen", that talks about the impact – not only, but also – of smartphones on today's teens and young adults.

Also, in 2020 a documentary called The Social Dilemma, directed by Jeff Orlowski, was released on Netflix, exploring the dangerous impact that smartphones (but mainly social networks) can cause on people. This documentary counts on specialists in this field, like Tristan Harris (previously mentioned), Jeff Seibert (former Twitter's

[4] The test is available at `https://virtual-addiction.com/`.
[5] See more at `https://digitalwellnesscollective.com/`.

Head of Consumer Product) and Bailey Richardson (a member of Instagram's earliest teams) [6].

These are just some examples of the people and institutions concerned with smartphone addiction and overuse. Solutions to these problems should be more than just creating centres for their study or by writing books or making documentaries that make people aware of it. There have been some efforts in an attempt to attenuate these effects or smartphone usage as a whole. In the next Section, some of these strategies that intend to minimize the negative impact of the smartphone overuse, through usage-tracking and self-control apps will be discussed.

2.4 Usage-Tracking Apps

It may seem a little strange to combat smartphone addiction with mobile applications, but combating opioids is also done using methadone — which is also an opioid. The same logic applies when social media documentaries are released on streaming platforms like Netflix. Therefore, many applications tend to raise awareness and reduce the time spent by the user on the smartphone. When mentoring someone for changing their behaviour, timing is a crucial factor, and it is one of the pros of the existence of usage-tracking applications, this way people can be alerted when caught in the act.

Also, as referred in Section 2.2.2, the smartphone can be used for multiple purposes, either for professional or personal reasons. For example, it is possible to use Instagram for Business or just scrolling without any proper reason; or to play a game as part of tests when working in the gaming industry or to chill out. Thereby, that is why it is so difficult to know the context in which smartphones are used.

Some changes can be made — and a few were previously suggested in this Chapter — like reducing the amount of notifications, switching the smartphone screen to greyscale or turning on the aeroplane mode [59]. In Table 2.5, it is possible to observe the different methods adopted to solve the smartphone overuse problem, according to Pinder *et al.* (2019) [43]. These usage-tracking apps intend, however, through different approaches, to make smartphone users' aware of their usage. In the following Sections, different applications available for tackling this issue will be discussed. The main goal of these apps is to change from *time spent* to *time well*

[6] See more at `https://www.thesocialdilemma.com/`.

spent, by a conscious process. As Shane Parrish said, "the internet is as useful as your self-control".

Table 2.5: Methods to counter problematic smartphone usage by Pinder *et al.* (2019) [43]

	Before	**Just-in-time**	**After**
On-device	Restrict access	Realtime feedback; Timebox current task	Usage information
Off-device	Restrict access	Ambient feedback	Usage information

2.4.1 Official Apps

Google and Apple are taking digital overuse into account and started creating apps for fighting this issue — both had together 99.42% of mobile OS market share at July 2020 [21].

Google developed a bunch of mechanisms that intend to look into the health, relationships, wellbeing and work-life balance in digital settings [91]. Also, since 2018, Google developed an Android application called "Digital Wellbeing" that allows its users to check how often the smartphone was checked, how frequently different apps are used and allows to limit apps' usage with timers. These features are also included in an application developed by Apple for their ecosystem products, launched in 2018 with the iOS 12 version [92].

Even if Google is developing the solution in all of their services, this does not mean that young people will activate this mechanism in order to help their digital wellbeing. We are dealing with a younger layer, and this requires more attention and better monitoring. It is necessary to use subliminal techniques — such as nudges — so that people, during periods of high cognitive load, are forced to stop using the mobile phone.

2.4.2 Non-Official Apps

Besides the apps developed by Apple and Google, there were several others developed by third-party companies, even before the official apps were launched. Even though the latter were released in 2018, they do not reach all smartphone users: while 24.82% of the global number of mobile users benefit from solutions offered by iOS, only 25.32% of Android users (those with Android 10 or higher), as of 2020, are reached by this company's solutions, even though Android controls 74.6% of the mobile OS' market [93].

It is difficult to say precisely how many users have a usage-tracking app installed on their smartphone, because according to the latest version of the Google Mobile Services (GMS) agreement, all the devices that launch or upgrade to Android 9.0 or higher after 3rd September 2019 should have a digital wellbeing solution [94]. This solution can be the Google solution, or the Original Equipment Manufacturer (OEM) can also create their solution, that should offer a usage dashboard with at least the following statistics [94]:

1. The total amount of time with the screen on;
2. The number of device's unlocks;
3. The count of notifications received.

Therefore, it is still essential to contribute with new approaches that, even if not already available on official apps, users can have access to, and they could be integrated in the future directly in the OS. Among the thousands of applications on the market, some, due to their popularity and characteristics, should be mentioned and discussed accordingly with the design features that they have and the cognitive components that they affect.

2.4.3 Design Features vs Cognitive Components

Lyngs *et al.* (2019) made a review on digital self-control tools, and besides that, made a correlation between the most prevalent design features of the reviewed apps and the cognitive component each one affects, as this can be seen in Figure 2.6 [24]. In this research paper, 367 apps and extensions from Google Chrome ($n = 223$), Google Play Store ($n = 86$) and Apple App Store ($n = 58$) were analyzed. Different design features are being used on usage-tracking apps:

1. Block/removal;
2. Self-tracking;
3. Goal achievement;
4. Reward/punishment.

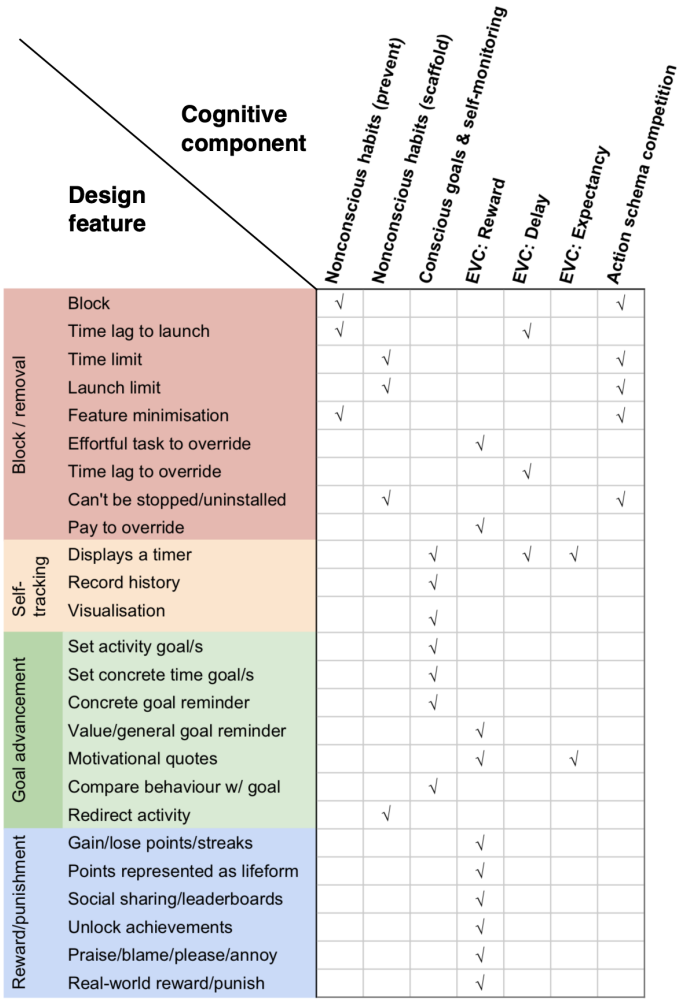


Figure 2.6: Design Features versus Cognitive Components. Image by Lyngs *et al.* (2019) [24].

Among the most popular on the market, some of these components are more prominent in some applications than others. Figure 2.7 details the most popular apps on the market and which design features are more prominent. There are also other apps — *e.g.* Siempo, Moment, SPACE, Own It, Boosted, RealizD, Calm or Flipd — but they have not been subject of research.

By analysing this figure, it is possible to conclude that the most prominent design feature area is self-tracking, which uses tools such as displaying a timer, record

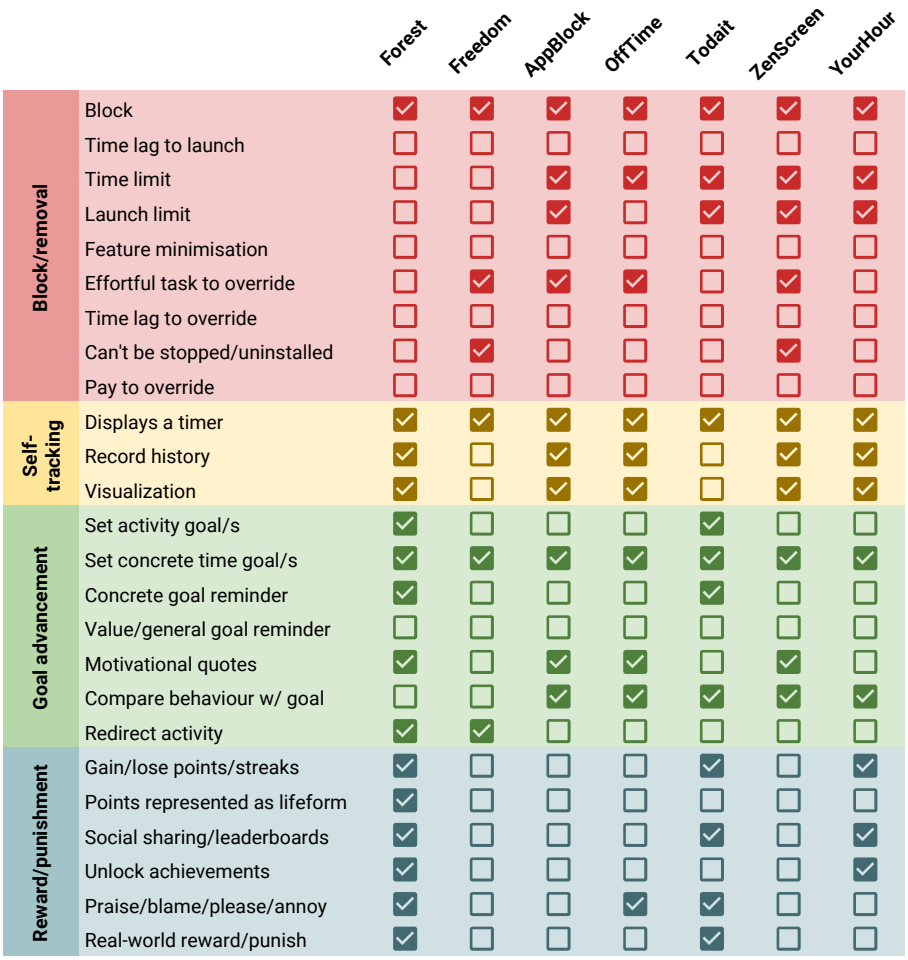


Figure 2.7: Design Features of most popular usage-tracking apps.

history and visualization. However, according to Lyngs *et al.*'s (2019) research, the *block* is the most used design feature in Google Play apps, which is also included in all apps that were analyzed.

Although the user can define time and launch limit, it is hard to know if they are using the smartphone for studying, researching, or for entertainment and this is a challenging task for developers, to design strategies to raise users' awareness, because not all strategies will be successful in all contexts and for all users. For now, the secret is to provide the user with its data so they can autonomously take action.

2.5 Chatbots

Besides the fact that some design features are more prominent on some mobile applications [24], conversational agents were not already tested as part of a solution to smartphone overuse problem. For this reason, it is important to understand and make an overview about conversational agents.

A chatbot, or a conversational agent, is a software technology that can chat or interact in the form of text and/or voice with an individual using a natural language as input – *e.g.* English or Portuguese [95]. The first chatbot, developed by Joseph Weizenbaum between 1964 and 1966, was called ELIZA and was created to simulate a psychotherapist. After that, other chatbots were developed, as A.L.I.C.E. and Mitsuku, award-winners of the Loebner Prize Competition — the oldest Turing Test contest to find the chatbot considered by the judges to be the most human-like [95, 96].

This competition helped boosting the process of chatbots' evolution, with a great evolution in the area of conversational agents during the last decades, since their main objective is to make them able to successfully pass the Turing test, in which a human interrogator deems a computer sufficiently "intelligent" to pass as a human [97]. Briefly explaining how a conversational agent works, when the user inserts and sends a text to the chatbot, the chatbot analyses it, ponders on which would be the best response and delivers that back to the user, accordingly with Figure 2.8.

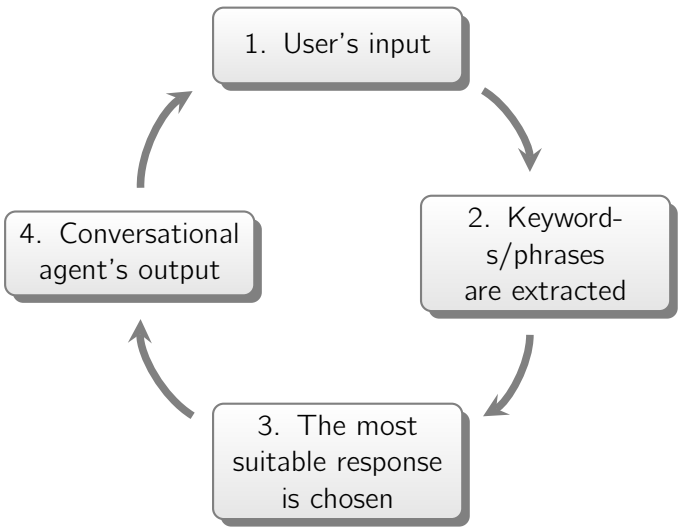


Figure 2.8: Conversational process between the conversational agent and the user.

There are benefits of using chatbots: they are always available to perform a task that otherwise would not be possible or would take a longer time; they are also characterized by their correctness and impartiality [25]. Chatbots can also play an important role when the user wants to learn or develop skills in a language, for customer service in e-commerce websites or entertainment purposes [95, 98]. Due to their versatility and ease of use (when compared with web-based or mobile applications), there is speculation that conversational agents may be a comprehensive user interface and may succeed "apps" — as a democratization of the versatile command-line [97].

There are different categories of chatbot, that can be identified and categorized by their level of intelligence: if the chatbot is limited to answer predefined questions placed by the user through preformatted answers, this is a rule-based chatbot, that use *if/then* logic to create specific and structured conversational flows, limiting to act accordingly with the information that was already set — one good example are Frequently Asked Questions (FAQ) chatbots [99]. However, a chatbot can be rule-based but use context to provide an adapted and personalized answer to the user, considering this as a relatively more evolved chatbot [100]. And there are also chatbots more sophisticated, interactive, personalized and more adaptive to different input styles and new tasks, when they are powered by Artificial Intelligence (AI) software. Despite their impressive capabilities, enormous amounts of training data and a team of highly skilled human specialists are required. Also, the fact they work like a black box, makes it hard to intervene if something goes wrong [97, 99]. In Figure 2.9, it is possible to see the level of maturity for chatbots, proposed by León Smiers, an expert in solution architecture [101].

Since 2010, GAFA companies — an acronym that was coined to refer to Google, Amazon, Facebook and Apple — have been developing conversational agents for their products in order to improve user's experience. The first was Siri, launched by Apple in 2010, and then there was Google Assistant in 2012, and Cortana from Microsoft and Alexa from Amazon in 2014 [100]. Besides these, there are also others that allow creating agents based on their Natural Language Processing (NLP), as will be discussed in Chapter 3. Through NLP, it is possible to create and develop interactions between computers and human natural languages, since it refers to the techniques used by machines to process and analyze a large amount of natural language data and then perform various language operations [100].

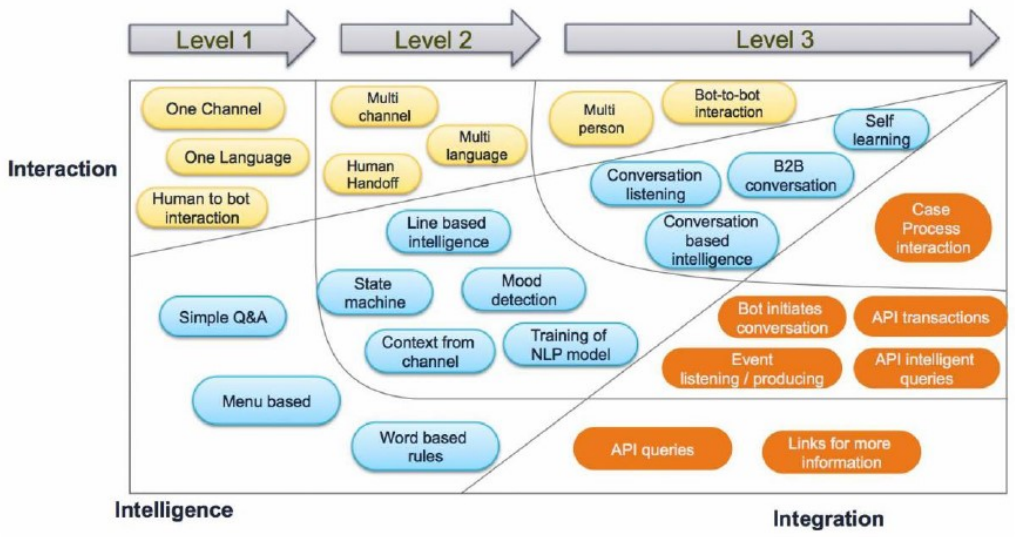


Figure 2.9: Maturity model for chatbots, proposed by Smiers (2017).

Since 2015, there is a sudden increase in the research output of chatbot or conversational agents, that can be justified by the development of AI and related technologies. Many of the existing studies are focused on a technical perspective, like how to surpass the Turing test. Accompanied by a lack of research from the humane and business point of view [95], they are not considered yet as a solution for the smartphone overuse problem. However, in 2018 [102]:

- 60% of millennials have already used them, of which 70% reported positive experiences;
- More than 50% of the millennials who have not already used them say they are interested in using them.

With this dearth of research, the opportunity to evaluate chatbots as agents of behavioural and habit change is being lost, for the problem of smartphone overuse and others.

Chapter 3

Description of the System

— You can kill a man, but you can't kill an idea.

Medgar Evers (1925-1963)

3.1 Approach

As presented in Section 2.5, there are different approaches and mechanisms embodied in digital self-control tools [24]. One of the available methods to construct a self-control app is by creating new unconscious but desirable habits: replace the old and bad ones (*i.e.* using too much the smartphone) for the good ones (*i.e.* read a good book instead). The habit formation is crucial for long-term behaviour changes, whose shifts should be a conscious process from themselves [103].

3.1.1 Personal Digital Wellbeing Chatbot

There are few mobile applications with integrated chatbots focused on minimizing the impact of the user's stress, anxiety, depression, loss or worry (most of these associated with the smartphone overuse). Wisa [1] and InnerHour Self-Care Therapy [2] are two of such examples of mobile therapy chatbots. These apps, however, do not retrieve the smartphone's usage data to send alerts from their conversational agents, in order to reduce their usage. To the best of our knowledge, this technology is still unheard of.

[1] See more at `https://bit.ly/WysaApp`.
[2] See more at `https://bit.ly/InnerHour`.

On the premise that prevention is more important than cure, the focus should be on triggering chatbot messages according to smartphone use, rather than expecting the user to voluntarily resort to the conversational agent. Digital wellbeing chatbots' performance, efficiency and precision can be improved by using real-time users' smartphone data — their real-time actions and smartphone behaviour — than just dealing with users' symptoms of anxiety or fatigue, etc.

As pointed out in Section 2.4, it might seem a bit inconsistent to use mobile applications to reduce smartphone usage. But this is actually the most convenient and timely way to alert users *in loco*, *i.e.* when they are exceeding normal or advisable levels of smartphone usage. This is preferable to alert users in other circumstances, when their smartphones are not being used, as the impact of the message will not be the same.

Since the smartphone is a multi-functional device that allows for both productive tasks and (un)conscious procrastination, and there is a lack of research in digital wellbeing solutions that use chatbots; the goal of the proposed system is to alert the user of their smartphone usage data and let them decide if it is beneficial or not [103].

In short, the approach is to build a personal digital wellbeing chatbot that monitors the user's smartphone usage data (as the total usage time and the number of unlocks – further details about the collected data are presented in Chapter 5), and messages the users, bringing them to a conscious state regarding their smartphone behaviour, ultimately to reduce their smartphone use, if necessary/advisable. The system's operation is summarized in Figure 3.1 whereas a more detailed description of the conversational agent's triggers and messages are presented in Chapter 4.

Since users tend to underestimate their smartphone usage and that can influence the results and the impact the application can have on them [27], objective data, retrieved from the smartphone, was used instead of subjective data, collected from user reports. Underestimation also happens because, compared with web tools, there are none that offer more granular control to the mobile user interface. Besides that, one of the research hypotheses is to try to understand if, throughout this study, people underestimate their smartphone usage before and after using the proposed application.

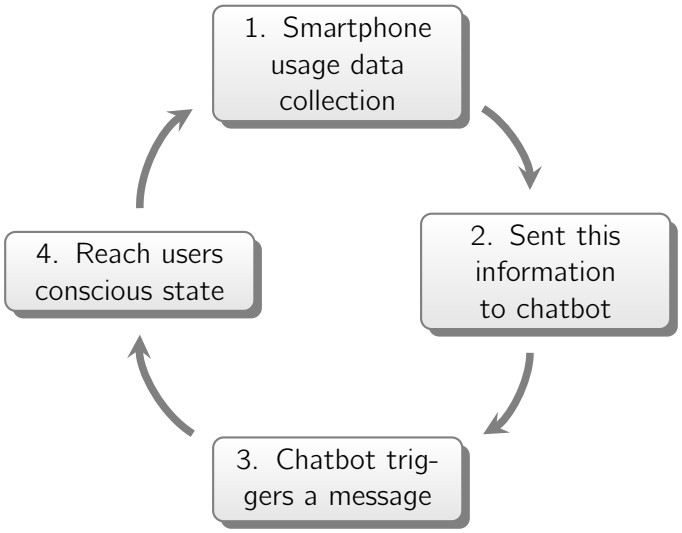


Figure 3.1: Step-by-step operation of the proposed application, that uses a conversational agent to mitigate the smartphone overuse problem.

3.2 Technologies Used

Software development is evolving really fast, being created solutions for peoples' needs in a matter of months or weeks – or even days – that can radically change peoples' lives. It is commonplace for developers to have one idea, one day, but see similar products being launched the next day, by a third party. For that reason, it is important for technologies to be the most simple yet innovative as possible: using available frameworks and platforms to accelerate software development — in this case, mobile development.

3.2.1 Android vs iOS Platforms

Since the goal is to develop a mobile application, the solution adopted had to be either Android or iOS or yet recent hybrid solutions like React Native, Flutter or Ionic. As stated in Section 2.4.2, Android (from Google) had 74.6% of the mobile market share in July 2020, against the 24.82% of iOS, from Apple. Together, they have the duopoly of mobile OS' market share, with around 99.42% of smartphones having one of these solutions [21]. Choosing the solution was based on the following items:

- A native solution was suggested since hybrid solutions did not fit the application's needs – they are restrictive in terms of available features and tools;

- The development of applications for the Apple Store are much more restrictive in terms of permissions and tools (*e.g.* apps' block scheduling is not available to iOS developers) [104];
- To develop iOS solutions, Apple products are needed and there was a lack of hardware for this purpose. For hybrid solutions this would not be case, though;
- Android reaches the majority of mobile users on the market, so finding subjects willing to participate in the study would not be such a problem as compared to solutions designed for iOS systems.

For these reasons, the decision was made to develop an Android application, knowing it would fit the application's needs. However, mobile developers have little control over how other apps are displayed as compared with web development, with blocking and restricting access being the only viable strategies [24].

3.2.2 Conversational Agent Platform

Today, there are a lot of development platforms and implementation options (*e.g.* via Software as a Service (SaaS)) on the internet, that allows building a personalised chatbot with a bunch of different features, which can be integrated into various platforms [97]. There are several messaging platforms – Messenger, Telegram, Viber, Kik or Slack – that allow integrating chatbot agents. However, the main goal of this project was to develop an Android app that could receive usage data from the smartphone and trigger messages through a chatbot agent.

Understanding humans isn't an easy task for machines, since there are a lot of nuances and subtle ways for humans to communicate, with complex linguistic patterns and rules, and that isn't very easy to replicate artificially. NLP stands as a sub-field of AI, linguistics and computer science for human language processing. NLP is concerned about how machines can process and analyze large amounts of natural language data efficiently, using standardization through a series of various techniques, as converting text to lowercase or correcting spelling mistakes [99].

Besides NLP, chatbots also use other natural language principles, as Natural Language Understanding (NLU) and Natural Language Generation (NLG):

- NLU stands for the machine reading comprehension, *i.e.* it helps the chatbot to understand what the user wrote — if the input was in the form of speech, it is

needed to use speech recognition technology previously — finding the intention and possible entities associated with it. This is achieved using language objects (such as lexicons, synonyms and themes) with algorithms to understand the meaning and context of a sentence and to construct conversational flows, that allow the chatbot to know how to respond [99].

- NLG is the next step after understanding what the user wrote or spoke, moving the conversation forward, creating a readable, meaningful, and personalized response or question through the chatbot. This is only possible by using available information, interrogating data repositories, semantic intents or third-party databases [99].

Generally, these principles are present in conversational agents, that can be built, for example, by different markup languages — *e.g.* Artificial Intelligence Markup Language (AIML) and Synthetic Intelligence Markup Language (SIML) —, programming languages' libraries — as the Natural Language Toolkit (NLTK) from Python — or scripting languages — as ChatScript and RiveScript — that generally encode rules for questions and answers. Besides that, there are also development platforms, some of them implemented as a SaaS (*e.g.* Pandorabots, Botsify, Chatfuel, Mobile Monkey, Dialogflow), that splits the testing responsibility between the service provider (who receives inputs, tests them, and takes action, sending outputs appropriate and realistic for each situation) and the client (who evaluates the ease of use and effectiveness of task accomplishment) [97]. There are also many conversational agent platforms available in the market, such as:

- Botpress, one of the most active platforms on Github;
- Wit.ai, established in 2013 by Facebook;
- Microsoft Bot Framework, the framework provided by Microsoft;
- Amazon Lex, released in 2017 by Amazon;
- Watson Assistant, established by IBM.

Some of these options are open-source or paid and can be integrated with most popular messaging systems (*e.g.* Microsoft Teams or Slack). Also, some allow the use of drag-and-drop to build a conversational agent.

As discussed in Chapter 2.4.2, Android has 74.6% of the market share of smartphone users worldwide. Since one of the reasons that motivate choosing the Android platform was by the fact of offering an application that suits for most of the smartphone users, the same principle was applied to the Conversational Agent Platform:

- According to the most recent data from Statista, Google Assistant has almost $\frac{1}{3}$ of the smart speaker with intelligent personal assistant market share, in addition to being integrated on almost $\frac{3}{4}$ of smartphones worldwide [105];
- There is a complete lack on Personal Assistant chatbots to help with Digital Wellbeing, so this chatbot was thought to be, if used, a big improvement and contribution to the Google Assistant;
- Although other solutions can also be integrated into an Android app, Dialogflow is the most suitable option for a future Google Assistant integration [106].

Since smartphone overuse is the main concern and almost three-quarters of smartphone users have an Android OS, Dialogflow was the choice for the Conversational Agent Platform. Some of the reasons for this are:

- Cost — With the Trial Edition, it is possible to create a conversational agent with all the requirements needed to build and apply our approach;
- Multi-channel easy integration — it is compatible with more than 20 languages and offers integration to more than 14 different platforms in a one-click distance, like Telegram, Slack and Skype;
- Google Assistant — It is possible to integrate the developed conversational agent in the Google Assistant;
- Easy integration — Being a platform acquired by Google in 2016, it was easier to integrate this system in the Android app, a mobile OS also from Google;
- Massive use — Since Android covers around three-quarters of the mobile OS worldwide, Google Assistant is one of the most used and popular conversational agents, what offers reliability (besides using NLP).

In Figure 3.2 it is presented the Dialogflow webpage, developing a conversational agent intent. On November 14, 2019, it was announced that support for Dialogflow V1 was going to be discontinued and that the migration to Dialogflow V2 [3] would

[3] See more at `https://bit.ly/DialogflowV2`.

have to be done. The platform was integrated using Application Programming Interface (API) calls, from Android Studio. In Figure 3.3 it is possible to observe the process flow when interacting with the Dialogflow API.

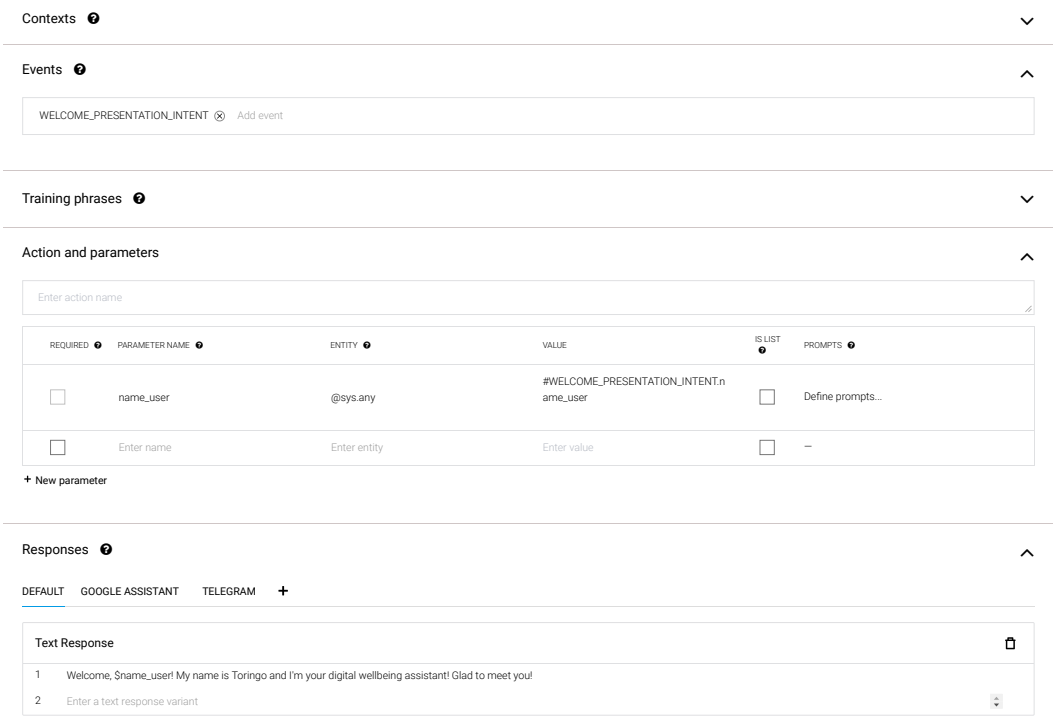


Figure 3.2: Development of intent in DialogFlow platform.

3.2.3 Firebase

Firebase is a Backend as a Service (BaaS) — that evolved from a prior startup founded by James Tamplin and Andrew Lee in 2011 — released by Google in the summer of 2016 that intended to provide the tools and infrastructure needed to build an app, thriving on the market and earning from it [107]:

- Develop — Managing separate code bases for complicated tasks such as database management, identity, messaging, and other typical attributes of apps will significantly increase the time and effort that is needed to invest in building and launching an app;
- Grow — Help with the marketing of the applications and, consequently, make them grow on the store;

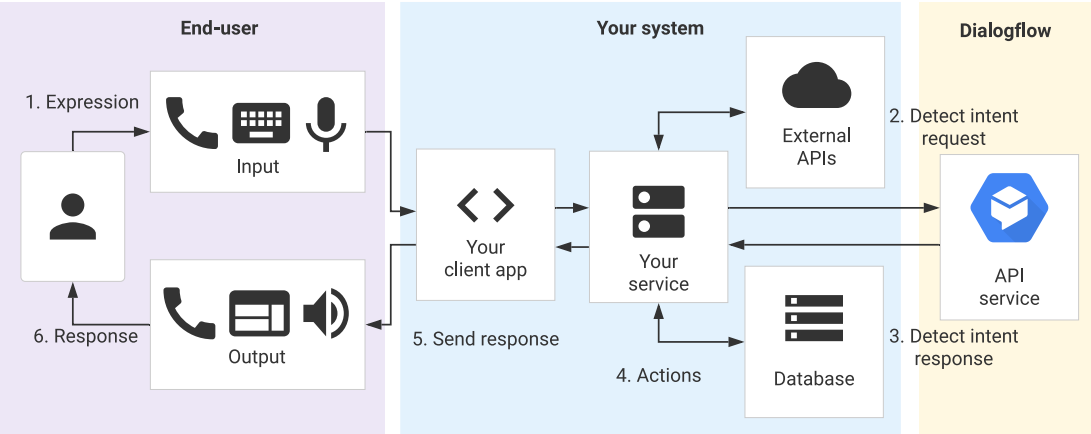


Figure 3.3: Process flow with the Dialogflow API. Image from Dialogflow documentation.

- Earn — Monetize the applications that could be charging for them or monetize by in-app content, advertising or both.

To accomplish these goals, Firebase has a lot of technologies that solve the specific needs of the users and facilitate application development. Since the main goal of this app is to avoid monetizing or making it grow on the market, most of the tools used are from the *develop* pillar. More than 5 technologies (and its API) were used for this project, which will be briefly enumerated and described theoretically and then, throughout Chapter 4, in a practical way (how they have been integrated and used).

The limits of the Firebase Spark (free) version sufficed the requirements to develop and test this application, which avoided buying a paid version.

Authentication

This technology allows us to identify the user that is accessing the app, allowing us to build and maintain a sign-in infrastructure. The authentication process is made with known credentials, provided, for example, by Google, Facebook or GitHub instead of inserting credentials and personal data, avoiding a possible user experience bump. With the Authentication API, it is possible to control who accesses which data from the other services such as Realtime Database, being this one of the advantages of using an ecosystem solution [107].

Since this app is developed for Android users, all of them necessarily have a Google account. In this way, even if there are more federated OAuth providers, only the Google sign-in was implemented (even though implementing more providers is effortless, it was not an imperative need).

Realtime Database

The Realtime Database is a cloud-hosted NoSQL-based database in JavaScript Object Notation (JSON) format that works differently from a traditional SQL database: all the code is on the client- side and not on the server-side, and there are no database access tiers. It intends to be scalable, allowing to build a realtime experience that serves a high number of users, since that provides synchronization at all the connected devices and data is still available when there is no network connectivity, through a local cache [107].

In the Firebase Realtime Database Security Rules, there are the expression-based rules which define the data structure and the users' access rules to the data. In this application, to prevent other people reading and writing on the database, only the users that logged in the app can make those changes. In Listing 3.1, we can see the access data rules for each node (the same rule could be defined for the entire database, but it is easier to establish separate rules in case of being necessary to change the rules for a specific node).

```
// Only allow authenticated users to read the data
{
  "rules": {
    "totalTimeOnScreen":{ // For requests to access the 'totalTimeOnScreen' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    },
    "messages":{  // For requests to access the 'messages' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    },
    "unlocks":{ // For requests to access the 'unlocks' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    },
    "usageData":{ // For requests to access the 'usageData' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    },
    "locks":{ // For requests to access the 'locks' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    },
    "users":{ // For requests to access the 'users' node
      "$uid":{
        ".read": "$uid === auth.uid",
        ".write": "$uid === auth.uid"
      }
    }
  }
}
```

Listing 3.1: Read and write access rules to database (JSON).

Crashlytics

This tool allows us to know the unexpected crashes and errors that occur in the devices where the application is installed, for whichever user or wherever they are. Through the Stack Trace available on the Firebase console, bugs can be fixed as early as possible and give the application the performance aspired.There are a lot of filters that also allow us to easily trace what we want, like errors by the version of the app or the fatal errors that may have occurred. In Figure 3.4, we can look into the Crashlytics on the Firebase console, with an example of a bug to fix on stack trace, detected during development.

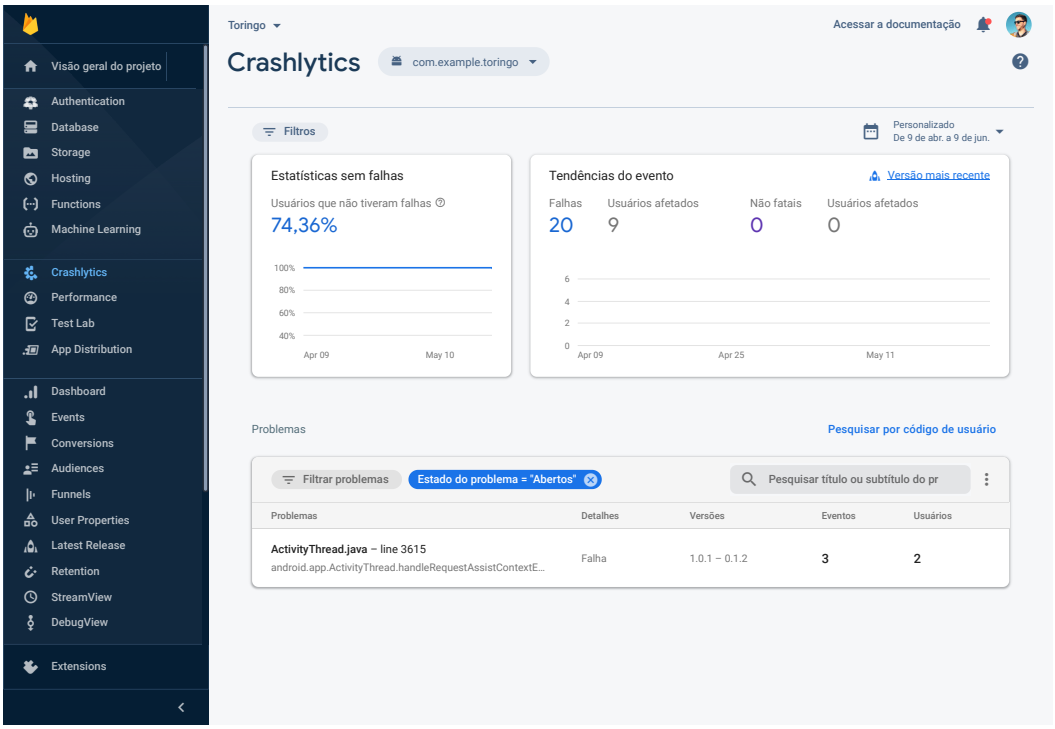


Figure 3.4: The Crashlytics on the Firebase console.

Test Lab

There are hundreds of different smartphones with different screen resolutions, equipped with a lot of different versions of Android OS. One of the constraints is that we can not test the application in all devices that end users might have, but Firebase Test Lab solves this problem making available devices hosted by Google in a Test Center. It is just needed to submit the `*.APK` file, and then the results come out as screenshots and crash reports. The variety of tests that can be done, however, are limited in the Spark (free) version.

App Distribution

This tool allows distributing the app for our trusted testers effortlessly, organising the app releases by version. The process is straightforward, just needing to upload the `*.APK` file of the version we want to test and add the testers to make them available to download the application.

Analytics

Google Analytics for the Firebase is a free and unlimited solution that provides insights about app usage and user engagement in a comprehensive way. There are a lot of events that can be defined using the Firebase SDK, that returns reports that allow understanding how the users behave on the app, facilitating the decisions about the marketing and performance optimizations of the app.

3.2.4 External Libraries

Since the Dialogflow's Java client library does not support Android, it was needed to use a third-party library that allows the communication between the mobile application and the Dialogflow [108]. gRPC is an open-source Remote Procedure Call (RPC) framework that can efficiently connect services in and across data centres, connecting yet devices, mobile applications and browsers to back-end services [109]. It was used for Remote Procedure Call to avoid the "`No functional channel service provider found`" error while creating `SessionsClient` from Dialogflow in the Android app.

Also, for the Usage Stats activity (see more at Section 4.1.4), it was used a library to create a pie chart that allows to customize it in many aspects [4]. In addition, it provides an animation, which is the loading of the graph depending on the user's usage data.

To build the floating widget (see more in Section 4.1.5), a library was also used [5]. However, a lot of modifications were made in order to accomplish the desired functionalities, as showing the total usage time on screen and adding the floating widget's colours (described throughout Chapter 4).

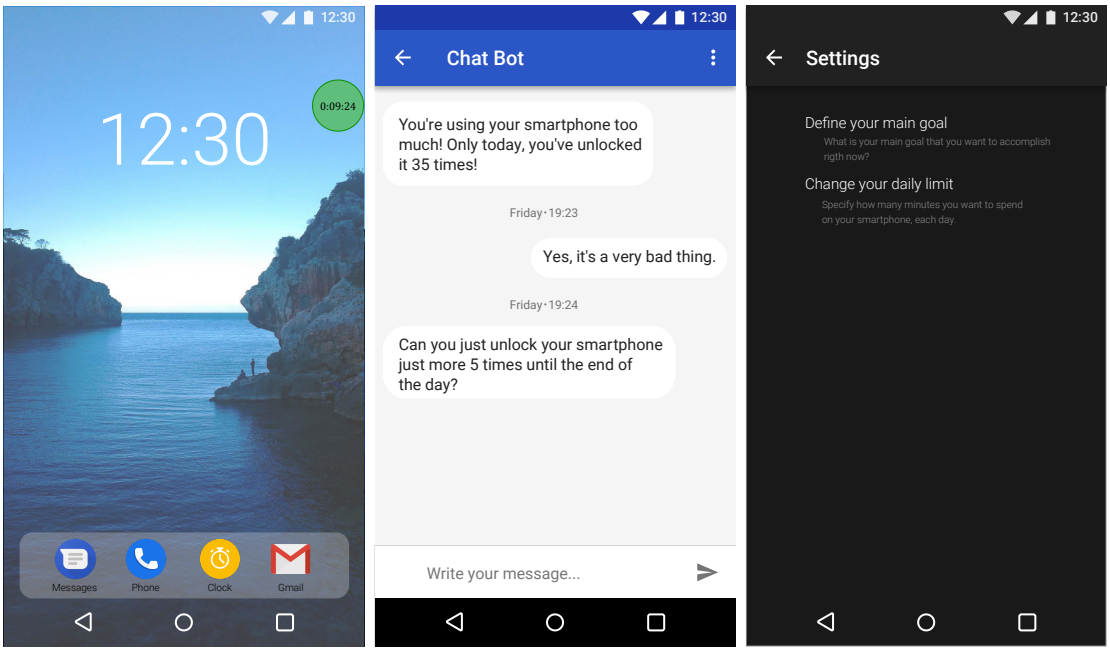
In addition, it was also used AndroidX libraries, since they replace the original support library APIs with packages in the androidx namespace [6].

[4] See more at `https://bit.ly/PieChartView`.
[5] See more at `https://bit.ly/FloatingService`.
[6] See more at `https://developer.android.com/jetpack/androidx/migrate`.

3.3 Prototyping

Building a product involves various steps to reach the point where it can be shared and launched for the mass audience (even for an application for research purposes). Each application tries, in some way, to solve the problems or constraints of their target audience, and to evaluate if it is being done right. It is recommended to make some tests with a working model, called a prototype. Since the goal for any product is its success, we should assure that it corresponds to the users' needs and it solves their problems at an early stage of the process.

For the prototyping, it was used a low-fidelity (lo-fi) tool called Adobe XD, that allows designing the wireframes of the application with visual attributes (*i.e.* buttons and widgets) of the final product, optimizing the design. Despite being a lo-fi prototyping tool, it allows creating interaction with the user from the wireframes linked to each other, also known as "connected wireframes". This way, during a test session, we can allow the users to navigate between the application features, providing a little bit of the environment of the final product. In Figure 3.5, we can see some examples of the wireframes for the application.



(a) (b) (c)

Figure 3.5: The wireframes of the app with (a) the floating widget, (b) the chatbot example and (c) the settings menu.

In order to follow the good practices of prototyping, we followed the 10 Usability

Heuristics of Nielsen and the material design and app quality proposed by Android Developers [7].

3.4 Architecture

The application architecture defines how the elements are organized to work together; that is, the high-level structure of the solution. Those elements can be databases, clients, and servers, and the way they are connected defines the architecture patterns since each app can be built in one or more architectural patterns.

To organize the files under the Android project in the Integrated Development Environment (IDE) — that is Android Studio — the Model-View-Controller (MVC) Architecture was used. Also, the final architecture of the application, with the Firebase and its tools integrated, will also be shared.

3.4.1 MVC Architecture

MVC is a software design pattern that consists of splitting an application into three components, where each of them has their own responsibilities, independently of each other. These components are:

- Model — This component contains the core of the application (the main business logic) and provides procedures and methods to access the data, like classes, services, threads and/or asynchronous tasks;
- View — Where all the information in the model is displayed for the user. A system can have one or more view components that, in Android, are eXtensible Markup Language (XML) layouts, which include drawable, strings, colours, dimensions and images;
- Controller — Interacts with the user and processes user inputs as events. In an Android application, activities and fragments deal with the user's interactions.

During the development of an Android application, it is easy to opt-out for a MVC pattern — as the Model-View-Presenter (MVP) or the Model-View-ViewModel (MVVM). But considering the requirements and needs of this project, the MVC

[7] See more at `https://bit.ly/AndDesign`.

was the one chosen to organize the files under the Android project, due to its benefits and liabilities.

In Figure 3.6, we can see the behaviour of this pattern, in the Android Project.

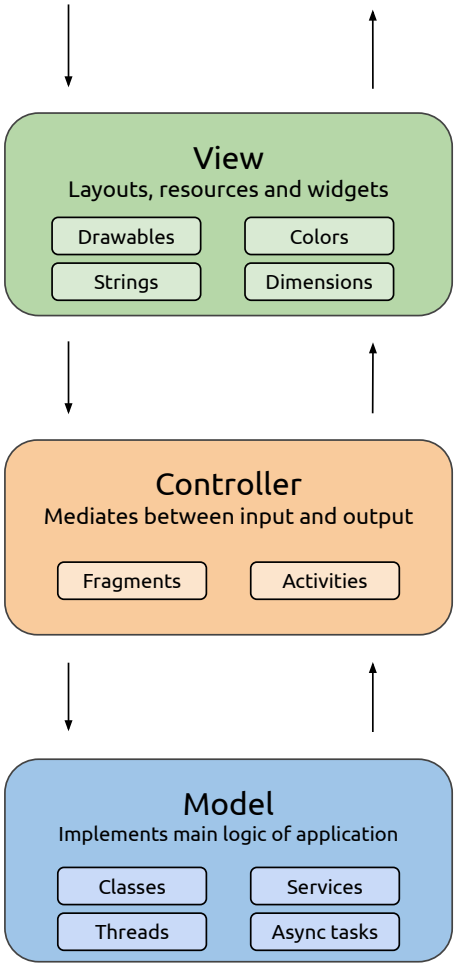


Figure 3.6: The logic under the Android project.

Therefore, it is also important to know the system architecture and to understand how the developed application is connected with the used technologies, as Figure 3.7 shows.

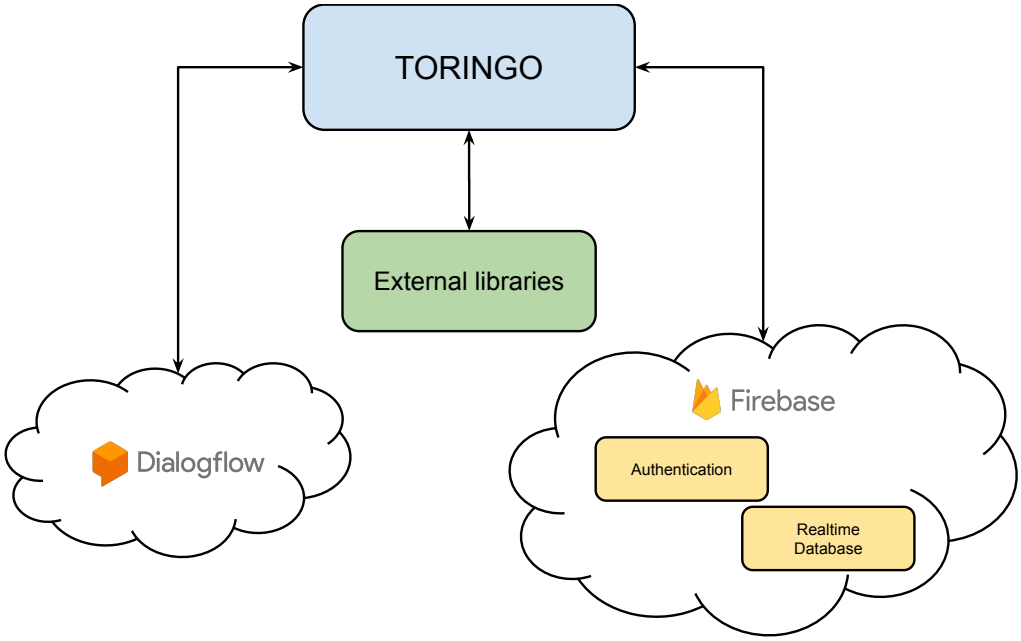


Figure 3.7: The developed app, TORINGO's system architecture.

Chapter 4

Application Implementation

> — Start with what is right, rather than what is acceptable.
>
> *Franz Kafka* (1883-1924)

4.1 Interface Design

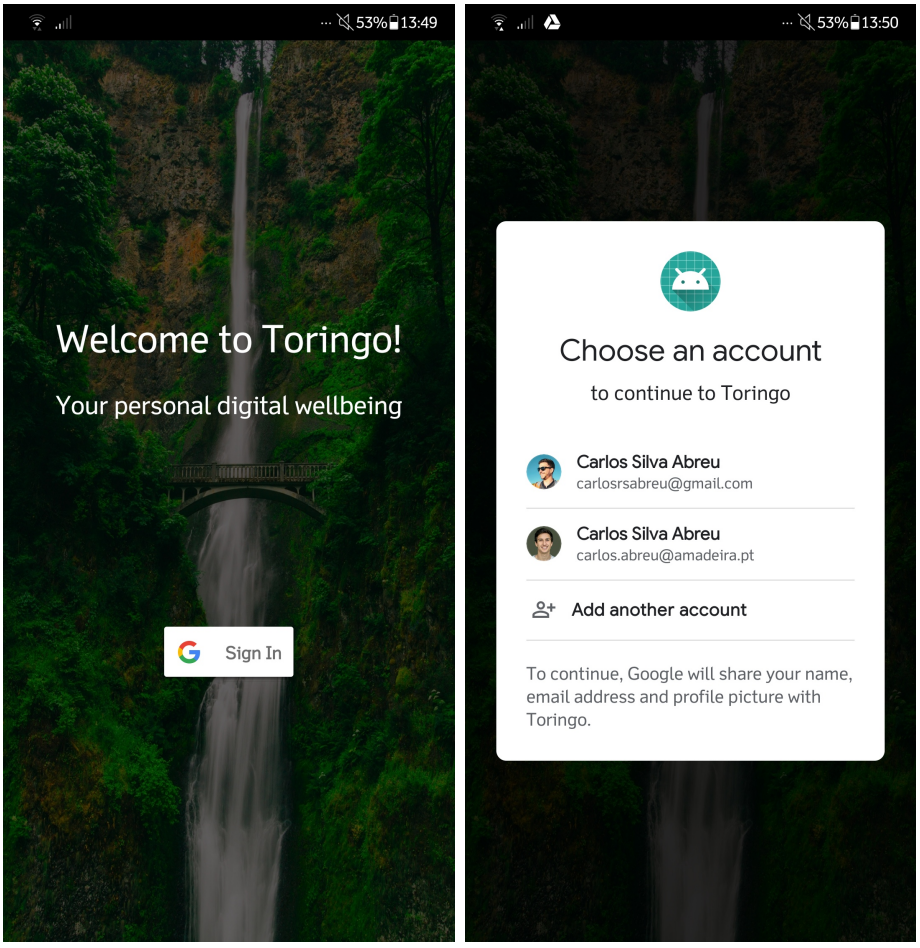
Having all the previous steps already defined, the time came to start implementing the application. First of all, and before starting with the code, this process began with the construction of the application layouts, in order to connect the visual component with the code.

Since smartphone screen sizes are small to show all functionalities of a developed application at once, it is needed to split them into different activities. The application has four main activities: login activity, chat activity, usage statistics activity and settings activity – that can be easily identified in code, when they are extended with `AppCompatActivity`. Then, there is a service that shows the user how much time they are on the smartphone screen – as will be discussed in Section 4.2.

All of these activities and services are designed using XML files, that are inside the `main` folder of the project, in `res/layouts/` path. The application only works in portrait mode, being landscape orientation unconsidered on this app. Next, it will be briefly described the app interface design, *i.e.* activities, visible services and application color palette.

4.1.1 Login Activity

This is the first activity that is shown to the user, that allows the sign-in in the application using Firebase Authentication Software Development Kit (SDK) — more details about the Authentication will be discussed in Section 4.2.1. Besides allowing users to sign-in, there is also a welcome message with the name of the chatbot and also the *motto* of the application. In Figure 4.1, it is possible to observe this activity.



(a) (b)

Figure 4.1: Login activity (a) before and (b) after clicking on the `Sign In` button. The background photo is covered by the Creative Commons Zero (CC0) license.

4.1.2 Chat Activity

This is the core activity of the application. After a successful login, the user is forwarded to this activity. It is in this activity that is possible to interact with the

chatbot: it is where the user inputs text to the chatbot and also where the user can observe its messages, triggered accordingly with smartphone usage. For the chatbot to work correctly, however, it is necessary to activate a permission called `Usage Access`, that allows to collect the smartphone usage data — more details about the data that is collected as the methods that were used will be discussed in Section 4.2.7.

In this activity, there is a drop menu in the app bar — also known as the `action bar` — that allows the user to navigate through the other activities, as the Usage Stats and Settings activity. Also, in the `app bar`, there is a button that activates the floating widget service (more details in Section 4.1.5).

It is important to mention that in the first time that users get into the app, the chatbot sends a couple of messages that tries to explain who is TORINGO and how user should proceed to allow and activate the available functionalities. In Figure 4.2 it is possible to observe the Chat activity.

4.1.3 Settings Activity

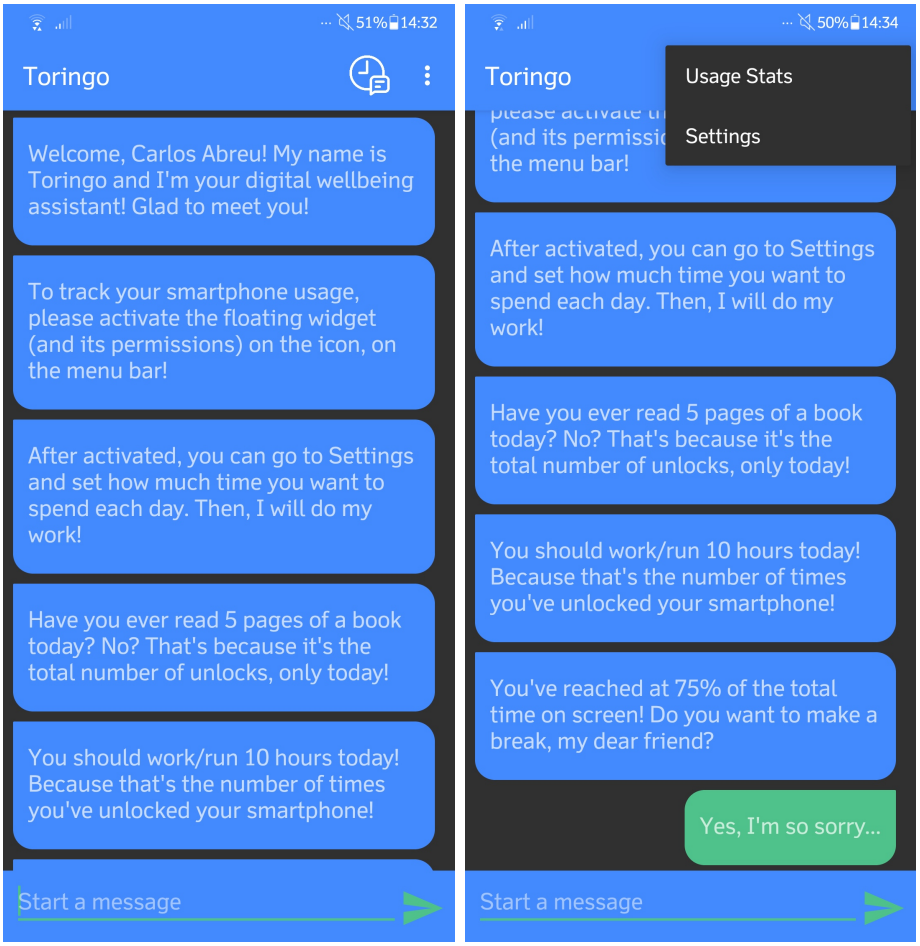
In this activity – that can be accessed through the menu in the chat activity –, the user can modify two fields. One of these fields allows the user to define the main goal, to know their intention and what they want to prioritize during that time. The other one intends to know how much time the user wants to spend on the smartphone, each day, in minutes. Unlike the other field above – that accepts letters and text – this one only accepts numbers as input.

These functionalities and their purpose will be briefly described in Section 4.2.3 and 4.2.4, respectively. In Figure 4.3 it is possible to observe the settings activity.

4.1.4 Usage Stats Activity

Besides triggering messages through the collected usage data, it is important to show to the user how their behaviour on the smartphone every day is. For that reason, this activity intends to display:

- The number of times that the smartphone was unlocked each day;



(a) (b)

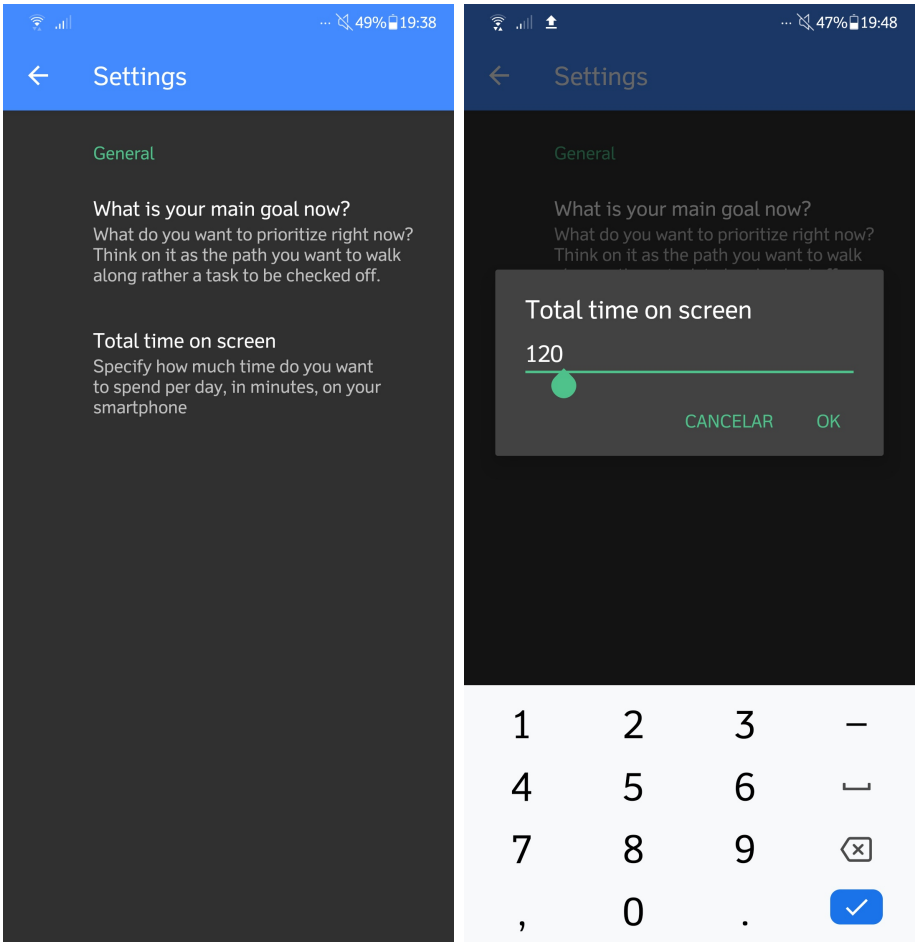
Figure 4.2: Chat activity (a) with and (b) without the drop menu collapsed.

- How much time the smartphone was used throughout the day, comparatively with the defined goal in the settings activity, in percentile points;
- A motivational quote, to make the user aware and conscious of their usage.

For the pie chart, it was used an external library as mentioned in Section 3.2.4, that includes an animation that slowly fills the percentile points, accordingly with the time that has been spent in the smartphone that day. In Figure 4.4 it is possible to observe the different elements that compose this activity.

4.1.5 Floating Widget Service

The floating widget intends to provide the user with how much time was spent throughout that day. This allows to alert the user with how close they are to reach



(a) (b)

Figure 4.3: Settings Activity with (a) the two different text fields and (b) with the second field clicked.

the defined maximum usage time goal, bringing them to a conscious state of mind and letting them decide how they want to proceed.

Since this floating widget is always displayed on screen, the idea of this floating widget was to not disturb the user when they are using the smartphone. So, characteristics such as size and transparency, and functionalities, such as mobility in the screen and it being hidden when some content is in fullscreen, were considered during the design strategy. In Figure 4.5, it is possible to observe the floating widget service.

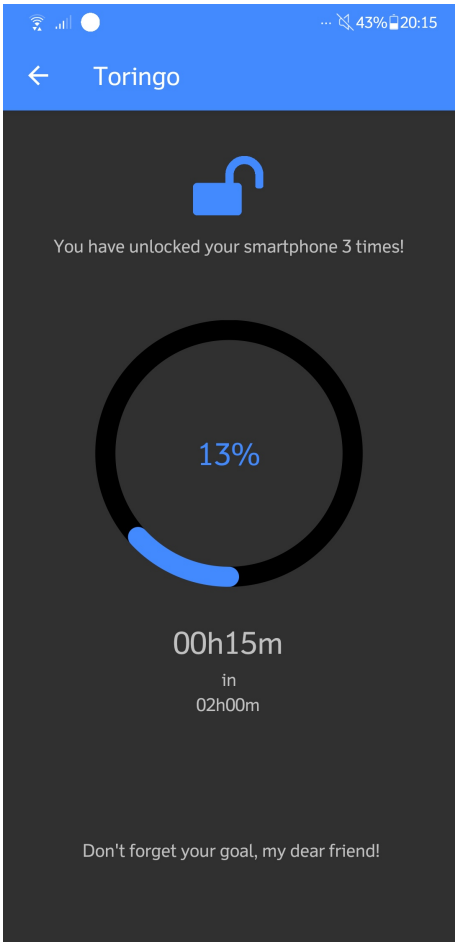


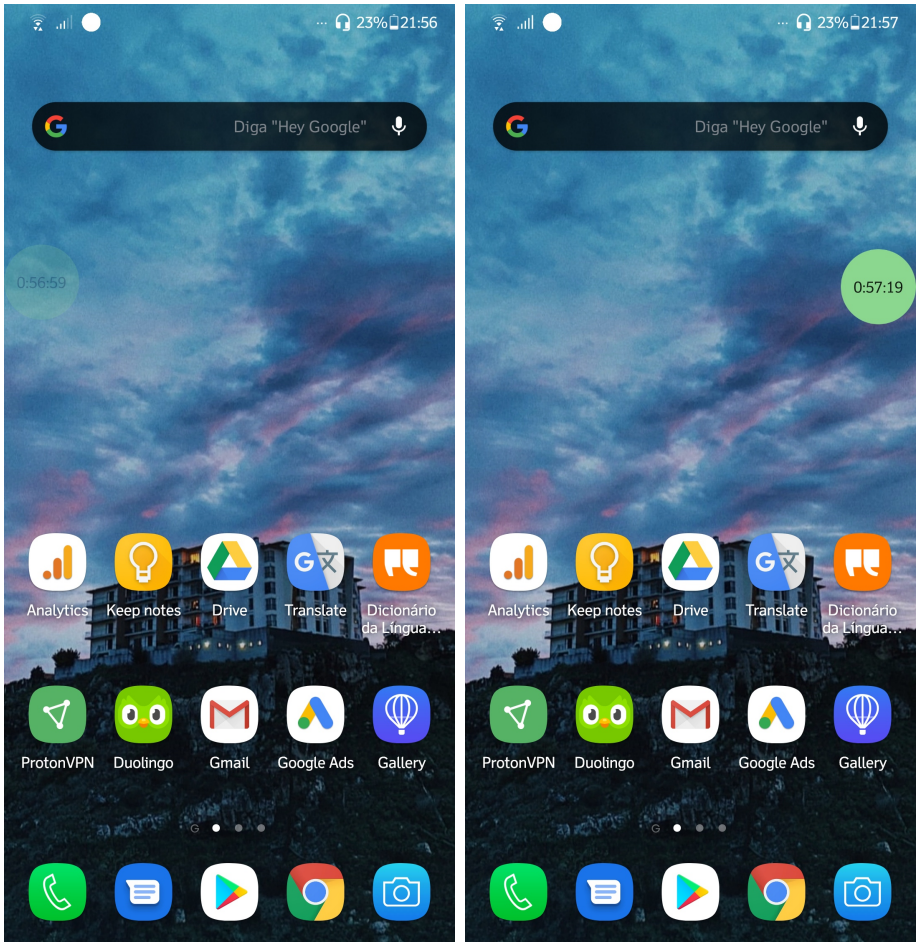
Figure 4.4: Usage Stats Activity with the different data that is shared to the user.

4.1.6 Application Color Palette

It is clear that colour is one of the most effective tools, not only, but also, in advertising, triggering emotions in people and influencing the decision-making process. For this reason, it was imperative to look into colours' meaning and choose which should be used on the app, accordingly with the defined goals. A study conducted in 2007 by Derrick Daye concluded that ads in color are read up to 42% more than black and white ads [110]. Also, one of the CHT recommendations to avoid smartphone overuse is to turn their screen into gray-scale mode, since colorful icons are positive reinforcements to unlock them [1].

One of the goals of this app is to make the chatbot, in the users' perspective, as "someone" reliable, trustworthy and transmit a feeling of friendliness/loyalty. Also, it was intended to choose a color palette that does not stimulate peoples' brains.

[1] See more at `https://humanetech.com/take-control`.



(a) (b)

Figure 4.5: Floating Widget Service (a) partially hidden due to inactivity and (b) after being dragged and dropped to another side of the screen.

Long-time exposure to blue light can cause digital eye strain symptoms. However, some studies point out that cold hues are recognized as more relaxing and better liked than warm hues [111].

Some research concludes that being presented with the colour blue lowers blood pressure, stimulates creativity and stifles hunger, with blue being associated with feelings of loyalty, sincerity, trustworthiness, as well as calmness and serenity [110–112]. Also, findings showed that the autonomic nervous system and visual cortex were significantly less aroused during blue than during red or white illumination, causing greater relaxation, less anxiety and hostility [113]. This mobile application intends to be used for very short periods of time, in order to enjoy the blue color benefits.

Green color is associated with nature, freshness and coolness, being also a relaxing color [110–112]. For these reasons, these were the two colours used in the application, being blue as primary color and green as a secondary colour. In Figure 4.2, it is possible to observe a screenshot of the app, using blue for chatbot messages and green for the user messages.

It was decided not to choose black and white colors because that could be inefficient if all the other applications were colorful, and it could bias the results indirectly. Thus, if users had only black and white apps, the developed application would even also have a greyscale palette.

4.2 Features and Functionalities

The goal of this application is to bring the user to a conscious state about their smartphone usage, alerting and making them aware about the way the smartphone is used throughout the day. For this reason, it was intended to develop a set of features and functionalities that are focused in mitigating the smartphone overuse problem.

4.2.1 Authentication

The application has an authentication system that allow users to access their data in a secure way multiple times, provided by the Firebase Authentication SDK. With this SDK, it is only necessary to choose one or more authentication providers, and then it handles the rest of the process. In this application, only Google Sign In was used, since Android smartphones have Google accounts associated with it — it could be done for other authentication providers, like Facebook, Microsoft or GitHub, but it was not considered as a mandatory functionality.

During the sign-in process, it returns the user identifier (also known as `UID`) as specified by the authentication provider, and also the name, profile photo and e-mail of the user. These data are used by the chatbot, for example, for welcoming the user by its name, as it is possible to see in Figure 4.2.

It is not checked if the user has a login in more than one device, what may make it hard to know if the usage stats correspond to more than one device (possibly used by someone besides the user). As will be discussed in Chapter 5, that did not

happen, but in any case that allows knowing all the usage data for each user, even if it is from one or more devices.

With the successful login, it is important to start thinking how the user's data will be managed and stored.

4.2.2 Database

As previously discussed in Chapter 3, Realtime Database is a cloud-hosted No-SQL database, that is characterized by its responsiveness, synchronization and availability — it uses a local cache when there is no internet connection.

At first, it was considered to use the Cloud Firestore as an alternative to the Realtime Database, even if it was still in beta. At that moment, Dialogflow was already integrated into the application, as well as its dependencies, and when adding Cloud Firestore's dependencies, that led into conflict — duplicated classes, a problem that was reported at the time on Github. Instead of having a workaround and have the possibility of future problems, it was decided to use Realtime Database, also complying perfectly with the application's needs.

In Listing 4.1, it is possible to observe how the application's Realtime Database is structured. Besides the fact that in the documentation it is referred that the data is stored as JSON, it is not possible to store arrays on it but instead saves dictionaries/associate arrays. For example, for each saved message in the database, it would make sense to save it on an array (using square brackets), but instead saving it as a dictionary (using curly brackets).

```
{
  "locks" : {
    "UID" : {
      "unique-id" : "timestamp"
    }
  },
  "messages" : {
    "UID" : {
      "unique-id" : {
        "message" : "message",
        "receiverID" : "UID / ChatbotID",
        "senderID" : "UID / ChatbotID",
        "timestamp" : "timestamp"
      }
    }
  },
  "totalTimeOnScreen" : {
    "UID" : {
      "unique-id" : {
        "day" : "totalTimeInSeconds"
      }
    }
  },
  "unlocks" : {
    "UID" : {
      "unique-id" : "timestamp"
    }
  },
  "usageData" : {
    "UID" : {
      "day" : {
        "nameOfTheApplication" :{
          "appName" : "appName",
          "packageName" : "packageName",
          "totalTimeInSeconds" : "totalTimeInSeconds"
        }
      }
    }
  },
  "users" : {
    "UID" : {
      "email" : "email",
      "photoProfile" : "profilePhoto",
      "username" : "NameOfTheUser"
    }
  }
}
```

Listing 4.1: Realtime Database structure model (JSON).

Using Realtime Database, it is possible to consult users' data in real-time — since the moment they are available in the cloud — and this allows and facilitates data analysis, with non-volatility and data security being a priority in this application.

4.2.3 Defining a goal

As previously mentioned in Section 4.1.3, and considering the existing social influence strategy theories, specifically the consistency and commitment principle, the user can define a goal or an achievement they want to prioritize in that moment. Among several studies, Cialdini *et al.* (2006) mention that people like to be consistent with what they have previously said or done [114].

This information, that is supposed to be filled out by the user, is intended to be accomplished by them. Using the nudge theory, little nudges are spread through the application in order to get the user to successfully complete their goal(s). An example of a nudge is getting a `toast` every time the user gets in the settings activity or having a fixed message at the bottom of the usage stats activity, as shown in Figure 4.4.

4.2.4 Defining a maximum total usage time

Since setting a goal can be the first step to achieve it — considering social influence strategy theories —, the user can also define how much time they want to spend each day, in minutes, staring at the smartphone's screen.

This field is filled out, by default, as a goal of 2 hours, considering half of the average time that subjects spent on the smartphone before starting to use the application (see more in Chapter 5). Every time this time goal is changed, there are immediate implications in the colour palette of the floating widget and an immediate update in the usage stats activity, accordingly with the change.

Like defining a goal (described in Section 4.2.3), the intention is to minimize the time spent in the smartphone's screen using, besides nudge theory and techniques, the floating widget and the chatbot itself, that will be discussed in Section 4.2.5 and 4.2.8, respectively.

4.2.5 Floating widget

The main purpose of the floating widget is to constantly show how much time the user is spending on the smartphone. This allows them to keep track of this information effortlessly by themselves at all times and helps them achieve their goal, *i.e.* if their goal is to use the smartphone for 2 hours and the widget shows they have already spent 1.5 hours on the device, the user becomes aware they need to try and avoid using the smartphone for the rest of the day.

To have the floating widget always on display, it is needed to activate a special permission that is called `Display Over Other Apps`, which is requested to the user the first time he wants to activate the widget. To develop this functionality, external

library was used, even though the time-counter and the rest of functionalities were implemented from scratch.

Every time the user unlocks the screen, the floating widget count starts to increase, second by second, according to the time that they spend on the smartphone's screen. To know when the screen is unlocked (to start the time-counter) and locked (to stop the time-counter) the `PowerManager.isInteractive()` method is used, added in the Android API level 20.

The floating widget can assume different colours, that varies accordingly with the smartphone usage and the defined maximum time goal. In Figure 4.6 the different colors that floating widget can assume are shown, for a 2 hours goal example.

Figure 4.6: Floating widget's colours when the user surpasses 50% (dark yellow), 75% (orange) and 100% (red-maroon) of the defined maximum total usage time, respectively. Before achieving 50% of the defined usage time, the widget is predefined to appear as green. For this example, a two hours goal set by the user was considered.

As described in Section 4.2.4, the user defines a goal, *e.g.* 3 hours, that can and should be changed throughout the user's experience with the app. When this change happens, the colour palette automatically changes to adjust the widget to the present goal. Two scenarios are given as examples:

- One scenario is when a goal of 2 hours is initially set; and after the user starts to adjust its behaviour towards their smartphone use, this goal becomes unrealistic for their new usage time, so the goal is downgraded for 1 h – previously, with a 1 hour usage, the widget would appear as dark yellow (50% of the goal), however, for the recently establish goal the widget now appears as red-maroon (100% of the goal);
- In the other scenario, as previously mentioned throughout this work, the user underestimates their total usage time of the smartphone and sets an unrealistic goal of 1h. After using the app they become aware that they actually spend more than 2 hours everyday on their device, so they must adjust their goal accordingly, and change it for 2 hours – previously, for a usage time of 1 hour

the widget would appear as red-maroon (100% of the goal), but for the new goal, the widget is changed for dark yellow (50% of the goal).

Since the floating widget is always on display, one of the concerns was it could disturb the user when using the smartphone. For this reason, some strategies were adopted:

- Its transparency is set to 80% when it is not moved by the user in the last 3 seconds;
- The size of the floating widget was adjusted to be small enough as not to disturb the user in their normal use of the smartphone; but not be too small and become ineligible;
- The possibility of dragging it for any side or corner of the screen was added;
- When the screen is in fullscreen, the widget is hidden, to avoid disturbing the user when he expresses an intention to watch certain content on the entire screen.

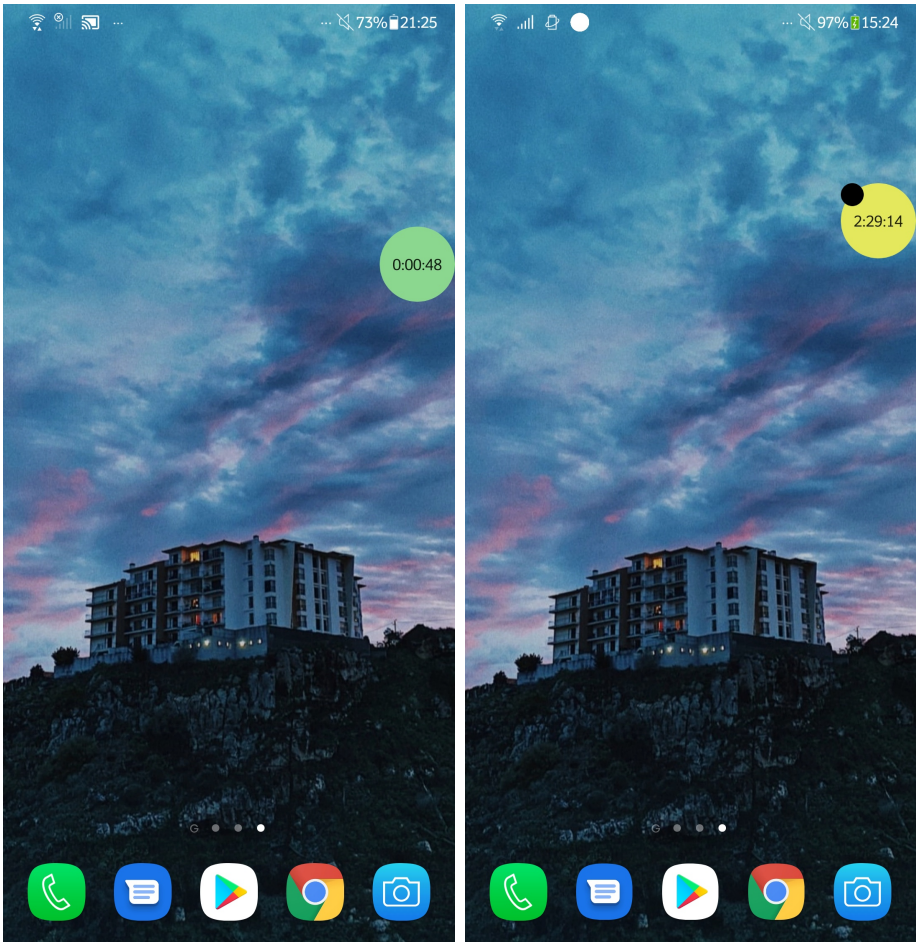
4.2.6 Notifications

As discussed throughout Chapter 2, push notifications are considered as disruptive because they distract and interrupt people at random moments [12, 57].

This was the main motivation that drove how the notifications by the chatbot were delivered to the user: instead of using push notifications to alert the user of a new message, the app used a foreground on the floating widget to deliver that new message, as Figure 4.7 shows. With this tool, the user only knows about the message when using the smartphone and looks into the floating widget: no vibrations, no sound and no push notifications about new messages when the screen is locked.

4.2.7 Usage Stats

The smartphone usage stats are what allows the chatbot to work correctly: without data, it is impossible to know how users are using the smartphone and, consequently, allow the chatbot to act accordingly. Without knowing how and how much and the user is using the smartphone, it is impossible to alert or raise awareness of its use.



(a) (b)

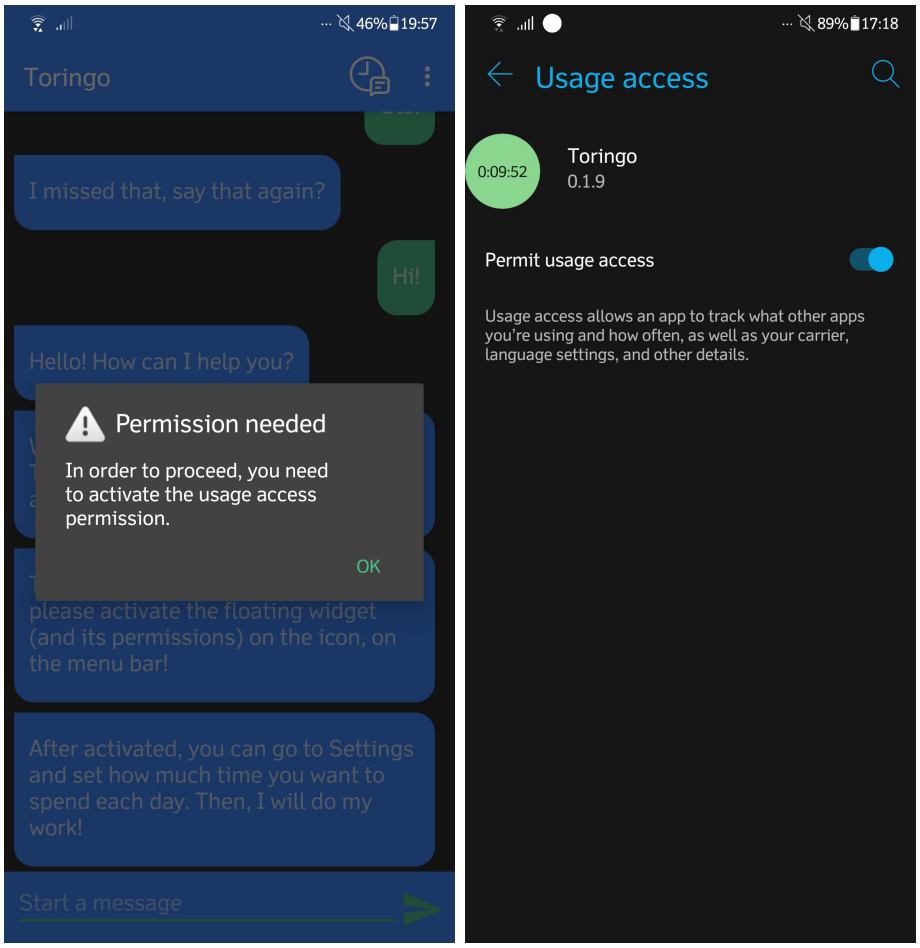
Figure 4.7: Floating Widget Service (a) without and (b) with a notification from the conversational agent, after surpassing 50% of the established goal, for a four hours goal.

One of the goals of this work is to know how much time the smartphone was used before installing this mobile application, and then compare it with the usage data after this application was used — a longer description and the results' presentation will be discussed in Chapter 5.

The usage data that is intended to be collected — that can be deduced from Listing 4.1 — are:

1. The timestamp when the user unlocks the smartphone's screen;
2. The timestamp when the user locks the smartphone's screen;
3. The usage data for each application installed in the smartphone;
4. The total number of seconds that the smartphone's screen was interactive.

To know how much time the installed applications were used during the previous days, it is requested from the user a special permission called `Usage Access`, described in Figure 4.8.



(a) (b)

Figure 4.8: When clicking in the Usage Stats menu, it is shown (a) an Alert Dialog Box that forwards the user to (b) activate the Usage Access permission.

4.2.8 Chatbot

The chatbot is the main feature of this mobile application. In addition to being a chatbot that answers the user's questions, through monitoring and data collection, it can act in an appropriate and personalised way for each of the users because it is also able to send customised messages to the user, accordingly with the smartphone usage given by the user throughout the day.

As discussed previously in Section 3.2.2, there are different levels of maturity of chatbots, that consequently influence their behaviour. Dialogflow uses Machine Learning (ML) algorithms to understand users' natural language expressions, match them with the conversational agent's intents and then extract structured data — a learning process that comes from the training phrases provided and the language models built into Dialogflow. Since early 2020, all requests made to Dialogflow use the hybrid mode, first attempting to match it with the rule-based grammar and, in case of unsuccess, switching to ML matching [115].

Although many chatbots, like the one used in this project, allow voice input, it was decided to only allow text input. It intends to:

- Track how many unlocks are made and alert the user about it;
- Give some support and advice to the user about smartphone overuse;
- Track how much time the user spends each day and alert them about it;
- Motivate the user to successfully complete the defined goal, as discussed in Section 4.2.3.

Some conversational messages are presented in Section 4.3. The chat has a 50 message history limit. It is intended for users to spend the least amount of time possible on the app and so the user is not allowed to infinitely scroll through all the exchanged messages with the chatbot. This decision was based on what is described in Chapter 2, since infinite scroll is one of the persuasion techniques intended to increase engagement in the smartphone screens by users. However, this message history limit can be increased or decreased simply by changing it in the following query:

```
db.child("messages").child(userID).orderByKey().limitToLast(50);
```

4.2.9 App Evaluation

After performing design feature analysis in the most popular usage-tracking apps, using Lyngs *et al.* (2019) [24] analysis, it is important to check the developed application. In Figure 4.9, it is possible to note that, according to application design features, the most prevalent cognitive component is *Conscious goals & Self-monitoring*, according to that described in Figure 2.6. This application promotes

user awareness and intends to have them make conscious decisions accordingly with their needs and their real smartphone usage.

Figure 4.9: Design Features of the developed application.

4.3 Conversational Agent Messages

In this Section, it will be explained how some conversational agent messages are triggered and which type of message can be sent. As mentioned before, the main goal of this application is to mitigate the smartphone overuse problem. For this, the user should not achieve nor surpass the maximum time goal defined (as explained in Section 4.2.4) and avoid quick and repeated glances at the smartphone screen. The conversational agent triggers the following kinds of messages.

Initiation

When the user successfully logs in, some messages that intend to welcome the user are triggered, introducing the conversational agent:

- Welcome, `$username`! My name is TORINGO and I'm your digital wellbeing assistant! Glad to meet you!
- To track your smartphone usage, please activate the floating widget (and its permissions) in the icon, in the menu bar!
- After activated, you can go to Settings and set how much time you want to spend each day. Then, I will do my work!

Smartphone Use

Accordingly with the smartphone usage, these kind of messages are triggered, intending to minimize the smartphone overuse problem:

- You've reached `$usagePercentage` (%) of the total time on this device as set in the settings! Do you want to take a break?
- Today, you received more than `$numberOfUnlocks` notifications. Don't you want to change the strategy of your notifications or block some of them?
- You've been using your smartphone for `$numberOfMinutes` minutes straight. Let's take a break?
- You've unlocked your smartphone more than `$numberOfUnlocks` only today! Aren't you worried about this number?
- Yesterday, you used the smartphone for 3 hours. At the end of a year, this corresponds to nearly 45 days using it. Let's change these numbers?
- Over the last hour, you unlocked the phone `$numberOfUnlocks` times. What are you doing now?
- You've reached the total time you set for today on your smartphone! Now it is time to read a book for the rest of the day or to do some other interesting thing!
- Have you ever read `$numberOfUnlocks` pages of a book today? No? That's because that's the total number of unlocks, only today!

These alerts, however, can be extended and improved, in order to be more efficient and precise, accordingly with the user's behaviour on the smartphone. Only natural language will be used, instead of using buttons (also known as quick replies). However, these two approaches can be used simultaneously [100].

Chapter 5

Tests and Results

— Be the change that you wish to see in the world.

Mahatma Gandhi (1869-1948)

5.1 Methods and Experimental Procedures

This section describes the steps — and the experimental procedures — that were taken for testing our application. The methodology described in Table 5.1 was adopted for each participant of this study [1].

Table 5.1: Evaluation stages for the digital wellbeing conversational agent.

#	Stage	Time	Duration
1	Usage data collection	Between 28th Sep. and 11th Oct.	2 weeks
2	Pre-questionnaire	12th Oct.	5 minutes
3	Developed application	Between 12th and 25th Oct.	2 weeks
4	Post-questionnaire	26th Oct.	5 minutes

The study was undertaken for four weeks, between 28th September and 25th October 2020, during an abnormal period — a pandemic crisis. This period was characterized not only, but also, by some aspects: in mid-April — during the pandemic crisis —, the percentage of Americans with symptoms of depression tripled when compared to the period before the pandemic [116], and some Portuguese research pointed

[1] Subjects' smartphone usage data was returned in JSON by Firebase's Realtime Database, and analysed with a custom script developed in JavaScript.

out that people used the internet more during the lockdown [73]. These data only reinforce the importance of understanding the impact that technology has had on people's lives, under unparalleled conditions in the present millennium.

Harris *et al.* (2020) [88] concluded that, despite an abundance of self-report scales that intend to determine whether there is a smartphone addiction or not, many of them lack internal consistency and reliability, besides the lack of research that supports the theoretical foundation of these scales. Despite the Smartphone Addiction Scale (SAS) [117]) being one of the most famous and reliable, it is suggested more research to better characterize problematic smartphone use. For this reason, an existing self-report scale was not applied.

Usage data collection

As mentioned by Andrews *et al.* (2015) [27] and by van Velthoven *et al.* (2018) [16], it is inadequate to use self-report methodologies because individuals tend to underestimate their usage, although self-reported "usage time per day" may be an adequate measure of use. For this reason, it is important to compare the collected data from the smartphone and the users' own perception, obtained from the questionnaires, described below.

A specific mobile application that only intended to collect the smartphone usage data, without influencing or conditioning the subjects' smartphone usage in this study, was developed and used by subjects. This application was distributed to the subjects on 28th September and used from this day until 11th October of 2020. During these 2 weeks, the collected usage data was not shared with the subjects, in order not to influence their smartphone usage behaviour nor their responses in the pre-questionnaire.

This application used the `getTotalTimeInForeground()` method from `UsageStats` class to collect the usage data, returning these data, for each user, filtered by application and day.

Pre-questionnaire

In order to validate the efficiency of the proposed application, it was important to know the subjects' own perception of how big their smartphone usage was, before

the proposed application was installed. Also, several questions were asked to outline the users' profile, as:

- What type of use was made on the smartphone;
- Whether they have previously installed and used usage-tracking apps or not;
- The impact that the pandemic crisis had on their studies;
- Initial ambitions and preliminary opinions on the functionalities of the developed application.

In Appendix A it is possible to observe the full version of the questionnaire. This questionnaire was answered by the participants on 12th October 2020, before installing the developed application — we translated the questionnaire into Portuguese so subjects answer it in their native language.

This information was taken into consideration for some aspects in the developed application. One of them was to know how much time these subjects spend on the smartphone, since there are studies that present different average use values, of 2 hours and 5 hours each day [12, 43]. With this information, it was easier to configure the default value for the maximum total usage time — functionality discussed in Section 4.2.4 — where the average was around 4 hours and 35 minutes and the default value was configured for 2 hours, in order to promote a smartphone use reduction of, at least, 50%.

Developed application

After the pre-questionnaire were filled out, subjects received the link to download and install the developed application, called TORINGO, that was used between 12th and 25th October 2020. As mentioned before, the main goal of the developed application is to collect the usage data for each subject, and use it to trigger alerts to decrease smartphone usage.

It was possible to compare the evolution of smartphone usage before and after using the developed application, and then conclude if there was a decrease or increase of usage. Besides application usage, the number of locks and unlocks made during the protocol period were also tracked, using the following intents:

- `Intent.ACTION_USER_PRESENT` — that is sent when the user is presently using the smartphone after it wakes up - when the keyguard is gone;

- `Intent.ACTION_SCREEN_OFF` — that is sent when the device goes to sleep and becomes non-interactive.

This data was useful to observe the trendline slope over the protocol period and conclude if there was a decrease or increase of smartphone unlocks.

Then, after the application was used until 25th October 2020, the users uninstalled the app and answered a post-questionnaire for comparison with the results obtained from the pre-questionnaire and the collected data.

Post-questionnaire

With a similar purpose to the first evaluation stage, that also consists in a perceptual analysis, this questionnaire aims to find out how subjects used their smartphone while being influenced by the developed application. Some aspects were asked to the subjects, as:

- What was their perception of smartphone usage;
- Their opinion regarding the application's functionalities, as the floating widget and the chatbot itself;
- In which weeks the subjects spent more time studying.

The full version of the questionnaire is available in Appendix B. This questionnaire was answered by the participants on 26th October 2020, after terminating the use of the developed application — we translated the questionnaire into Portuguese so subjects answer it in their native language.

Getting people's perception of their use of the smartphone is important as there are several studies that indicate that people generally underestimate the time they spend on the smartphone per day. This turned out to be part of the motivation of a questionnaire after using the application, to understand the evolution of perception before and after using the application.

5.1.1 Participants

For this study, 16 students of the University of Madeira at the time were recruited. They were all portuguese, with ages between 18 and 24 years ($M = 21.4$, $SD = 2.0$), and with a gender representation of: 56% male (9), 44% female (7), 0% other

genders (0). As mentioned before, due to the chosen app's development platform's restrictions, the users must use the Android OS, whose API had to be greater than 24 (Android 7.0). As discussed in Chapter 2, there are users that stare at smartphone screens around 5 hours each day, and students were chosen to test this application since, as discussed in Chapter 2, young people are one of the most vulnerable age groups [12, 14]. In Table 5.2 it is possible to check some details of the recruited subjects' profiles, including which of them use regularly usage-tracking applications, gathered from pre-questionnaire.

Table 5.2: Participants' profiles.

Subject	**Gender**	**Age**	**Already has usage-tracking apps**
U1	Male	24	No
U2	Male	22	No
U3	Male	20	No
U4	Male	20	Yes
U5	Male	18	No
U6	Female	20	No
U7	Male	24	Yes
U8	Female	20	No
U9	Female	19	No
U10	Female	24	Yes
U11	Female	21	No
U12	Male	23	No
U13	Male	20	No
U14	Female	22	Yes
U15	Male	22	No
U16	Female	24	No

The ethical requirements inherent to empirical research and data collection were met through the presentation and signing of free, prior and informed consent protocols, which model is available in Appendix C.

5.1.2 Methods

In order to analyse the difference in smartphone usage before and after installing the TORINGO app, and conclude if they are statistically significantly different, the Analysis of Variance (ANOVA) method was used. Introduced by Sir Ronald Fisher, the ANOVA is a statistical technique used to compare the average values of random variables when subject to different experimental conditions — identified by one or more independent variables, called factors [118] — in which the experimental procedures are applied to $k \geq 2$ populations.

The SPSS software was also used, with a significance level of 0.05, being a standard value used, meaning that we have 5% of hypothesis of rejecting the null hypothesis when this hypothesis is true. The null hypothesis in the ANOVA states that there is no difference between the average values of the different experimental conditions.

5.2 Results and Discussion

The initial evaluation's results suggest that the approach is indeed effective in reducing smartphone usage, since 81.3% of the subjects reduced their smartphone usage, comparing the period before (Weeks 1 and 2) and during the use of the developed application (Weeks 3 and 4). In Figure 5.1 the final balance of usage is shown, evidencing the difference in the periods before and after the user of the developed application.

After checking that the assumption of normality was met [2], and conducting an ANOVA with repeated measures with a Greenhouse-Geisser correction, the mean scores for the usage time were statistically significantly different ($F(1, 15) = 13.099$, $p \approx 0.003$) between pre-testing and post-testing conditions. Indeed, the post-testing condition revealed a reduction of (36.95 ± 10.21 minutes/day) when compared to the pre-testing condition.

Although subjects showed a decrease in their smartphone usage, there were some in which their activity increased. This increase, however, never exceeded the groups' average decrease (36.95 minutes). Interestingly, all subjects who mentioned already having usage-tracking apps' showed a reduction in smartphone usage. In contrast,

[2] In order to check the normality assumption, the Shapiro-Wilk test was used.

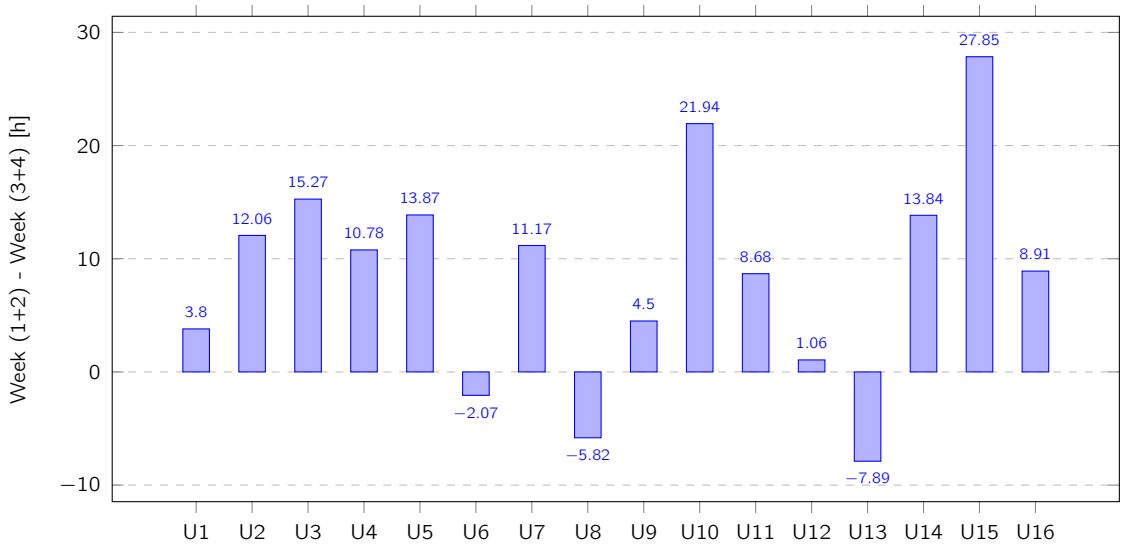


Figure 5.1: Usage data balance, per user, after using TORINGO. Greater the value, greater is the smartphone usage reduction.

all the subjects that increased smartphone usage are 20 years old, but another two subjects with the same age decreased their usage.

Consequently, comparing the evolution of smartphone usage data with the average of all users throughout the four weeks, it was noticed a reduction of smartphone use, as Figure 5.2 shows. That is, the average usage before using the application (1st and 2nd weeks) was of 4 hours, 46 minutes and 45 seconds and after installing the application (3rd and 4th weeks), the average usage reduced to 4 hours, 9 minutes and 47 seconds, which corresponds to a reduction of 14.79 %. In Table 5.3, we can see the average usage, per user, in each week — remembering that the application was installed at the start of the 3rd week.

Table 5.3: Evolution of average time spent on smartphones each week, per user. TORINGO were installed in the beginning of the third week.

Week	Number of seconds	Duration in hours
1	17483	4 Hours, 51 Minutes and 22 Seconds
2	16928	4 Hours, 42 Minutes and 07 Seconds
3	15296	4 Hours, 14 Minutes and 55 Seconds
4	14681	4 Hours, 04 Minutes and 40 Seconds

When talking about smartphone use, it is also important to compare, for each user, the real usage data with their perception. Therefore:

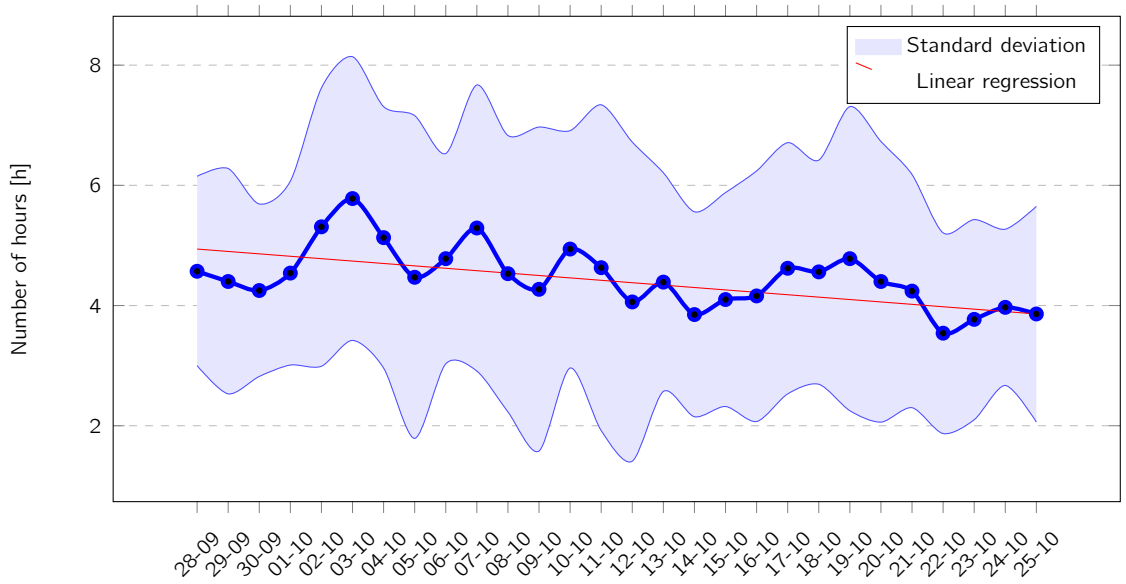


Figure 5.2: Average usage data, for each user, filtered by day. It is possible to observe that the linear trendline decreases, which indicates a reduction of smartphone use throughout the time. Filled blue areas represent the standard deviation.

- In the pre-questionnaire, it was asked about their perception of how much time they spent, on average, on the smartphone during the previous seven days, *i.e.* between 5th and 11th October;
- In the post-questionnaire, it was asked how much time was spent, on average, on the days that TORINGO was used, *i.e.* between 12th and 25th October.

About the perception before using TORINGO, Figure 5.3 compares the average usage time per day and their perception from the pre-questionnaire for the same time period. Considering the percentage change between these two groups of data, the median obtained was -25.75%, which indicates a general underestimation about smartphone use by subjects [3]. It is interesting to note that people tend to underestimate their smartphone use, since 68.8% of the subjects mentioned a lower value than the real one before using TORINGO.

About the period that TORINGO was used, Figure 5.4 compares the average usage time per day for all users and their perception from the post-questionnaire for the same time period. Here, considering the percentual change between their perception

[3] A Shapiro-Wilk test showed, at the level of significance of .05, that the data is not normally distributed ($W(16) = 0.7026$, $p < .001$). With that said, the median is the best measure of central tendency, since is unaffected by extreme values in one direction.

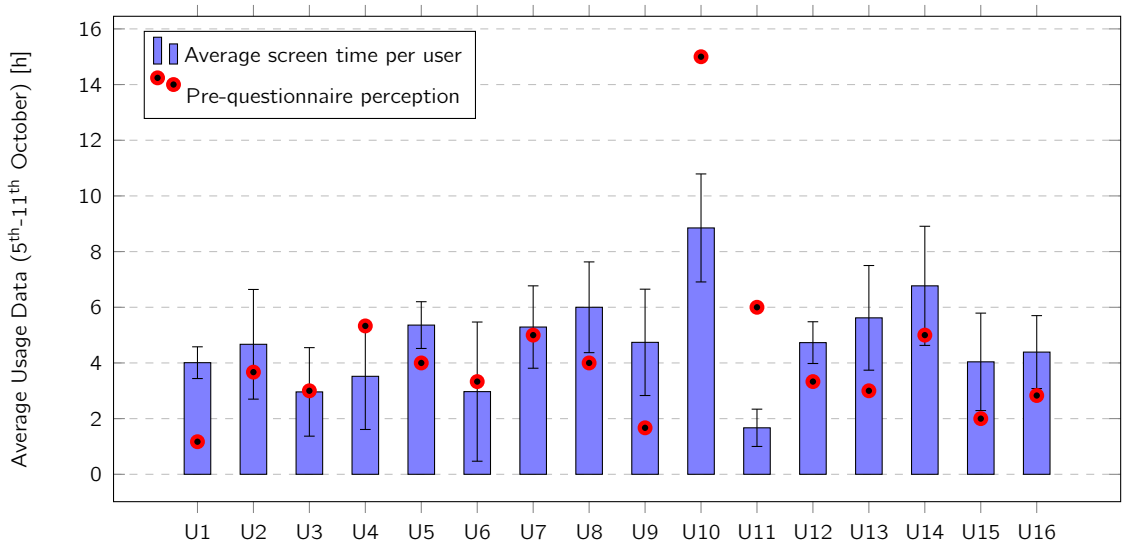


Figure 5.3: Average usage data, for each user, filtered by day, comparing with their perception after filling the pre-questionnaire.

and the real data, the median obtained was 10.31%, which indicates an overestimation about their smartphone usage [4]. This could be attributed to an increase in awareness on the users' part while making a conscious effort to decrease their overall smartphone use. When considering the period after using TORINGO, their perception was more realistic: only 31.3% of the subjects underestimated their smartphone use (that could be explained by the fact the floating widget was always displaying the total usage time).

This study reinforced the notion that users tend to underestimate the total time they spend per day, on average, on their smartphone, as was previously discussed by several authors [12, 16, 27, 28].

In short, it is possible to conclude that, since subjects were more aware of their smartphone usage data, they were more realistic about their smartphone use. When comparing the perceptions of their usage with the real values, after using TORINGO, it was revealed that the real value was only higher in five subjects out of the sixteen, *i.e.* only five subjects underestimated the time spent on their smartphones. This constitutes a decrease in half the number of subjects underestimating their usage, from the results of the pre-questionaire, from eleven to five.

Besides the general applications' usage data, the number of locks and unlocks were

[4] A Shapiro-Wilk test showed, at the level of significance of .05, that the data is not normally distributed ($W(16) = 0.8849$, $p < .05$). With that said, the median is the best measure of central tendency, since is unaffected by extreme values in one direction.

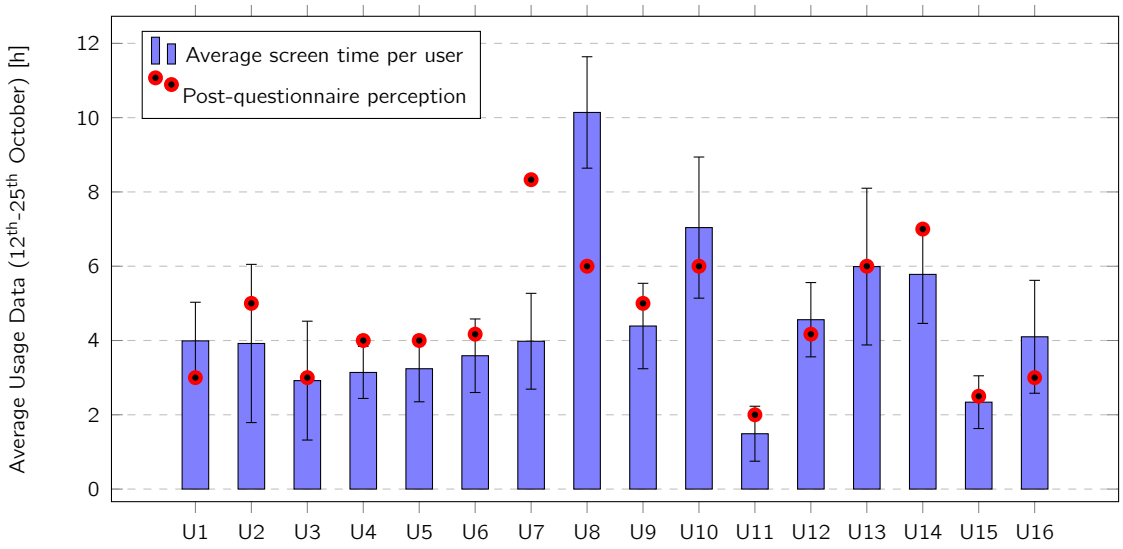


Figure 5.4: Average usage data, for each user, filtered by day, comparing with their perception after filling the post-questionnaire.

collected. This information was also shared with the users — as Figure 4.4 shows — in order to raise awareness about the frequency of unlocks. An unlock is what happens when the smartphone's screen is turned on and the smartphone is unlocked. This action should not be confused with only turning on the smartphone screen for a quick and repeated check/glance at the smartphone screen.

For Figure 5.5, it was considered the average number of unlocks for each user, during the period that TORINGO was in use. It is possible to observe that the linear trendline is decreasing, what allows us to conclude that unlocks were lower throughout the study protocol. This decrease may have been caused by the intended action of the designed application, since it allowed to track and monitor this data, as well as launch alerts to prevent that number from growing. However, the subjects' number of unlocks, during the 3rd and 4th week was around 73 each day (SD = 14.25).

It is curious to mention that during the weekends, marked with a red circle in Figure 5.5, smartphone unlocks were lower than in weekdays (with an outlier at 22th October), but when comparing these results with the smartphone usage data in Figure 5.2, a decrease of use in the weekends is not observed. Probably, the fast smartphone interactions, previously mentioned in Chapter 2, were lower due to unexistence of boundaries, like classes.

With the pandemic crisis, there was an increase in consumption of internet and, consequently, of smartphones, as the Portuguese study developed by SICAD (2020)

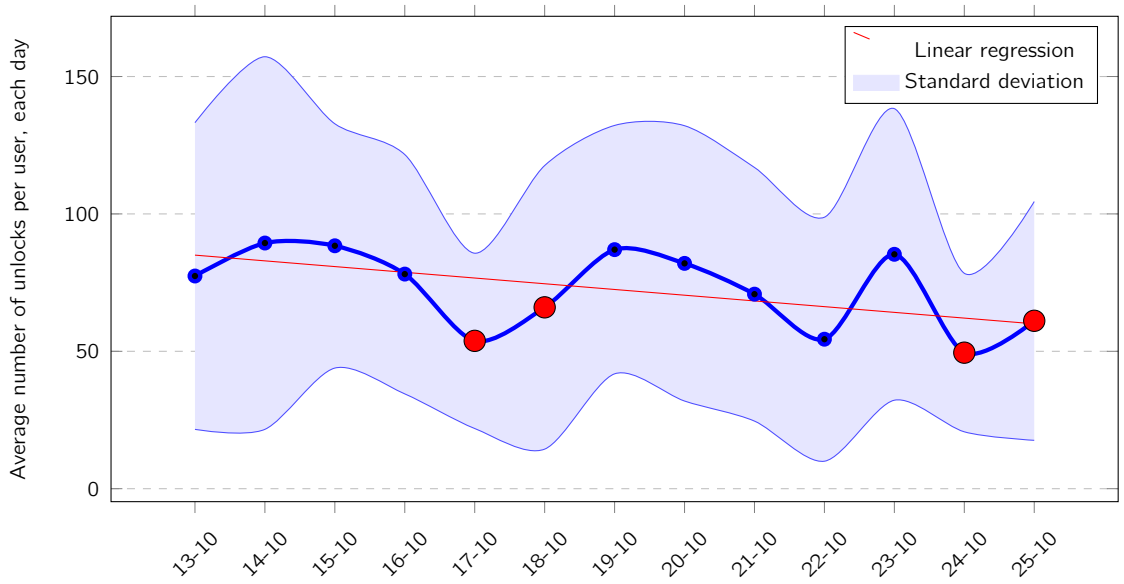


Figure 5.5: Average number of unlocks, for each user, filtered by day. It is possible to observe that the linear trendline decreases, which indicates a reduction of unlocks throughout the time. Weekends marked with a red circle and filled blue areas as standard deviation.

indicates [73]. In addition, according to the post-questionnaire, 75% of students reported that they used the smartphone for study and educational purposes, namely for video calls, consultation of online documentation — academic documents — and clarification of doubts.

Since the fact it was not possible to collect all the timestamps of the unlocks made on the days before the usage-tracking application was used, it is not possible to take any conclusions about the unlocks like was done for the smartphone usage data. However, Andrews *et al.* (2015) [27] mentioned that people have little awareness about how many times they usually unlock their smartphones.

Besides the general reduction of smartphone use by the subjects, the collected data from the questionnaires allows drawing some qualitative conclusions about the features offered by the application, as the floating widget, the goal definition and the chatbot.

5.2.1 Floating Widget

The main function of the floating widget is to raise awareness from the user about their smartphone usage. As shown in Figure 4.5, the floating widget is a service that

is displayed on the screen — that is even displayed while other apps are being used — that shows how much time the smartphone's screen is on. In order to evaluate the success of this approach, users' feedback was collected by asking several questions, after they used the developed application. And according to Figure 5.6, 81.3% of the subjects considered as beneficial for their "smartphone behaviour" to have the floating widget always on display, making sure that they know how much time they are using the smartphone.

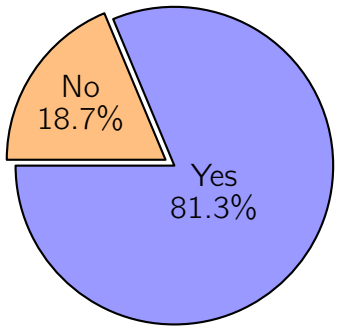


Figure 5.6: Perception of the users about having the floating widget always on display.

As specified in Section 4.2.5, the floating widget can assume different colors, with respect to the smartphone usage and the maximum goal defined time. Besides the fact that the floating widget is always displaying the time users are using the smartphone, 100% of the subjects perceive the colours' matching accordingly with the defined time goal as a helpful feature.

5.2.2 Defining a goal

It is important to understand if the ability to let users define an objective makes them more likely to do it and to work towards it. This research hypothesis is supported by existing social influence strategy theories, according to which people like to be consistent with the things they have previously said or done, as mentioned in Section 4.2.3. For this reason, in the pre-questionnaire, it was asked the users if defining a main goal and being reminded that they still have not achieved it, makes them work harder to achieve it. So, as Figure 5.7 shows, 68.7% of the subjects answered that they would work harder to achieve it.

Also, in the post-questionnaire, it was asked to users what was their perception after using the developed application and this feature. According to Figure 5.8, 81.3% of

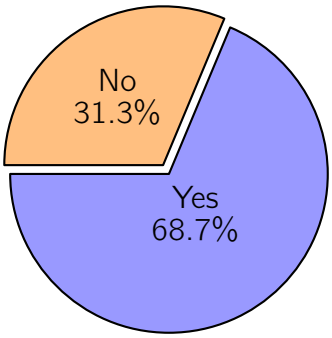


Figure 5.7: Perception of the users about defining a goal.

the subjects found useful the fact of defining a goal and letting the chatbot remind and alert them of it. Besides that, 68.7% of the subjects mentioned that they worked harder to accomplish the established goal.

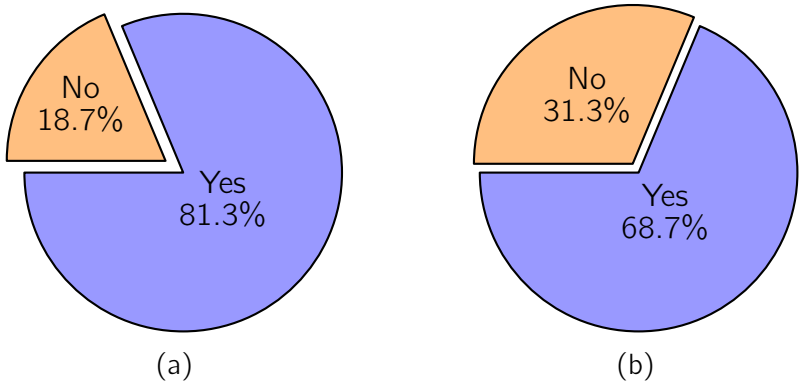


Figure 5.8: Perception of the users about (a) usefulness of defining a goal and being alerted by the chatbot and (b) if they worked hard for the established goal to accomplish it.

5.2.3 Chatbot

As described before, the developed application intended to track smartphone usage data and trigger chatbot messages to the users, in order to raise users' awareness and reduce their smartphone use. For this reason, it is important to know how users evaluate this feature, as the main functionality of the developed app.

Before installing the TORINGO app, 68.7% of the users answered that defining the maximum total time they want to spend on the smartphone as a goal and being alerted not to exceed it would encourage them to reduce the smartphone usage (Figure 5.9).

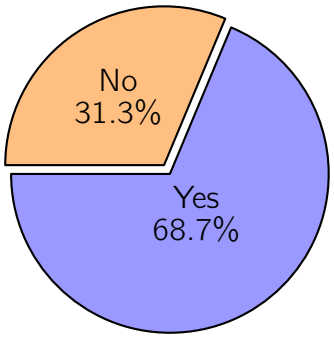


Figure 5.9: Perception of the users being alerted of their exceeded smartphone usage.

After using TORINGO, 100% of the users found the chatbot reminding and alerting them about the total time spent or the amount of unlocks on the smartphone as useful: "chatbot should send more alerts/notifications, there were few" (U12).

It is important to discuss, also, the users' perception about the way adopted to alert them about new messages from the chatbot. Throughout the Chapter 2, it was discussed that push notifications are considered as disruptive since they are implemented to get users as soon as they arrive, using sounds, vibrations and, in some cases, LED indicators [12, 57, 58]. Taking that into account, the proposed mechanism to alert the user for new conversational agent's messages did not use this approach, but a foreground in the floating widget — as discussed in Section 4.2.6. 100% of the users mentioned that the way the chatbot alerts users about new messages is not distracting/disruptive.

5.3 Limitations

As with all quantitative and qualitative studies approaching novel systems for behaviour change technologies, this study has its strengths and weaknesses. In terms of the limitations of the study, we highlight the following:

- Since that for these kinds of studies, one needs to collect personal data, gathering students available to participate was a demanding endeavour, even when letting students know the only data collected would be the amount of time they spent on their smartphones and the exchanged data with the developed app.

- The sample size is not sufficient, nor is the sample design adequate for it to be representative of the students at the University of Madeira. A non-probabilistic sample was built because we do not have access to the list of all elements in the universe. However, this methodological option responds to the objective that guided the study and gives us clues for more in-depth and generalizable studies.
- The study had a limited time duration. This means nothing can be claimed regarding the study's efficacy in long-term.
- It is not possible to filter the usage data by equipment, which does not allow to know for how long and in which periods the WMD were used. However, as the way the database is designed, it is possible to know all the time spent in WMD by each user.
- Since Android 8.0 (API level 26), in order to improve the user's experience, there are imposed limitations on what apps can do while running in background, what limited the available options to collect smartphone data from older Android versions [5].

[5] See more at `https://developer.android.com/about/versions/oreo/background`.

Chapter 6

Conclusions and Future Work

— Responsibility is proportionate to opportunity.

Woodrow Wilson (1856-1924)

6.1 Conclusions

Smartphones can be compared to Swiss Army Knives since people can use them for both leisure and work purposes. For this reason, it is difficult to know if people are using them most productively and rightfully. Knowing that people like to be consistent with the things they have previously said or done [114], it is important to establish limits and try to find innovative ways to guarantee people's digital wellbeing.

In this work, an approach was presented that triggers conversational agents alerts according to smartphone usage data. The smartphone usage data was collected throughout four weeks for 16 University of Madeira students — since young people are more willing to try out new technology and thus be more prone to problem use, that also rely heavily on smartphones. This approach was revealed effective in reducing smartphone usage: 81.3% of the participants reduced their smartphone use in the two weeks they used the developed application, when comparing with the first two weeks before installing it – a period that allowed knowing subjects' behaviour on the smartphone. Also, people get more aware of their smartphone usage, since they tend to underestimate the time spent each day on these devices.

About the number of unlocks, these were lower throughout the study protocol, what proves that the developed approach can be used also to reduce the number of times people check the smartphone.

6.2 Future Work

For future work, it would be interesting to add voice inputs into the conversational agent, besides using quick replies. Also, it could be interesting to define goals other than reducing the overall usage time, since the main goal is to try to humanize the users' decisions, as the following example:

- Chatbot (CB): Hi! Choose an app you want to use less. I will help you during the following week! I suggest (example) because it's the app you use more.
- User (U): (User introduces an app)
- CB: Deal! Let's set a maximum limit per day of how much time?
- U: (User introduces a number in minutes: 10, 20 or 30 min)
- CB: Okay, I will alert you until you're bored using it! :D

This would be a process that would happen fluently and discretely throughout a chat with the conversational agent, persuading the user to take actions that would benefit its smartphone usage management. The goal is not to press or compel the user to stop using an app (*e.g.* blocking it) but talking with a conversational agent that persuades the user to make slight differences in their behaviour, bringing them to a conscious state so and that the initiative to stop using the application (so much) comes from the user. The aim is for the user to do something not because they are forced to, but because they want to.

It would be interesting if the chatbot was expanded, not only to alert the user but also to be a digital therapist, giving advice and tips. Besides that, it would be very interesting having the Google Assistant with all of these functionalities – or, at least, some of them.

With the ambition to publish the application on the market for general use, there is, in addition, a set of modifications that could be made to guarantee its potential:

- First of all, after installing the application and login successfully on it, the chatbot starts to meet the user to present the app goal and obtain some information that allows it to define user personality:
  - What kind of activity the user does: if it is a student or not, what is their job, ...;
  - How the user is feeling;

  - What the user think about their smartphone usage, as the primary perception;
  - Understand what motivated the user to install the application, to understand how the chatbot can act and help the user. For example, what made them think that they spend too much time on given apps, so the chatbot can focus on those applications and compare the time spent using them for comparing with other apps and monitor those apps' usage more rigidly;
  - Identifying all user devices, to track all usage data independently of the device.

- During the first weeks, the chatbot would be collecting data and obtaining the user's behavioural and personality traits, without acting with alerts about their smartphone usage;
- Share with the user, after this initial period, a summary with the usage data;
- Define the objectives for the user, in terms of access numbers, unlocking the phone, maximum time, or what that user would like to do on smartphone on that day (*e.g.* spend less time on social media today or decrease the number of WhatsApp's accesses);
- Then, the chatbot could start triggering alerts according to the defined objectives and the smartphone usage's patterns by user;
- Regularly conduct surveys to obtain subjective data (*e.g.* each 2 weeks or 1 month) to compare their perception with the data obtained from using the mobile phone and follow the smartphone usage evolution;
- Using Big Data and Machine Learning concepts, the chatbot could do it by itself, acting in an assertive and personalized way for each individual, with the appropriate and necessary information to guarantee the digital wellbeing of the user.

These are quite ambitious objectives, but which, according to the results obtained in this work, may be very promising.

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Appendix A

Pre-Questionnaire

During this study, the application will be able to collect, for research purposes:

1. All the exchanged data through the app, which includes the messages sent to the chatbot;
2. The total time using the smartphone during five consecutive days;
3. The entire time used divided by application during 12 straight days (7 days before and five days relative to the study period);
4. The number and the timestamp of each screen lock and unlock.

If you do not feel comfortable with that, please let me know before continuing.

A.1 General

- How old are you?
- What is your gender?
- Do you evaluate yourself as a smartphone-addicted?
- How much time do you think it's necessary to spend each day, on average, to make a smartphone-addicted person?
- How much time do you think you used the smartphone on average, per day, during the last 5 days?
- How many times do you think you unlocked the smartphone on average, per day, during the last 5 days?

A.2 Usage Track Apps

- Does your smartphone have the ability to show usage data (Digital Wellbeing tool, for example)?
  - If yes, do you usually use or check it?
  - If not, it is through a third-party application?
- Did you ever use an application that tracks:
  - Your smartphone usage?
  - Your smartphone unlocks?
- At this moment, do you use an application that tracks:
  - Your smartphone usage?
  - Your smartphone unlocks?

A.3 Studying

- With the COVID-19 pandemic crisis, do you find more stressful during this period?
- Did you find it more challenging to obtain concentration and focus on studying?
  - If yes, why?
    - Studying at home is a challenge, due to the constraints;
    - Virtual classes are challenging to support and keep contact;
    - Distractions, meaningly smartphone, did not allow me;
- Do you think that you used more time your smartphone to keep in contact with friends and colleagues during the COVID-19 pandemic crisis than you usually do?
- How do you classify your smartphone as a distracting tool during your study?
- Do you think that you spent, overall, more time on the smartphone during the COVID-19 pandemic crisis than you usually do?

A.4 Application

- Would you say that defining the maximum total time you want to spend on the smartphone as a goal and being alerted to not exceed it, encourages you to reduce the smartphone usage?
- Would you say that defining a main goal and being reminded you still have not achieved it, makes you work harder to achieve it?
- Would you be comfortable if a virtual assistant chatbot alerts your behaviour on the smartphone accordingly with your usage?
  - Would you prefer to talk about your smartphone behaviour with a chatbot or a person?
- Do you think that you would be comfortable talking with a chatbot about your smartphone usage and behaviour?
- Some notes you want to share?

Appendix B

Post-Questionnaire

During this study, the application will be able to collect, for research purposes:

1. All the exchanged data through the app, which includes the messages sent to the chatbot;
2. The total time using the smartphone during five consecutive days;
3. The entire time used divided by application during 12 straight days (7 days before and five days relative to the study period);
4. The number and the timestamp of each screen lock and unlock.

If you do not feel comfortable with that, please let me know before continuing.

B.1 General

- How much time do you think that was spent on your smartphone during the time you used the app, on average?
- How many times do you think that you have unlocked your smartphone during the time you used the app, on average?

B.2 Previous Usage Stats

- After being aware from the app data, do you think that the amount of time that you spent on the smartphone reduced?
- Do you think that the amount of time that you spent on the smartphone, after using this application, it is an horrifying number?

- After being aware from the app data, do you think that the number of times you unlocked the smartphone reduced?
- Do you consider that the number of times you have unlocked the smartphone, during the period you have used this application, it is an horrifying number?

B.3 Studying

- During the test period, did you use your smartphone for study purposes?
  - If yes, select those appropriate options:
    - Reading documents;
    - Talk with friends/colleagues to clarify doubts;
    - E-conference & e-learning platforms;
    - Others.
- Did you need more time to study between:
  - 8th and 12th June;
  - 15th and 19th June;
- Do you think that this app makes you feel less stressed and more focused during periods of study?
- In general, do you think that this app reduced your smartphone-usage during periods of study?

B.4 Floating widget

- Do you consider it is beneficial for your "smartphone behaviour" to have the floating widget always-on display, making sure you know how much time you are using your smartphone?
- Do you find the floating widget uncomfortable and intrusive, since it is always displayed on screen?

  - If you find it uncomfortable, what do you think that would solve the problem?
  - Making the floating widget more transparent;
  - Reduce the size of the floating widget;
- Besides the fact that the floating widget is always displaying the time you are using the smartphone, do you perceive the colours' matching accordingly with the defined time goal?

B.5 Chatbot

- Do you find useful the fact of defining a goal and letting the chatbot reminding and alerting you of it?
- Do you think that defining a goal incentivized you more to accomplish it and to work towards it?
- Do you find useful the fact of the chatbot reminding and alerting you about the total time spent or the amount of unlocks on the smartphone?
- Do you think that the way how the application delivered the chatbot notifications was pervasive (through the black dot in the corner of the floating widget)?
- Do you think that the fact of letting a chatbot collect and analyze your data to alert you, makes you feel that your privacy was invaded?
- Did you expose your smartphone behaviour concerns with the chatbot?
  - If not, why?
    * I didn't feel comfortable talking about my smartphone usage with a chatbot;
    * I don't find it so friendly or interesting to talk with it;
- What do you would change in the chatbot functionalities?

B.6 Final Comments

- Do you want to leave some comment about the app?

Appendix C

Free, Prior and Informed Consent Protocol

Free, Prior and Informed Consent Protocol Study Participation

Master's Dissertation in Informatics Engineering

You were selected to participate in a scientific study conducted by Carlos Reinaldo Silva Abreu (2020514@student.uma.pt), Master's student in Informatics Engineering at the University of Madeira (www.uma.pt), whose goal is to understand the frequency and the perception of smartphone use by higher education students, – in this case, from the University of Madeira – during this semester. In order to obtain an accurate report, it is very important to know your experiences regarding the use of the smartphone as a higher education student.

Your participation is voluntary, that is, you will be able to abandon this study at any time if you wish, without this decision having any consequences for you. Thus, it is asked if you are interested in participating and answering a set of questions, individually, anonymously and confidentially, within the scope of the master's dissertation conducted by the person in charge above.

As with scientific research, your answers are not shown to anyone with your identification and nowhere will it reveal who you are. So, if you agree, we appreciate that you answer the following questions clearly:

- I understand that the information I will provide will be treated confidentially;
- I agree to be interviewed (if necessary), but I realized that I can give up the investigation at any time;

- I understand that the interview (if necessary) will be recorded with a voice recorder and transcribed;
- I agree to be contacted in the future to decide if I want to be part of the investigation again, if necessary;
- I understand that the data I will provide will be archived;
- I understand that nothing about my identity will be made public;
- I agree that the data will be used by students, teachers and researchers for other research and publications;
- I confirm that I completed and signed the Free, Prior and Informed Consent Protocol when inquiring by the person in charge of this scientific research work.

I have read this document and am aware of what to expect as regards my participation in the dissertation of the responsible person indicated above. I had the opportunity to ask all the questions and the answers answered all my doubts. Thus, I voluntarily accept to participate in this study.

(Name and signature of the subject)

(Date and Place)