# Cognitive Bias Modification on Tabletops

Jose Ignacio Rocca Temesio
Supervisor: Prof. Russell Beale

Submitted in conformity with the requirements
for the degree of MSc. in Human-Computer Interaction
School of Computer Science
University of Birmingham

# Declaration

The material contained within this thesis has not previously been submitted for a degree at the University of Birmingham or any other university. The research reported within this thesis has been conducted by the author unless indicated otherwise.

Signed ..........................................................................................................

# Abstract

Interest in Cognitive Bias Modification (CBM) has been increasing in the field of Human Computer Interaction recently. CBM is usually presented as a training mechanism in desktops computers in the context of psychology therapy. Tabletop technologies can provide an interesting platform for delivering CBM training effectively due to their unique characteristics. However, no evidence of previous CBM interventions over Tabletop has been found. Furthermore, Smartphones are part of our daily life and although using these devices is highly enjoyable, most users develop a psychological dependency over them and lose control on its usage creating an addictive behaviour. Smartphone addicts can experiment problems such as low productivity, social isolation, mood changes, and sleeping disorders among others. In this report we present an experimental study that explore the feasibility of a CBM intervention on a Tabletop to counter Smartphone addiction. An Approach Avoidance Task (AAT) prototype was developed an deployed in a Microsoft Surface. 40 participants were recruited to receive CBM training. Our preliminary results provide evidence of a possible approach bias towards the Smartphone device and interesting interactions between the factors of our experiment. Although further data analysis is required to strongly support these claims, our study provide interesting insights for both Smartphone addiction and CBM research fields.

# Acknowledgements

To begin with I would like to give thanks to my family who supported and encouraged in my MSc journey. Without your love and guidance in each step of my life I would not achieve anything. I would also want to thank to all my friends and colleagues back home and those new friends this year abroad has given me, thanks for making this trip much more interesting. Moreover, I wish to express my gratitude to all the professors and fellow students at the Computer Science School, especially to Russell Beale and Charlie Pinder my supervisors who were an inspiration to complete this project. Thanks to Bob and Rowanne, who guided me during this project. I would like to thank the 40 participants who give their time to help me with my research. Finally, I would like to thanks the Chevening Scholarship Programme and the Uruguayan National Agency for Research and Innovation (ANII) for sponsoring my MSc in Human Computer Interaction.

# Contents

# List of Figures

# List of Tables

# Chapter 1

# Introduction

The aim of this research report is to address the design, development and evaluation of a Cognitive Bias Modification (CBM) intervention on a Tabletop to counter Smartphone addiction. In this chapter we introduce the main concepts and objectives of the study.

## 1.1 Cognitive Bias Modification

Cognitive Bias Modification (CBM) can be defined as "a direct manipulation of a target cognitive bias, by extended exposure to task contingencies that favour pre-determined patterns of processing selectivity" [28]. These procedures attempt to change biases that are thought to contribute with undesirable emotional reactions or disorders [18].
As it will be presented in Chapter 2, previous studies have shown that cognitive biases can indeed be modified. Moreover recent literature reviews in this field, remark an increasing interest in the use of this non-conscious behaviour change technique [8].
Dual Process Theories (DPT) state that several behavioural decisions come from a fast, associative and automatic set of non-conscious processes, usually referred as system one. On the other hand, the system two is composed by a set of abstract, rule-based, logical and serial processes that can not block system one automatic responses. Therefore most of our desirable and undesirable

behavioural impulses reside in our non-conscious system. Most of the research done in the field of technology behaviour change interventions is usually based on more rational models of ration-action such as the Theory of Planned Behaviour or the Transtheoretical Model. However, recents studies, for example in the abandonment of activity trackers [7, 14], provide empirical evidence that these behaviour change approaches tend to fail in the long term. CBM in contrast, try to modify the unconscious, fast and automatic processes so that the *"default"* behaviour becomes the *"desired"* behaviour, rather than having to rely on cognitively costly self-control or remembering techniques.

## 1.2 Smartphone Addiction

Nowadays, Smartphones are present everywhere and every time making our daily lives substantially easier. A study conducted by Dscout [12] in 2016 show that the average person uses his or her device approximately 145 minutes, engaging around 76 separate phone sessions with different kinds of applications, on a daily basis. The experience of using a Smartphone is highly enjoyable [44] because these devices provide not only the traditional features related with making calls and sending text messages, but also a variety of value-added features such as social networks, games, camera and video, music, localization and maps.
However, as Shambare et al concluded in [46], the use of the Smartphone can be "dependency-forming, habitual and addictive". As a result, users can create an unhealthy dependency with their device or some application which can lead to negative consequences such as low productivity, social isolation, mood changes, and sleeping disorders among others. Empirical evidence, that will be analysed in detail in Chapter 2, show that Smartphone users may develop a psychological dependency and lose control on its usage. Smartphone addiction is a form of Information Technology (IT) addiction and can be defined as the user's maladaptive dependency on the usage of Smartphones and the obsessive-compulsive use of the devices [4].

## 1.3 Tabletop Technologies

A Tabletop is defined as a large surface that affords direct, multi-touch, multi-user interaction [33]. Although the term Tabletop was first used in 2001, the relevant research on this field began in 1992 [55] with a desktop pad display that was overlooked by a projector and some cameras. Since then, the features and possibilities around these devices have been improving and increasing, but, despite the advances on the underlying hardware and software technologies, Tabletops have not reached a mass market yet [33, 2].

Most multi-touch Tabletops, which are similar to traditional tables, allow new forms of gesture interaction and novel visualizations combining the physical and digital environments by placing objects over them. Research related with Tabletop technologies is focused mainly in three fields, Computer Support Collaborative Work (CSCW), Human Computer Interaction (HCI) and Ubiquitous Computing [33].

These technologies have been used in different contexts like museums, public spaces or more private settings [43], to support a wide range of individual and collaborative applications such as designing [40], planning tourism sight-seen [31], photo sharing, playing games [39], learning or map navigation.

## 1.4 Motivation

The increasing problem of technology and Smartphone addiction needs to be analysed from a CBM perspective. It is important to define and explore the possible cognitive biases and cues that trigger the user unwanted behaviour in order to design suitable interventions to modify those biases.

Moreover, no evidence or prior research has been found on the development of CBM interventions using Tabletop technologies. Research is needed in this field to explore the feasibility of the platform to deliver CBM training. For example, the unique characteristics of Tabletops could improve the effectiveness of some CBM interventions.

Consequently, the aim of this study is to analyse the relevant gaps in the literature and present a prototype implementation and experimental study that

provide relevant evidence and insights in the fields of CBM interventions over Tabletops. We will be focusing in the domain of Smartphone addiction, which as we state before remains unstudied from a CBM perspective.
This report organizes as follow. In chapter 2 we present the relevant background related with CBM techniques, Smartphone addiction and Tabletop technologies. In chapter 3 we introduce our experimental design for a CBM intervention on a Tabletop to counter existent biases on Smartphone addicts. In chapter 4 we discuss and analyse the results of the experiment and finally in chapter 5 we draw up our conclusions.

# Chapter 2

# Background

The aim of this chapter is to present the previous work and relevant literature related with CBM, Smartphone addiction and Tabletop technologies.

## 2.1 CBM previous work

There are 4 broad types of CBM interventions [36] depending on the kind of bias each intervention attempts to change. First, CBM-Attention (CBM-A [37, 45, 9]) aims to change attentional biases towards particular cues. Usually, CBM-A interventions train our attention to alternative cues or away from the original unwanted cues. Second, CBM-Approach (CBM-Ap [41, 59, 61]) has the objective of reducing approach biases from unwanted cues and increase the approach biases towards wanted cues. Third, CBM-Interpretation (CBM-I [53, 56, 25]) focuses in alter biases that interpret ambiguous information in a negative or undesired way. For example, it is possible to train patients to interpret ambiguous stimuli in a positive way, by completing neutral sentences with positive valence words. Finally, CBM-Memory (CBM-M [20]) focuses in changing memories related with negative information. Next we are presenting some relevant pieces of CBM research.

### 2.1.1 Relevant interventions

First, regarding CBM-A techniques, in [9] the authors conducted a series of studies in order to confirm and modify a cognitive bias towards social threat and responsiveness on subjects with low levels of self-esteem. The training task which was implemented in a touch screen panel, consisted in finding a positive face in a grid with rejecting or threatening faces. Their findings document the capacity of attentional training to modify people's vigilance for threatening social stimuli by training their attention away from rejection.
Then, Wiers et al. [59] presented an important piece of CBM research after conducting 4 training sessions (15 minutes each) with a CBM-Ap training task designed for alcoholics. The task, based on previous research by Rinck et al. [41], consisted in pushing away images of alcoholic drinks and pulling images of soft drinks using a joystick. This kind of task is usually known as Approach-Avoidance Task (AAT). Wiers et al. findings show that these training sessions had a small but significant effect on the patient's relapse rate when measured one year later (59% relapse in control versus 46% relapse in experimental group). This piece of work is also important because they could obtain and measure the effects of the intervention in the long term.
Furthermore, regarding CBM-I (one of the most common approaches used by researchers [16, 8]), in [25] the authors, presented a CBM-I intervention that tried to modify biases towards intrusive negative thoughts which is a condition of depression. The intervention was conducted in one unique session using E-Prime software. The training task consisted in paragraphs descriptions that remained ambiguous until the final words and the participants were presented as to-be-completed word fragments, positive or negative according to their experimental condition that resolved the valence/ambiguity of the paragraph. After that, participants watched a depressive film and monitored the occurrence of depressive intrusions in a diary for one week. Their findings show that it is possible to manipulate the maladaptive appraisal of intrusive negative thoughts.
Finally some authors explored combining different CBM techniques or approaches in order to improve the efficacy of the intervention. For example

in [36], a combined approach between CBM-A and CBM-Ap was designed as part of a study focused on increasing the consumption of healthy foods. In this study, the authors designed a task to unlock a Smartphone (incidental behaviour change) by accepting healthy and rejecting unhealthy foods (CBM-Ap). However they increased the rating in which healthy food was presented to the user at a ratio of 9:1 and therefore, they also are addressing the attentional bias towards healthy food. Their main findings after conducting a pilot study are that a short course of incidental Smartphone CBM alters some measures towards food attitudes.

### 2.1.2 Summary

To summarize, some literature reviews and meta-analysis in the field of CBM should be analysed. To begin with, in [22] the authors claim that the whole research field is moving towards delivering longer interventions within more realistic settings, applying several technologies for deliver CBM training. To design an effective intervention it is important to identify first the targeted bias and then design the training task, which should be focused on extensive practice of a cognitive task rather than on a conscious instruction. This idea is also supported in [60], although in some cases, it is not clear if all biases should be targeted together or separate. Also, the content used to address the different biases is crucial to ensure an effective training.

Furthermore, as the main idea behind CBM is to generate behavioural change, it is essential to define measurements of the targeted behaviour in order to evaluate the efficacy of the intervention. Those behavioural measures should be, ideally, taken pre-, during and post- intervention including long term measurements [38]. However, this is difficult for most CBM studies. A possible approach would be combining a validated measure of habit, such as the Self-Report Habit Index, with more implicit techniques of evaluating non-conscious activity, for example Stroop test, response times, errors committed in tasks, or similar.

Finally, two interesting meta-analysis articles focused on the size effects and results of applying CBM training in the domain of anxiety and depression were

detected. In this context, CBM had stronger effects for interpretation biases compared to attentional biases [16], despite that the overall effects sizes observed in anxiety and depression are small. In [8], the authors claim that many positive outcomes, may be driven by extreme outliers, small and low-quality trials and publication bias.
To conclude, the relative small size of the effects have a direct impact on the experimental design and sampling strategies, because we will need a bigger sample in order to detect and provide statistical support for the effects. Also, it is important to state that several studies have provided evidence on the existence of such effects across different domains. In the Table 2.1 on page 15 we present a brief summary of all the CBM interventions analysed.

## 2.2 Smartphone addiction

As stated previously, Smartphone addiction is a form of Information Technology (IT) addiction, which can be classified as a behavioural addiction, such as gambling or compulsive shopping. In [50], Turel et al. described the symptoms for IT addiction and therefore it is possible to identify and describe similar symptoms for Smartphone addiction [5].
Firstly, salience, the Smartphone dominates user's thoughts and behaviour. Secondly, withdrawal, when negative emotions arise if the person cannot use the device. Thirdly, conflict can occur if the usage of the device conflicts with other important tasks and for example affects the user productivity or concentration. Fourthly, relapse and reinstatement can be detected if the user fails to reduce the Smartphone usage voluntarily. Fifthly tolerance if a greater usage of the device causes thrill. Finally, mood modification if the device usage produces thrill and relief altering the user's mood.
As a result of this condition a person can experience disrupted emotional functioning, compromising its social life, affecting school, family and work negatively [26, 52].It has been widely discussed that technology addiction goes beyond the concept of technology overuse, high engagement or habitual use [6, 26]. As stated by Roberts et al. in [42] Smartphone addiction "does not happen overnight, and, like most forms of behavioural addiction, occurs via

a process". Addicts may start with a benign behaviour, such as owning a Smartphone to stay in touch with family and friends, but may become more dependant on the device as they start checking email, Social Networks, and eventually engaging dangerous behaviours such as texting while driving [42]. Therefore, there is a continuous line between the habitual use of technology, the over-use of technology and finally the dependant addictive behaviour described previously. In this section we will analyse some relevant research related with Smartphone addiction.

### 2.2.1 Prevalence and scales

According to the World Health Organization (WHO) [57] the prevalence found in previous studies vary by age (being higher in adolescents and young adults compared with older people) but also in geographical and socio-cultural factors. For example, in British adolescents the prevalence of this problem is around 10% [27], meanwhile in Switzerland is close to 17% [17]. However, the report of the WHO state that epidemiological research in this field has usually faced unreliable data and measurement challenges. New scales and diagnostic instruments should be defined internationally in order to provide clear data about the prevalence of this problem worldwide.
For example, Roberts et al. in [42] proposed a self-reported Smartphone addiction scale composed by 4 questions on a 7 points Likert-type scale. However, the scale has no psychometric evaluation and hence may not diagnose the condition properly. Furthermore in [24] the authors developed a self-diagnostic technique and a scale for evaluating Smartphone addiction (Smarphone Addiction Scale, for short SAS). The scale is based on the on the Korean Scale for Internet addiction (K Scale) and consists of 48 questions. The questions are all weighted equally on a 6-point likert scale and then grouped into six sub-scale factors. The six sub-scale scores are summed up to yield a total SAS score with a range between 48 and 288. The higher the score the more serious the addiction. Finally the same authors in [23] developed a short version of the scale composed by 10 questions (SAS-SV), then the scores of the SAS-SV range from 10 to 60. The study establish, after conducting ROC analysis, a

cut-off value for predicting Smartphone addiction of 31 for male and 33 for female.
Even though the field of Smartphone addiction is rather new and more understanding about this issue is required, recent research has provided interesting insights which are presented in this section. For example, in [43] the effects of habitual use, perceived enjoyment and type of user were related with Smartphone addiction. It is also interesting to analyse literature related with the broader field of technology addiction in order to get better understanding and possible solutions to tackle this problem.

### 2.2.2 Habits and biases

In [34] the authors identified the Check habit as one of the most important habits that Smartphone users form. This habit is related with social networks applications, messaging, email and notifications. Cognitive psychology defines habit as an automatic behaviour triggered by situational cues such as places, people or preceding actions [62, 48]. Habits are executed unconsciously without too much effort under the fast and associative system one, making them difficult to stop. The Smartphone Check habit may be triggered by internal (boredom) and external (seeing the device on the table) cues. Once the behaviour is triggered by these cues, the Smartphone provides access to content quickly. Moreover, most applications are designed with feeds and other mechanisms that grant a variable systems of rewards to the users, making their habit formation even stronger [29, 3]. As stated previously, this habit can generate overuse and long term dependency if is not controlled. Furthermore, in [49] Turel et al. discusses the mobile email overuse and its addictive potential due to the pervasive and ubiquitous characteristics of Smartphones.
Alternatively, in the field of technology and gaming addiction there are some interesting insights that can be taken into consideration when thinking about Smartphone addiction. In [51] the authors presented empirical evidence showing that the overuse of auction sites (such as Ebay), modified the user's belief system, their perceived enjoyment and usefulness. As a result, some level of addictive or problematic behaviour was detected. The users also developed some

cognitive biases towards their purchases experiences. Firstly, emotional bias, when the users minimized negative and maximized positive aspects of a purchase experience. Secondly, confirmation biases occurred when the users looked for and used information to confirm their existing predispositions and beliefs about the site. Thirdly, biases towards re-evaluating the purchase, seeking for logical arguments, were detected. Finally, some cognitive dissonance biases, which tried to solve opposite thoughts about the user's behaviour (shame vs perceived rewards) were also reported.
Finally in [32, 10] the authors of these studies, provided evidence of the presence of attentional biases in addicted gamers of internet massive multi-players. In both articles, there is consensus that excessive on-line gaming closely resembles a behavioural addiction such as pathological gambling. It is believed that over time, addictionassociated cues (like gaming keywords) acquire the ability to capture addicts attention. What is more, this process is thought to occur both automatically and implicitly.

## 2.3 Tabletops research

Tabletops technologies have been studied in several domains of application such as education and collaborative learning, tourism, healthcare, gaming and entertainment, among others [33, 31]. Especially, the collaborative aspect of these technologies has been addressed by several studies which are analysed below. The aim of this section is to present previous Tabletop applications and studies that increase our understanding about the special characteristics of this platform.

### 2.3.1 Games and rehabilitation

In [11], Delbressine et al. presented a prototype for a Tabletop game which, combined with a wearable device, helped stroke patients to train and improve their arm mobility. Their preliminary findings over an evaluation of the prototype show that their approach oriented on playful rehabilitation tasks was successful and further features and games could be developed in order to help these patients. Moreover in [39] the authors developed and evaluated a Tabletop game designed for training social skills and collaboration in youngsters with Aspergers Syndrome (a syndrome similar to autism). This work provide a starting point for thinking in broader contexts and users populations for effective Tabletop interventions in the context of group therapy. Finally in [13] the authors developed a Tabletop game focused on older adults. The objective of these games developed as part of the Eldergames project, was to train several cognitive abilities such as memory, reasoning and attention, which usually decrease with ageing. In their prototype the interaction is made using pens and the whole hardware was built as part of the project thus, no commercial Tabletop technology was used.

### 2.3.2 Platform characteristics

Relevant insights about Tabletop usage are reported in a survey conducted to researchers and developers by a Microsoft Research team [2]. One of the main findings, is that Tabletop sessions are typically between 15 and 60 minutes due to ergonomics of the horizontal layout. This should be considered when designing CBM intervention for a Tabletop.

Moreover interesting future trends for these technologies were reported as part of the survey. For example, the need for other types of inputs like a stylus or physical objects. This may change the way of interacting with Tabletop applications, possibly affecting also future CBM interventions. In addition, rotating from a horizontal (suitable for collaboration) to a vertical (suitable for individual work) display arrangement was reported as a future desired feature. This would allow longer training sessions for individual CBM treatment for example.

Furthermore, regarding the collaborative characteristics of Tabletop platforms, in [43] the authors explored if horizontal or vertical displays improved collaboration. They found that, as expected, horizontal displays improved the switching between roles, awareness and exchange of ideas. In the same way, in [19] higher levels of awareness were detected on multi-touch collocated groups working on collaborative tasks.

Finally Marshall et al. in [31] presented an field study of a multi-touch Tabletop application for collaborative planning of activities in a tourist centre. Their findings on how groups approach to Tabletop in the wild differ from what previous results in a lab context had obtained. These results provide insights for the design of Tabletop applications for use in public settings for collaborative tasks which would be an interesting context for a future CBM intervention.

## 2.4 Discussion

As a result of analysing the relevant literature related with CBM interventions, Smartphone addiction and Tabletop technologies, we identify several research gaps that could be address by different approaches.

Firstly, the Smartphone addiction field needs more studies in order to identify the prevalence, causes and possible treatments for this condition. In terms of Smartphone addiction from a CBM perspective, studies are needed to characterize the specific biases and possible cues that trigger the user's unwanted behaviour (for example, the checking habit). Some of these studies could be conducted as surveys, interviews or observational studies. However, it would be really difficult for most users to explain which are the cues that trigger their unconscious behaviour. Is it the presence of the device over a table or desk? Is it the disruptive nature of notifications that cue the checking habit? Is it the specific application icons (e.g. Facebook, Twitter, etc.) that trigger the behaviour or maybe a combination of different cues? Therefore, in this context, adopting an iterative approach in order to validate possible hypothesis would be more effective.

Secondly, how to effectively implement a CBM intervention over Tabletop technologies is still an interesting question. Do the special characteristics of these platforms improve the size effects of CBM interventions? As we analyse previously, the size, orientation and interaction of Tabletops could improve the effects of a CBM intervention due to more realistic settings in comparison with other platforms. Regarding this hypothesis, comparative studies between, for example, a PC, a Smartphone a Tablet and a Tabletop, could be executed. In addition, the feasibility of Tabletop technologies for delivering CBM interven-

tions (mainly CBM-A and CBM-Ap types) has never been addressed before.
Finally, what are the characteristics of collaborative CBM interventions? Is it possible to take advantage of the Tabletops collaborative possibilities to implement a successful intervention? Will this possibilities increase the size effects or improve the treatment outcome? These questions could be answered by conducting more studies.

In the next chapter of this report, we are presenting a study that answers some of these questions and provide interesting insights for the CBM and Smartphone addiction body of knowledge.

Table 2.1: Summary of CBM interventions

| Ref | Type | Domain | Tech | Intervention | Post Analysis | Size Effects |
|---|---|---|---|---|---|---|
| [9] | CBM-A | Social threat/selfesteem | Web | Single | After intervention | $F(1, 15) = 4.81$, $p = 0.044$ |
| [45] | CBM-A | Threat/Anxiety | Web | 18 day training | After intervention | $F(1, 38) =,4.60$, $p = 0.05$ |
| [37] | CBM-A | Hoarding disorder | Tablet | Not executed | Not executed | Not executed |
| [41] | CBM-Ap | Fear to spiders | Desktop | Single | After intervention | $F(1,24) = 12.39$; $p = 0.002$ |
| [59] | CBM-Ap | Alcohol | Desktop | 4X15 min sessions | 1 year questionnaire. | 59% relapse in control group,46% in experimental group |
| [61] | CBM-Ap | Smoking | Web | Single | 4 weeks questionnaire. | sAAT:$t(37) = 2.93$, $p=.006$,mAAT:$t(32) = 2.95$, $p=.006$,CG: $t(54) = 1.26$, $p = .212$. |
| [25] | CBM-I | Depression | Desktop | Single | After intervention | $t(41) = 2.39$, $p= .02$ |
| [56] | CBM-I | Disgust biases/Anxiety | Desktop | Single | After intervention | No significant differences |
| [53] | CBM-I | Self-Stigma/Psychosis | Desktop | Serious game | Not reported | Not reported |
| [54] | Mixed | Dysphoria | Combination | Multiple (7 days) | 14 days after intervention | $t(18) = 4.85$, $p = .001$ |
| [36] | Mixed | Healthy food | Smartphone | Multiple (incidental game) | After intervention | $t(17) = 2.35$, $p = 0.03$. |

# Chapter 3

# Experimental Study

In this chapter we are presenting an experimental study which assess the existence of approach cognitive biases on Smartphone addicts and test the feasibility of Tabletops for delivering CBM training to counter these biases.

## 3.1 Objectives

### Motivation

As explained in the section 2.4 of the chapter 2, several research gaps were detected in the previous literature. Our experimental study address some of these gaps and has two main objectives. The first objective is to detect and characterize the cognitive biases present on Smartphone addicts. Particularly, we are interested in providing evidence of the existence of an approach bias toward the Smartphone device itself. The theoretical existence of this bias can be supported by the Mere Exposure Effect [6]. As we are trying to address and modify an approach bias, the most suitable CBM technique for this purpose is CBM-Ap. Thus, our second objective is exploring the feasibility for delivering CBM-Ap training using a Tabletop application as there are no previous experiences of implementing CBM on Tabletops and these platforms may increase the effectiveness of the intervention due to their unique characteristics (see section 2.3.2).

In order to define our experimental design, previous CBM-Ap interventions such as [41, 59, 61] were analyzed in detail. Those studies introduce various implementations of CBM-Ap adapted to different domains and contexts. Usually, in each study, several experimental blocks are defined where the participants are presented with a number of Approach Avoidance Tasks (AAT). In each task, participants are asked to respond with an approach movement (pulling a joystick or mouse) to pictures of one type and with an avoidance movement (pushing the joystick or mouse) to pictures of another type [59]. We defined our experimental design following the implementation of these previous studies [41, 59, 61]. Our experimental design also informed the requirements for the development of the CBM-Ap prototype for Tabletops.

**Hypothesis**

We define two hypothesis for our experiment:

1. Smartphone Addiction correlates with an approach bias towards the Smartphone device itself.

2. A CBM-Ap intervention using Approach Avoidance Tasks (AAT) on a Tabletop can counter the approach bias towards the Smartphone.

## 3.2 Experiment design

### 3.2.1 Variables, outcomes and measurements

Our experiment can be classified as a 2 X 2 X 2 factorial design as our independent variables are: Condition(between participants, 2 levels: Intervention group or Control group), Session(within participants, 2 levels: Pre Assessment and Post Assessment) and Type of image(within participants, 2 levels: Smartphones and Books). So in brief, the participants of the study were assigned either to a control group or an intervention group, presented pictures of Smartphones or Books and measured in two different sessions (Pre Assessment and Post Assessment).
Moreover, our dependant variables are: Response Times (RT) measured in miliseconds and Number of Errors committed to complete each task presented.

Nevertheless, our main outcome is the Approach-Avoidance Task Index (AAT-Index) in relation to a stimuli. In our case, we obtain for each participant 4 values of the AAT-Index, one for Smartphones and one for Books, and both measured in Pre and Post Assessment tasks. The AAT-Index is calculated as the difference between the median RT to avoid a stimuli and the median RT to approach the same stimuli. The median RT are analysed because they are less sensitive to outliers in comparisson with the means [41]. A positive AAT-Index indicates an approach tendecy (faster pulling than pushing) to the simuli, which can be interpreted as relatively automatic action tendencies. This would provide evidence of an approach bias towards the stimuli (in our case the Smartphone device) [58].

### 3.2.2 Participants

40 participants (12 females, 28 males; mean age 26.9 years, SD 4.17) were recruited from the University of Birmingham for the study. Participants were invited to take part in the experiment using text messages but also, as the Tabletop was deployed in the Sloman Lounge of the Computer Science Department, many participants joined the experiment voluntarily, attracted by interest or curiosity in the Tabletop.

All participants agreed to a consent form presented at the beginning of the SAS-SV on-line questionnaire (see 3.3.1 and declare owning and using a Smartphone regularly (4.93 hours spent daily on the Smartphone on average, SD 3.97 and 53.89 checks per day, SD 45.4). When asked if they believe to be addict to their Smarphone, 17 participants agreed (42.5%) , 16 disagreed (40.0%) and 7 declared not knowing (17.5%). Finally 15 participants (37.5%) scored below 30 in the SAS-SV and therefore were considered as non-addicts, meanwhile 25(62.5%) were considered as addicts. Regarding their experimental condition, 19 (47.5%) participants were assigned to Intervention group and 21 (52.5%) to the Control group.

## 3.3 Materials and procedure

### 3.3.1 SAS-SV Questionnaire

Following the design used by Wiers et al. in [59], first step of our study attempted to measure the level of Smartphone addiction each participant had beforehand. To assess this, an on-line questionnaire of the short version of the self-reported Smartphone Addiction Scale (SAS-SV) provided by Kwon et al. in [23] was implemented using LimeSurvey. All participants reported their current addiction level using the questionnaire composed by 10 questions in a 6 point scale (1-strongly disagree, 6-strongly agree).
As a result of conducting this measurement, we were able to establish 2 main classes. Participants whose score was 30 or more were considered addicts, meanwhile those participants scoring less than 30 were considered non-addicts. Although Kwon et al. in [23], established different threshold levels for male (31) and female (33) to predict Smartphone Addiction, a common threshold of 30 was defined to simplify the balance of the experimental groups (explained in detail in section 3.3.3).
Before using the on-line questionnaire for the experiment, a small validation was conducted with researchers, IT professionals and students from other Universities. The objective of this validation was to asses the language used in the questionnaire and the general understanding of it. The questionnaire was open for 10 days and included a feedback section at the end to register comments. During this period, 34 complete responses were registered collecting 11 comments regarding the language of questions, the style of the questionnaire and issues related with the look and feel. All these comments were used to improve the questionnaire before the experiment.
The final questionnaire included an introduction section with an informed consent and a brief explanation about the study. Then a section composed by 6 demographic and general questions, followed by the 10 questions defined in the SAS-SV. Finally, a summary score (sum of 10 SAS-SV questions) and the user ID. The user ID (a random 3 digit number) was provided to the participants by the experimenter before starting the questionnaire and its objective was

merging the results from the on-line questionnaire with the results obtained in the CBM-Ap prototype. For the complete questionnaire go to the Appendix: D.

### 3.3.2 CBM-Ap prototype

The CBM-Ap prototype used for our experiment was developed and deployed in a Microsoft Pixelsense SUR40 (formerly called Microsoft Surface) Tabletop which is owned by the Computer Science Department of the University of Birmingham. The Microsoft Surface is a 40-inch multi-touch Tabletop that works with optical touch to recognize fingers and objects placed over it. The application was coded using the Microsoft Surface SDK 2.0, Windows Presentation Foundation (WPF) and Entity Framework to implement the Microsoft SQLSever Data Base used to store all the data and results from the experiment. Both components (application and data base) are deployed in the Microsoft Surface device.

Due to its architectural design it is possible to argue that the CBM-Ap prototype allows to change the domain of the CBM intervention quite easily. The application stores in the data base some parameters needed to execute and run the experiment. For example, the text for user interface labels and the number of sessions for each block (Training, Pre Assessment, Experimental and Post Assessment). What is more, the directories from where the Avoid and Approach stimuli is selected for each trial are stored as applications parameters. Therefore, changing these parameters or changing the content in those directories will alter the domain of the intervention. To access the code of the application and further documentation go to the Appendix: A.

The CBM-Ap prototype for Tabletops is inspired on a common problematic use case described by Perlow in the book [35]. If you have your Smartphone in your bedside table at night, you might check it before going to sleep and as soon as you wake up, but what about a short check of my messages in the middle of the night? The presence of the Smartphone on your bedside table, may trigger the checking habit and as a result you feel more awake and sleepless after spending some minutes on your phone. The idea behind the CBM-Ap prototype, was to propose an alternative stimuli to the Smartphone in this scenario. Why not grabbing a book from your bedside table? In this section, we are describing the most important design decisions involving the CBM-Ap development.

#### Gestures and effects

As we were implementing a set of Approach Avoidance Tasks (AAT) in a different platform, we had to choose the gestures that participants should do in order to pull or push the different stimuli presented to them. Regarding this, we decided to use a drag and drop gesture. Therefore, the participants have to touch the object (with one or more fingers) and drag it into two different defined areas according to what was instructed. To some extent, this gesture increases the realism of the experience, in comparison with pulling or pushing a joystick, because it is similar to grabbing an object from a table. When a participant was dragging an object, its transparency was increased and when the object was over one of the two defined areas, its transparency was restored to normal. This way, the prototype provided feedback to the participants on the movement of the object.

#### Approach and Avoidance Areas

Then, where should the participants finish their drag and drop gesture to complete the task? In our design, we defined two rectangular areas to establish the targets for each gesture (approach or avoidance). The approach area which is closer to the participant and the avoidance area which is in the opposite end of the surface. Both areas were clearly defined using text and white frames to help the participants to find them easily. As a result of these definitions, participants had to produce bigger gestures with their arm and hand in order to push away objects.
Although previous implementations of AAT had a zooming effect in order to provide coherent feedback to the user [41], in our design, the zooming effect was considered unnecessary and therefore, not included. Due to the location of each area in the surface, every time a participant completed the required

movement, the object was indeed closer or further away from the participant perspective and because of that no further feedback was considered necessary.

### Smartphone selection

Furthermore, as our first hypothesis is related with an approach bias towards the Smartphone device itself, one of the first steps of our CBM-Ap prototype was to select a Smartphone similar or familiar for the participant. As explained by Chen et al. in [6] users tend to approach their device as a response to the mere exposure effect. However, people usually create an emotional attachment with their personal Smartphone [47, 21], and therefore if they see over the table a device that does not look like their own device the whole cue may not be triggered. Because of this, a gallery composed by 10 devices (List of Best Selling Smarphontes of 2016 by IHS Markit, [30]) was presented to the participants with the instruction of selecting the Smartphone more familiar to them; see figure 3.2 in page 24.

### Stimuli size, position and contents

Moreover, using a Tabletop allowed us to present bigger and higher quality images for each stimuli. Regarding the sizes, for the different image formats (landscape, portrait and square), although the overall size of the image was increased, the relations between height and width were preserved using the original proportions by Wiers, et al. in [59].
Similarly to others AAT implementations, the images were presented in the center of the screen and if the participant committed a mistake they had a 10 seconds window to fix it, after that the task changed automatically [58]. The full set of pictures for Books and the selected Smartphone was used randomly across the different steps of the experiment. This may affect the generalization performance of the results as discussed in the section 4.2.
Then regarding the look and feel of the CBM-Ap prototype there are several aspects to remark. First, we decided to use a wooden background image for the whole application to give the feeling of a realistic table setting. As a result of this decision, the pictures of the different stimuli presented (Books

and Smartphones) had to had a transparent background. Therefore, a white bold frame was drawn around the image especially for the Pre Assessment and Post Assessment task, where participants were asked to respond to the format of the picture see 3.3.3, to help distinguish between landscape and portrait formats; see figure 3.1 in page 23. Finally, the number of pictures for the different Smartphones was not constant ranging between 3 and 8 depending on the participant selection. Still, pictures of 52 Book covers were used as "alternative" or neutral stimuli.

Figure 3.1: CBM-Ap prototype

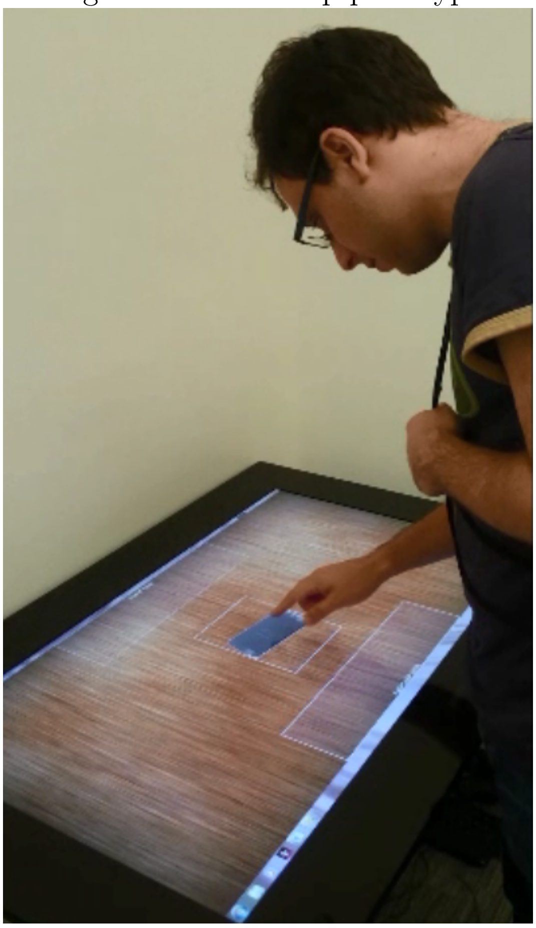


Figure 3.2: CBM-Ap Smartphone Selection

### 3.3.3 Procedure

In this section we are explaining the experimental procedure followed by the participants

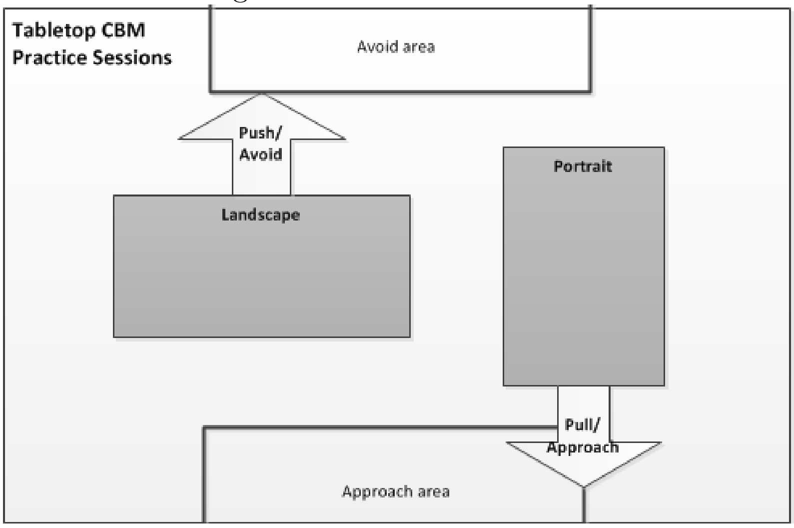
#### Set up

As stated before, the participants had to complete the SAS-SV on line questionnaire to begin with the experiment. After doing that, they logged into the CBM-Ap prototype by completing their user ID and SAS-SV score. At this point, a balancing algorithm was invoked, deciding if the current session would be assigned to Control or Intervention group. As a result both (Control and Intervention) groups are balanced using the SAS-SV score. So half of the addicts will be assigned to Control group and the other half to the Intervention group. The same reasoning applies for non-addicts. Then, the next step of the CBM-Ap prototype was selecting a device as explained before and basic instructions about the tasks were explained to participants at this point.

#### Practice sessions

After setting up, the next step of the experiment, as in [58], was to execute 10 practice trials in which the participants were trained in approaching or avoiding neutral images (a grey rectangle) in response to the format of the picture. Participants were instructed to make an approach gesture (dragging the rectangle to the approach zone, close to their body), for those rectangles in portrait format. In contrast, for those rectangles in landscape format, participants responded with an avoidance gesture (moving the rectangle towards the avoid zone, away from their bodies). Both approach and avoidance training tasks are balanced and presented in random order. Details of the practice sessions are shown in 3.3 on pag 25.

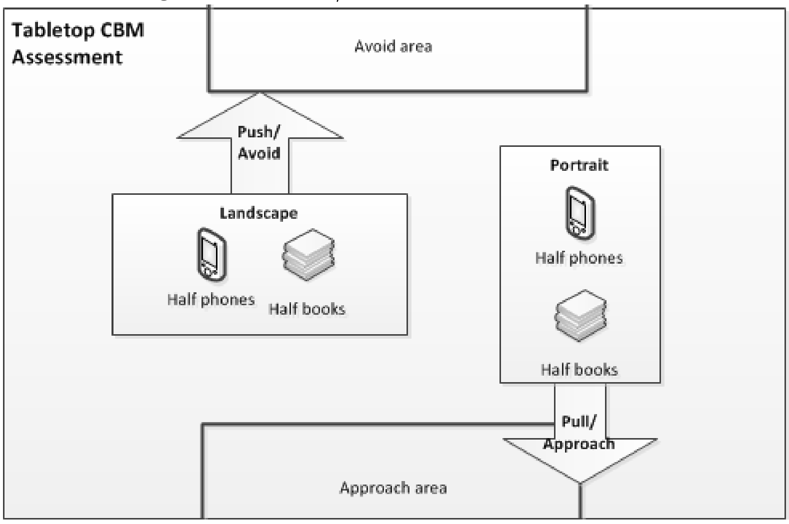
Figure 3.3: Practice sessions




### Pre Assessment Task

Then after the practice sessions all participants were instructed to run a Pre Assesment Task. Again, participants responded with an approach gesture to those images in portrait and with an avoid gesture to those pictures in landscape, but this time, images of Smartphones and Books were presented. Consequently, the required response is not related with the contents of the pictures and thus equal number of images of Smartphones and Books were shown in the different formats. A total of 40 balanced tasks were executed in random order by the participants. Details of the Pre Assessment Task are shown in 3.4 on pag26.

Figure 3.4: Pre/Post Assessment Tasks



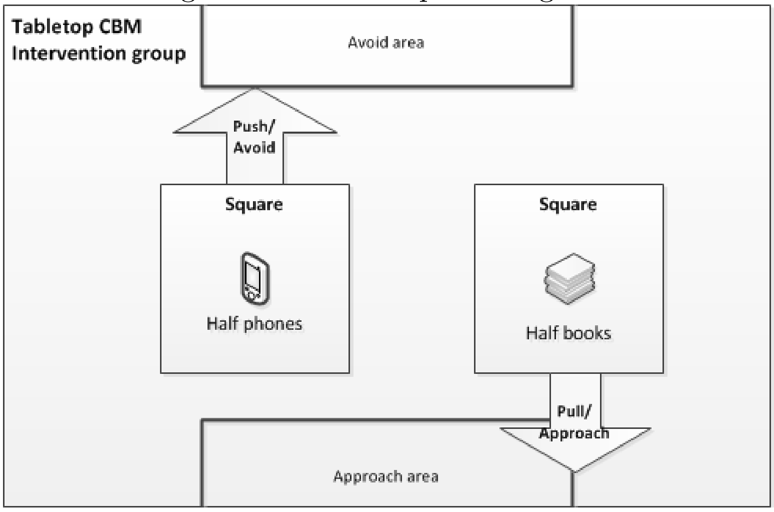

### Intervention Task

At this point, the Control group, as in [59] will not execute any more tasks (no-training group) because Wiers et al. did not find any difference between a sham training (similar to the Pre Assessment task) and a no-training control group.
On the other hand, the Intervention group was instructed to approach all images of Books and to avoid all images of Smartphones. To distinguish this task from the Pre Assessment, all images were shown on a square format. Therefore, the Intervention group is receiving CBM-Ap training to avoid Smartphones. A total of 60 balanced tasks were presented in a random order. Details of the Intervention task are shown in 3.5 on pag 27.

### Post Assessment Tasks and Study Explanation

Finally, a Post Assessment task was executed by all participants. Similarly to what happened in the Pre Assessment, participants had to respond to the format of the image (see 3.4 on pag 26). The objective of this step is compare and asses differences between the Control group and the Intervention group after training. After completing the task, a detailed study explanation text was presented to the participants to provide them with relevant information

Figure 3.5: CBM-Ap training task




and candies were offered as gratitude for their collaboration.
To summarize a the table 3.1 on page 27 a resume of the number of trials each group executed is presented.

Table 3.1: Experimental procedure

| | Number of trials | |
|---|---|---|
| **Step** | **Control Group** | **Intervention Group** |
| SAS-SV Questionnaire | Yes | Yes |
| Training | 10 | 10 |
| Pre Assesment | 40 | 40 |
| Intervention | 0 | 60 |
| Post Assessment | 40 | 40 |

## 3.4 Results

### 3.4.1 Data analysis

In order to analyse the data, first, we only considered those completed tasks recorded during the Pre and Post Assessment experimental steps. The resulting distribution of response times is positively skewed as remarked in [1]. This is a common aspect of studies involving response times as a dependent vari-

able. Our next step, after filtering the data, was to calculate the AAT-Index for each participant, Session and Type of image. The AAT-Index was calculated as the difference between median RT for avoiding and the median RT for approaching one type of image. This is the traditional way of computing the AAT-Index. For the sake of simplicity, we did not calculate the D-Scores used by Wiers et al. in [59]. These scores standardize the differences in response latencies by dividing with a *personalized* standard deviation.
Moreover, as part of our data analysis, we did not exclude any outliers (for example those RTs bigger or smaller than 2 standard deviations) and also did not normalize the RT. First, the normalization step is not trivial. Should we use a global mean and standard deviation for all RT or more personalized values for Session or Type of Image? Second, as remarked in [58] "no arbitrary cut-off points need to be formulated regarding outliers", due to the nature of the AAT-Index calculation, which rely on medians and not on means, hence, the index is less affected by outliers. With the AAT-Index calculated for each participant, Type of image and Session, we conducted the statistical analysis and model fitting that was presented in section 3.4.

### 3.4.2 Preliminary results

Similary to what happen in [41], due to the ease of the task the amount of errors committed was very low (around 1.4% of all tasks not varying between experimental conditions) so we are only reporting results regarding the AAT-Index (with standard deviations). The results for addicts and non addicts in the Pre Assessment task are reported in the table 3.2 on pag 30. Meanwhile, the comparison between Control and Intervention group for each stimuli in Pre Assessment and Post Assessment tasks are presented in table 3.3 on pag 30.
Firstly, regarding the Pre Assessment, there were no significant differences between addicts and non-addicts in relation to their AAT-Index for Smartphones. The results were analysed using a t-test for addicts an non-addicts groups. Neither for Smarphones ($t(19.60) = 1.3002$, $p = 0.20$) nor for Books ($t(37.99) = 1.5237$ , $p = 0.13$) significant differences in their AAT-Index were

detected.
However, if we calculate the mean AAT-Index at Pre Assessment for all participants without considering the previous SAS-SV score, the results are: 61.9 (483.2) for Smartphones and 2.35 (320.6) for Books. This is an interesting result, that may indicate a *general* approach bias towards Smartphones and might mean that despite what was the SAS-SV result for a person, this result may not predict or correlate to the strength of the approach bias towards Smartphones this person might have. This idea will be discussed in Chapter 4.
Secondly, with reference to the results presented in table 3.3, an interesting outcome is that the overall AAT-Index for Smartphones decreased for both groups in the Post Assessment session. Those participants under the Intervention condition changed to a stronger avoidance bias towards the Smartphone, with a reduction for their approach bias towards Books, meanwhile those participants assigned to Control group experimented also a reduction in the approach bias towards Smartphones and a *strange* increase in the approach bias towards Books. This outcome may indicate an effect of CBM training or just a *practice effect* for both groups although this should be mitigated by our balanced design (with equal number of tasks in each session). It is possible to visualize this trend by looking at the Box-plots presented in figure 3.6 on pag 30.
Finally, in order to analyse any possible interaction between the factors (Condition (2) X Type of image(2) X Session(2)) of our study, a Mixed-Effect model was constructed using the lme4 package for R. As described by [1] these models allow us to analyse the data and model the individual response of a given subject to a given item. Furthermore, the model increases the statistical power and protect us against Type II errors.
Our model was defined by:

```
model <- lmer(AATScore ~ Intervention * Type * Session
  + (1+Type|UserId) + (1+Session|UserId),
  data = scores, REML = "false")
```

Then we fit our model and used the package pbkrtest (to run Parametric Bootstrap and Kenward Roger Methods for compare Mixed Models) to get the p values. As a result we find main effects on Type of Image (Estimate for Books b = -171.1 milliseconds, SE = 85.4, p = 0.045) and an interaction between Type of image and Session (Books—Post Assessment got an estimate b = 309.1 milliseconds, SE = 115.8, p = 0.007). However, this interaction can be superseded by a higher order, therefore more complex, interaction composed by Condition x Type of image x Session (Intervention—Books—Post Assessment with an estimate b= -361.1 milliseconds, SE = 168.0, p = 0.03). The results are shown in table 3.4 at pag 31. All others interaction were insignificant, for further details check the appendix B.

Although these results are similar to those obtained by Wiers et al in [59], where a more complex three-factor interaction replaced a two-factor interaction, separate models for Image type (Books and Smartphones) could be constructed and compared in order to perform follow-up analysis on the interactions with Condition and Session. Moreover, further analysis is required in order to validate the interaction size and direction of our complex 2 X 2 X 2 interaction, which is opposite to the effect produced by the Type of image x Session, meaning that for Books we might reduce the Approach Bias as a result of training (opposite from what we might expect after training). The results presented in this section are discussed in detail in chapter 4.

Table 3.2: Pre Assessment Results

| **Picture type and group** | | **Gesture type** | | **AAT - Index (avoid-approach)** |
|---|---|---|---|---|
| | | Avoid | Approach | |
| Smartphone | Addicts | 2214.9 (378.7) | 2239.4 (456.9) | -24.5 (359.2) |
| Book | Addicts | 2213.9 (387.7) | 2263.9 (468.9) | -50.0 (363.6) |
| Smartphone | Non-Addicts | 2353.6 (620.9) | 2147.7 (487.0) | 205.9 (627.4) |
| Book | Non-Addicts | 2247.9 (418.7) | 2158.2 (376.8) | 89.6 (216.0) |

Table 3.3: Post Assessment Results

| **Group** | **Pre Assessment** | | **Post Assessment** | |
|---|---|---|---|---|
| | AAT - Smartphones | AAT - Books | AAT - Smartphones | AAT - Books |
| Intervention | -6.9 (282.3) | 56.9 (243.4) | -11.6 (259.7) | 0.23 (183.2) |
| Control | 124.1 (612.3) | -47.0 (376.5) | -11.5 (259.1) | 126.4 (290.0) |

Table 3.4: Mixed Effects Model Results

| **Interaction** | **Estimate** | **SE** | **p** |
|---|---|---|---|
| Main effect TypeBook | -171.1 | 85.4 | 0.045 |
| TypeBook:SessionPostAssessment | 309.1 | 115.8 | 0.007 |
| Intervention:TypeBook:SessionPostAssessment | -361.1 | 168.0 | 0.031 |

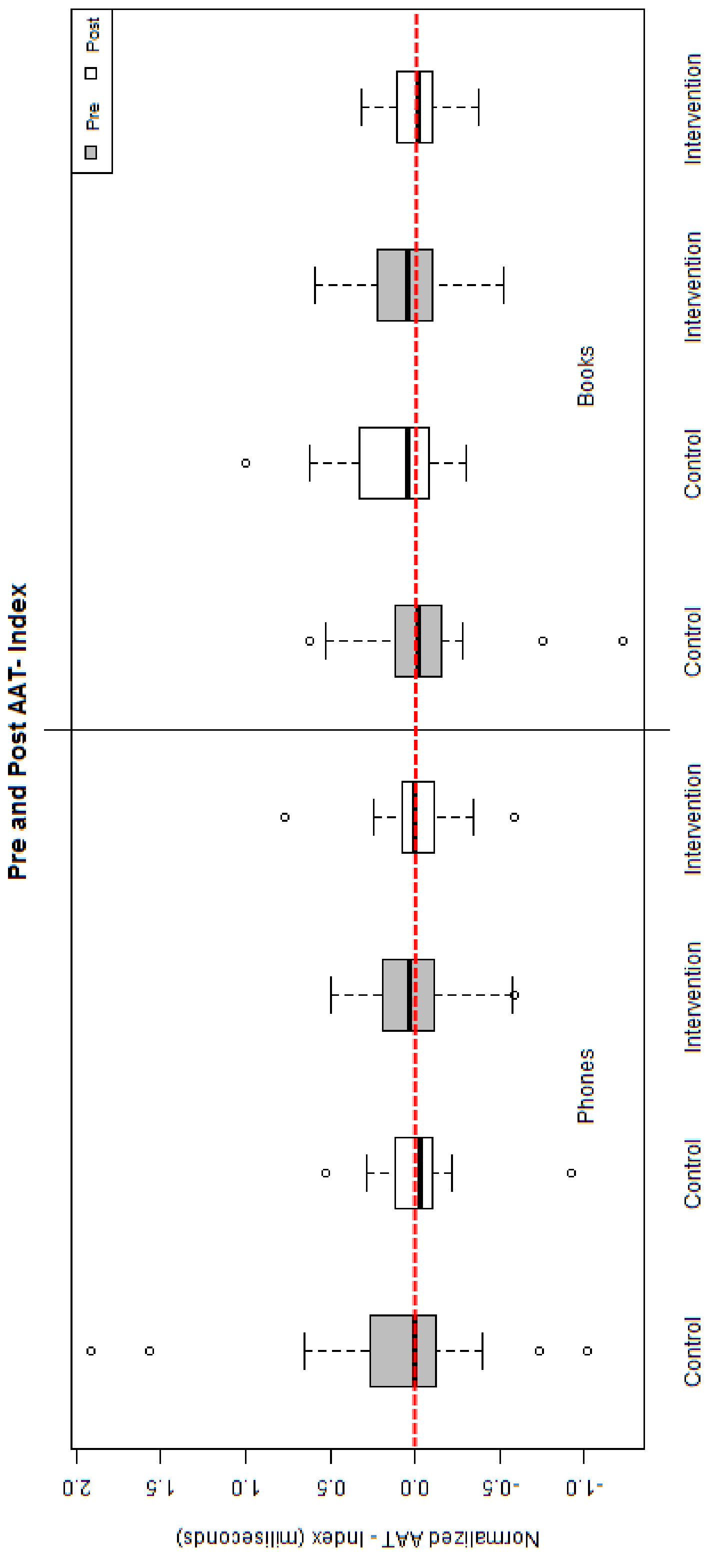



Figure 3.6: AAT-Index Pre/Post Assessment Comparison

# Chapter 4

# Analysis and discussion

The objective of this chapter is present how the analysis of the data was performed and discuss the general results of conducting the experiment in terms of our original hypothesis and objectives. Moreover we will discuss the limitations of our study and further lines for future research will be drawn.

## 4.1 Experimental notes

The main outcome from our experiment are response times required to complete the different tasks presented to particpants. As explained in [1], response times are not statistically independent so, trial by trial some amount of sequential correlation can be found and usually there are several factors that might affect individual response times. In our study, we support with experimental notes (see appendix B ) several aspects that indeed affected the individual response times.

First, due to the horizontal layout of the Tabletop, issues related with positioning of the participant towards the surface and ergonomics can be reported. For example, as we could observe during the experiment, taller participants found easier to complete the avoidance movements in comparison to shorter participants who had to bend over the surface in order to complete the gesture. As the number of trials increased, some participants changed their hand to interact with the application, stretch their back or simply executed shorter

and faster gestures as a response to what seems to be tiredness (Control group executed a total of 90 and Intervention group 150).
Second, some aspects related with the hardware used for the experiment may affect the response times. The optical recognition system of the Surface can be affected by the lighting conditions or the angle in which participants placed their finger. Also the velocity of recognition is slower in comparison with capacitive touch-screens that can be found nowadays, in most Smartphones and Tablets. As a result, during the first trials, participants experienced errors when dragging items through the surface.
Third, the design of the CBM-Ap prototype and the contents used for each stimuli may also affect the response times. For example, participants who did not find their Smartphone in the catalogue selected a similar Smartphone based on price, features or OS. Even then, the number of different images for the selected model ranged between 3 and 8. This generated a lot of repetitive tasks, in which the same image appeared and, as a consequence, faster response times for Smartphones. However, this was not the case for Books, where the total set of images was 51, generating different combinations. Also, most of the images of Books contained text, which distracted the participants who tried to read the title before completing the gesture, provoking longer response times. This is also reported in the experimental notes. Then regarding the design of the task itself, as explained before, for the Pre and Post Assessment tasks, users had to respond to the format of the picture relying on the white frame drawn around the picture to distinguish the landscape from portrait layouts. This also may increase the response times.
Finally, also the language used in the SAS-SV questionnaire and in the CBM prototype might affect the participants reaction times. For example, terms with negative valence like Avoid or Avoidance were displayed in the instructions and main screen of the CBM prototype. This, combined with the strong language of some questions of the SAS-SV (e.g "I find myself using my Smartphone longer than I originally intended") that may indicate a problem in the user could generate faster response times in terms of responding Smartphones images.

### 4.1.1 Discussion

As stated previously, the main objective of the present study, was to test the feasibility of our prototype to deliver CBM-Ap training in the domain of Smartphone addiction. Regarding this objective, it is possible to say that both the analysis of the quantitative data and the qualitative insights obtained during the experiment, support the idea that indeed, it is possible to deliver CBM training using Tabletops. Also the low error rate indicates that participants found the training relativity easy to complete. What is more, we managed to successfully map and implement the requirements from previous effective CBM-Ap studies into a Tabletop prototype. In this section we will present our conclusions in terms of the two experimental hypothesis we defined in section 3.1.

#### First hypothesis

Regarding the first hypothesis of our study, it is possible to say that no significant differences were found between addicts and non addicts groups in terms of their AAT-Index for Smartphones. Accordingly, it is not possible to conclude that addicts have a stronger approach bias towards the device. However, there are several aspects that are interesting to analyse and discuss.

First, our definition of addict relies on the results obtained in the previous SAS-SV questionnaire [23]. Although, according to the authors, the scale may predict the addictive behaviour, this is not completely clear in practice. The version of the scale we used (SAS-SV) relies only in ten self-reported questions which are written using a strong language that may indicate a possible problem in the user as explained before. As a result, some participants may have completed the questionnaire with this idea in mind which could affect the overall results and proportions of addicts and non-addicts groups.

Finally, an interesting result may come from the analysis of the overall AAT-Index in the Pre Assessment session for all participants. From analysing the mean of the AAT-Index for Smartphones, an approach bias (61.9) was indeed detected. This result can be used to provide evidence of the existence of an approach bias towards the Smartphone device itself, regardless condition or level of addiction a person may have. However, as Rinck et al. pointed out in [41] analysing overall differences in response times between avoiding and approaching might be too risky as the individual response times and also the AAT-Indexes are affected by a variety of factors. These factors were discussed previously. Overall, it might be interesting to follow up with further studies these results to provide stronger evidence of the existence of approach biases towards the Smartphone device.

**Second hypothesis**

In terms of our second hypothesis, if we analyse the overall Smartphone AAT Indexes for control and intervention groups in the Post Assessment session it is possible to say that the reduction of both indexes simultaneously can be explained as a simple *practice effect*. This idea can be supported also, by the experimental notes where it was noticed that regardless the condition (Intervention or Control), after completing some tasks participants adapted their strategies and gestures to complete the tasks faster and committing less errors.
However, according to our mixed effects model, significant interactions between the factors of our experimental design (Condition X Type of Image X Session) were detected. Specially, regarding the AAT-Indexes for intervention group in the Post Assessment session. This could provide evidence to support that the CBM-training indeed have some effect to counter the approach bias towards the Smartphone even though the direction of the effect was opposite to what we expected originally. To bring light to this issue and support the claim that the training had an effect, further data analysis and experimental interventions (for example with longer sessions and more participants) could be conducted.

## 4.2 Limitations

In this section we are discussing the main limitations of our study.

### 4.2.1 Approach bias towards the device

As we stated before, the existence of an approach bias towards the device can be supported theoretically by the Mere Exposure Effect [6]. However it could be discussed if Smartphone addicts are dependant on their device or on the applications and contents their device provide to them [42]. As Griffiths state in [15], "there is a fundamental difference between addicts *to* the Internet and addicts *on* the Internet". Consequently this could affect the validity of our first hypothesis and open a new line of research for future studies.

### 4.2.2 Experimental script and controlled settings

Regarding this point we would like to report two main issues. First, due to lack of time, no experimental script or material was prepared for the participants. Hence the experiment had to explain the main objectives of the study for each participant, and introduce how to interact with the Tabletop each time. The lack of the script also generated some problems in terms of answering questions or helping the participants to complete some tasks. The information given during the experiment, for example number of tasks remaining or idea behind the experiment could bias the participants while they were executing the experiment. Second, it is also important to remark that the conditions in which the experiment was executed were not completely controlled. As explained before the Tabletop was located in the Sloman Lounge of the Computer Science School. Specifically the device was located in a small kitchen inside the lounge. This area is not ideal for running an experiment because some participants got interrupted or distracted by people that wanted to use the water dispenser or heat food in the microwave. Also this area of the school is quite noisy during term time and demo week.

### 4.2.3 Replication differences

As stated previously, the objective of the CBM-Ap prototype was to replicate effective previous CBM interventions on the Tabletop. Regarding this it is possible to report some experimental differences between the implementation of our prototype and what was done in previous studies. Due to lack of time, the full set of pictures (Books and pictures of the selected Smartphone) were used in the different steps of the experiment. In previous AAT implementations half of the images were preserved for testing generalization in the final step of the experiment (Post Assessment Task). Furthermore, stimuli was presented in random order and not in pseudo-random order (restriction that no more than 3 pictures of the same type were presented successively [41]) as in previous studies.

### 4.2.4 Generalization power

Finally, an important limitation of the present study can be reported regarding the generalization of the results we have find. First, further data analysis and improvements (such as calculating the D-Scores, filtering extreme outliers, cross validate statistical models and other arrangements) could be executed in order to assess the validity of the results reported and give stronger support to our claims. Second, increasing the number of observations will also improve the generalization power of the results. For example, for each participant we have only 10 values of Avoid Smartphones in the Pre Assessment task. We take the median of these values and then calculate the difference to get the AAT index for Smartphones in the Pre Assessment. Alternatively, we could have 20 RTs and discard the first 5 as training or fitting to the task.
To conclude, it is important to report that the sample process for the experiment was far of being random or ideal. As a result, the experimental sample was biased. Most of the participants were acquaintances of the experimenter and at is possible to see the majority are students of different MSc programmes from the University of Birmingham. Most of them also have a strong use of technology and that would explain the unbalanced scores in favour of Smartphone addicts in the SAS-SV.

## 4.3 Future work

As a result of conducting the present study, several lines for future research can be drawn. First regarding the CBM-Ap prototype that was developed, it would be interesting to test the prototype in other domain, for example, healthy eating, smoking or alcohol. The benefit of doing this, is that these domains have been address by previous research and therefore, it would be possible to compare the results of the previous intervention with the ones obtained by the Tabletop prototype. In addition to this line, comparative studies, could be conducted between a PC, a Smartphone a Tablet and a Tabletop in order to compare and assess the effectiveness of each platform to counter cognitive biases.

Furthermore, researching how the CBM-Ap prototype could be used in public contexts to support incidental or collaborative CBM is also another interesting approach. Clearly, a limitation to the generalization of the present study was the low number of participants we recruited to run the study in *controlled settings*. To overcome this issue, the CBM-Ap prototype could be modified to support more flexible tasks and asses the existence of several cognitive bias. Then we could deploy this new version of the CBM prototype in public context in order to get a larger and more random sample. As reported in the experimental notes (see appendix B) the way in which people approach and interact with these devices, would increase the number of participants for sure.

Turning into the Smartphone addiction domain, as stated previously, more studies are required in this field. First, more reliable scales and methods to diagnose this conditions are required. In this line, a more rigorous analysis of the data collected using the SAS-SV questionnaire could be conducted. In our experiment, the SAS-SV questionnaire main purpose was to classify participants in addicts and non-addicts. However, lot of interesting data still to analyse is present on the completed questionnaires.

Then, although our research provide interesting insights about the underlying cognitive bias that Smartphone addicts may have, more understanding and evaluation is still needed. As stated before, assessing if Smartphone addicts suffer from attentional or approach biases towards Applications or Notifications, apart from those biases towards the device itself, will facilitate further CBM techniques to counter those biases and therefore support long term behaviour change. Consequently, we could modify the CBM-Ap prototype in order to include stimuli for Applications and Notifications and compare those biases to the one we obtained in this study.

Finally, in terms of the CBM field, it would be interesting to work on standardized procedures for analysing the data obtained from, for example AAT interventions. In order to replicate studies in a more reliable and consistent way, the results and data analysis procedures should clearly reported. One of the main critics that previous CBM studies have received is related with the issue that many positive outcomes, may be driven by extreme outliers [8]. This might also seem the case here, although our data analysis is still in initial stages due to lack of time. So, from a methodological point of view, the field still require to define and convey how the data analysis should be done for standard interventions such as AAT.

# Chapter 5

# Conclusions

In this report we presented a study that addressed the design, implementation and experimental evaluation of the first prototype to deliver CBM training on a Tabletop. Our focus was the the domain of Smartphone addiction. As part of our work, relevant background studies in the fields of CBM and Smartphone addiction. were identified and analysed in order to extract requirements to define our experimental design. Also also relevant research in the field of Tabletops was analysed in order to take advantage of the special characteristics these platforms.

Our experiment is focuses on approach biases towards the Smartphone device itself. Consequently, our experimental design combined the crucial aspects of previous effective CBM interventions with the special characteristics of Tabletops. The objectives of our experiment were, first, evaluate the existence of an approach cognitive bias towards the device and second, try to counter that bias by CBM training. Taking our experimental design as a base, we developed, tested and deployed the CBM-Ap prototype on the Microsoft Surface property of the Computer Science Department of the University of Birmingham. Our CBM-Ap prototype, implemented the first Approach Avoidance Task (AAT) on a Tabletop and therefore some relevant design decisions were made and are reported as part this report. Moreover, our prototype could be easily modified to address other possible domains.

Regarding our experiment, 40 participants took part in our study. As a result, some evidence suggesting the existence of an approach bias towards the Smart-

phone device was detected. Although, further analysis on our data should be conducted to support this claim, the existence of such bias could be supported theoretically by the Mere Exposure Effect [6]. In addition to this, significant interactions between the factors of the experiment may suggest a positive effect produced by the CBM training. Further analysis on the data obtained from the experiment and further interventions will be conducted to increase the validity of our preliminary results.
The main objective of this project was to test the feasibility of Tabletops technologies to implement and deliver common CBM-Ap interventions. Not only, the prototype was developed and tested for ensuring the expected quality, but also the prototype was used on an experimental study which provide interesting insights for researchers and practitioners in the fields of Smartphone addiction and CBM.

# Appendix A

# Software Implementation

The source code of the CBM-Ap prototype can de found at the Git repository. Moreover, further contents required for deploying and documents regarding the project management can de found at the Dropbox repository.

# Appendix B

# Detailed results

## B.1 Raw data and scripts

The raw results from the experiments (experimentDataFull.csv) and the SAS-SV questionnaire (questionnaireResults.csv) can be found in the Data Analysis folder of the Dropbox repository. This folder also includes the R scripts for data analysis and output archives.

## B.2 R output

### B.2.1 Hypothesis one

```
Welch Two Sample t-test

data:  dataH1$AATScorePhones by dataH1$condition
t = 1.3002, df = 19.606, p-value = 0.2086
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -139.7367  600.5674
sample estimates:
mean in group Non Addict     mean in group Addict
               205.91299                -24.50241
```

```
Welch Two Sample t-test

data:  dataH1$AATScoreBooks by dataH1$condition
t = 1.5237, df = 37.999, p-value = 0.1359
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -45.89519 325.21432
sample estimates:
mean in group Non Addict     mean in group Addict
                89.64357                -50.01600
```

### B.2.2 Hypothesis two

```
                                             Estimate         p.z
(Intercept)                                  124.1647  0.134536412
Intervention1                               -131.0764  0.276255945
TypeBook                                    -171.1837  0.045251087
SessionPostAssessment                       -135.7400  0.144322517
Intervention1:TypeBook                       235.0246  0.058138411
Intervention1:SessionPostAssessment          130.9584  0.331692298
TypeBook:SessionPostAssessment               309.1988  0.007583101
Intervention1:TypeBook:SessionPostAssessment -361.1083  0.031620314
                                                  p.KR
(Intercept)                                  0.140175126
Intervention1                                0.280938977
TypeBook                                     0.050123235
SessionPostAssessment                        0.149933481
Intervention1:TypeBook                       0.063327915
Intervention1:SessionPostAssessment          0.335884000
TypeBook:SessionPostAssessment               0.009916558
Intervention1:TypeBook:SessionPostAssessment 0.035975316
```

## B.3 Experimental Notes

- Participants read the titles of the books
- Participants get confused by image format and image content.
- Participants mentally count the number of tasks executed or remaining.
- Participants asks what the Questionnaire Score means before starting the CBM-Ap prototype.
- Participants see 2 or 3 times the Tabletop then they touch it and decide to participate.
- A participant drinks coffee during tasks.
- A participant played with the images and rotated some frames in Pre Assessment.
- People goes into the room where the experiment is taking place, causing distraction.
- Participants change their strategies to complete the movements:
  - right hand vs left hand.
  - several fingers vs one finger.
  - from longer drag and drop touch gestures to shorter to faster gestures.

# Appendix C

# Ethics Declaration

The ethical declaration for the experiment followed the procedures established by the School of Computer Science for the Summer Projects. The Ethics self-assessment form was completed in canvas on the 09/07/2017 and the ethical review was discussed with the school ethics officer (Russell Beale), before executing the experiment. The participants of the experiment were presented with a Consent form as part of the Online SAS questionnaire.

# Appendix D

# Smartphone Addiction Questionnaire

Smartphone Addiction Scale Questionnaire
A survey to find out more about Smartphone Addiction and possible ways to counter it.

Welcome!

There are 20 questions in this survey

# Consent

The following questionnaire seeks to understand more about smartphone addiction and ways to counter this problem, as part of my summer project for the MSc in Human Computer Interaction at the University of Birmingham, UK.

Please first think about your daily smartphone usage and habits.

Then read each question carefully and answer it as truthfully as you can. There are no correct or incorrect responses.

Your data will be stored confidentially and in accordance to the University of Birmingham policies.

If you have any questions about the survey, please contact me at jir687@student.bham.ac.uk

Thanks again for participating.

**1 [0]By continuing, I confirm that I am over 18 years of age, and I understand that I can withdraw at any time.**

# Demographic Questions

**2 [ParticipantID]Participant ID ***

Please write your answer here:

Should be provided by the experimenter

**3 [Age]What is your age? ***

Please write your answer here:

Your age in years. We need this to determine whether there is any significant difference in Smartphone Addiction between different age groups.

**4 [Gender]Gender ***

Please choose **only one** of the following:

- Female
- Male

Select your gender

**5 [Profession]What is your profession? If you are a student, please state level (e.g. Undergraduate, Masters, PhD) and subject. ***

Please write your answer here:

**6 [HoursPerDay]Approximately how many hours do you spend on your smartphone per day? ***

Please write your answer here:

Estimate the total number of hours you spend on calls, emails and apps using your smartphone

**7 [ChecksPerDay]Approximately how many times do you check your smartphone each day? ***

Please write your answer here:

Estimate the number of times you check your phone to look at apps and notificactions each day

**8 [SelfAssessment]Do you think you have maladaptive dependency or addiction over your Smartphone usage? ***

Please choose **only one** of the following:

- Yes, I'm addicted to my Smartphone
- No, I'm not addicted
- I don't know

# Smartphone Addiction Scale

This is a slightly modified version of the published Smartphone Addiction Scale Short Version by Kwon et al (more information at http://bit.ly/2qF9XIe)

For each question please rate the answer according to how true you feel it is for you

### 9 [SAS1]I miss planned work due to my Smartphone use *

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

### 10 [SAS2]Due to my Smartphone use, I can find it hard to focus while working, doing assignments or attending classes *

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

### 11 [SAS3]I feel pain in the wrists or at the back of the neck while using a Smartphone *

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**12 [SAS4]I would not bear not having a Smartphone ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**13 [SAS5]I feel impatient and worried when I am not carrying my Smartphone ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**14 [SAS6]I have my Smartphone in my mind even when I am not using it ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**15 [SAS7]I will never give up using my smartphone even when my daily life is already greatly affected by it ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**16 [SAS8]I constantly check my Smartphone so as not to miss conversations between other people on Twitter, Facebook or other Social Networks ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**17 [SAS9]I find myself using my Smartphone longer than I originally intended ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**18 [SAS10]The people around me tell me that I use my smartphone too much. ***

Please choose **only one** of the following:

- Strongly Disagree
- Disagree
- Weakly disagree
- Weakly agree
- Agree
- Strongly Agree

**19 [SASScore]{sum(SAS1, SAS2, SAS3, SAS4, SAS5, SAS6, SAS7, SAS8, SAS9, SAS10)}**

# Final results and feedback

Thank you for answering the questionnaire.

### 20 [FinalScore]

### Your Participant ID is {ParticipantID}

### Your final Score is {SASScore}.

### Please remeber these values for the next step of the experiment.

# Bibliography


[1] R. Harald Baayen and Peter Milin. Analyzing Reaction Times. *International Journal of Psychological Research*, 3(2):12 – 28, 2010.

[2] Hrvoje Benko, Meredith Ringel Morris, a J Bernheim Brush, and Andrew D Wilson. Insights on Interactive Tabletops : A Survey of Researchers and Developers. *Research Microsoft. com*, page 8, 2009.

[3] Sidney W Bijou. Patterns of reinforcement and resistance to extinction in young children. *Child Development*, pages 47–54, 1957.

[4] Chongyang Chen, Kem Z K Zhang, and Sesia J Zhao. Examining the Effects of Perceived Enjoyment and Habit on Smartphone Addiction: The Role of User Type. In *International Conference on E-Technologies*, volume 209, pages 224–235. Springer, 2015.

[5] Chongyang Chen, Kem Z K Zhang, and Sesia J Zhao. Examining the Effects of Perceived Enjoyment and Habit on Smartphone Addiction: The Role of User Type. In *International Conference on E-Technologies*, volume 209, pages 224–235. Springer, 2015.

[6] Chongyang Chen, Kem Z K Zhang, Sesia J. Zhao, Matthew K O Lee, and Tianjiao Cong. The impact of mere exposure effect on smartphone addiction. *Proceedings of the Annual Hawaii International Conference on System Sciences*, 2016-March(April):1507–1514, 2016.

[7] James Clawson, Jessica A Pater, Andrew D Miller, Elizabeth D Mynatt, and Lena Mamykina. No longer wearing: investigating the abandonment of personal health-tracking technologies on craigslist. In *Proceedings of the*

*2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pages 647–658. ACM, 2015.

[8] Ioana A. Cristea, Robin N. Kok, and Pim Cuijpers. Efficacy of cognitive bias modification interventions in anxiety and depression: Meta-analysis. *British Journal of Psychiatry*, 206(1):7–16, 2015.

[9] Stéphane D Dandeneau, Mark W Baldwin, Jodene R Baccus, Maya Sakellaropoulo, and Jens C Pruessner. Cutting stress off at the pass: reducing vigilance and responsiveness to social threat by manipulating attention. *Journal of personality and social psychology*, 93(4):651–66, 2007.

[10] Seamus A Decker and Jessica N Gay. Cognitive-bias toward gaming-related words and disinhibition in World of Warcraft gamers. *Computers in Human Behavior*, 27(2):798–810, 2011.

[11] Frank Delbressine, Annick Timmermans, Luuk Beursgens, Maaike de Jong, Alexander van Dam, David Verweij, Maikel Janssen, and Panos Markopoulos. Motivating arm-hand use for stroke patients by serious games. *Conference proceedings : ... Annual International Conference of the IEEE Engineering in Medicine and Biology Society. IEEE Engineering in Medicine and Biology Society. Conference*, 2012(August 2015):3564–7, 2012.

[12] Dscout. How much are we really attached to our phones physically, cognitively. Technical report, Dscout, 2016.

[13] Luciano Gamberini, Francesco Martino, Bruno Seraglia, Anna Spagnolli, Malena Fabregat, Francisco Ibanez, Mariano Alcaniz, and Javier Montesa Andrés. Eldergames project: An innovative mixed reality table-top solution to preserve cognitive functions in elderly people. *Proceedings - 2009 2nd Conference on Human System Interactions, HSI '09*, pages 164–169, 2009.

[14] Rúben Gouveia, Evangelos Karapanos, and Marc Hassenzahl. How do we engage with activity trackers?: a longitudinal study of Habito. In

*Proceedings of the 2015 ACM International Joint Conference on Pervasive and Ubiquitous Computing*, pages 1305–1316. ACM, 2015.

[15] Mark D Griffiths. Facebook addiction: concerns, criticism, and recommendationsa response to andreassen and colleagues. *Psychological Reports*, 110(2):518–520, 2012.

[16] L S Hallion and A M Ruscio. A Meta-Analysis of the Effect of Cognitive Bias Modification on Anxiety and Depression. *Psychol Bull*, 137(6):940–958, 2011.

[17] Severin Haug, Raquel Paz Castro, Min Kwon, Andreas Filler, Tobias Kowatsch, and Michael P Schaub. Smartphone use and smartphone addiction among young people in Switzerland. *Journal of behavioral addictions*, 4(4):299–307, 2015.

[18] Paula T Hertel, Andrew Mathews, and Andrew Mathews. Cognitive Bias Modification : Past Perspectives , Current Findings , and Future Applications. *Perspectives on Psychological Science*, 6:521–536, 2011.

[19] Eva Hornecker, Paul Marshall, Nick Sheep Dalton, and Yvonne Rogers. Collaboration and interference: Awareness with Mice or Touch Input. *ACM 2008 Conference on Computer Supported Cooperative Work (CSCW'08)*, pages 167–176, 2008.

[20] Jutta Joormann, Paula T Hertel, Joelle LeMoult, and Ian H Gotlib. Training forgetting of negative material in depression. *Journal of abnormal psychology*, 118(1):34, 2009.

[21] Chung K Kim, Mina Jun, Jeongsoo Han, Miyea Kim, and Joshua Y Kim. Antecedents and outcomes of attachment towards smartphone applications. *International Journal of Mobile Communications*, 11(4):393–411, 2013.

[22] E H Koster, E Fox, and C MacLeod. Introduction to the special section on cognitive bias modification in emotional disorders. *J Abnorm Psychol*, 118(1):1–4, 2009.

[23] Min Kwon, Dai-Jin Kim, Hyun Cho, and Soo Yang. The smartphone addiction scale: development and validation of a short version for adolescents. *PloS one*, 8(12):e83558, 2013.

[24] Min Kwon, Joon-Yeop Lee, Wang-Youn Won, Jae-Woo Park, Jung-Ah Min, Changtae Hahn, Xinyu Gu, Ji-Hye Choi, and Dai-Jin Kim. Development and validation of a smartphone addiction scale (SAS). *PloS one*, 8(2):e56936, 2013.

[25] Tamara J. Lang, Michelle L. Moulds, and Emily A. Holmes. Reducing depressive intrusions via a computerized cognitive bias modification of appraisals task: Developing a cognitive vaccine. *Behaviour Research and Therapy*, 47(2):139–145, 2009.

[26] Yu Kang Lee, Chun Tuan Chang, You Lin, and Zhao Hong Cheng. The dark side of smartphone usage: Psychological traits, compulsive behavior and technostress. *Computers in Human Behavior*, 31(1):373–383, 2014.

[27] Olatz Lopez-Fernandez, Luisa Honrubia-Serrano, Montserrat Freixa-Blanxart, and Will Gibson. Prevalence of problematic mobile phone use in British adolescents. *CyberPsychology, Behavior, and social networking*, 17(2):91–98, 2014.

[28] Colin MacLeod and Andrew Mathews. Cognitive bias modification approaches to anxiety. *Annual Review of Clinical Psychology*, 8:189–217, 2012.

[29] Tiago V Maia. Reinforcement learning, conditioning, and the brain: Successes and challenges. *Cognitive, Affective, & Behavioral Neuroscience*, 9(4):343–364, 2009.

[30] IHS Markit. List of best-selling smartphones for 2016. Technical report, IHS Markit, 2016.

[31] Matt Marshall, Paul and Morris, Richard and Rogers, Yvonne and Kreitmayer, Stefan and Davies. Rethinking'multi-user': an in-the-wild study

of how groups approach a walk-up-and-use tabletop interface. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, volume 14, pages 3033—-3042. ACM, 2011.

[32] Olivia Metcalf and Kristen Pammer. Attentional bias in excessive massively multiplayer online role-playing gamers using a modified Stroop task. *Computers in Human Behavior*, 27(5):1942–1947, 2011.

[33] Christian Müller-Tomfelde and Morten Fjeld. Introduction: A Short History of Tabletop Research, Technologies, and Products. *Tabletops Horizontal Interactive Displays*, pages 1–24, 2010.

[34] Antti Oulasvirta, Tye Rattenbury, Lingyi Ma, and Eeva Raita. Habits make smartphone use more pervasive. *Personal and Ubiquitous Computing*, 16(1):105–114, 2012.

[35] Leslie A Perlow. *Sleeping with your smartphone: How to break the 24/7 habit and change the way you work*. Harvard Business Press, 2012.

[36] Charlie Pinder, Russell Beale, and Robert J Hendley. Accept the Banana : Exploring Incidental Cognitive Bias Modification Techniques on Smartphones. *CHI Extended Abstracts on Human Factors in Computing Systems*, pages 2923–2931, 2016.

[37] Charlie Pinder, Russell Beale, and Robert J Hendley. Zephyr : Exploring digital behaviour change interventions to treat hoarding. *Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct, MobileHCI*, pages 875 – 882, 2016.

[38] Charlie Pinder, Jo Vermeulen, Russell Beale, and Robert Hendley. Exploring Nonconscious Behaviour Change Interventions on Mobile Devices. *Proceedings of the 17th International Conference on Human-Computer Interaction with Mobile Devices and Services Adjunct - MobileHCI '15*, pages 1010–1017, 2015.

[39] Anne Marie Piper, Eileen O'Brien, Meredith Ringel Morris, and Terry Winograd. SIDES: a cooperative tabletop computer game for social skills

development. *Proceedings of the 2006 conference on computer supported cooperative work*, pages 1–10, 2006.

[40] Jochen Rick, Amanda Harris, Paul Marshall, Rowanne Fleck, Nicola Yuill, and Yvonne Rogers. Children designing together on a multi-touch tabletop: an analysis of spatial orientation and user interactions. In *Proceedings of the 8th International Conference on Interaction Design and Children*, pages 106–114. ACM, 2009.

[41] Mike Rinck and Eni S Becker. Approach and avoidance in fear of spiders. *Journal of behavior therapy and experimental psychiatry*, 38(2):105–120, 2007.

[42] James Roberts, Luc Yaya, and Chris Manolis. The invisible addiction: Cell-phone activities and addiction among male and female college students. *Journal of behavioral addictions*, 3(4):254–265, 2014.

[43] Yvonne Rogers and Siân Lindley. Collaborating around vertical and horizontal large interactive displays: Which way is best? *Interacting with Computers*, 16(6):1133–1152, 2004.

[44] Mohammad Salehan and Arash Negahban. Social networking on smartphones: When mobile phones become addictive. *Computers in Human Behavior*, 29(6):2632–2639, 2013.

[45] Jacey See, Colin Macleod, and Russell Bridle. The Reduction of Anxiety Vulnerability Through the Modification of Attentional Bias : A Real-World Study Using a Home-Based Cognitive Bias Modification Procedure. *Journal of Abnormal Psychology*, 118(1):65–75, 2009.

[46] Richard Shambare, Robert Rugimbana, and Takesure Zhowa. Are mobile phones the 21st century addiction? *African Journal of Business Management*, 6(2):573, 2012.

[47] Gísli Thorsteinsson and Tom Page. User attachment to smartphones and design guidelines. *International Journal of Mobile Learning and Organisation*, 8(3-4):201–215, 2014.

[48] Haridimos Tsoukas and Christian Knudsen. *The Oxford handbook of organization theory*. Oxford Handbooks, 2005.

[49] Ofir Turel and Alexander Serenko. Is Mobile Email Addiction Overlooked? *Communications of the ACM*, 53(5):41–43, 2010.

[50] Ofir Turel, Alexander Serenko, and Paul Giles. Integrating technology addiction and use: An empirical investigation of online auction users. *Mis Quarterly*, 35(4):1043–1062, 2011.

[51] Ofir Turel, Alexander Serenko, and Paul Giles. Integrating technology addiction and use: An empirical investigation of online auction users. *Mis Quarterly*, 35(4):1043–1062, 2011.

[52] Alexander J A M Van Deursen, Colin L. Bolle, Sabrina M. Hegner, and Piet A M Kommers. Modeling habitual and addictive smartphone behavior: The role of smartphone usage types, emotional intelligence, social stress, self-regulation, age, and gender. *Computers in Human Behavior*, 45:411–420, 2015.

[53] Bard O Wartena and Hylke W van Dijk. Bias Blaster Aiding Cognitive Bias Modification- Interpretation through a bubble shooter induced gameflow. *Games for Health SE - 4*, pages 47–60, 2013.

[54] Rebecca Watkins, Ed R and Baeyens, Celine B and Read. Concreteness training reduces dysphoria: proof-of-principle for repeated cognitive bias modification in depression. *Journal of abnormal psychology*, 118(1):55, 2009.

[55] Pierre Wellner. Interacting with paper on the DigitalDesk. *Communications of the ACM*, 36(7):87–96, 1993.

[56] Alexis Whitton, Jessica Grisham, Julie Henry, and Hector Palada. Interpretive Bias Modification for Disgust. *Journal of Experimental Psychopathology*, 4(4):341–359, 2013.

[57] World Health Organization Who. Public Health Implications of Excessive Use of the Internet , Computers , Smartphones and Similar Electronic Devices Meeting report. Technical report, World Health Organization, 2014.

[58] Reinout Wiers, Mike Rinck, Robert Kordts-Freudinger, Katrijn Houben, and Fritz Strack. Retraining automatic action-tendencies to approach alcohol in hazardous drivers. *Addiction 02/2010*, 105:279–87, 02 2010.

[59] Reinout W Wiers, Carolin Eberl, Mike Rinck, Eni S Becker, and Johannes Lindenmeyer. Retraining Automatic Action Tendencies Changes Alcoholic Patients' Approach Bias for Alcohol and Improves Treatment Outcome. *Psychological Science*, 22(4):490–497, 2011.

[60] Reinout W Wiers, Thomas E Gladwin, Wilhelm Hofmann, Elske Salemink, and K Richard Ridderinkhof. Cognitive bias modification and cognitive control training in addiction and related psychopathology: Mechanisms, clinical perspectives, and ways forward. *Clinical Psychological Science*, 1(2):192–212, 2013.

[61] Charlotte E Wittekind, Ansgar Feist, Brooke C Schneider, Steffen Moritz, and Anja Fritzsche. The approach-avoidance task as an online intervention in cigarette smoking: a pilot study. *Journal of behavior therapy and experimental psychiatry*, 46:115–120, 2015.

[62] Wendy Wood and David T Neal. A new look at habits and the habit-goal interface. *Psychological review*, 114(4):843, 2007.