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A FRAMEWORK FOR DESIGNING PERSUASIVE MOBILE HEALTHCARE APPLICATIONS

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Abstract

This research presents a framework for designing persuasive mobile healthcare applications. The aim of the proposed framework is to help the analysis and design of mobile healthcare apps. Two versions of the framework are presented. A study was conducted with experts in order to test the framework and also to provide suggestions for it. The test with the experts showed that the framework was able to help identify the strengths and weaknesses of the applications and proved to be effective. It is expected that the proposed framework will help designers and programmers to design and analyse mobile applications with a persuasive character, and thus assist users in changing and maintaining healthy behaviour.

Key-words: Persuasive technologies; Mobile applications; Mobile healthcare applications; Mobile interaction design; Healthy behaviour.

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1 INTRODUCTION

Interactive systems are progressively used for persuasive goals in various domains (Spagnolli et al., 2016). There is also an increasing interest and investment in designing technology to promote health and wellness by different actors, such as researchers, health professionals, technology designers, and public health and government agencies (Orji and Moffatt, 2018). However, Blandford (2019) points out that despite widespread investment in innovative healthcare technologies, most of them are difficult to use and few have achieved wide market penetration. In addition, Langrial et. al. (2012) claims that although the use of persuasive technologies in native mobile applications is expanding, new research is still needed to help designers develop effective and persuasive mobile applications.

Persuading people to change their daily behaviour is not an easy task, as distinct behaviours require different strategies and techniques. Persuasion is considered a "ubiquitous part of contemporary life" and also a way of influencing socially (de Carolis and Mazzotta, 2017). Persuasive systems that aim to encourage people to change their habits are important tools for healthcare. Persuasive Technologies are interactive systems designed to help people to change their attitude and/or behaviours (Chatterjee and Price, 2009, Fogg 2003, Hamari et al., 2014). Therefore, these technologies applied to mobile health apps can influence attitudes and behaviours of users (Matthews et al. 2016).

Mobile Healthcare (also known as mHealth) refers to medical practices supported by mobile devices, including applications aimed at maintaining or improving the quality of life and wellbeing of individuals, such as personal guidance systems (European Commission, 2014). According to the report "mHealth App Economics 2017/2018", the mobile healthcare application market is around 10 years old and has been growing steadily in recent years. In addition, the report states that, in 2017, there were 325,000 health apps (health and fitness and medical apps) available in all major application stores (Research2Guidance, 2017). Mobile healthcare applications can be useful in different ways, such as helping healthcare providers in monitoring, improving and learning about their patients' health, and as a tool to evaluate and motivate mobile users who have limited access to healthcare (Higgins, 2016).

The design of persuasive healthcare technologies can be challenging as it involves a variety of fields, including social psychology, information technology, design and related areas. For inexperienced designers it is even more difficult, because few well-defined processes exist in the construction of persuasive technologies (Fogg, 2009). Frameworks, models and guidelines are important tools to help designers to build persuasive health technologies that are effective and efficient. The relevance of frameworks for system design has been argued by various authors (e.g. Blizzard and Klotz, 2012; Souto, 2014). As Blizzard (2012) explains, frameworks can encourage and facilitate the application of principles that might otherwise be difficult to understand. In addition, frameworks can help to generate requirements from fieldwork data (Doherty et al., 2010), and may be used to inform both design and analysis (Rogers and Muller, 2006). In literature, it is possible to find different frameworks and models that can be used to analyse and understand the factors related to applications aimed at persuading the practice of healthy habits. However, most of them focus on aspects related to health behaviour and persuasive approaches.

This research aimed to propose a framework for designing persuasive healthcare applications. First, a literature review of frameworks, guidelines and models related to cognitive, persuasive and technological aspects that help in understanding the main aspects of mobile device applications for practising healthy habits is presented. Then an initial version of the framework is described based on both an analysis of mobile health applications, and on the literature review. Then, an empirical study is presented, with experts that were required to use the framework and also give their perception and suggestions about it. Finally, based on this study, a final version of the framework is proposed and discussed.

2 LITERATURE REVIEW

Different reviews on persuasive systems have been published, such as: Hamari et al. (2014) reviewed 95 studies on persuasive technology, whereas Spagnolli et al. (2016) reviewed the theories and concepts that aim to guide the design and evaluation of interactive persuasive systems, and Matthews et al. (2016) made a systematic review on persuasive technology, focusing on mobile applications that promote physical activity, and examined 20 papers from 2008 to 2014.

A recent review specifically about persuasive applications on health and wellness, the focus of this study, was conducted by Orji and Moffatt (2018). They reviewed 85 papers from 2000 to 2015 to investigate the effectiveness and trends of persuasive technology for health and wellness. Based on this review, Orji and Moffatt (2018) concluded that: persuasive technology is a promising approach to promoting desirable health and wellbeing behaviors; however, the lack of large-scale evaluations makes it impossible to establish its long-term impact on promoting these behaviours.

To design the proposed framework, broader and more specific research contributions on frameworks, models, and guidelines related to (but not exclusively on) persuasive mobile health applications were considered. The literature review revealed three major themes in the design of these systems: healthy behaviours, persuasive technology, and mobile user interface design.

2.1 Healthy behaviours

Behaviour change is one of the key aspects in designing persuasive mobile healthcare apps. Studies on behaviour change techniques can explore how health behaviour change applications can become more attractive and effective and thus avoid content, features, and technologies that embarrass, annoy, worry, or overwhelm users (Dennison et al., 2013). Studies have focused on different aspects of healthy behaviours. For example, Fogg (2009) proposes an Eight-step Process list of guidelines, in which the first step in creating a persuasive technology is the choice of target behaviour. Many attempts at designing these technologies fail because people do not understand which factors lead to behaviour change. There are many theories of behaviour, some of which are broader, such as the Elaboration Likelihood Model of Persuasion (Petty and Cacioppo, 1986) and others of a more specific application such as the Health Belief Model (Becker et al., 1978; Rosenstock et al., 1988) or the Integrative Model of Behavioural Prediction (Fishbein, 2000) developed to predict, explain, and change

health-related behaviours.

Both HBM and IMBP have been used in a series of studies to understand healthy behaviours. The Health Belief Model (HBM) investigates why people do not take preventative health measures, and is one of the oldest and most widely applied health behaviour theories (Orji and Mandryk, 2014). Although HBM is one of the base models used to build the IMPB, the two have many differences. HBM does not consider that economic and/or environmental factors may prevent the individual from taking action (Janz and Becker, 1984). In IMBP, on the other hand, external factors along with the individual's abilities and intention are what trigger the behaviour.

Unlike the other models presented above, the Fogg Behavior Model (FBM) is linked to practical issues in the design of behaviour change technologies. The FBM states that for a person to perform a targeted behaviour, they must be motivated, have the ability to perform the behaviour, and be triggered to perform the behaviour. It can be applied in various fields such as education, commerce and even health (Fogg, 2009). Still, it has a simpler and more systematic character. However, FBM does not take into account decision-making processes such as HBM and IMBP. What all these theories, models, and their applications have in common is that understanding behaviour change requires knowledge of the internal and external factors that affect the individual and his/her context.

2.2 Persuasive Systems

Media technology has long played a significant role in facilitating the delivery of persuasive messages to buy, donate, vote, grant or act (Ijsselsteijn et al., 2006). Persuasive systems aim to help and motivate people to adopt behaviours that are beneficial to themselves and their community, while avoiding harmful ones (Orji and Moffatt, 2018). According to Oinas-Kukkonen and Harjumaa (2008), persuasive systems can use human computer persuasion (i.e. using some interaction patterns similar to media) or computer mediated persuasion (i.e. people are convincing others through computers). Models on persuasive technologies help to understand the systems' characteristics and also help in the design and evaluation of such systems.

Fogg (1998) believes that computational technologies can play different roles for the user and, from this belief, created a conceptual framework called functional triad. According to the framework, interactive technologies operate in three basic modes: as tools, as media, and as social actors. The Functional Triad can be applied in a broad context, and can help to reveal how an interactive technology can persuade: increasing a person's skills, giving users an experience, or boosting the power of social relationships (Fogg, 1999). However, Oinas-Kukkonen and Harjumaa (2009) note that although Fogg's framework provides a useful way to understand persuasive technology, it does not explain how the suggested design principles can and should be transformed into software requirements and implemented as real system characteristics. Based on Fogg's framework, Oinas-Kukkonen and Harjumaa (2009) developed the Persuasive system development model.

The Persuasive Systems Development (PSD) model provides an overview of the stages of persuasive system design. According to this model, the elaboration of persuasive systems consists of three steps: understanding the central question that sur-

rounds it, the context that surrounds it and its attributes. They also propose 28 design guidelines, mostly based on Fogg's functional triad, for persuasive system content and functionality, describing examples of software requirements and implementations (Oinas-Kukkonen and Harjumaa, 2009).

Like PSD, the eight criteria for persuasive interactions (Némery et al., 2011) were also designed for application in various persuasive contexts and systems. However, the model proposed by Némery et al. (2011) is especially focused on the persuasive features of the interface and does not consider the user's context or the context in which it is used. Its purpose is to assist in the design and evaluation of persuasion in the field of human-computer interaction. The model by Némery et al. has eight criteria: credibility, privacy, personalization, attractiveness, solicitation, initiation, commitment, and ancestry, that are divided into two dimensions: static and dynamic aspects of the interface. What these theories and models have in common is that understanding behaviour change requires knowledge of the internal and external factors that affect the individual and his or her context.

2.3 Mobile user interface design

The user interface (UI) is a major issue in the design of persuasive mobile healthcare applications as it is the interaction point between the user and the system. The UI design process is one of the most important in mobile application development, which requires specific design experience due to its physical limitation (e.g. small screen size) (Wetchakorn and Prompoon, 2015). User interfaces change the lives of many people, for example, helping doctors make more accurate diagnoses; too often, however, users deal with frustration when they encounter complex menus, incomprehensible terminology or chaotic navigation paths (Snheiderman and Plaisant, 2005).

According to Cooper et al. (2014), the key to designing effective product interactions and interfaces is to integrate design principles, processes, and patterns. In addition, Matthews et al. (2016) claim that design principles that influence the effectiveness of persuasive technology must be understood to ensure that mobile technology resources are best used to improve people's wellbeing. UI design principles have been proposed by many authors, such as the well-known design principles by Norman (1988), the Eight Golden Rules of Interface Design by Shneiderman (1986), and the Heuristics for User Interface Design by Nielsen (1994). However, many of these principles were proposed prior to the popularization of mobile devices, and often do not address the limitations and attributes of these new technologies.

Already considering the mobile interface, Nillson (2008) presents a structured collection of UI design patterns for mobile applications. These patterns are suggested solutions to problems and can be used as an index to identifying patterns to use or to give a comprehensive overview of the issues when designing user interfaces for mobile applications.

Another framework for UI mobile applications was proposed by Ayob, Hussin and Dahlan (2009). They developed the 'Three layers design guideline for mobile application' to assist in designing interface-focused mobile devices, but also consider users and industry requirements. The framework focuses on the study of m-commerce platforms and is divided into three phases: the context of use; the media context; and the context of the evaluation.

Examples of heuristics focused on UI design in mobile applications are: the usability heuristics for mobile devices (Inostroza et al. 2012; 2016), and the heuristic evaluation on mobile interfaces (Gómez, Caballero, and Sevillano, 2014). These heuristics are similar as all have a major influence on Nielsen's heuristics. On the other hand, they differ in relation to their scope. While the heuristics of Gómez, Caballero and Sevillano (2014) focus specifically on the virtual interface, those of Inostroza et al. (2012; 2016) also involve the device. In addition to the studies on UI mobile applications, there are the guidelines proposed by the mobile operational systems. Both Apple and Android systems have human interface guidelines that aim to help designers to build more effective applications and to inform them about the system and restrictions.

Although there are many mobile UI studies, Punchoojit and Hongwarittorrn (2017) state that standards for mobile UI design patterns have not yet been established. In addition, specifically regarding UI for mobile healthcare applications, although there are many studies on the effect of the UI on mobile healthcare applications (e.g. Gkatzidou et al., 2015; Warpenius et al., 2015; Bhandari et al., 2017; Copeland et al., 2018), no conceptual framework has been found that highlights user interface issues in persuasive mobile healthcare applications.

3 DESIGNING THE FRAMEWORK FOR PERSUASIVE MOBILE HEALTHCARE APPLICATIONS: INITIAL VERSION

The aim of the framework is to guide the design of persuasive applications related to the practice of healthy habits, as well as the analysis of such applications. It is specifically focused on native applications of touch-sensitive mobile phones. The initial version of the framework was proposed based on both the literature review and the exploratory analysis of health applications briefly described below.

3.1 Exploratory analysis of mobile health applications

This analysis has been conducted to understand how health applications use persuasion to help people maintain healthy. Fifteen applications were selected for analysis and were chosen based on the 'Rating' topic in Apple's app store. The applications analysed fall into the categories 'nutrition and diet' and exercise, the second being divided into aerobics (e.g. running, cycling, walking), weight training and/or stretching (e.g. pilates, yoga, stretching). The functionalities available in five applications of each group were observed: aerobics (Strava running and cycling, Sports tracker, MapMyRun, Runtastic Running and Fitness, Runkeeper), weight training and/or stretching (Workout Trainer, Sworkit lite, BTFIT, Freeletics, JETfit) and nutrition and diet (My fitness pall, Lifesum, Tecnonutri, Nutrabem, Dieta e Saúde).

Aerobic applications are the most numerous and popular exercise apps. The functions of the listed applications are very similar and vary mainly according to the focus of the application. Some are very specific to some activities, like Strava, which only offers activities like running and cycling and has a competitive character, while others, like Runkeeper, have other activities, not necessarily aerobic, but with a focus on running and walking.

Applications aimed at weight training and stretching were found in fewer numbers when compared to aerobic activities. They have several offshoots, such as the

Runastic six-pack, specifically aimed at defining the abdomen. Therefore, they offer ready-made workouts with certain types and amounts of exercises. This type of application makes a lot of use of videos and images to guide and explain activities, as weight training and stretching exercises are not as intuitive as aerobic exercises. In practice, exercises are monitored by timing.

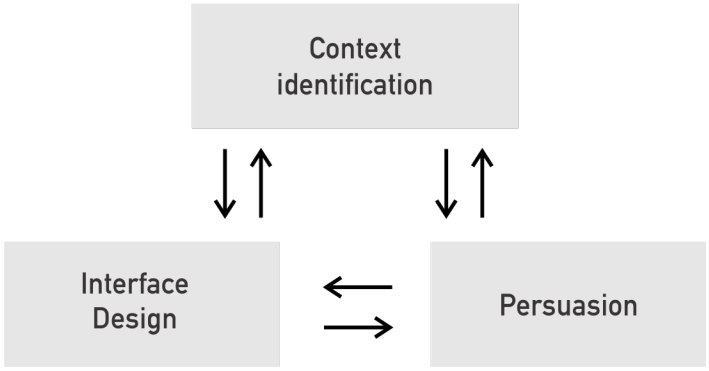
Nutrition and diet applications were available in fewer numbers on application stores compared to aerobic activity applications. These applications are food oriented, some more diet oriented, some healthy eating, or both. Regardless of the focus, these applications have a food database, this can be seen as a facilitator, as the user does not waste time recording meals daily. Some of the applications like Lifesum and Diet and Health have aerobic activity database, while My Fitness Pal can be integrated with exercise applications. Tracking calorie expenditure allows nutrition and diet applications to perform more accurate caloric analysis.

The analysis showed that aerobic applications (AE) and weight training and stretching applications (WS) are in the same group (exercise applications), so it is natural that they have more functionality in common. However, the focus of each type of application requires different content. For example, in WS applications, instructional photos are widely used, unlike AE applications do not make use of this resource because there is not such a wide variety of exercises, and their activities do not require visual instruction. Nutrition and diet (ND) applications, on the other hand, have a very different purpose than exercise, so many of their functionalities are distinct, such as water consumption monitoring, food database, barcode scanner, among others. Despite this, both exercise apps (AE and WS) and ND have common features such as weight and calories monitoring, personalization of goals and objectives, online user profile, among others. These functionalities are more general, not so much dependent on the application's focus, and are repeated in persuasive health applications.

3.2 Initial Version of the framework

The framework was initially divided into three main components: context, interface design and persuasion. Apart from these three main components the framework presented 18 sub-components. A previous study of this version was published in Demonte and Souto (2015). Figure 1 shows the first version of the main components of the framework and how it works: context should guide interface design and persuasion. The component/subcomponent descriptions of this first version are briefly presented below.

Figure 1. Schematic that shows the dynamics of the analysis using the first version of the framework.



Source: Authors.

Context

In this study, context is relative to everything that affects the interaction of the user with the system, especially external factors. The context is presented in two models: Persuasive Systems Development (PSD), which presents the context of persuasion (Oinas-Kukkonen and Harjumaa, 2009) and Three layers design guideline for mobile application, which presents the context of use (Ayob , Hussin and Dahlan, 2009). Both emphasize the moment of use of the system. In addition, the PSD highlights the intent of the persuader and considers possible differences between users.

The context can be divided into four parts: (1) purpose of the application, (2) context of use, (3) user characteristics, and (4) particularities of touch-sensitive smartphones, described below.

Interface Design

Interface design is essential for persuasion. This is because the interface design is considered one of the most important parts of any software, as it determines the interaction with the system (Ayob, Hussin and Dahlan, 2009). Users communicate and interact with the system through the interface. Therefore, the interface must be well planned; otherwise, the experience can be negative and ineffective.

Two criteria were used to define interface design subcomponents: ambiguity between components should be avoided and their naming should be as self-explanatory as possible. Firstly, the components of the interface design models presented in the theoretical framework were grouped, and then some of these were combined or eliminated. The models were: Three Layers of Design Guidelines for Mobile Applications (TLD) by Ayob, Hussin and Dahlan (2009); Heuristics Focused on Mobile Devices with Touchscreen (UHTM), by Inostroza (2012); Checklist for Heuristic Evaluation on Mobile Device Interfaces (CHEMI) by Gómez, Caballero and Sevillano (2014); and iOS Human Interface Design (iOSHID) by Apple (2018).

The interface design subcomponents in the framework for the analysis and creation of persuasive applications of mobile devices aimed at the practice of healthy habits are: (1) System status visibility, (2) User control, (3) Minimize memorization, (4) Consistency, (5) Aesthetics, (6) Prevention and treatment of errors, (7) Help and documentation, (8) Customization, (9) Privacy.

Persuasion

The third component of the proposed framework is persuasion. In this way, it emphasizes the importance of persuasive aspects to encourage the change of user behaviour, making healthy practices easier and pleasant. It is important to remember that persuasion in this work is not taken as coercion. Its purpose is not to force behaviour but to promote voluntary change on the part of the user (Fogg, 2003).

The aim of the framework is to build systems that help not only with changing a habit but also promote the continuity of a habit. The Fogg Behavior Model (Fogg, 2009) presents the conditions for the occurrence of an immediate behaviour. Fogg (2009) argues that behaviour is due to the convergence of three factors: motivation, capacity, and triggers.

In addition to immediate action, it is important that the application helps maintain healthy habits. Some tricks are often used in current applications to maintain user interest. Most of them connect to social networks, have internal social networks, encourage cooperation and competition among users, and assign human characteristics to devices (e.g., voice command applications simulating personal trainer). According to the PSD and functional triad, these actions are associated with social influence. In addition, it has been noted that many of the applications reward users for their actions. Finally, both the PSD and the Eight Criteria for Persuasive Interactions (Némery, Brangier, and Kopp, 2011) highlight the importance of credibility in a persuasive system.

The proposed framework presents the following components for the analysis of persuasion: (1) simplicity, (2) triggers and timing, (3) credibility, (4) social influence, and (5) reward.

3.3 Final considerations of the proposed framework: first version

This framework was created based on models, guidelines and frameworks, so it is possible to note some similarities, differences and adaptations made from existing theories. The influence of the PSD (Oinas-Kukkonen and Harjumaa, 2009) is clear, because this model is the closest to the proposal of this article. The PSD was created for analysis and design of persuasive systems; however, the framework proposed here presents a more specific character, being restricted to mobile devices and applications aimed at healthy habits.

HBM (Becker et al., 1978; Rosenstock, et al., 1988), IMB (Fishbein, 2000) and FBM (2009) behaviour models have helped to understand that both internal and external factors may influence user persuasion, highlighting the importance of contexts. However, the FBM (Fogg, 2009) had a greater influence on the design of the proposed model. This is because among the three models, it is the only one that is focused on computational persuasion. The models of Gómez, Caballero and Sevillano (2014), Inostroza (2012) and Ayob, Hussin and Dahlan (2009), related to interface design in mobile devices, also helped in the construction of some components, with particular emphasis on the particularities of these devices. However, unlike the framework proposed in this chapter, they are not specific to persuasive technologies.

For the persuasion component, the Fogg (FBM 2009 and Functional Triad 2002), PSD (Oinas-Kukkonen and Harjumaa, 2009), and the Eight Criteria for Persuasive Interactions (Némery, Brangier, and Kopp, 2011) were essential for the definition of its subcomponents. Based on existing mHealth applications, it was possible to observe

the most commonly used tools of persuasion and thus to consider the importance of these within the framework.

As explained, the aim of the framework is to assist designers and developers both in analysing existing health applications and in designing health applications. In order to understand the applicability and effectiveness of the framework, it was tested with interaction design experts, as is described below.

4 ANALYSIS OF FRAMEWORK WITH EXPERTS

In order to verify the application of the framework and the understanding of its components, experts were asked to use the framework by analysing a mobile Health application. The use of the framework was followed by a semi-structured interview.

4.1 Method

Participants were initially asked to browse a mobile Health application freely for 5 minutes to familiarize themselves with the application. The application chosen for analysis was the My Fitness Pal (MFP), an application that counts the user's calories and works as a food diary. It was chosen because it was very well rated in the app stores.

All analyses were performed on the iOS platform on the iPhone 4S device offered by the researcher. Initially, participants were informed in a clear and accessible way about the test, about their anonymity and asked to sign a consent form. Then participants were given a few pages. The first presented the complete framework without the descriptions, and on the following pages the framework with the definition of each subcomponent and a space to analyse the application. All analysis was done in writing. The application was made available to the experts during the analysis. During the test, the researcher only voiced an opinion if a doubt arose

After the analysis, the experts were asked to participate in a semi-structured interview. The interviews were used to obtain the perception and opinion of experts about the use and structure of the framework presented. The interview was based on a script with five questions (e.g. 'Would you change any component featured in the framework?'). As with the analysis of the framework, the interviews aimed to achieve the answers more spontaneously. Therefore, no explanations were given on how to use the framework. The interviews were recorded in audio recordings.

4.2 Experts

Ten experts participated in this study: five programmers and five designers. The age group of the participants ranged from 20 to 50, and the majority were between 26 and 30 years old. They had different degrees: computer engineering, graphic design, computer science and social communication. All of them had worked with interaction design for at least two years and with applications for at least a year. Half of them had already used health applications. Three participants had already worked with health applications. Only three of them confirmed that they knew persuasive technologies.

4.3 Results of the Application Analysis by Experts

On the context component, participants expressed different types of responses: descriptive, critical, or a combination of the two. Some experts were more descriptive, exposing their perceptions regarding each of the subcomponents. For example, the users' characteristics, according to one of the experts: "The user is mainly a person who wants to lose weight or control their diet". Others have been more analytical, showing some features of the application that help in adjusting to the context, as illustrated by the response of one of the experts: "Simple and straightforward interface that favours use in context".

In relation to the analysis of the interface design aspects, the experts identified the application's functionalities, its flaws and also its strengths. Some responses were more direct and only confirmed the presence of a certain functionality and its effectiveness, while other answers were more descriptive and pointed out advantages and disadvantages of the same component.

Finally, in the analysis of persuasion there were many descriptive answers identifying the functionalities corresponding to the components, such as this response on social influence. The experts argued that some components could not be analysed as they did not have a lot of experience with the application. As one of them pointed out about the triggers: "With little use and engagement it is not possible to identify the triggers but it is possible that, with the time of use, the application requests some actions from the user." According to the experts, triggers, timing, social influence and reward would require a greater knowledge of the system for analysis. Credibility was interpreted in two ways: some experts questioned the real credibility of the information, including the accuracy of the data it provided, while others focused on the perception of credibility.

4.4 Interview Results and Discussion

In general, the experts, both designers and programmers, confirmed the ease of use of the framework. However, they also recognized its extent and technical character. They concluded that some theoretical and practical knowledge is needed to use it. The language, although technical, is considered adequate to the purpose of the framework, which is to assist people who have experience in analysing and designing applications.

Regarding the goal of the framework to assist in the analysis and design of applications, experts agreed that the framework meets its goal. Some agreed that it has a greater emphasis on analysis. It was noticed that it does not serve as a step by step guide, but it aids in the development of functionalities, making the connection between design persuasion and purpose of the application. During the analysis of the application it was clear to the experts that the framework helped to identify features, failures and even strengths.

It was noted that some experts were not comfortable with the openness of the framework. They felt the lack of something more concrete for evaluation. Some suggested that descriptions should include examples or questions. However, it was pointed out that it could be risky to give more details and examples; as one noted: "You can put in examples to help, but you risk directing the person". In addition, other changes

were suggested, such as: prioritization of the components, fault severity measurement, addition of a component related to the market. It is important to emphasise that the idea of the framework is not to restrict, but to help the expert to explore the possibilities and to direct the data found in the way that is most convenient to him/her, as well as many of the frameworks presented in the theoretical framework.

It is also relevant to point out that some of the experts were able to note during the analysis how components, even of different parts (context, interface design, and persuasion) interfere with each other; for example, as a specialist points out: "I came to think that I had answered things from one place in another, and then I looked and I saw that I had not". The answers were similar, but the questions were different. However, this integration was not used much by the experts to assist in the analysis as a whole, probably because it was noticed only after the analysis.

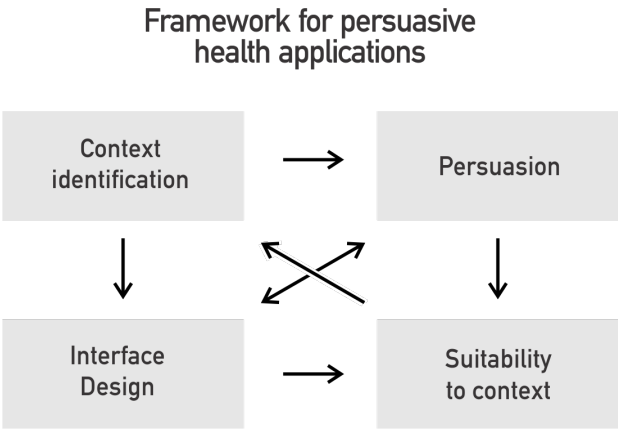
It is noticeable that the context caused some confusion. Two types of responses appeared; some of the experts only identified and described the components according to their perceptions, while others made a critical analysis of the adequacy of the features to the context – questioning the order in which the components of the framework were presented.

It is possible to conclude from the analysis with the experts that the framework reached its aim: to assist the experts to analyse the application, findings its strengths and weaknesses. However, the results showed that some participants did have specific problems with some components, such as particularities of the device and visual personalization, as well as in its dynamic of use. In order to make it more appropriate, changes were made according to what was observed and suggested during the analysis with the experts.

5. FRAMEWORK FOR PERSUASIVE HEALTH APPLICATIONS: FINAL VERSION

The initial version of the framework was revised based on both the test and the interview with the experts, presented above. It is now divided not into three but four parts: context identification, interface design, persuasion, and context suitability. First, the experts should define the context and from there build the Interaction Design and Persuasion. Finally, a check should be made to verify if the final result (the application) is in agreement with the proposal that was drawn up in the first instance. Figure 2 shows the final proposal with the four main components of the Framework. Finally, the complete Framework for persuasive health applications is presented, with the components, subcomponents and descriptions (Table 1).

Figure 2. Framework for persuasive health applications: final version – main components and the dynamic of the analysis.



Source: Authors.

5.1 Context identification

Context identification is the first part of the framework due to the fact that persuasive technologies are characterized by intentional behaviour-oriented construction (Fogg, 1999). This component is relative to this initial intention: what the target is, the target audience, where and at what time it was made to be used, what features of the device that the application will work with. The PSD model (2009) also highlights the importance of "choosing the path" of persuasion. Both the use and user contexts should be analysed, in order to help the developer to recognize inconsistencies in the user's thinking, know the best times to deliberate a message and effectively use persuasion techniques (Oinas-Kukkonen and Harjumaa, 2008).

5.2 Interface Design

The second part of the framework is interface design, which was based mainly on heuristics focused on touch screen mobile devices (Inostroza, 2012) and the heuristic evaluation checklist on mobile device interfaces (Gómez, Caballero and SEVILLANO, 2014). There were few changes in this subcomponent after the experts' analysis.

5.3 Persuasion

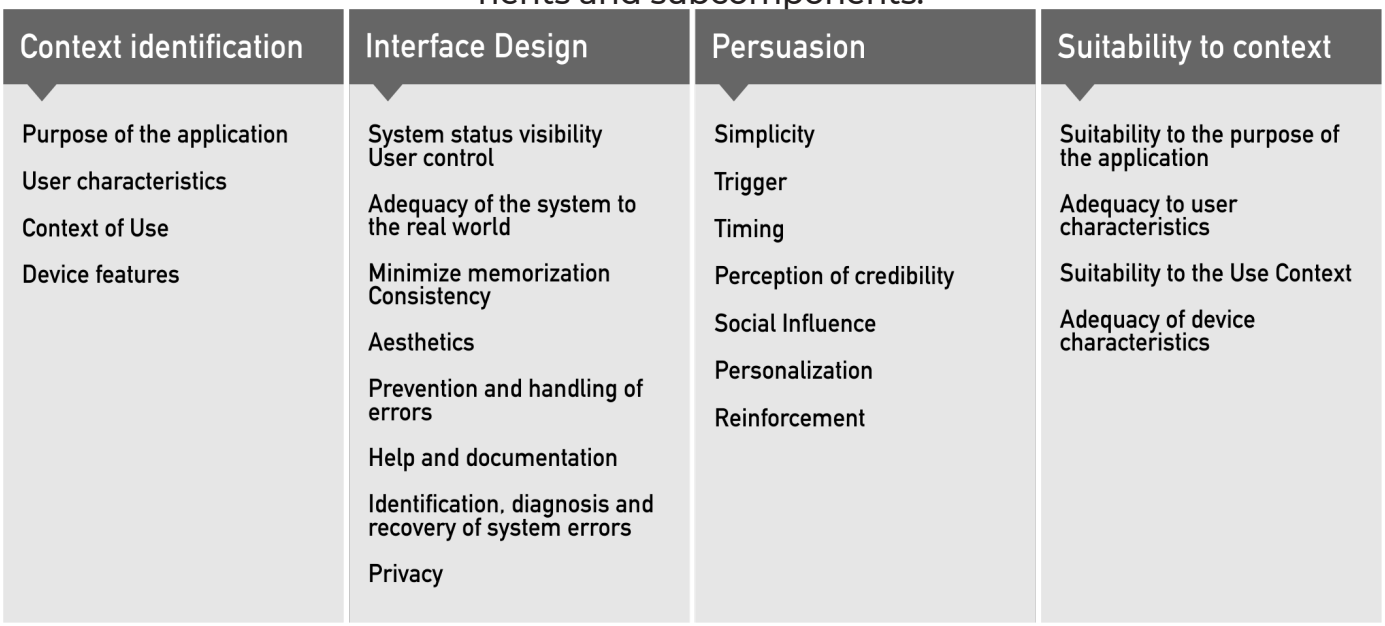
This focuses not only on immediate behaviour change, but also on the cultivation of this behaviour. Subcomponents, attractiveness and personalization were added, also present in the model eight criteria of persuasive interactions (Némery, Brangier, And Kopp, 2011). The component that was once "reward" now encompasses all types of reinforcements. In addition, some descriptions have been incremented, while other subcomponents have had the names changed to facilitate understanding. Persuasion showed to be the component least familiar to specialists.

5.4 Suitability to context

The last component of the framework is the appropriateness to the context. This

component may seem repetitive at first glance, but after analysing it, the experts noted that the framework does not work in a linear fashion. The adequacy to the context is the final part of the analysis, after the analysis of all the other components has checked whether the system fits the context that was proposed in the first place. Figure 3 shows the framework for persuasive health applications with the components and the sub-components, and Table 1 shows the framework for persuasive health applications: complete final version with the components, sub-components and their descriptions.

Figure 3. Framework for persuasive health applications: final version – main components and subcomponents.



Source: Authors.

Table 1. Framework for persuasive health applications: complete final version with the components, sub-components and their descriptions.

Components	Sub-components	Descriptions
Context identification	Purpose of the application	The purpose of the application is relative to the problem domain, the purpose of the application, of persuasion.
	User characteristics	This subcomponent seeks to know the user who will benefit from the application. It is important to consider that the person's perception can be influenced by their individual characteristics and by variables such as: culture, gender, schooling, past experiences, abilities, motivations, among others.
	Context of Use	The context of use is relative to the situation at the exact moment of use of the system, factors to which it is subject.
	Device features	The particularities of smartphones are related to the limitations and attributes of this type of device.
Interface Design	System status visibility	System status visibility is relative to immediate system state feedback, indicating the user's location and actions within the application.
	User control	The system should enable the user to have control over their actions. You can even reverse them and use more than one way to get where you want or perform a certain action.

	Adequacy of the system to the real world	The system must speak the users' language, follow the conventions of the real world, display the information in a logical and natural way.
	Minimize memorization	Minimizing user memory can be through visual cues, objects, actions, and options that should always be clear and visible.
	Consistency	Consistency is related to how content is presented to the user. The system must follow established conventions, so that the user can carry out the actions in a familiar way and without much effort. Similar contents must present an aesthetic unity, and distinct contents must represent this distinction clearly.
	Aesthetics	The system should avoid displaying irrelevant content. This rule should apply to all elements of the interface; these should follow a logic that must consider the perceptual and cognitive characteristics of the user. Among other things, multimedia content, iconography, palettes, typography, and spacing among elements should be noted.
	Prevention and handling of errors	Mistakes should be avoided at all costs. Features that are not available should remain hidden or disabled. Graphic design of the interface should be careful to avoid user errors.
	Help and documentation	The application must be prepared to attend both frequent and new users, so it should provide help in familiarizing with the system if necessary. When a task is complex and involves several steps or when it comes to a new user the application should guide you step by step in a clear and succinct way.
	Identification, diagnosis, and recovery of system errors	Errors should be avoided at all costs. The system helps the user to identify errors clearly and simply (without codes), indicating the problem, and suggesting a solution.
	Privacy	The system must protect the user's information so that it will only be accessed by whomever he/she allows.
Persuasion	Simplicity	Simplicity is related to the functions and requirements of the application to perform certain tasks. There are six barriers that influence simplicity: time, money, physical effort, brain cycles, social deviation and not routine.
	Trigger	Triggers are thrusters of action. These should be clear, always associated with a particular action and should occur in a timely manner.
	Timing	Timing is the right time for action. Without it, the trigger may have no effect, or even have a negative effect. Therefore, this must be in accordance with the capacity and motivation of the user to perform the action suggested by the trigger.
	Perception of credibility	Credibility is relative to how credible the system appears to be.
	Social influence	Social influence aims to facilitate integration by supporting users, acting as a social actor. The social presence in a technology can be given physically, psychologically, through language, social dynamics and social roles.
	Personalization	The system should seek a greater alignment with the user by customizing goals, objectives, and frequent actions, according to the contextual needs.
	Reinforcement	Reinforcement is Aa way to strengthen certain behaviour. The reinforcement may be positive, a stimulus element is added, or a negative stimulus aversive to the individual is withdrawn.
Suitability to context	Suitability to the purpose of the application	The system must be clear in its purpose and be faithful to its purpose.
	Adequacy to user characteristics	The system must be prepared to serve different users, considering their goals, objectives, possible individual characteristics and variables.
	Suitability to the use context	The system must consider the adversities that are presented in the context of use and prevent them from harming user experience.

Adequacy of device characteristics	The system considers the specific characteristics of the device in which it will be run, thus using its limitations and attributes in favour of the system.

6 FINAL CONSIDERATIONS

Mobile technologies, especially smartphones, have great potential in the health field, especially when it comes to behaviour change. However, changing and maintaining new habits is not simple, and building systems for this purpose is an arduous task. Healthcare systems are complex and new strategies for designing interactive health technologies are needed to meet the needs and values of their diverse users (Blandford, 2019). Thus, this research aimed to propose a framework for designing persuasive healthcare applications. The framework, divided into four main components (context identification, interface design, persuasion and context appropriateness), was tested and redesigned from research with a group of experts. The framework was able to help identify the strengths and weaknesses of the applications and proved to be effective. It is expected that the framework proposed will help designers and programmers to design and analyse mobile applications that have a persuasive character, and thus assist users in changing and maintaining healthy behaviour.

It was noted that healthy behaviour is linked to individual perceptions and external environmental and economic factors, among others. In order for persuasion to act, it is important to keep in mind the perceptions and external factors that move people, and from this to develop strategies to guide a change in behaviour and then help to maintain it. However, for the device to be able to influence a person in some way it should provide a good user experience. Positive user experiences are linked to the interface design, and, for this, one must always consider the characteristics of the device in which the system will be presented.

It is important to highlight some limitations of this study. For technical reasons, all tests were performed with the researcher's device, and it was noted that some specialists were not very familiar with the system. Therefore, the use of the participant's own device could facilitate the expert's analysis. In addition, the experts noted that the framework could be used in other ways, such as, for example, comparing the adaptation of a system to different devices. Finally, in the evaluation of the framework, one of the experts observed that some of the components could have been analysed more deeply with a longer time of use of the application.

Future studies should be done with different types of application to test the other framework possibilities observed by the experts. For example, this could involve a study that allows experts and users to have more experience with the application and use it for a few days. The framework was created with the aim of helping the design of mobile persuasive healthcare. Therefore, an experimental study on the applicability of the framework to design a real mobile persuasive healthcare application is important. In addition to assisting in design, the proposed framework can assist in application evaluation and verifying the requirements for persuasion and health behaviour change. Thus, from the framework a tool could be created to measure the effectiveness of these systems.

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