Dissertation Title
Design an iOS application to promote medication adherence in adults

Student Name: Ioannidis Efstatios
SID: 3306150005

SCHOOL OF SCIENCE & TECHNOLOGY
A thesis submitted for the degree of Master of Science (MSc) in Mobile and Web Computing

NOVEMBER 2016
THESSALONIKI – GREECE
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Supervisor: Dr. Christos Moridis

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Abstract
Keywords: pill reminder, medication management, medication adherence, user interface, pill dispenser, mobile health, notification system, iOS
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Abstract

The use of mobile health apps for medication adherence has proved to be efficient in improving the health welfare and habits of adult populations. However, most of the apps did not take into consideration that users are emotional beings and how to improve their results by implementing affective feedback techniques. We carried out a systematic review of all available for download mobile apps for Android, iOS and Windows platform. We investigated to which extent affective feedback is used. This dissertation presents how affective feedback techniques may influence medication adherence in adult populations. We developed an intervention which made use of emoticons, personalized messages and also embedded font-size adjustment. This intervention was tested by a group of volunteers. Results were encouraging, indicating that these attributes have the perspective to contribute to adherence. The developed paradigm has the potential to be expanded and become more complex for the needs of future research.

Abbreviations

Native language: A programming language that is the most appropriate for a particular platform. It can take full advantage of the operating system and the hardware of the particular platform. Native applications usually gain all available benefits from the existing technology, are more prone to updates and age better (usually do not crash after an operating system upgrade). According to Spyros Xanthopoulos and Stelios Xinogalos “Native apps are developed using an Integrated Development Environment (IDE) that provides the necessary development tools for building and debugging the applications. Native apps are harder to develop and require a high level of experience and technological know-how than other types of applications”. [1]

Cross platform: Cross-platform mobile applications are those whose source code can be compiled to support multiple operating systems. Cross-platform applications are usually based on web technologies like HTML, CSS, and JavaScript. [2]

Affective feedback: Is the feedback that targets on the quality of the action taken and either praises or criticizes the user using verbal expressions or nonverbal like gestures, emoticons or emotional tones. [3]

Affective Computing is “computing that relates to, arises from or
deliberately influences emotions.” [4]

**Usability:** “the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction in a specified context of use” [5]

**Reliability:** is a quality characteristic that includes fault tolerance, maturity, recoverability, and security compliance. [6]

**Availability:** is the ability to use a system or application when asked and it is measured as the percentage of time it is ready for use.

**Maintainability:** is the quality characteristic that includes analyzability, changeability, stability, testability and maintainability compliance. [6]

**Affordability:** is the ability to bear the cost of software [7]. Also, it is referred as "the degree to which the Whole Life Cycle Cost (WLCC) of an individual project or program is in consonance with the long range investment capability and evolving customer requirement.” [8] As a product becomes cheaper, affordability increases.

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1 Introduction

Mobile health is an emerging field of study and a vast market. Mobile Health is a part of eHealth. There is not an established official definition but, according to the Journal of Consumer Health on the Internet “Mobile health, or m-Health, is the use of portable devices such as smartphones and tablets for medical purposes, including diagnosis, treatment, or support of general health and well-being.”[9] M-Health is implemented by taking advantage of the modern technology, from simple tasks such as SMS up to more sophisticated functions that modern smartphones may utilize. M-Health imbibes computer power along with software engineering and medicine knowledge and produces tools for public benefit. The primary objective of m-Health is to provide 24/7 service through cell phones and mobile networks to areas all over the globe.

1.1 Deluging the world

During the past ten years, the mobile technology has taken huge leaps of advance. This fact lead to the adoption of the smartphones into the everyday life of the average person not only in the “developed world,” but spanned across even in countries where there is a lack of critical infrastructure. Smartphones are considered to be the fastest adopted modern electronic device. [41] It is not only the computational power that propelled the popularity of mobile devices or the cost reduction. The applications, which cover almost every possible subject in various ways, augmented that popularity. [99] It is estimated that smartphone users will be approximately 6.3 billion by 2021. [97] As a result, mobile health infiltrated the mobile development industry with numerous of different implementations for all the available platforms. According to some statistics for 2012, approximately one-fifth of smartphone users used a mobile health application. [10] Mobile health has the potential to enhance the existing medical systems and the welfare of the people. There is a great variety of apps for different occasions such as: diagnostic support, treatment support, education, disease-epidemic tracking, remote monitoring, helpline, remote data collection, communication training for workers, emotion logging, dosage supplying, quit smoking and medicine reminding.
1.2 Embrace the new trend

Despite the fact that mobile health has only a few years that was introduced to the vast majority of people, it has already gained popularity and high levels of acceptance. It is estimated that 58% of mobile users have downloaded a mHealth-related application. [96] Several factors contributed to that result. First of all, most mHealth applications are free to use because they are either developed for educational purposes or provided by government authorities or distributed for business reasons (advertising). No matter which are the initial motivations of the application’s creation and distribution, depending on different circumstances, people embraced mobile health. The numbers of users tend to grow continuously indicating that there is recognition of the mHealth significance and necessity. The users of mobile health are not only those who are considered as patients. Since there is no need for “medical prescription” people download applications and use them as means that monitor, sense and keep track of physical and physiological activities. [79] The most widespread applications among users are fitness and self-monitoring applications. [86] People use them driven by personal interest or because it is being dictated to them by the modern healthy lifestyle.

1.3 Affective feedback

According to McDarby affective feedback is “the process of using technology to help people achieve and maintain specific internal states.” [100] Interest in affective computing is rapidly increasing the last years. The reason is that systems with human-like behavior, such as recognizing feelings or responding differently to each occasion may be the solution to human-computer interaction issues. Although response speed and other distinctly technical attributes are necessary, designing to please the users is what really matters. Emotions have a significant role in human behavior. As people are not always rational, many of their decisions are based on feelings and emotions. [25] Studies have revealed that emotions and affect appear prior to cognition and they have an influence on it. [33] [34] Affective feedback can be used to encourage people to use a system. [64] Also, all human affective expressions are a result of many emotions. [69] People tend to be emotionally attached to devices and services, creating a more personal relationship with them. [78] [23] Emotion is believed that it is triggered by physical and cognitive events. Humans perceive various stimulus and interpret them to
emotions. During the past years, all efforts on developing applications were aiming at making them appear fancy instead of placing emphasis on helping users stay adhere to their medication. Biological response alters how people handle situations, and therefore it may also have an effect on the way they react with computer systems. [24] Affective feedback has two forms: explicit and implicit. While on implicit we try to determine an emotion by monitoring the user's biological data (inspiration, facial movements, etc.), on explicit we provide a direct approach to the user asking him/her to confess his/her affective state. Delving into users' reactions while using an affective system, will lead us into developing a successful mobile application, which will improve the welfare of its users.

1.4 Mobile health in generic practice

Mobile health applications have already been into practice, in an attempt to improve public health. It is globally accepted as a useful tool for delivering health related services. For instance, there are regions in the world where the health infrastructure is either inaccessible or unaffordable and of poor quality. In such countries, mHealth seems to be a possible solution to a significant problem or a means that will soothe situations of health hazards like epidemic spreading. For instance, in countries like Peru, Rwanda and India mHealth applications prevented the outspread of outbreaks. [13] In Nigeria studies are being conducted in order to develop a mobile system to counter chronic illnesses like diabetes, hypertension, and malaria. Their primary goal is to develop a self-regulation based system, with which the users will have full awareness of their actions. [12] The dissemination of epidemics like tuberculosis has declined drastically in countries like China. Research in China has revealed that reminders from applications increased adherence in contrast to SMS reminders. [13] Diabetes is another illness that many mobile applications (like Diabetic, Diabetic Logbook) are currently being used on a daily basis to aid patients to overcome it. Also, there are related studies that confirm how beneficiary an mHealth app can be for this disease. [68]

1.5 Medication Adherence

The patient’s adherence to medication is a major factor that influences the effectiveness of treatments. Non-adherence to medication can be
categorized into intentional and unintentional with both having the same negative impact on people’s health. [93] Health literacy which is “the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions” affects medication adherence. [20] Low levels of health literacy are connected with low levels of medication adherence. [21] Patients with chronic diseases tend to be less adherent compared to those with acute conditions, as 50-60% of them seems to be affected. [15] [94] There are over two hundred variables that affect adherence to medication. [92] Despite the fact that there are different reasons that patients do not stick with their medication, forgetfulness is believed to be the most common. [16] The omission of the medication apart from increasing the treatment costs (for both the patient and the health care system) also imposes health risks. Research has revealed that approximately one-third to one-half of US patients show nonadherence leading to 100$ billion losses annually. [18] Children and adolescents are also considered to be less adherent with their medication, as they usually do not fully understand the importance of the diagnosis and treatment. [17] The group of people that age fifty years and more is considered to be the most significant of all. [19] As people age their ability to remember decreases along with their motor and judging skills. There is one undeniable truth, even the best and most effective drugs have no value if they are not used as directed.

1.6 Mobile Medication Reminders

Numerous mobile health applications have already been used in order to counter patient’s forgetfulness. It is a small budget strategy demanding only the user to own a smartphone device. Cell phone reminder systems are considered to be one of the most efficient ways that strengthen the patient’s adherence to taking their prescriptions. It is believed that mobile applications are going to have a significant role in enhancing functional abilities, in particular for the elder. [25] Mobile based medication reminders have already been into to test to counterfeit medication adherence with encouraging results. [95] A vivid example is iNephro software alongside with the iOS application "Medikamentenplan” (“Medication Plan”) which was used by thousands of people. [89] In South Africa there was conducted an experiment with the aid of "My pill reminder” app, in order to check people’s adherence. Results were satisfactory, indicating that the use of mobile reminders improved adherence to patients with chronic conditions. [14] A research
revealed that transplant recipients might also be benefited by such an intervention. [22] A medication reminder system prompts the users with simple messages and reduces their anxiety and confusion. Other applications need a network connection in order to function, and other do not. The messages may be scheduled to be repeated or appear just once. Medication adherence applications vary regarding design, usability, maintainability, affordability and reliability. There are already many medication reminders implemented for both Android and iOS (more than 80), but the vast majority of them are not designed in an efficient way. Affective feedback and emotional support do not seem to be part of the design in most of the cases. Instead, most applications focus on overwhelming their menu with complicated features. On top of that, some apps seem to be "outdated," since they have not received any update for several months or even years. The language opposes a barrier to people, as the vast majority of the applications are developed exclusively in English and in few occasions, there are some additional languages available too. Furthermore, there is not a single one iOS application addressing the Greek market. Driven by the abovementioned facts, this dissertation will define the proper attributes that a medication reminder should have. As a research tool, an app for iOS, specially developed in the Greek language will be implemented. This thesis proposes the use of a mobile application intervention as a means to improve medication adherence.
2 Literature Review

In order to conduct research for the existing mHealth applications, the most popular platforms (iOS, Android, and Windows) had been taken into consideration. Based on sales for the first quarter of 2016 Android has 84.1%, iOS 14.8 and Windows 0.7 of the global market share. [29]

<table>
<thead>
<tr>
<th>Operating System</th>
<th>1Q16 Units</th>
<th>1Q16 Market Share (%)</th>
<th>1Q15 Units</th>
<th>1Q15 Market Share (%)</th>
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<tr>
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<td>84.1</td>
<td>264,941.9</td>
<td>78.8</td>
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<tr>
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<td>60,177.2</td>
<td>17.9</td>
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<td>0.2</td>
<td>1,325.4</td>
<td>0.4</td>
</tr>
<tr>
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<td>0.2</td>
<td>1,582.5</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>349,251.4</strong></td>
<td><strong>100.0</strong></td>
<td><strong>336,297.8</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

Source: Gartner (May 2016)

The targeted applications were either specific to a particular health condition or of generic use. As intrusion criteria, we took into consideration their popularity, rating and searched for specific keywords inside Google play, App Store, and Windows Store. The keywords were: "Pill reminder, Medication Reminder, Υπενθύμιση φαρμάκου, Υπενθύμιση αγωγής." To be part of our analysis, the applications had to be able at least to generate a schedule for one medication and provide any kind of notification. Results revealed several different applications, which are going to be analyzed in the fore coming paragraphs.

The vast majority of the mobile applications were free to use and rest required payment or supported purchases inside the applications. Some applications offered interconnectivity with other systems. An interface with a plethora of buttons and functions is more likely to stress the potential user.
Not exaggerating with functionality makes the application more convenient for elder users. [89] As literature has shown the fewer available functions, the better for people aged 50 years and over. [61] Apart from the different way that these apps have been implemented they share some common characteristics, flaws, and virtues. Developing companies for most of these applications did not take into consideration (up to an extent) usability, reliability, maintainability, and affordability. In more detail, while conducting testing of the existing applications some of them were totally incomprehensive and difficult to use. Others seemed to be "outdated" since some of their internal features did not function properly or at all, probably due to lack of updates or bad initial programming. Concerning affordability, most applications are free to use or partly free. Some applications require payment or offer exclusive services under some fee, fact which is totally acceptable but reduces access to the general public. As literature has shown initial cost, high data entry burden, loss of interest, and hidden costs are the dominant reasons that can lead to the application rejection by the users. [96] Fact which is reasonable since for many people even the cost of buying a smartphone is already prohibiting. [88] [87] The most significant finding was that the prodigious majority of those applications do not provide affective feedback or any form of emotional support. The common medication reminder app aims only on conforming the patient that unintentionally avoids medication. So there is little or no effort at all to persuade-motivate those skipping medication on purpose. As a result, those applications are not designed sufficient enough. Moreover, developers are not aware of the literature involved with this kind of mobile applications. [86] Also, a native application for the Greek market does not exist on the iOS platform, and the existing Greek medication reminder for the Android platform is inadequate, lacking many features. These facts indicate that the development of an application in the Greek language will fill the void that exists and will offer to people that do not have knowledge of the English language a valuable service. Apple's iOS is known for its simplicity and ease of use. [51] Hence, people that are not in the optimal physical condition are more likely to prefer it. As research has revealed individuals with disabilities and especially blind and deaf people have a preference for the iOS devices. [30] This thesis is dedicated to defining the key features and design principles that a mobile medication reminder application shall include regardless of the platform, with affective feedback as the determinant component. On top of that, a
Greek medication reminder app for the iOS platform is going to be implemented, which will be more sophisticated in comparison to the existing ones and will take into consideration all the positive elements that arise from research. The mobile application intervention is called "Χαρπι Υπενθύμιση Φαρμάκων" and will wage to alter the affective state of the users. This tool will be installed on the volunteers' devices and will attempt to aid the stick with their medication plan. Our goal is to successfully transmit a comprehensive affective message to the user in order to increase his/her pleasant experience with the application.

2.1 Existing mobile applications

At the moment the available applications, from a technical point of view, can be divided into four categories. Those that are explicitly for iOS, those that exist only for Android or Windows and the cross-platform applications which are available simultaneously on more than one platforms. The exposition of medication reminder applications for each platform has turned the process of searching for a reliable application into a toilsomeness task. Therefore, it is not reasonable to examine every single one, but the top rated and most influential of them. We installed the applications on their respective platforms. In order to conduct the research an iPhone 7 Plus, iPhone 6s, iPhone 5c, iNew v7, Samsung Galaxy Tab 4, Ulefone Metal and a Teclast X98 Air have been used as test devices. Here it should be stated that there are medication reminder applications, which due to region restrictions were not available for testing e.g. "Mango Health."

2.2 Mobile Application Compatibility Issues

The version of the mobile operating system and the type of the device may affect the compatibility of the application. As time lapses, new devices are being introduced into the market with more powerful hardware. Mobile operating systems are adapting to this change by applying newer, better versions, but more resource consuming. As a result, many devices stay with an obsolete version of the operating system, a fact that may pose a barrier for many people to use an application. Therefore, it is crucial for an application to be as much as possible backward compatible. The benefit of developing an application for iOS is that Apple does not permit third party manufacturers to install its operating system. As a result, there are specific available mobile
devices, with the version of the operating system and their technical characteristics known.

2.3 Comparison of existing mobile applications.

2.3.1 Cross platform applications

Medisafe Medication Reminder and Pill Organizer by Medisafe Inc., version 4.2.6 (iOS 8.0 or later, compatible with iPhone, iPad and iPod touch); 6.21.01799 (Android 4.0 and up), last updated 10/05/2016. Available languages: English, Arabic, Danish, Dutch, Finnish, French, German, Hebrew, Italian, Japanese, Korean, Portuguese, Russian, Simplified Chinese, Spanish, Turkish. Rated as the best pill reminder application in both Android and iOS, Medisafe has a tuple of features to offer in fifteen different languages. The user may add medications, appointments, diary entries, measurements, instructions about the doses and refill reminders. It is easy to use, medicine intake can be scheduled according to the user’s needs, and the user may add info about his personal doctor, appointments or check the weekly medication adherence. The application’s interface bears great resemblance between the two different platforms, having the same usability. Medisafe can function properly offline, but logging into an account grants access to all available capabilities. Two unique features characterize this application: Medfriends and Medtones. Medfriends permits a family member or friend to be notified if the user misses a dose. Medtones is a funny addendum to the traditional sound notifications, making the application more user-friendly and fun to use. Also, multiple users can be monitored through the same application using different internal profiles. Moreover, scanning of medicine barcodes is available so that they will be automatically imported in the user’s vault, but testing of this feature revealed disappointing results. None of the Greek medicines tested was identified. It can export the schedule in Excel format. Albeit Medisafe is a well-built application, it does not provide font-size change option. Also, the measurements menu sometimes is not available for use, and there is no affective feedback.
Med Helper – Pill Reminder and Medication eceTracker by Earth Flare Inc., version 1.6.3 (iOS 7.0 or later, compatible with iPhone, iPad and iPod touch) last updated 13/09/2016; version 2.7.7 (Android 2.3 and up), last updated 29/06/2014. An application that supports multiple user profiles, with a pleasant and straightforward interface. Med Helper has a tuple of useful features and manages to meet the average user’s needs. Name, medication alias, RX number, prescription instructions, the reason for receiving the medication, description, side effects, reactions, other substances to take with, are the provided options inside the order list. Apart from medication reminders, the user can set reminders for doctor appointments. Also, pharmacies’ information may be added. A reporting feature is available, providing the user with the opportunity to personal email data. Pro version of Med Helper comes with a small cost, but the only additional feature is the removal of the advertisements banner from the menu. Comparing the same application in the two different platforms, the user interface is almost identical, but it is clear that the Android version is a little more enhanced. Med Helper on the Android platform provides instant access to tutorial, manual and a list of preferences like: notifications, units of measure, hints, theme selection and back up. Although it is a rich application with a variety of options, there are some significant drawbacks. There is no font size adjustment, image capture, personalized notifications and support for the Greek language. Apart from the aforementioned, it is a little trickier to add a new reminder in this application, since it requires more actions than the average application.

Pill Reminder by Aplicativos Legais LTDA, version 1.4.5 (iOS 7.0 or later, compatible with iPhone, iPad, iPod and iWatch); version 1.6.3 (Android 4.0.3 and up). Available languages: English, French, German, Italian, Portuguese, Spanish. Pill reminder is available in a free and a paid version. The free edition permits up to three
different meds, has advertisements banner in the bottom menu, almost all extra features locked, apart from the medicine color change. In comparison with the competitive applications, Pill Reminder has many limitations in its free version. So with a small amount of money, there is granted access to an improved version of the application which: does not have advertisements, has sound customization enabled, provides photo capture functionality and schedule for any desired number of days. The colors of the user interface do not pose high contrast. Overall it is not either a state of the art application nor a decent one; there are missing features like refill reminder, affective feedback, and units of measure.

**My Pillbox – Pill reminder and Meds Tracker** by Ying Liu, version 1.6 (iOS 7.0 or later, compatible with iPhone, iPad and iPod touch), last updated 13/03/2016; version 1.999b (Android 2.2 and up), last updated 11/06/2015. Available languages: English, Simplified Chinese. My Pillbox has a tuple of features: Multiple accounts support, twelve medicine appearances to choose, nine available colors for medicines, view list of what medicines that are due for the day, meds log by any period, backup data on Excel sheet, refill reminder, password protection, status bar or popup window to choose for notification, select reminder sound, disable the reminders for different medicines, four date formats to choose, PRN function, edit snooze time, backup files on an excel sheet and sent it via email, restore data from file, type of medicine intake, add medication instructions. The application presents advertisements at the bottom of the screen which can only be disabled by paying a small amount of money. While testing the application, a small bug was discovered. If the user gets a pill that is not scheduled or forgets to take it on time, there is not the ability to add it to the application’s history.

**Dosecast** by Montuno Software LLC, Version 9.0.9 (iOS 7.0 or later, compatible with iPhone, iPad and iPod touch), last updated 13/01/2016; application version and Android version varies with the device,
last updated 25/02/2016. Available languages: English, French, German. It is a flexible application with a plethora of options, organized in a beautiful and convenient way. The primary interface is clear, yet strict giving an impersonal feeling. Navigation through the application is easy, despite the fact that the additional features of the paid version are present everywhere yet disabled. Sound notifications can be adjusted, using the available tones of the device. Dosecast is able to detect if the user changed the time zone. In that case, it changes the schedule of the reminder. The user may create his personal drug database by storing medicines and taking photos of them. There is an additional feature to that for the U.S. market only, where medicines already exist in the database and the system pre-populates them. What distinguishes this application, is its unique ability to synchronize with other devices. Unfortunately, this feature did not work as intended, in all cases, through the various devices that were tested. Unlike other pill reminders that offer a buy once paid version, Dosecast has a different pricing policy which is based on monthly or annual subscription, decreasing the affordability for many potential users. Also while setting the reminder, it was spotted that the minutes can be configured as derivatives of 5 and not at any particular point in time.

CeyHello Medication Reminder, Prescriptions and Pill Organizer by MedSqr LLC, Version 1.04, platform iOS (7.0 or later, compatible with iPhone, iPad and iPod touch), last updated 05/05/2016; version 1.13 (Android 4.1 and up), last updated 04/05/2016. Available languages: English, Spanish, Portuguese, German, French, Hindi, and Chinese. CeyHello is both a medication reminder app and a cloud-based web platform that provides personalized medication management. It has a well-designed graphical interface that helps it distinct from other applications. The application makes use of funny and pleasant “moticons” to motivate users and increase their morale each time they take medication. Moreover, the user (that has purchased the paid version) is able to add his moticon or voice messages. With CeyHello users may try to motivate their friends to adhere to their medication by sending them moticons. Also, a doctor or a caregiver has the ability to check
online the patient's status, change his/hers prescriptions and the rewarding moticons. Medication management is comprehensive through CeyHello. The main page of the application can be switched to either calendar view or 24-Hr Care view. The advanced features of the application rely much on internet connectivity, a fact that may be a drawback in cases where there is a signal loss, expire of internet connection or problems that reside on the server of the developer. During the testing of the application, server response errors did actually occur.

2.3.1.1 iOS applications

Pill Reminder by Drugs.com, Version 2.38, platform iOS (7.0 or later, compatible with: iPhone, iPad and iPod touch, last updated 11/12/2014. Available languages: English, Danish, Dutch, French, German, Greek, Indonesian, Italian, Korean, Norwegian Bokmål, Norwegian Nynorsk, Portuguese, Spanish, Swedish. It is a flexible medication application. Apart from setting reminders for medication, the user can set refill reminders, keep the history of received drugs, add custom notes, choose among different notifications and export data via email. Moreover, the application has multiple users support, lets the user capture photos of the medicine for easy visual reference and has pin lock to prevent unauthorized access to the application. Another nice feature of Pill Reminder is that it automatically detects a change in the time zone and adjusts the alerts. One problem of this application is that if you deviate from the schedule and take your medication, for example, two hours later the application will check it as if it was taken on time. Font-size change is not an option in this application, making it difficult to use for those with sight problems.

Perfect Pill Reminder by Byoni Ltd, Version 1.4.1, platform iOS, last updated 04/12/2014. Available
languages: English. This app includes all the essential features that a reminder app should have including the name, type, strength quantity, frequency, minimum interval, input type, notes and image capture. Also, it provides the user with the option to export his data on an excel sheet and keep records. It was built with the LiveCode platform. From a technical viewpoint, this means that it cannot be upgraded to have the advanced functionalities and performance that applications built on native language have since it is based mainly on HTML 5. This is also indicated by the user comments inside the app store. Most users have complaints about it being unstable and crashing frequently. Moreover, the application does not give the option to adjust the font size according to the user’s needs.

Pill Reminder (Pro) by Bahtiyar Polat, version 2.1, platform iOS, Last Updated 10/10/2014. Available language: English. This application is available in two versions free and pro. The main difference between the two versions is that the free permits up to two unique medication reminders. The menu is very simplistic; the user may set up the reminders on a daily or weekly basis. Notifications have the form of sound alert and text message. The app supports only the English language. Despite the fact that in the settings there is the option to adjust the font size, it does not function. Moreover, the existence of pop-up messages that prompt the user to download other apps from the same developer is rather irritating. Also, in the information menu of the app, instead of some information about the app, there is again a prompt to download other apps from the developer. Customer reviews in iTunes mention that the app does not work as intended. Also, there is no evidence about the technologies that were used for the development of the app.

Sup – Meds & Pill Reminder by Alex Prushynskyy version 1.0, platform iOS (6.0 and later, compatible with iPhone, iPad and iPod touch), last updated 12/05/2014. Available language: English. Sup is a beautiful yet simple reminder application. It
keeps track of supplements in a diary as wholly or partially taken. One key aspect of this application is the real medicine database, which allows the user to search for existing medicines. Another is the password code protection. Each supplement can be characterized by its name, type of unit, interval, and notification. The notification used, is the default device notification and each supplement cannot have more than one notifications per day. So it is compulsory to create more than one entries for the same supplement if the medication has to be taken more than one times per day.

2.3.1.2 Android applications

Healthy Reminder by Executive Marketing Services LLC, Version 3.0, platform Android (4.0.3 and up), last updated 03/11.2015. Available language: English. The Healthy Reminder is relatively easy to use and simple. An excellent feature of this application is the emergency contact, someone that will be informed either by email or by SMS when the patient does not adhere to the medication. Apart from the default notification, it does not provide any alternative type of notification. There also exist some significant drawbacks for this application. Medicine interval can be set only daily or weekly not monthly making it inconvenient for chronic patients. It does not provide multiple notifications for the same drug during the day. So if someone, for example, needs to take medication three times a day, three different notifications must be created separately. The application does not provide any notes function or affective feedback or font size adjustment. At the bottom of the page, there is a non-removable advertisement banner.

Υπενθύμιση Φαρμάκων by Bytelogic version 1.0, platform Android (2.3 and up) last updated 28/12/2015. Available language: Greek. Being the only available application in the Greek language aggregated this application to the comparison list. The success of this application relies on its core functionality and language localization. It supports medicine interval at multiple times per day, but it does
not provide an ending condition. The default notification of the device is used in order to remind the user to take the medication. Apart from that, there is literally no other functionality in this application, lacking many features that the competition offers. An important aspect to note is that at the bottom of the screen appear advertisements, which cannot be disabled. Υπενθύμιση Φαρμάκων is free to use.

PocketNurse – Pill Reminder by Instait Ltd., version 1.2.0.1, platform Android (requires 2.2 and up), last updated 16/06/2015. Supported languages: English, German, Spanish, Italian, Hungarian, and Romanian. It is a robust medication and refills reminder; which can support complex medication schedules. There are five alert sounds to pick from, vibration option and many notification adjustments. It even has a reminder in advance. The settings menu provides the ability to add extra units of measurement, additional patients related to the application and symptoms of diseases. Database operations include import and export of data. Apart from the expected attributes for a medication reminder that are implemented, the application does not provide any form of affective feedback or personalized notification.

Lady Pill Reminder by Baviux, version 2.3.2, platform Android (requires 2.3 and up), last updated 09/05/2016. Language Available: English, but takes some advantage of the languages installed on the device and presents the diary aggregations based on local language. Although this application is dedicated to birth control pills for ladies, it has to be mentioned since it is widely used by women worldwide. Notifications can be heavily customized, pill types and intervals are well planned, and it also has the unique option of a reminder for placebo pills. The in-application purchases through "Lady Store" offer "Lady Pill Icon pack" and "Lady Pill Widgets." Both of them enhance the emotion state of the user by
presenting visually and emotionally appealing graphics.

2.3.1.3 Windows Phone Applications

**Pill Toaster** by Signum, version 1.3.1.0, platform Windows 10, 8.1 phones-tablets (compatible with x86, x64, and ARM processors). Available language: English. Basic functionality, simple menu, free to use and lack of additional options are the key features of this application. Inserting a new medicine or a new course may prove to be troublesome since the keyboard does not appear unless the touch screen is pressed multiple times. Albeit Pill Toaster has a lot of space for improvement, it has a unique feature. It permits manual backup and restores of the application through OneDrive.

**The Pill** by Infotechnique, Scheidegger, version unknown, platform Windows 10, 8.1 phones-tablets (compatible with x86, x64 and ARM processors). Available language: English. A simple application for women that aims to help them adhere with their birth control pills and calculate the next menstruation. Notes can be taken on each day by selecting the date from the calendar. The Pill lacks any advanced or additional features, and it only provides simple functionality in a girly colored environment, which may prove to be troublesome for a color impaired person. It is distributed for free.

2.4 Important Features

Among the diversity of the features of the aforementioned applications, there are some which according to our research are more significant than the others and may ascribe quality attributes to our system.
2.4.1 Font family and Font size adjustment

The first reason that aggregates this feature to this list is apparent. The eyesight ability is diverse from person to person. There are people with disabilities that struggle to read font-sizes that appear normal to ordinary people. Also while small font sizes are adequate for office-home conditions, in extreme lighting conditions like sunshine or darkened room they become unreadable for many people. [91] Fancy font families may seem appealing on first sight, but in the process, they turn to be tiresome for someone trying to read a text. Some researchers suggest that particular font families like Tahoma and Verdana provide better readability than others. [90] From the examined applications there was not even a single one to implement font-size adjustment. We consider selecting a proper font-family and giving the ability to change font-size, as key features for such an application.

2.5 Affective Feedback

Studies have revealed that in learning positive affective feedback had significant results in increasing the performance of students. [3] Affective feedback techniques are also being implemented in video games and manage to influence the player successfully. [80] [36] In addition to that, positive affect boosts the facilitation of flow, making users extremely focused on the software. [28] Also research has revealed that empathic comments during virtual interviews altered the affective state of the subjects, by decreasing their stress levels. [28]

Emoticons are considered to be a means of affective gestures which greatly rely on affective feedback. The profound way that emotions are transmitted is via visual signals. [58] Emoticons alongside with text gestures have been previously implemented to improve instant messaging. [35] Also images with facial expressions have been successfully used to receive affective feedback from users. [40] Systems that communicate with users via emoticons (else avatar expressions) give the impression that are more interactive and intelligent. [44] Moreover, emoticons can transmit the state of someone’s feelings easier than words. [72][73] To our best knowledge a research concerning the combination of affective feedback and medication reminder applications has not been conducted yet, but we intuitively think that these kinds of features might be helpful to counteract medication
nonadherence. Therefore, we consider that equipping the application with positive affective feedback techniques will result in better medication adherence. Affective values are going to be introduced with the means of emoticons. Buttons representing emotions and states of awareness will be used to trigger the user’s affective state, giving us the opportunity to collect results at the end of the medicine interval. [31] The classic emoticons of iOS are embedded into our system.

2.5.1 Personalized Messages

Personalized messages to patients and positive affect have proven to be effective while trying to cure depression. [85] Research has revealed that personalized messages are more useful in comparison with the generic ones. [83] [82] Additionally, personalized messages improved students understanding, according to some experiments. [74] Following this practice into health-related messages, it will enhance readership and memorizing. Also, the user will have the feeling that he/she gets personalized attention. [81] Therefore, this is probably going to be a key feature to improve adherence to those that willingly avoid medication. In our application, the user will be addressed by the system messages with the name or nickname that he/she inserts. Moreover, depending on the age of the user, the text messages will vary from formal for the elder to casual easy going for the younger participants. On top of that, the notification message will also include an emoticon.

<table>
<thead>
<tr>
<th>Application name</th>
<th>Affective feedback</th>
<th>Cost - Pricing</th>
<th>Font size adjustment</th>
<th>Personalized notifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medisafe Medication Reminder and Pill Organizer</td>
<td>No</td>
<td>Free</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Med Helper – Pill Reminder and Medication eceTracker</td>
<td>No</td>
<td>Free (in-app purchases)</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Pill Reminder by Aplicativos Legais LTDA</td>
<td>No</td>
<td>Free/Optional purchase</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Application</td>
<td>Free (in-app purchases)</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>--------------------------</td>
<td>----</td>
<td>-----</td>
<td></td>
</tr>
<tr>
<td>My Pillbox – Pill reminder and Meds Tracker</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dosecast</td>
<td>No</td>
<td></td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>CeyHello Medication Reminder, Prescriptions and Pill Organizer</td>
<td>Yes (emoticons)</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Perfect Pill Reminder</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pill Reminder (Pro)</td>
<td>No</td>
<td>Yes (not working)</td>
<td>No</td>
<td></td>
</tr>
<tr>
<td>Sup – Meds &amp; Pill Reminder</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Healthy Reminder</td>
<td>No</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Υπενθύμιση Φαρμάκων</td>
<td>No</td>
<td></td>
<td></td>
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<tr>
<td>Pocket Nurse – Pill Reminder</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Lady Pill Reminder</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Pill Toaster</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The Pill</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Our proposed application</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>

### 2.5.2 Cost

The development of a mobile application encloses various expenditures which may include the developer’s salary, server infrastructure and the cost to upload on the app store. In many occasions, developers may desire to gain some profit. Our application was developed for educational purposes and therefore will be distributed for free. Providing a cost-free application will proliferate our potentials users after this dissertation is complete. Additionally, other developers will have the chance to access the
application untrammeled, benefit from the outcome of our research and possibly embrace some of its features.
Good design is a very challenging goal to be fully achieved. By good design, we mean both in terms of functionality and usability but also in terms of color, layout, and feedback. While the first seem to be compulsory for an appropriate mobile application, since the beauty part is harder to quantify, there are numerous cases however that because an application was aesthetically appealing it was very successful in terms of sales and popularity. [25] Pleasing interfaces along with usability result into desirable digital products. [33] Beauty or aesthetic pleasure offers a positive experience to the user, it is immediate, and it is not connected to any other aspect of the application. [32] It has been proven that in mobile commerce well-designed aesthetics improve customer loyalty. [42] Complementary to this fact is the fact the people tend to correlate perceived ease of use with aesthetics. [43] The user interface is an important part of our application. Since users do not read manuals, it is compulsory for the interface to be user-friendly. The whole experience inside the system must be of equal difficulty because the user's emotions turn from positive valence to negative if the difficulty increases. [48] In this project the goal was for these values to thrive, as the ultimate goal was to develop an engaging and useful application.

Since the application was implemented for the iOS platform, it was advisable to follow the iOS Human Interface Guidelines that Apple suggests. [45] Among the values and principles that Apple propounds are clarity, deference, depth, aesthetic integrity, consistency, direct manipulation, feedback, metaphors and user control.

A user must have in mind a number of goals, which he/she wants to fulfill, to be motivated to download and use our application. In order to receive a positive effect, the user will have to successfully complete a predefined task, which is our case is to receive his/her medication. Providing the user with the feeling of accomplishment may lead him/her to enter a state of flow. [37] When somebody is in a state of flow then he/she has pleasant feelings, is very efficient, concentrated and irrelevant things can not disrupt his/her consciousness. [38]

The non-skeuomorphic or flat design makes more sense in a mobile application as it makes use of digital assets in a digital world, whereas skeuomorphic design tries to replicate real world in a digital one hence inheriting limitations from it. A beautiful example of inherited limitation was
that users thought the iBook bookshelf had limited free spaces due to the skeuomorphic design of it. [27] Even Apple that made heavily use of skeuomorphic design in its products, gradually abandoned this type of design since the release of iOS 7.0 and later on. Moreover, research has revealed that users tend to prefer the non-skeuomorphic design and think that it is more formal and professional. [26] [46] In this project the decision was to follow the non-skeuomorphic design approach for the user interface since it is not very graphic intensive and the design has a direction of creating a beautiful interface with minimalistic graphic elements and typography. Our intervention was implemented with colors that have high contrast (green and white) and are more convenient to see for people with visual impairment. The selected font family was the default iOS font family which can ensure good readability since it resembles a lot with Verdana.

Emotion is multimodal and during our experiment users will receive visual and auditory affective signals, which will be transformed into emotions. [59] The system design implements synchronous affective feedback (or immediate responses) to the occurring events. For instance, if the ringer rings for the first time a text message informing the user to take his/her medication will appear along with an emoticon of the anxious state.

Smartphones touchscreen is the major mobile interface paradigm. All the interaction between the user and the system is going to be handled via the touchscreen of the iPhone. As literature has shown, there are six different types of finger action on a touchscreen: tap, double, long tap, drag, flick, and multi-touch. [49] New advancements in technology will probably suggest that there is one additional action, "force-touch" or else called by Apple "3D touch". But everything inside our application is going to be handled via simple taps, for the ease of things and to sustain a friendly interface for all types of users. The sole action that may require slide gesture is deleting a medication as it is the iOS default way to delete items from a table. Time or intensity of taps will not affect the outcome of an action. In addition to this, no more than one fingers will be needed to carry out an action. By following the method, our application will be more friendly to visually impaired people, who elect the use of simple gestures. [50]
3.1 Color Impaired friendly

For an application to be serving the purpose of its creation, it needs to be communicating the information it wants in a pleasant way but with clarity and efficiency in mind. This in terms of colors may be achieved by selecting a color pallet based on the Kuler methodology of color design, which is inheritably harmonious, and apply it to all the application buttons sliders, etc. An excellent example of this for experimentation may be visited at Adobe's site [https://color.adobe.com/create/color-wheel/](https://color.adobe.com/create/color-wheel/). Conveniently enough the iOS platform which has been selected for the implementation is able to support such a color theory fully. Hence the design of the application will apply an already tested and familiar to the user’s color pallet which means almost zero time for adaptability (in terms of UI) for the application. In other words, the user feels at home. Another reason we made the design decision to use this particular color pallet is that if we want to maximize the users of the app, we need to ensure that we do not exclude the color impaired users, and this pallet is color impaired tested.

3.2 Sound Stimuli

Auditory stimuli have the potential to ignite affective reactions on people. It has been proven that both negative audio stimuli (e.g. couple fighting) and positive audio stimuli (laughing) can affect the emotional state of a person. [55] Carefully selected audio stimuli can regulate the emotion of the user in HCI. [39] It has been found that the sound of applause may benefit male users by reducing their anxiety levels when answering correctly during learning, but women, on the other hand, react differently. [54] Since the use of sound stimuli has dubious results we suggest that the default notification sound is the proper sound stimuli that will not interfere negatively or positively to the user’s reactions.

3.3 Ethical, Privacy and Security Safety issues

Ethics is a vital aspect of this application. This application respects the human effort in a way that healthy and differently abled people may enjoy it equally. Actions are going to take place intuitively, based on common sense and by doing so, the system will ameliorate the life of the users. The system must be transparent. The user must feel and be protected from an undesirable
usage of his data or violation of his privacy. So everything must be done under his/her consent. Invisible operations like sending private metrics to third party or revealing the actual location of the user will not take place. The application will have to be straightforward without any hidden “Easter eggs.” The system is going to be decentralized, respecting human rights. It is critical that the user has the feeling that he/she is in control of his/her data. Therefore, our application will not keep track of any data related to usage that the volunteer did. This will also be stated in the privacy policy that will be published. All required information will be asked through a questionnaire at the end of the experiment. Questionnaires have proven to be a very efficient way to gather user’s affective responses. [52] There are many different delivery methods to collect answers from questionnaires. The most common in our modern world is via email. Other methods are in person, by phone or by postal. In our case delivery in person was the most suitable, since many participants of our sample group did not possess the required skills to use email or computer effectively.

Many medical applications require access to sensitive personal information in order to provide functionality, a fact that is unacceptable by many users. [77] As a result users tend to be more suspicious with health applications, discouraged and in the end avoid this kind of applications.

Safety is number one priority. This application does not only inform about medication intake but has the potential to affect the subject’s life. In order to ensure safety extensive testing of the application shall be made. By doing so, we avoid software faults and wrong software responses. On the other hand, the application should be programmed that way (based on the principle of forgiveness), so that if the user makes a mistake or forgets something, having the option to reverse the situation. The application is designed in such a way so that it does not require kinematic load or a lot of cognitive effort.

3.4 Research participants

Inclusion criteria:

- Men and women aged between 18 and elder
- Owning an iPhone, iPad, iTouch device
- Their device is running iOS 8.2 or later.
- Are willing to install and make use of the apps.
The participants had to be willing to answer the questionnaire after the experimental period.

Exclusion criteria were:
- People with obsolete devices (iOS version before 8.2).
- Individuals who do no longer possess the ability effectively communicate and use digital devices.

The subjects had different educational backgrounds and varied from experienced smartphone users to newcomers. These attributes had to be completely random, in order to emulate real life conditions and actual potential users. In our experiment, 32 people participated.

Applications to improve medication adherence have been on the market for a long time, but there is little research on design issues that are going to improve the user experience. As a result, most applications look very much alike offering more or less the same user experience. This thesis concludes that by implementing affective feedback techniques inside, m-Health applications is the proper method to increase medical adherence. Ultimately, future works will have to apply affective feedback in their design.

4 Code Implementation

From the developing point of view, we had to select between native code implementation or cross-platform code implementation. Although developing on a native programming language is a more challenging task, we came to that decision because we wanted to ensure the maximum user experience for our subjects. As the native code is usually faster than an interpreted code. [53] Also developing on a native programming language provides full access to the platform’s features and we avoid any possible incompatibilities. Screens and layouts perform much better with native code, everything is working as intended. A great example is the Facebook application. It started as a cross-platform application, but the soon noticed the poor user experience and turned into developing separate native Android and iOS applications.

Our system was developed using Xcode IDE and the Swift programming language. Swift is a modern language, and Apple created it in order substitute Objective-C that had been in use for several years. Swift has some significant advantages over Objective-C which are:
- Easier to be read by humans
• Easier to maintain since Xcode and LLVM have the ability to do automated work, reducing the time needed to accomplish various tasks.
• Is faster, as it is a language developed with the modern standards.
• Swift manages memory in a much more efficient way.
• Less code is needed, as it has a much simpler and friendly syntax.
• Safer
• Does not collide with names from other open source projects.
• Playgrounds in Swift give an excellent place for experiments before putting into development a part of code
• Supports dynamic libraries
• From the version 2.0 and further Swift is an open source language, meaning that developers are free to contribute to the language development.

Our software has to be robust so that it will not crash by itself or by any kind of input. In order to support this state, it must support data in a robust way. There were two available options for storing data. NSUserDefaults and Core Data. Despite the fact that the whole application could be implemented using NSUserDefaults, we decided to include the main storage functionality in Core Data. As literature has revealed, Core Data provides some strategic advantages when we have to deal with dynamic data. The key features are: [56][57]

• Save and Undo functionality
• Sorting and filtering
• Reduced amount of code
• Improved memory management
• Ability to display data
• Data GUI, as it has a new graphical object model editor

The interface consists of graphical objects such as text fields, UIButton, and switch buttons.

When the user enters the system for the first he/she will be asked to enter his/her name or nickname, age, and gender. For Every action taken inside the system, there is going to be feedback projected to the user.
Customization will be available with the form of font-size adjustment. The system is designed in such a way that it will be usable with a minimum amount of training.

4.1. Usability goals

As it already has been discussed the main purpose is to improve medication adherence. Usability can be considered as part of quality, which may lead to user’s satisfaction. [63] The main task will be the set of one or more medication intervals that will lead to the successful intake by the patient. When the user gets notified by the system to take his/her medicine, the next subtask to do is to press the confirmation button. There is an independent variable which is the message the user receives and its correlated with the age and the name that he/she enters when accessing the setting of the app.

5 Experimental protocol

The experiment was held in two phases. In the first phase, the volunteers were asked to use the version of the pill reminder app that does not implement any kind of affective feedback. This version provided the ability to add medication intervals and used a simple beep sound for sound notification and the text message "Ήρθε η ώρα για το φάρμακο " (translated: It is time to take your medicine). The next two weeks the same users were given the full version of the app, which implements affective feedback techniques. After the experimental period, all volunteers that participated in the experiment were asked to fill in a questionnaire. With the questionnaire, we wanted to distinguish different behaviors for different age groups. Therefore, volunteers have been invited to select their age group. The available age cohorts were 18-39 (early adulthood), 40-59 (middle adulthood) and 60+ (late adulthood). The vast majority of the participants belonged to the first two groups, as people fare late adulthood rarely use smartphones at this point. Also with our questionnaire, we wanted to detect if people with chronical health problems were benefited by using it. As previously arisen by literature review people skip their medication either willingly or unwillingly, and we wanted to measure if our app had some impact on their behavior. There was a use of close-ended questions. Close-ended questions have been used with success in the past to extract data as we can witness in the picture
below

3) Por favor, trate de recordar un periodo en el que usted estuviera en un estado de ánimo elevado. ¿Cómo se sintió entonces? Por favor, conteste todas estas afirmaciones independientemente de su estado actual.

<table>
<thead>
<tr>
<th>Sí</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Necesito dormir menos</td>
<td></td>
</tr>
<tr>
<td>2. Me siento con más energía y más activo/a</td>
<td></td>
</tr>
<tr>
<td>3. Me siento más seguro/ade mi mismo/a</td>
<td></td>
</tr>
<tr>
<td>4. Disfruto más de mi trabajo</td>
<td></td>
</tr>
<tr>
<td>5. Soy más sociable (hago más llamadas telefónicas, salgo más)</td>
<td></td>
</tr>
<tr>
<td>6. Quiero viajar y viajo más</td>
<td></td>
</tr>
<tr>
<td>7. Suelo conducir más rápido o de forma más arriesgada</td>
<td></td>
</tr>
<tr>
<td>8. Gasto más/demasiado dinero</td>
<td></td>
</tr>
<tr>
<td>9. Me arriesgo más en mi vida diaria (en mi trabajo y/u otras actividades)</td>
<td></td>
</tr>
<tr>
<td>10. Físicamente estoy más activo/a (deporte, etc.)</td>
<td></td>
</tr>
<tr>
<td>11. Planeo más actividades o proyectos</td>
<td></td>
</tr>
<tr>
<td>12. Tengo más ideas, soy más creativo/a</td>
<td></td>
</tr>
</tbody>
</table>

*Figure 17* Picture taken from E. Vieta et al. [67]

We selected this kind of answers in order to gain more statistical significance from our results and categorize the respondents. The questionnaire required between 5 to 10 minutes to be completed. With the questionnaire, we wanted to examine to which extent an mHealth app that implements affective feedback techniques can affect the way patients stay adhere to their medication. A possible confirmation of this hypothesis will lead to a series of great improvements in existing and fore-coming mHealth apps.

Human senses and their assignment to sensory modalities that our experiment will rely on. [63]

<table>
<thead>
<tr>
<th>Sensory Perception</th>
<th>Sensory organ</th>
<th>Modality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sight</td>
<td>Eyes</td>
<td>Visual</td>
</tr>
<tr>
<td>Hearing</td>
<td>Ears</td>
<td>Auditory</td>
</tr>
<tr>
<td>Touch</td>
<td>Skin</td>
<td>Tactile</td>
</tr>
</tbody>
</table>

The experiment enrollment began on December 20 2016 and was completed on January 20 2017. In the four-week experimental phase, a group of 32 adolescents aged 18 years and over that had to take any kind of medication used our intervention. The apps were deployed to the devices by
direct installation from a MacBook Pro as many of the participants did not have internet connectivity. Participants assigned to the intervention received instructions in person on how to use the app immediately after the installation. Xappi intervention was developed to assist patients to adhere to their medication. Images from the apps that were used to conduct the experiment

As app icon for the simple application, a pill-shaped imaged was designed.

Figure 18 App icon of "Απλή υπενθύμιση φαρμάκων"

Figure 19 App icon of "Χαρπί υπενθύμιση φαρμάκων"
This is a screenshot of both apps installed on an iPhone.

When the app is launched this is the loading screen.
When the app is executed for the first time, a pop-up message appears asking for permission to send notifications to the users mobile device.

This screen appears only the first time the app is executed. It informs the user about the purpose of the app and that his/her data will remain inside the mobile device. If the user consents then he/she may proceed and use the app.
Generic screen for both versions of the app. This is the main menu where the user may add, delete or edit medication.

The screen that the user adds medication is common in both applications.
How the menu screen looks like when a medication interval is saved.

Deletion screen that pops up if the deletion upper left button is pressed.
Additional deletion screen, which pops up if the user makes use of the generic iOS deletion feature of sliding to the left.

Settings screen of the simple app.
Xappi settings screen. It there are a lot of differences from the previous app and this one in this section.

This screen appears when the user presses the button that has all the information needed to change the font size.
Notification screen where Xappi has sent alerts for different preferences.

Beneath follows the exit questionnaire as it was formed in Greek language and in parenthesis is the English translation in order to provide the reader better understanding.

Έρευνα για τη χρήση και τον σχεδιασμό των εφαρμογών υπενθύμισης φαρμάκων στους ενήλικες για την πλατφόρμα iOS.

(Research about designing an iOS application to promote medication adherence in adults)

Οι εφαρμογές «Απλή Υπενθύμιση Φαρμάκων» και «Χαρπί Υπενθύμιση Φαρμάκων» αναπτύχθηκαν για ερευνητικούς σκοπούς στα πλαίσια της διπλωματικής εργασίας του μαθήματος Human Computer Interaction με τίτλο «Design an iOS application to promote medication adherence in adults» του μεταπτυχιακού φοιτητή Ιωαννίδη Ευστάθιου για λογαριασμό του Διεθνούς Ελληνικού Πανεπιστημίου με επιβλέποντα καθηγητή τον Dr. Χρήστο Μορίδη. Το ερευνητικό πρόγραμμα αυτό συμπληρώνεται έπειτα από τη χρήση των εφαρμογών. Οι πληροφορίες που μας παρέχονται συνέρχονται και επεξεργάζονται ανώνυμα. Επίσης θα
έχουν χρήση μόνο μέσα στα πλαίσια της διπλωματικής έρευνας και δεν
θα διαμοιραστούν σε τρίτους. Η θετική ανταπόκριση και η συμμετοχή σας
στο πείραμα και στο ερωτηματολόγιο είναι πολύτιμη καθώς οι
πληροφορίες που καλείστε να προσφέρετε είναι μεγάλης αξίας για τη
συγκεκριμένη έρευνα. Το ερωτηματολόγιο είναι σύντομο (εκτιμώμενος
χρόνος: 5') (The apps “Simple Medicine Reminder” and “Xappi Medicine
Reminder” were developed for research purposes in the framework of
Human-Computer Interaction course entitled «Design an iOS application to
promote medication adherence in adults» by the graduate student Ioannidis
Efstathios on behalf of the International Greek University under the
supervision of Professor Dr. Christos Moridis. The questionnaire is meant to
be completed after using the aforementioned apps. All provided information
are collected and processed anonymously. Additionally, they will be used
only within the framework of this dissertation research and will not be
handled to any third parties. Your positive response and participation in the
experiment and the questionnaire are valuable as the information you are
asked to offer is of great value for this research.

Ερωτήματα (Questions):

1. Επιλέξτε φύλο: (Select gender)

   Αντρας (Male) □ 
   Γυναίκα (Female) □ 
   Άλλο (Other) □

2. Ποια είναι η ηλικιακή σας ομάδα; (Which is your age group?)

   A)18-39 □ B) 40-59 □ C) 60+ □

3. Ήσασταν συνεπής στις θεραπείες σας; (Were you adhere to your
medication?)

   Ναι (Yes) □ Οχι (No) □

4. Όταν δε λαμβάνετε κάποιο φάρμακο είναι επειδή το αμελήσατε ή
tο παραβλέψατε εσκεμμένα; (In case you were not adhering to your
medication is it because you forgot to receive it or you did it on
purpose?)

   Το αμέλησα (I forgot to) □ Το παρέβλεψα (I did it willingly) □
5. Ποια από τις δύο εφαρμογές σας βοήθησε περισσότερο να ακολουθήσετε την φαρμακευτική σας αγωγή; (Which of the apps aided you the most to stay adherence to your medication?)

Απλή Υπεθύμιση Φαρμάκων (Εφαρμογή Α) (App A) ☐, Χαρπί Υπεθύμιση Φαρμάκων (Εφαρμογή Β) (App B) ☐ καμία (None) ☐

6. Σας άρεσε το γραφικό περιβάλλον της δεύτερης εφαρμογής; (Was the graphical interface appealing to you?)

Ναι (Yes) ☑ Όχι (No) ☐

7. Ο συνδυασμός των χρωμάτων σας βοήθησε να διακρίνεστε εύκολα τα αντικείμενα στο μενού; (Did the combination of colors help you to easily distinguish the menu items?)

Ναι (Yes) ☑ Όχι (No) ☐

8. Θεωρείτε χρήσιμη τη δυνατότητα αλλαγής του μεγέθους της γραμματοσειράς; (Do you consider useful the ability to adjust the font-size?)

Ναι (Yes) ☑ Όχι (No) ☐

9. Αντιμετωπίζετε κάποιο πρόβλημα όρασης; (Do you face any visual impairment?)

Ναι (Yes) ☑ Όχι (No) ☐

10. Πάσχετε από κάποιο χρόνιο πρόβλημα υγείας; (Do you suffer from a chronic health problem?)

Ναι (Yes) ☑ Όχι (No) ☐

11. Η χρήση των εικονιδίων (emoticons) της εφαρμογής έκανε την εμπειρία σας πιο ευχάριστη; (Did the use of emoticons inside the app make your experience more enjoyable?)

Ναι (Yes) ☑ Όχι (No) ☐
12. Η ανατροφοδότηση (feedback) που λάβατε μέσω των ηχητικών και γραπτών ειδοποιήσεων ήταν επαρκής; (Was the feedback you received through visual and audio stimuli sufficient?)

Ναι (Yes) □ Όχι (No) □

13. Σας έκανε να νιώθετε πιο οικεία το γεγονός ότι εμφανιζόταν το όνομα - ψευδώνυμο στις ειδοποιήσεις της εφαρμογής? (Did the appearance of your name make you feel more intimate?)

Ναι (Yes) □ Όχι (No) □

14. Θα χρησιμοποιούσατε ξανά την εφαρμογή ή κάποια παρόμοια σε μελλοντική σας θεραπεία; (Would you use this application again in a future treatment?)

Ναι (Yes) □ Όχι (No) □ Ίσως (Maybe) □

Our App Feedback Design Examples

<table>
<thead>
<tr>
<th>App</th>
<th>Απλή Ύπενθύμιση Φαρμάκων</th>
<th>Χαρπί Ύπενθύμιση Φαρμάκων</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medication taken</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Medication missed</td>
<td>✗</td>
<td></td>
</tr>
<tr>
<td>Medication alarm on</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Medication alarm off</td>
<td>✗</td>
<td></td>
</tr>
</tbody>
</table>

Inside our questionnaire volunteers were separated into three different age groups (18-39, 40-59, 60+). Based on the inserted age in the app, the user will get different messages according to his/her age. It is evident that the simple generic application provides a typical informative message regarding the medication intake. On the other hand, Xappi calls each single user with the name or nickname they entered. Moreover, the message is differentiated according to the user’s age. Messages for younger people are more immediate, using everyday spoken language. For participants that are in their mid-adulthood messages are little more formal, and finally for participants that are in their late adulthood messages are formal. Following this procedure, we suggested that the participants will feel more convenient while using the app and therefore, adhere with their medication. Messages in Xappi
The app also include an emoticon that represents the anxious state, in an attempt to motivate the user, get his/her medication.

<table>
<thead>
<tr>
<th>App</th>
<th>Απλή Υπενθύμιση Φαρμάκων (app A)</th>
<th>Χαρρί Υπενθύμιση Φαρμάκων (app B)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Morning Notification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-39</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Ξυπνά!!! Ωρα για φάρμακο (UserName Wake up!!! Time for medicine)</td>
</tr>
<tr>
<td>40-59</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Είναι πρωί ώρα για φάρμακο (UserName It is morning, time for your medication)</td>
</tr>
<tr>
<td>60+</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Πήρατε το πρωινό σας φάρμακο; (UserName Did you get your medication?)</td>
</tr>
<tr>
<td><strong>Afternoon Notification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-39</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Μεσημέρισε!!! Πάρε το φάρμακό σου (UserName It’s about midday, get your medication)</td>
</tr>
<tr>
<td>40-59</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Ωρα για το μεσημεριανό φάρμακο (UserName the time has come for midday medication)</td>
</tr>
<tr>
<td>60+</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Πήρατε το φάρμακό σας το μεσημέρι; (UserName Did you get your midday medication?)</td>
</tr>
<tr>
<td><strong>Evening Notification</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-39</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Πήρες το φάρμακό σου το απόγευμα; (UserName Did you get your afternoon medicine?)</td>
</tr>
<tr>
<td>40-59</td>
<td>Ἄρρα για το φάρμακο (It is time to take your medicine)</td>
<td>Username Είναι η ώρα για το απογευματινό σας φάρμακο! (UserName it is time to take your afternoon medication)</td>
</tr>
</tbody>
</table>

47
<table>
<thead>
<tr>
<th>Age Group</th>
<th>Time to Take Medicine</th>
<th>Notification Message</th>
</tr>
</thead>
<tbody>
<tr>
<td>60+</td>
<td>Ήρθε η ώρα για το φάρμακο (It is time to take your medicine)</td>
<td>UserName Έλατε απόγευμα! Θα πρέπει να πάρετε το φάρμακό σας! (UserName Afternoon has arrived! You should take your medication.)</td>
</tr>
<tr>
<td>18-39</td>
<td>Ήρθε η ώρα για το φάρμακο (It is time to take your medicine)</td>
<td>UserName Βράδιασε !!! Μην αργείς πάρε το φάρμακό σου. (UserName It's nighttime!!! Don’t be late get your medicine.)</td>
</tr>
<tr>
<td>40-59</td>
<td>Ήρθε η ώρα για το φάρμακο (It is time to take your medicine)</td>
<td>UserName Είναι βράδυ ώρα για το τελευταίο φάρμακο της ημέρας. (The night has come, time for the last medication of the day.)</td>
</tr>
<tr>
<td>60+</td>
<td>Ήρθε η ώρα για το φάρμακο (It is time to take your medicine)</td>
<td>UserName Πήρατε τα βραδινά σας χάπια; (UserName Did you get your night time pills?)</td>
</tr>
</tbody>
</table>

6 Statistical Analysis

In our experiment participated in total 32 adult people, 19 females and 13 males. In the screenshots that follow are the results of the questionnaires after they have been completed and collected.

<table>
<thead>
<tr>
<th>Participant</th>
<th>Age Group</th>
<th>Time to Take Medicine</th>
<th>Did You Take Your Medication?</th>
<th>Reason For Not Taking Medication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male A</td>
<td>20-29</td>
<td>Yes</td>
<td>Did not feel right</td>
<td></td>
</tr>
<tr>
<td>Female A</td>
<td>30-40</td>
<td>Yes</td>
<td>Did not feel right</td>
<td></td>
</tr>
<tr>
<td>Female B</td>
<td>40-50</td>
<td>Yes</td>
<td>Did not feel right</td>
<td></td>
</tr>
<tr>
<td>Female C</td>
<td>50-60</td>
<td>Yes</td>
<td>Did not feel right</td>
<td></td>
</tr>
</tbody>
</table>

Figure 20Results page 1/4
<table>
<thead>
<tr>
<th>Was the graphical interface appealing to you?</th>
<th>Did the combination of colors help you to easily distinguish the menu items?</th>
<th>Do you consider useful the ability to adjust the font size?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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</tbody>
</table>

*Figure 21 Results page 2/4*

<table>
<thead>
<tr>
<th>Do you have any visual impairment?</th>
<th>Do you suffer from a chronic health problem?</th>
<th>Did the use of animations inside the app make your experience more enjoyable?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
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</tbody>
</table>

*Figure 22 Results page 3/4*
84.375 of total participants found our choices for the app interface to be appealing, and 81.25 thought that the color combination attributed to the readability of the interface. 41.10 of female participants and 30.76 of male participants are facing some problems with their eyesight. If we put together these facts, it means that people with visual impairment benefited by such a design.
The clear majority of the participants replied positively and were willing to make use of an app for medication adherence. The portion of the participants that were not that likely to use such an app has mostly consisted of females. Also, there was a 12.5% of the participants that were not sure if they would like to use such an intervention again.

The font-size adjustment which is a unique feature of our application had great acceptance over the participants, especially in the male population. The existence of emoticons, the messages that were delivered with
notifications, and the personized message (mentioning the name of the user and more age appropriate addressing) had high acceptance too.

From our elder population of the participants, 60% percent of them were facing some chronic disease. Whereas the first and did not, which means that we cannot extract useful results from our sample.

Younger participants were not that adhere to their medication, whereas middle and late adulthood groups showed remarkable adherence.
7.1 Results Interpretation

It is profound after examining the questionnaires that affective feedback influenced up to an extent adult populations. The different age groups had different reactions though, towards our experimental app. Elder age groups seemed to be more adhere to their medication. On the other hand, only 25% of male and 53.84% of female participants were adhering (female participants were expected to have better results as they show better mobile intimacy [71]). The fact with comes in contrast with some other studies. [76] Font size adjustment seemed to be a valid feature for such apps as participants embraced it. Also clear colors with good contrast ratio aid people to use mobile applications. We could not get a useful result for results regarding chronical patients as our sample lacked them.

To sum up, affective feedback techniques can be effective if they are implemented inside medication adherence apps.

Sample size

Our planned enrollment was expected to be around 50 people; however, many of the potential participants either did not have the need to take any medication by the time the experiment was held or changed their mind. This fact reduced the power to examine more people by 36%.

7.2 Limitations

There are several limitations regarding this experiment. As the trial lasted for one month, we cannot determine with accuracy which is going to be the behavior of the patients for a longer period. However, studies have revealed that short adherence may lead to long-term adherence to medication. [62] Moreover the population of our participants was not equally diverted according to age. The clear majority belonged in the early adulthood group. Younger people are more keen with new technologies and therefore, more likely to use a smartphone device, in comparison with the other age groups. Also, we did not monitor the responses of the users towards the apps in real time.
8 Conclusions

This dissertation began with an introduction to the general topic of mHealth, then examined the use of mobile apps for various health problems, and finally proceeded to investigate the subject of medical adherence of adults in combination with mobile apps. Apps from different stores were reviewed, and the conclusion was that they do not implement any affective feedback techniques.

An experimental paradigm was evolved to examine the affective feedback based on visual auditory and tactile messages. The visual messages that were selected by the form of emoticons and personalized messages had some impact on our participants.

8.1 Future work

We hope in future that we will utilize a more advanced and sophisticated application that we will measure user’s responses in real time, providing the opportunity to get results without any further user interaction. Although such an application will require a lot more access to user’s privacy.

The field of affective mobile applications is in its infancy. As time lapses devices with embedded 3D touch technology will be more widespread and those that do not utilize it will become obsolete. Mobile Health users are expected to be up to 1.8 billion till 2018. [66] Therefore, a possible improvement for our application will be to take advantage of such pressure sensitive interfaces and provide supplementary functionality. Augmented reality is also beginning to emerge as a technology. Although most efforts are concentrating in the entertainment industry, we believe that an advanced augmented reality component, which has the ability to distinguish medications via the smartphone camera, will be of great use in the m-Health industry too.
References


[10] S. F OX AND M. D UGGAN, “Mobile health 2012 - half of smartphone owners use their devices to get health information and one-fifth of


[38] M. Csikszentmihalyi, Flow and the foundations of positive psychology.


[46] David Oswald, Steffen Kolb, “FLAT DESIGN VS. SKEUOMORPHISM – EFFECTS ON LEARNABILITY AND IMAGE ATTRIBUTIONS IN DIGITAL PRODUCT INTERFACES”, in INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION, 04/09/2014-05/09/2014


Vinamra Jain and Ashok Sharma. The consumers preferred operating system: Android or iOS. Department of marketing, Amity Business School, Amity University, 2013.


Graham Wilson, Euan Freeman, and Stephen A. Brewster, “Multimodal Affective Feedback: Combining Thermal, Vibrotactile, Audio and Visual Signals”, Glasgow Interactive Systems Group, ICMI


[73] D. Sukyadi, S. Setyarini and A. Junida, ”A Semiotic Analysis of Cyber Emoticons (A Case Study of Kaskus Emoticons in the Lounge Forum at Kaskus-the Largest Indonesian Community)”, *k@ta*, vol. 13, no. 1, 2011.


[76] Smartphones help to improve medicine adherence in teenagers and young adults”, *The Pharmaceutical Journal*, 2014.


