BraPolar: an M-Health Application for Remote Monitoring of People with Bipolar Disorder

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***Abstract*—Bipolar Disorder (BD) is a disease characterized by unusual changes in mood, energy, activity levels, and self-awareness of the condition. Research related to the screening and collection of subjective information has shown that specialists may help patients using this information. In this article, we present the design of BraPolar, an m-Health application for remote monitoring of patients with BD, detecting fluctuations in mood and behavior. The data parameters collected by the application will indicate early mood changes before the disease reaches extreme functional consequences. We also present a pilot usability evaluation involving six users with non-BD (3 male and 3 female), with an age range from 26 to 54 years. It includes users with non-BD to identify possible usability problems according to different ages and different levels of cell phone dependence of users, to later evaluate the application with BD users. The users mentioned that the application is satisfying and easy to use, but we identified that some features need to be improved to allow a better end-user experience.**

Keywords— m-health; bipolar affective disorder; remote monitoring.

I. INTRODUCTION

Bipolar Affective Disorder (BD) is a disease characterized by unusual changes in mood, energy, activity levels, and the ability to perform everyday tasks. Many of the patients with BD present reduced awareness of the disorder, its symptoms, and its cognitive and social functioning; such a condition is known as loss of insight [1]. In BD, there are Early Warning Signals (EWSs) that are a set of behaviors that could predict when a patient may enter a manic or depressive phase [2]. This information, over a period of time, may be useful in anticipating and detecting a change of state in patients with BD [3].

In the literature review, we found that m-health applications which have been used to follow up patients with BD [4] [5] [6] [7] [8], among them [6] [7] [8], have some characteristics of our interest, such as visualization of the information collected and a set of parameters that were analyzed for the detection of fluctuations in mood. Other studies [6] define a new field that conceptually establishes data collection in the user's relationship with the use of the smartphone, called digital phenotyping.

The unification of digital phenotype analysis from EWSs may allow visualizations as markers of status and trait of noninvasive therapeutic intervention. However, no studies following this approach have been found in the literature. Also, applications that include all the necessary features for BD intervention have not also been found.

Therefore, we have developed BraPolar, an m-Health system that aims to provide BD specialists with a mapping of the behavior of patients involved through the collection and visualization of a set of behavioral indicators. With this, through the interaction of the patients with the cellular, the specialists will recognize symptoms of EWS, identifying when the patient will start with a manic or depressive episode [9]. In addition, specialists will get direct feedback from the patient before they start a manic crisis. Patients will also have access to the information collected to directly encourage the self-recognition of their condition in the BD.

In this study, we present the BraPolar design process and a pilot evaluation. The design of BraPolar aims to encourage further studies on the inclusion of specifications that we included in BraPolar, so that they may be appropriate for the remote monitoring of patients with BD. In the pilot evaluation, we included a cell phone dependency test, and a usability test aims to identify the degree of mobile phones dependency in people with non-BD and possible usability problems, respectively.

Initially, we decided to carry out the tests in patients with BD but we needed prior approval from a Research Ethics Committee and other governmental bodies to carry out experiments with human beings, a process that would take a few months, so we decided to carry out this pilot study with non-bipolar subjects. This allowed us to identify, for example, that some participants with a higher cellular dependence did not feel comfortable when viewing the stored information, a factor that we believe could be detrimental in later studies in patients with BD. On purpose, we identified some usability problems that will be corrected in future versions of BraPolar, before being launched for use in patients with BD. More details are explained in the results section of this work

This article is structured as follows. In Section II, we present the conceptual framework of BD and the importance of its study. In section III, we present studies about existing m-health, showing the main limitations found. Section IV details BraPolar's development process and how EWSs were part of the

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requirements when serving as mood markers. In section V, we present the evaluation method, showing usability and cell phone dependency tests performed with non-BD individuals. In section VI, we present the results, and in section VII, the main limitations of the study. To close, in Section VIII, we present the conclusions.

II. BIPOLAR DISORDER

BD is considered by Craddock et al. [10] as a complex psychiatric disorder characterized mainly by pathological mood alterations. These changes range from a period of mania (or euphoria), characterized by elation and more energetic behavior, to a depressive period, marked by low self-esteem and reduced activity [11].

According to the 4th edition of the Statistical Manual of Mental Disorders (DSM-IV) [12], there are four main subtypes of bipolar disorder: type I, type II, cyclothymic disorder, and the not otherwise specified (NOS). Type I Bipolar Disorder is characterized by manic or rapid (daily) cycling episodes of mania and depression. Type II Bipolar Disorder is identified by recurrent depression accompanied by hypomanic episodes (a milder state of mania in which the symptoms are not severe enough for hospitalization, but are sufficient to be observable by others). Cyclothymic Disorder is a severe state of alternating between hypomanic and depressive episodes. In the case of NOS, the symptoms suggest the diagnosis of bipolar disorder, but they are not frequent or long enough to classify the disease in one of the types above.

Approximately 25% of patients with this disorder attempt suicide at some point in their lives, and about 11% complete this attempt. It is estimated that 4.4% of the US adult population experiences bipolar disorder at some point in their lives [13], and similar figures are seen in the Brazilian population [14]. In this sense, the lack of self-awareness about the illness (loss of insight) makes it difficult to define a diagnosis, besides influencing the patient's adherence to treatment [15].

A mobile solution for the remote monitoring of these patients will provide experts with a map of their mood change by the visualization of a set of behavioral indicators in the data collected. This, together with the specialists' recognition of EWS symptoms, may assist them by indicating when the patient may cycle to a manic or depressive episode [9]. In fact, obtaining direct feedback from patients through the cell phone will help prevent untreated consequences of the mood changes. On the other hand, through the visualization of the gathered information, we aim for patients to increase their self-awareness about the illness, improving their ability to make decisions about it, and increasing their functional capacity.

III. RELATED WORK

According to Hernández et al. [10], the development of technologies and the rise of health costs have fostered a new frontier area: e-Health. .In this context, several applications for the treatment of mental illnesses have placed mobile devices as medical devices (m-Health) on the support for the treatment of mental disorders [16] [4] [5] [17].

Studies on the use of these applications show significant results in the health and care of the patients involved. Some of them evaluate the advantages of mobile applications on the treatment of BD, such as State Mood Tracking Journal and Diary [18], eMoods Bipolar Mood Tracker [19], BiAffect [6], MONARCA [7], What`s Up [8], as detailed above.

- State Mood Tracking Journal and Diary [18], also known as Moodtrack Diary, is an m-health designed for users who want to keep up with their mood swings. The Moodtrack Diary allows users to rate their own mood several times a day. It provides a calendar for keeping track of daily events and medication use. According to that, the application displays the information in graphs, allowing users to detect patterns and triggers for their moods. It also allows users to export a report to view on a computer, as well to share their profile to mental health professionals.
- eMoods Bipolar Mood Tracker [19] describes the daily mood ratings in a list form, also, provides a color-coded chart of the severity ratings of depressed: depressed or anxious mood. This app also has a blog to help users with general questions about mood and health. The paid version of the application allows marking a set of reminders to take the pills and generate detailed reports on the daily activity.
- BiAffect [6], is a winning project of the Mood Challenge for Apple's ResearchKit tournament developed for iOS. It is an application for understanding the mood and neurocognitive functioning in BD, using typing dynamics, such as typing speed and errors, to track and predict mood episodes. This is because the problematic in communication is one of the main symptoms of people with BD.
- MONARCA [7] is a system that helps users to monitor and visualize their behavior. For example, it indicates users' physical state, reminding them to perform specific tasks. It provides feedback on their behaviors and recommends healthier actions. Similar to other personal health technologies, the design of the MONARCA system employs a mobile phone application as the main component.
- What`s Up [8] is an application to provide relief tools in case of depression. It is based on the methods of Cognitive Behavioral Therapy (CTT) and Acceptance Commitment Therapy (ACT) to help deal with depression, anxiety, and stress. What's Up does not have options to share data or include in-app mental health specialists, but it can be useful to individuals with mild to moderate depression who do not have access to traditional treatments.

However, none was found to analyze the digital phenotype and visualizations as markers of status and trait of noninvasive therapeutic intervention, items relevant to detect early alterations in patients' self-awareness, before they reach extreme functional consequences. On the other hand, in all applications, the interaction of patients with the application is a necessary condition for the mapping of their state, and this may cause some discomfort in patients evaluated. When this is the case, BraPolar

runs in the background, requiring the least possible user interaction.

Through a longitudinal study proposed by the specialists of the Institute of Psychiatry of Federal University of Rio de Janeiro (IPUB/UFRJ), we aimed to establish a Baseline formed by the records of patients' interaction with the smartphone, which will describe their typical state. This will be compared with previous records to look for unusual patterns or parameters.

IV. DESIGNING THE BRAPOLAR APPLICATION

The idea of the development of BraPolar arose from a need of IPUB and of the Department of Psychology of PUC-Rio from our University. Several meetings and brainstorms with the researchers were carried out during 3 months, when the requirements and the organization of the project were defined.

We selected the web-based Trello application [20], for the project management, to encourage the collaborative remote work culture. Taking advantage of the characteristics of Trello, and looking for an agile methodology for the development of m-Health, we decided to use a Scrum-based approach, defining participants and workflow. We performed four iterations during a development process for the first version of the app. Conceptual maps and prototyping by the experts were taken into account.

In that process, we conceived the Brapolar application. It consists of an application will allow therapists to monitor in real time patients with BD, through the collection and analysis of the data generated in their cell phone. Brapolar allows the patients to define their mood, sleep hours, medications consumed, and others described in this article in later sections.

It is important to consider that each patient with BD may have different degrees of dependency on cell phone use, which may influence the results. According to this, BraPolar application runs in the background, in a light and discreet way, to avoid patient rejection and to encourage the continuity of the study. Therefore, as an initial step, we perform a cellular dependence test (nomophobia) proposed by Yildrim [21], since no study was found to prove the cellular dependence of patients with BD.

Ethical and legal regulations were followed during the development of this study.

In the following subsections, we present the design of BraPolar, including the collection of requirements, the design itself, and the detail on how data analysis intended to be done by the experts through the application.

A. Requirements

Gathering requirements is a key part of software development. According to the IPUB experts' suggestions, the functionalities of BraPolar were developed considering that the behavior of patients with BD varies according to their emotional state. Faurholt-Jepsen and colleagues [22] identified a set of states (triggers) in patients with BD and their interaction, when they are in a depressed or manic state, coinciding with some approaches proposed by Brazilian specialists and adopted in BraPolar.

However, other researchers [23] determine a set of key parameters that could indicate EWSs and serve as a basis for the longitudinal study: (a) sleep-wake / activity, (b) mental activity and (c) nature and frequency of social interaction. In fact, examining the criteria for episodes of hypomania and depression, the main indicators of the onset of episodes (changes in activity, sleep, frequency and intensity of speech, frequency and intensity of social contact) can be collected passively using the set of sensors and device usage log features available on all smartphones (see Fig. 2).

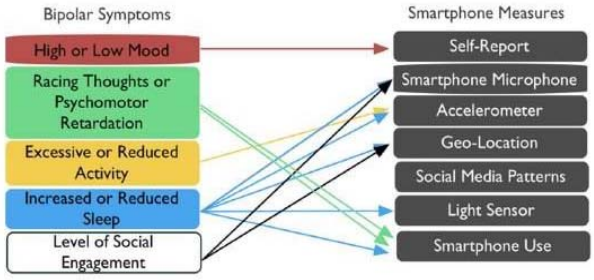

Fig. 1. Bipolar symptoms and potential smartphone measures (Matthews et al *[30]*)

Considering previous research [4] [5] [7] [23], we defined two main groups: active data (A) and passive data (P) to be collected. Based on the study by Seles da Costa [23], and according to our work team, we decided to add acoustic characteristics, specialized assistance, and state visualization, regrouping the focus of the study in the following eight categories:

- Mood state (A): The application allows the patient to specify his / her state of mood daily or whenever he or she wishes. If they do, they can contact a specialist.
- Acoustic characteristics (P): During a call on the cell phone, patients in a depressed state tend to talk lower and slower, and the reverse happens when they are in a manic state. For these reasons, in [24], we used openSmile to extract acoustic characteristics and the emotional state of the speaker, which was adopted in our application.
- Physical movement (P): Patients with depression tend to move less, with less force and more slowly, the opposite occurs in manic patients. In this sense, we will use the number of messages, calls, and GPS to determine how much the user has moved in a day.
- Psychomotor Activity (P): Most people with BD have their displacement routines dominated by a set of places they usually visit in a given time pattern. These patterns tend to change in depressive and manic states, becoming less frequent or more erratic, respectively. Also, depressed people tend to go out less. Therefore, information obtained from the accelerometer, light sensor, and geographical location is relevant for this group.

- Quality of sleep (A): Considering the last time the patient has used his cell phone at night and the first time he uses it during the day, the application asks the patient, through a notification, how was his sleep quality the night before. The application offers a sleep quality scale for the patient to choose the desired option.
- Social Interaction (P): The way people interact with others can vary widely. However, what people with BD have in common is that, in a depressive phase, the desire and capacity for social interaction are reduced, while during a manic phase, it is increased. For this reason, we developed a virtual keyboard that is installed along with the application to capture the pulsations and speed of writing, to determine how much and at what speed the user types. This keyboard replaces the keyboard used in other applications of the patient's cell phone.
- Specialized Assistance (A): This feature allows direct contact with the specialist. If you feel that you need help, you can contact us via chat. This feature will be visible on all screens of the application so that it is easy to access to the user.
- Status overview (A): Patients and experts can refer to each of the parameters above through a detailed summary presented on a dashboard. For patients, they can manually change these indicators if the application has captured any abnormal parameters. This interaction will also be recorded for experts' analysis.

BraPolar has two modes: one for patients and one for professionals. Similar requirements were requested in both modes, but in the specialists' version, the visualization of the patient information is the main objective.

B. *BraPolar Architecture*

The design of this application is an integration of a real-time system, and its architecture should respond to the standards of the market. With this in mind, to speed up the development process, we use Mobile Backend As Service (MBaaS) which is a template to provide developers with a way to bind their applications to cloud back-end stores [25]. Other projects have achieved satisfactory results with the use of a cloud-based architecture [26] [27]. For the development of this project, we applied Firebase, which uses MBaaS to create applications for iOS, Android, and Web, providing automatic data synchronization, authentication services, messaging, file storage, and analysis.

In Firebase, the data transmission is written to a FirebaseDatabase reference and retrieved while attaching an asynchronous listener to the reference. If a patient loses the network connection, m-Health will continue to work because Firebase maintains the internal version of active data itself. Firstly, data recording occurs locally, and then m-Health synchronizes this data with the remote servers.

Fig. 2 shows the diagram of components we take as a framework, which is proposed by Shaikh in [27]. The cloud server is in charge of managing the database through Google's Realtime Firebase Database, storing the documents, and exchanged information. On the other hand, both doctors and patients can access the application by logging in and sharing information through Firebase. The administrator will define which users who will be able to interact with the system and will also manage the database and the system storage.

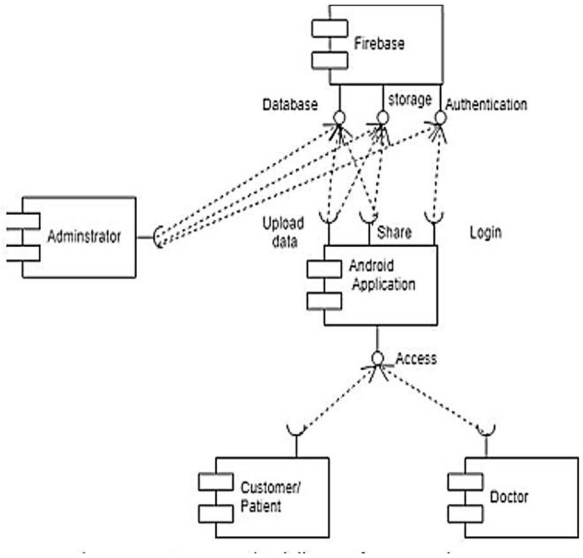

Fig. 2. Component level diagram for proposed system (Shaikh et al. [27])

C. *BraPolar User's interface*

We designed hand-drawn paper prototypes of the user interface of Brapolar application (Fig. 3).

Fig. 3. Example of a hand-drawn paper prototype of the BraPolar application – Mood State Screen.

The design of the BraPolar interface is user-centered as it followed recommendations proposed by Brazilians specialists, involving patient-specific needs, preferences, and limitations. We also consider some application features available in the Play Store and related studies [18] [19] [6] [7].

As an example, Fig. 4 show the interfaces of the mood and social interaction functionalities available in BraPolar. As part of the "mood" function, the application shows a calendar where the patient selects the option on the mobile phone as s/he feels on a given day (Fig. 4-left). As part of the "social interaction" feature, the application shows the timeline of the mobile phone applications s/he used during a particular day or period (**Error! Reference source not found.**-right).

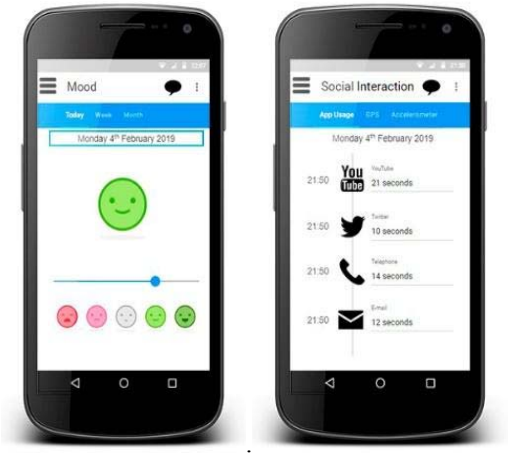

Fig. 4. Examples of interface functionalities of "mood" (left) and "social interaction" (right) on the BraPolar.

At the end of the day (at 10:00 pm), the patient will get notifications on the cell phone, asking if s/he would like to transmit the data of that day and send it to the researchers. If the patient disagrees, all data for that particular day will be deleted. Otherwise, the data will be sent to the research team.

D. Data Analysis

The transmission of data in BraPolar is one of the main functionalities and the general objective for which it was developed. At this point, it is important to emphasize that the functionalities related to the processing and visualization of information will not be collected, neither the content of the messages nor the conversations of the patients. Statistical information of these interactions and the volume of the voice of each call will be stored, as done in other researches in the area [4] [5] [28] [7], thus protecting patient privacy according to the legal framework.

Data transmission will be done in a secure manner, and anonymity will be guaranteed. The team of specialists decided to follow up the patients for three months as a minimum period to assess whether the patient had any changes in their behavior.

At this point, it is important to emphasize that for the functionalities related to the visualization and processing of information, neither the content of the messages nor the conversations of the patients will be collected. Only statistical information of these interactions and the voice volume of each call will be stored, as done in other researches in the area [4] [5] [28] [7], thus protecting patient privacy according to the legal framework.

Once m-Health is developed, the application will be tested with 40 patients with BD, selected from the IPUB. Therefore, we will conduct a longitudinal study according to the experts' suggestions, thus establishing a Baseline (BL), formed by the records of the interactions of the patient's smartphone, which will describe the typical state of the patient. Once the BL is established, the measured data (active and passive) will be continuously compared to new records, creating the Digital Phenotype (FD), aiming to detect changes in the parameters measured at the beginning of the analysis. This will allow the monitoring of rapidly changing parameters and the comparison with the subjective state of the patients; this can be used as a way of measuring the response to treatment.

It is worth mentioning that the specialist can, at any moment, contact the patient if any anomaly is detected in the parameters being measured. Subjectively questions may be asked, for example: how many meals did you take? How much time did you spend away from home and at work? Etc. All such observations may be recorded to intervene, if necessary. It should be noted that once the data are collected and visualized, specialists can offer new strategies for normalizing insight through psycho-educational counseling.

For the application to be suitable for end users, we initially performed a usability assessment, which we present in this study, below.

V. EVALUATION METHOD

We performed a cell phone dependence evaluation and a pilot usability evaluation. These were performed with non-BD individuals, since the intention was to evaluate the nomophobia and the usability and user's satisfaction with BraPolar, to later take BraPolar for the use of people with BD.

Six users (3 female and 3 male) with an age range from 26 to 54 years participated in the two evaluations (Table 1). This is because we intended to include people from the age group of our future target users. It is estimated that this quantity of users is often sufficient [29] to perform usability tests. The participants are identified here as P1 to P6.

All participants individually received a prior explanation of BraPolar application and the activities to be performed in the tests. Also, we sent an email to the participants explaining the dependency test, which they completed online. The date and time of the tests were marked with each participant, which were performed as described below.

A. Cell phone dependency test

Initially, we applied the cell dependence test (nomophobia) proposed by Yildrim [21]. This consists of with a set of questions about the frequency of use of the cell phone, such as: approximately how much time per day (hours), do you think you spend using your smartphone? How many phone calls are made per day? On the other hand, it includes questions where the user should answer on a scale of 1 to 7 about how much he/she agrees or disagrees with statements, such as: I lose track of how much I am using my smartphone, I would be nervous because I would be disconnected from my online identity, etc.

TABLE I. PARTICIPANTS OF STUDE

Participants	*Sex*	*Age*	*Nomophobia*
P1	M	53	Moderate
P2	F	26	Mild
P3	F	54	Severe
P4	F	35	Moderate
P5	M	51	Mild
P6	M	47	Moderate

The results of the test are evaluated on a scale from 0 to 140, where the score obtained indicates the degree of cell phone dependence in four categories from least to most severe: no nomophobia (result < 19), mild (20 < result < 59), moderate (60 < result < 99) and severe nomophobia (result > 100).

The test was applied online via Google Form. In the results, we identified that two participants (P2, P5) were mildly dependent, three with moderate dependence (P1, P4, P6) and only one participant with severe dependence (P3). We used these results to identify if the degree of cell phone dependence is a factor that may influence the usability of BraPolar application.

B. Usability test

We perform the usability test with each participant individually. The test was done in a laboratory of our university, where the participant received instructions from the test script, which consisted in performing a set of activities in BraPolar application and, later, filling in a post-test interaction satisfaction questionnaire. Each test lasted approximately 35 minutes. We used the think aloud technique to better identify the participant interaction experience with the application.

Each participant was invited to perform the following tasks, and we used the Think Aloud technique to better identify the participant interaction experience with the app:

- Install the Brapolar application.
- Indicate in Brapolar what his/her state of humor at any moment.
- Establish that BraPolar capture his/her interactions with the cell phone during the test
- Configure the BraPolar keyboard and send an email using another application outside of BraPolar.
- Make a call and send an SMS to check if BraPolar disrupts interaction with other apps installed on his/her phone.
- Establish the number of hours that the user slept the last night.
- View the data collected.

These tasks, together with the post-test questionnaire, allowed us to evaluate the following aspects:

- Application Reaction: In this activity, the participant will define what they found of the application during the execution of the tasks when using BraPolar.
- User interface: The colors and size of the fonts used in the application, the amount of information displayed by each screen and the transition between the screens of the app were evaluated.
- Terminology and application information: It was evaluated how the information in the app is presented to the user. Both the information or error messages generated after an interaction were evaluated, as well as the iconography elements that represent the tasks that the user can perform in the app.
- Learning and use: The degree of difficulty of the users was evaluated when interacting with the application and execution of tasks. We have evaluated at this point, the interaction with BraPolar's custom keyboard and if the application interferes with user interaction with other applications installed on your phone.
- Data collected: we observe the reaction of the participants when viewing their data collected in the evaluation interval and the ease of the app when sending the information to the research team.
- System Capability: We have identified participants' perception of how the application works and how easy it is to recover from errors.

It should be noted that for the post-test, we adopted the Questionnaire for User Interaction Satisfaction (QUIS). QUIS is a tool that includes a set of questions to estimate users' subjective satisfaction focusing on specific aspects of the human-computer interface [21]. We have adapted QUIS to our context, including questions about the aspects mentioned above to identify user usability and user experience with BraPolar.

VI. RESULTS

We describe in this section the results found in the QUIS and usability tests.

As a result of the evaluation obtained in the QUIS, participants became familiar with the interface, according to the categories below.

- Application Reaction: Most attendees have flagged that the application is satisfying and easy to use, retaining similarity to other similar Android apps on both dependent users (P1, P3, P4, P6) and people less familiar with mobile phones (P2, P5).
- Terminology and application information: The use of terms used in the application turned out to be clear to participants P1 to P4, P6. However, it was observed that both participants with a severe degree of nomophobia (P3) and mild or moderate (P5) nomophobia, required moderator instructions at specific times of this activity because they were not familiar with m-Health. The messages presented were clear, but the terminology was sometimes confusing to older people.

- Learning and use: In general, the system was considered easy to learn and operate by trial and error. The tasks required were almost always carried out logically. Participants with medium or high nomophobia were more likely to remember terms than less familiar participants. Therefore, we need to include instructions in the interface in the next versions the first time the application is run.
- Data collected: we identified that participants, both dependent (P1, P3, P4, P6) and non-dependent (P2, P5) felt unnecessary data collection or felt uncomfortable with viewing their data stored in the application. Therefore, we need to be careful when exposing the data collected by the participants since the participants (P3 and P6), even knowing the behavior of the app, were annoyed by the fact that an app is tracking them. We believe this could be detrimental to patients with some mental illness.
- Application Capability: Participants commented that the application is fast and the transition between screens has a logical order. The custom keyboard was well accepted due to the ease of error correction. The application has been designed to meet all levels of both experienced and novice users

Regardless of the level of cell phone dependence of the participants, the application has proven to be easy to use for most participants, yet some aspects need to be improved, such as terminology and data presented on participants' screen. It was found that the younger participants demonstrated a greater ability to perform the indicated tasks. On the other hand, even the P3 participant, who is 54 years old and severe nomophobia, should have been more familiar with the use of the application. Nevertheless, it was necessary to explain to him the functioning of the task to establish hours of sleep.

Regarding user satisfaction, the participants demonstrated to understand the items that were presented in the interface. Their reaction was observed before and after the interaction. Although the application response time was satisfactory, older participants had difficulty installing the application, requesting more detailed information at the beginning of the test. Even so, the participants performed each activity, and it was possible to obtain a perception of how they think about the interface. This allows us to identify some features that need be improved, such as terminology and clarity in the results presented. We believe that this could cause some inconvenience in patients with BD illness.

According to the results obtained, we will update the BraPolar version with the required improvements, to later evaluate with users with BD. We hope that the new version of BraPolar will allow a better user experience, and thus, greater reliability of the data received by the specialists. In this ways, we intend that the remote monitoring with the specialists will help the detection of alterations in the testing and subsequent normalization of the mood

VII. .LIMITATIONS AND FUTURE WORKS

One of the main limitations of the study is the long periods required in the evaluation of the application with people with BD, which implies a longer time to obtain reliable results. A large amount of time is needed to assess whether the quality of life of the patients involved will improve after the application has been used and how this will help the experts in the remote monitoring process.

However, a pre-evaluation of the application with people with non-BD helped improve the usability and quality aspects of end-user interaction.

In the next studies, the IPUB will select patients with type II bipolar disorder following the criteria of the DSM-IV. Initially, we will perform usability tests involving users with BD following the same criteria of this study. Later, we will perform a usability test with specialists to determine the easy to use of the system as a whole. We intend to establish a baseline of 5 months, a period in which we will follow up on participants using the BraPolar, with the aim of detecting and assessing early, any alteration behavior of patients before it leads to harmful consequences helped from therapeutics.

VIII. CONCLUSIONS

This article introduces BraPolar, an m-health to monitor patients with BD, storing all the information in a cloud. This application aims to increase the efficiency in the exchange of patient-specialist information, reduce health costs, and the real-time monitoring of each patient, improving the quality of care.

In this study, we present the design of BraPolar and a usability evaluation involving users with non-BD, aiming to identify possible application failures. In the results we found that the participants were able to do the tasks oriented the participants with moderate nomophobia were easier to remember terms than less familiar participants, but we must be careful when showing the data collected in the application.

This study also intends to encourage new studies on the inclusion of specifications that were raised and included in the design of BraPolar, to make them appropriate for the remote monitoring of patients with BD.

We also emphasize that smartphone technology opens a new possibility of interventions specific to the context of the BD. The adaptations and solutions for the control and follow-up of mental health, present promising results to be studied. bipolar, is the first step for future researches of applications for the control and monitoring of mental illnesses for people with BD being this one, pioneer in Brazil.

REFERENCES

[1] Bipolar Insights, "Mental Healt Education Center," 2016. [Online]. Available: http://bipolarinsights.com/?page_id=247.

[2] Centre for Clinicar Interventions, *Detecting Early Warning Signs,* Sydney, 2015.

[3] A. Puiatti, S. Mudda, S. Giordano and O. Mayora, "Smartphone-Centred Wearable Sensors Network for Monitoring Patients with Bipolar Disorder," in *33rd Annual International Conference of the IEEE EMBS*, Boston, 2011.

[4] V. Osmani, A. Maxhuni, A. Grünerbl, P. Lukowicz, C. Haring and O. Mayora, "Monitoring activity of patients with bipolar disorder using

smart phones," in *MoMM '13 Proceedings of International Conference on Advances in Mobile Computing & Multimedia*, New York, 2013.

[5] J. E. Bardram, M. Frost, K. Szántó, M. Faurholt-Jepsen, M. Vinberg and L. V. Kessing, "Designing mobile health technology for bipolar disorder: a field trial of the monarca system," in *CHI '13 Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, Paris, 2013.

[6] J. Zulueta, A. Piscitello, M. Rasic, R. Easter, P. Babu, S. A. Langenecker, M. McInnis, O. Ajilore, P. C. Nelson, K. Ryan and A. Leow, "Predicting Mood Disturbance Severity with Mobile Phone Keystroke Metadata: A BiAffect Digital Phenotyping Study," *Journal of Medical Internet Research,* vol. 20, 2018.

[7] "An Item Response Theory Evaluation of the Young Mania Rating Scale and the Montgomery-Asberg Depression Rating Scale in the Systematic Treatment Enhancement Program for Bipolar Disorder (STEP-BD)," *Journal of Affective Dissorders,* vol. 205, pp. 73-80, 2017.

[8] HealthLine, "The Best Bipolar Apps of 2018," 2018. [Online]. Available: https://www.healthline.com/health/bipolar-disorder/top-iphone-android-apps.

[9] J. Scott, F. P. e. Colom, A. Benabarre, N. Cruz, M. Valenti, J. M. Goikolea, J. Sánchez-Moreno, M. A. Asenjo and E. Vieta, "Long-Term Mental Health Resource Utilization and Cost of Care Following Group Psychoeducation or Unstructured Group Support for Bipolar Disorders: A Cost-Benefit Analysis," *The Journal of Clinical Psychiatry,* pp. 378-386, 2009.

[10] T. A. Hernández Rocha, L. Augusto Fachini, N. Cristina da Silva, A. C. Queiroz Barbosa, M. Do Carmo and J. Marçal Rodrigues, "Saúde Móvel: novas perspectivas para a oferta de serviços em saúde," *Epidemiologia e Serviços de Saúde,* 2016.

[11] F. Alves Fonseca, *O insight implícito em pacientes com Transtorno Bipolar,* Río de Janeiro, 2017.

[12] American Psychiatric Association, Diagnostic an Statistical Manual of Mental Disorders, Washington, DC: American Psychiatric Association; 4th edition (2000), 2000.

[13] National Institute of Mental Health, "Transforming the understanding and treatment of mental illnesses," 2017. [Online]. Available: https://www.nimh.nih.gov/health/statistics/bipolar-disorder.shtml.

[14] Academia Nacional de Medicina, "Sessão de 20 de julho de 2017 – ANM realiza Simpósio sobre psicopatologia e análise clínica do Transtorno Bipolar," 2017. [Online]. Available: http://www.anm.org.br/conteudo_view.asp?id=2542.

[15] Y. Cheng-Fang, C. Cheng-Sheng, K. Chih-Hung, Y. Ming-Li, Y. Shang-Ju, Y. Ju-Yu, H. Chi-Feng and W. Chia-Cheng, "Relationships between insight and medication adherence in outpatients with schizophrenia and bipolar disorder: prospective study," *Psychiatry and Clinical Neurosciences,* vol. 59, pp. 403-409, 2005.

[16] F. Gravenhorst, A. Muaremi, J. Bardram, A. Grünerbl, O. Mayora, G. Wurzer, M. Frost, V. Osmani, B. Arnrich, P. Lukowicz and G. Tröster, "Mobile phones as medical devices in mental disorder treatment: an overview," *Personal and Ubiquitous Computing,* vol. 19, pp. 335-353, 2015.

[17] M. Matthews, S. Voida, S. Abdullah, G. Doherty, T. Choudhury, S. Im and G. Gay, "In Situ Design for Mental Illness: Considering the Pathology of Bipolar Disorder in mHealth Desing," in *MobileHCI'15*, Copenhagen, 2015.

[18] G. Lúcio Pita, "Design por todos: participação de deficientes visuais no codesign de interação humano-computador," 2016. [Online]. Available: https://repositorio.ufba.br/ri/bitstream/ri/23860/1/TCC%20-%20Gabriel%20Pita.pdf.

[19] C. A. Depp, B. Mausbach, E. Granholm, V. Cardenas, D. Ben-Zeev, T. L. Patterson, B. D. Lebowitz and D. V. Jeste, "Mobile Interventions for Severe Mental Illness: Design and Preliminary Data from Three Approaches," *The Journal of Nervous and Mental Disease,* vol. 198, no. 10, pp. 715-721, 2014.

[20] M. Aisa Lopez, "Remote work culture in IT companies," 2016.

[21] C. Yildrim and A.-P. Correia, "Exploring the dimensions of nomophobia: Development and validationof a self-reported questionnaire," *Computers in Human Behavior,* vol. 49, pp. 130-137, 2015.

[22] M. Faurholt-Jepsen, M. Vinberg, M. Frost, E. M. Christensen, B. JE and L. V. Kessing, "Smartphone data as an electronic biomarker of illness activity in bipolar disorder," *Bipolar Disorders: An International Journal of Psychiatry and Neurosciences,* 2015.

[23] R. Seles da Costa, M. R. Zoéga Soares and R. Grossi, "Estrutura das sessões de uma intervenção analítico-comportamental em grupos para pessoas diagnosticadas com transtorno bipolar," *Acta Comportamentalia: Revista Latina de Análisis del Comportamiento,* pp. 57-72, 2017.

[24] F. Eyben, B. Huber, E. Marchi, D. Schuller and B. Schuller, "Real-time Robust Recognition of Speakers' Emotions and Characteristics on Mobile Platforms," Gilching, Germany, 2015.

[25] M. Carney, "AnyPresence partners with Heroku to beef up its enterprise mBaaS offering"".

[26] M. A. Mohammed, A. S.K. Bright, F. Degadzor Ashigbe and C. Somuah, "Mobile-Based Medical Health Application - MediChat App," *International Journal of Scientific & Technologicy Reseach,* vol. 6, 2017.

[27] Z. Shaikh, D. Piyush Doshi, D. Nitin Gandhi and D. Manoj Thakkar, "E-Healthcare Android Application based On Cloud Computing," *International Journal on Recent and Innovation Trends in Computing and Communication,* vol. 6, no. 4, 2018.

[28] "A Protocol for the Hamilton Rating Scale for Depression: Item Scoring Rules, Rater Training, and Outcome Accuracy with Data on its Application in a Clinical Trial," *Journal of Affective Disorders,* vol. 200, pp. 111-118, 2016.

[29] D. Stone, C. Jarret, M. Woodroffe and S. Minocha, User lnterface Design and Evaluation, San Francisco: Morgan Kaufmann, 2005.

[30] M. Matthews, S. Abdullah, E. Murnane, S. Voida, T. Choudhury, G. Gay and E. Frank, "Development and Evaluation of a Smartphone-Based Measure of Social Rhythms for Bipolar Disorder.," *US National Library of Medicine,* 2018.