A Wee Bit More Interaction: Designing and Evaluating an Overactive Bladder App

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ABSTRACT

Overactive Bladder (OAB) is a widespread condition, affecting 20% of the population. Even though it is a treatable condition, people often do not seek treatment. In this paper, we describe how we co-designed and evaluated with 30 stakeholders (9 medical professionals and 21 end-users) an OAB mobile health application that aims to increase adherence to self-managed treatment. Our results support previous research that visualizing progress, setting goals, receiving reminders and feedback increases use. We discovered that games could be used successfully as a distraction technique for urge suppression. Contrary to the current research direction, automatically calculated features could be a detriment to app interaction. Regarding evaluation, we found that designers may not want to rely only on questionnaires when assessing the success of a game and its emotional impact on users.

CCS CONCEPTS

• Human-centered computing ~ User studies; Usability Testing; Field Studies

KEYWORDS

Mobile Health Applications; Assistive Technology; Co-Design; Interviews; Usability; Overactive Bladder

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1 INTRODUCTION

The number of people suffering from Overactive Bladder (OAB) worldwide is expected to reach 20.1% by the end of 2018 [31]. The condition incurs high direct costs (treatment), indirect costs (low productivity) and intangible costs (quality of life) [18]. OAB is a treatable condition as 70% of people can be cured or have their symptoms ameliorated [1]. However, it remains undertreated due to people not seeking treatment, lack of proactive questioning by physicians and embarrassment [1]. Moreover, traditional treatment requires motivation and involvement, leading to a drop out whenever results are not quickly seen [10, 56]. Smartphones are popular ubiquitous devices, with 78% of UK adults using one [53]. By often interacting with them, people create a personal bond with the devices [60]. Given their computing capabilities, smartphones can recognize behavior patterns and provide real-time interventions [36]. As people with OAB need assistance wherever they are, a mobile health (mHealth) app could be an appropriate tool to increase adherence to self-managed treatment and raise awareness of symptoms.

Since the app intends to act as a personal tool, we followed a co-design methodology to investigate what features would best fit OAB users' needs. This approach has proved successful in health areas such as falls [58], knee rehabilitation [2], and cancer treatment [33]. We conducted three studies with key stakeholders: people with OAB, continence specialist nurses, and medical consultants. We wished to answer the following research questions (RQ): **RQ1:** What key features should an OAB mHealth app have to support people during self-managed treatment? **RQ2:** How might an OAB app help people self-manage their treatment and raise awareness of symptoms? **RQ3:** Does context have an impact on how users engage with the app?

This paper is structured as follows. We start by providing a background overview of OAB and mHealth app research studies. We then present the three studies we conducted: **Study 1**: requirements gathering interviews with all stakeholders; **Study 2**: interviews whilst stakeholders interacted with the proposed app prototype; and **Study 3**:

evaluating the app's usability and the user experience (UX) during a short exploratory field study with end-users. The outcomes from the three studies are then discussed in the context of our three RQs, before outlining our conclusions and proposed future work. Some of the findings from the first two studies have been published in [51]. University ethical approval was granted for all studies. We will refer to people with OAB symptoms taking part in the studies as user participants (UP) and medical participants as MP.

2 BACKGROUND

In this section, we present the OAB condition and its treatment. We then outline the current research in the area of mHealth apps. Finally, derived from the literature, we highlight key issues surrounding OAB that could be used to support users.

2.1 Overactive Bladder

OAB is defined as frequency (more than eight voids per day), urgency (with or without incontinence) and nocturia (more than two voids per night) [20]. The first assessment stage consists of bladder diaries and quality of life questionnaires [20]. Patients are asked to fill in a paper-based bladder diary (Fig. 6 right) for three consecutive days, in which they record: when, what, and how much liquid they drank (mls or cups), when and how much they urinated (mls), the urge to urinate, and any leakages [20].

Although drugs are available to ameliorate the symptoms, due to their side-effects (dry mouth, constipation, blurred vision) [1], medical staff are advised to suggest non-pharmacological therapies first (e.g., lifestyle changes, Pelvic Floor Muscle (PFM) training, and bladder training). The ***lifestyle changes*** consist of avoiding bladder irritants (certain food and drinks) and consuming a proper amount of liquid per day. The ***PFM training*** consists of performing daily PFM exercises. The ***bladder training*** is composed of extending the time between voids by applying urge suppression techniques to try and avoid rushing to the toilet whenever there is an urge to urinate. These techniques are divided into *brain distraction techniques* (e.g., trying to take the mind off the urge), and performing *quick PFM contractions* [20].

2.2 Mobile Health Applications

Different approaches have been used when designing and evaluating mHealth apps. Geurts et al. [22] designed an app for cardiac patients with medical staff. Owen et al. [44] used scenarios based on prior health research when developing an app to support the self-management of people with chronic conditions. Although they evaluated the apps with end-users, they did not involve them in the design. Hakobyan et al. [26] developed an app for older adults with age-related macular degeneration and involved both medical staff and end-users in the design phase. Later, the authors evaluated the app by conducting both controlled and field studies. Micallef et al. [38] co-designed an app with stroke survivors to assist with upper arm therapy. The authors conducted a design workshop with end-users and medical staff and evaluated the app's usability in a controlled field study. Matthews et al. [37] co-developed an app with people with bipolar disorder and highlight that people are aware of the stigma surrounding their condition.

Given the new technological possibilities, smartphones can provide personalized context, understand the user and the environment to offer better UX [19]. The *Mobilyze!* system [11] collects accelerometer, GPS, Bluetooth, WIFI, and ambient light to determine the physical and social behavior of patients with depression. In the MONARCA project [48], the smartphone collected data such as speech duration and number of calls to determine the social activity, and acceleration for the physical activity recognition of bipolar disorder patients.

Several OAB apps referring to either bladder diaries or PFM exercises are currently available on the market. Although some have involved medical staff in the design process [55], none of them mention any end-user involvement [35, 43]. PFM exercise apps provide customizable exercises plans [55], professional video tutorials on how to do the exercises [43, 55], discreet reminders [43, 35], show progress [43, 55], and encourage users to stay motivated by unlocking achievements [43, 35]. The bladder diary apps track progress by showing a comparison between pre- and post-therapy results [57] and require precise urine quantities [57, 30]. Our app differs from the other OAB apps in the following ways: (1) it has been co-designed with potential end-users, (2) it brings together several parts of the non-pharmacological treatment and diagnosis, (3) it aims to collect environmental sensors data that could offer a high level of personalization, (4) it offers a variety of distractions such as games, (5) it uses urine quantity approximations and (6) provides reminders for more than one function.

2.3 Key Concepts to Support in an OAB App

Although non-pharmacological treatments are well accepted by medical staff, they are time-consuming and require motivation. Therefore, people often fail to adhere to the treatment [10, 56]. Moreover, people with OAB often feel embarrassed and would prefer to keep the condition private [10]. Below we discuss issues highlighted in the literature that could be part of an OAB app.

Progress: Low adherence to treatment is an issue not only related to OAB, as other research investigating knee [2], falls [58] and stroke rehabilitation [38] provided similar findings. To overcome this, Ayoade and Baillie [2] recognized the importance of showing progress and improvement to patients. Similarly, displaying user achievements also proved effective for people with bipolar disorder [37]. Choe et al. [15] reviewed self-tracking apps to understand what data people track and discovered that visualizing data using line and bar charts is very useful.

Reminders: Another method of increasing adherence to treatment is by providing users with reminders. Reminders proved effective in increasing medication adherence for HIV patients [49], increasing exercise adherence for stroke survivors during rehabilitation [38], and in persuading people to drink a proper amount of water [14]. Min et al. [41] show how mobile instant messengers (e.g., *WhatsApp)* do not consider social appropriateness, making people feel embarrassed by an unexpected exposure of their incoming messages. Matthews et al. [37] discovered that people with bipolar disorder are embarrassed by their condition and would like reminder alerts to be discreet when using an app for their condition.

Distraction Techniques: Since urge suppression techniques are very important for a successful bladder training, we considered it useful to investigate what activities we could provide to distract people. Games, for example, have proved to be successful in rehabilitation areas such as falls [59] or in promoting healthier lifestyles [25, 14]. Ploderer et al. [46] developed an app that enabled people trying to quit smoking to access and share distractions and tips. However, these did not work as the smokers said that they were not distracting enough, and they continued to smoke while using the app.

Embarrassment: Embarrassment is an important emotion that plays a significant role in how people interact in a society [40]. Healey et al. [29] evaluated various graphical user interfaces for capturing emotions on a smartphone. Wilson et al. [62] investigated the modalities of conveying emotions by means of visual, thermal and vibrotactile feedback. Although technology is evolving, more research needs to be conducted in the HCI community in the area of emotions [16]. Given the fact that people do not seek medical help due to embarrassment and prefer to remain anonymous [52], we decided to investigate if people would like any elements to be designed discreetly.

Location: People with OAB tend to perform their activities close to toilet locations to avoid leakages and embarrassing situations [32]. Considering this, we wanted to discuss the issue of toilets and location, and how the app could assist.

Bladder Diary: A bladder diary is a form of assessment. A drawback to this practice is that people often show a lack of interest in filling in health diaries [61]. We wanted to understand whether people fail in filling in bladder diaries.

3 STUDY 1 – REQUIREMENTS GATHERING INTERVIEWS

We conducted interviews with MPs and co-design interviews with UPs to discuss the main functions and features derived from literature review and to understand what additional features would be best for OAB users. Interviews were composed of both quantitative and qualitative questions. Qualitative answers were analyzed using an adapted version of the Constant Comparative Method [4], initially part of Grounded Theory [23]. We used this method to avoid exclusions on thematic grounds.

3.1 Medical Participants

3.1.1 Methodology. We started with MPs interviews as we wished to understand whether they agreed with the concepts derived from the literature and whether they would suggest additional ones. We interviewed four MPs: two medical consultants (MP1-2) and two urinary continence specialist nurses (MP3-4). Three interviews were conducted via telephone and one face-to-face (MP2). Each interview lasted one hour and was divided into three phases (Table 1).

3.1.2 Findings. **Phase 1:** People delay seeking treatment because they develop their own way of dealing with the condition. For example, they either tend to change their daily routine to avoid embarrassing incidents in public spaces: "*Going from toilet to toilet. Use pads."* (MP4) or drastically reduce their fluid intake: "*Some people end up dehydrated."* (MP3). MPs believe people mostly want an easy treatment with a quick outcome: "*Patients want an easy answer to their problem – magic solution, magic tablet.*" (MP2), leading to a low adherence to treatment [10, 56]: *"Frustration that it doesn't work fast or at all."* (MP1).

Phase 2: As indicated in [20], in the UK, urologists often use bladder diaries and questionnaires for diagnosis. As shown in [61], people fail to fill in these diaries.

Phase 3: All MPs interviewed agreed with the app concepts obtained from our literature review. The only contradiction found was regarding the toilet mapping concept, where both nurses disagreed with the medical consultants and questioned the usefulness of the concept: "*It should be used*

as a backup plan and not to ease their access to toilets. Going to the toilet just in case needs to be avoided." (MP3). Finally, MPs requested that we include a treatment description in our app.

Table 1. Medical Participants – Interview Structure.

Phase	Content
Phase 1 OAB Condition	Issues and challenges.
Phase 2 Treatment	Treatment and diagnosis.
Phase 3 Mobile Phone App	Literature review concepts.

3.2 User Participants

3.2.1 Methodology. During our MPs interviews, we asked about how we should approach our co-design with UPs. We were advised to use single or same gender paired interviews and not to use any group-based techniques (e.g., focus group, design workshops). We interviewed nine UPs - two males and seven females (UP1-9) since the OAB prevalence is higher in women [17]. UPs' age range was 23-80, mean age 51. Their symptoms varied from mild (voiding frequency just outside the normal parameters, mild urgency, and no leakages) to severe (increased number of voids, high urgency, and leakages). Most UPs (8/9) were confident in using a smartphone. Each interview lasted two hours and was divided into three parts (Table 2). UPs were recruited via newsletter and research contacts.

Table 2. User Participants – Interview Structure.

Phase	Content
Phase 1 Experiences	Open-ended questions.
Phase 2 Screenshots	Screenshots illustrating literature review concepts.
Phase 3 Sketches	UPs' drawings of possible app functionalities.

The first phase was the same as for the MPs - aimed to gain a deeper understanding of the condition. However, for the remaining two phases we focused more on getting detailed design ideas, instead of validating the proposed app concepts. Similar to Uzor et al. [58], during the second phase of the interview, we presented UPs with paper-based bladder diaries, icons, and screenshots depicting literature review concepts and asked them to provide feedback. In the third phase, UPs were asked to design or suggest their own version of functions or to recommend new features. The motivation behind this was to encourage the more visual participants to engage in the app design [4].

Before the UPs interviews, our MPs validated that our interview plan was appropriate. We also wanted to make sure that the interview structure did not cause any emotional distress. Therefore, we used Baillie et al.'s emotion wheel [5], an adapted version of Russel's [50], to capture UPs' emotions during different phases. This approach has proved successful when investigating players' emotional reactions towards location-based games [5] and viewing and augmenting emotional perception when viewing images [3].

3.2.2 Findings. **Phase 1:** Two UPs did not consider seeking help as they felt the condition is not troublesome. Only three UPs had filled in a bladder diary before. As highlighted by MPs, two had problems with filling it in completely due to a busy lifestyle or forgetfulness: *"Yes, I kept delaying filling it in because of lack of time. I used to do it based on memory. And it's so unpractical on paper." (UP6).* Confirming MP3's statement, most UPs (6/9) restrict their daily fluid intake.

Phase 2 and 3: A contradiction was found between the two stakeholder categories with respect to one of the functionalities proposed. As opposed to nurses' view regarding the toilet map, all UPs agreed with the feature: *"That would be more than helpful. It would be indispensable in an area that is completely unfamiliar to me."* (UP1). Regarding location information/points of interest, whenever in need of a toilet, UPs tend to go to restaurants and bars (4/9), coffee shops (3/9) and public toilets on the street (2/9).

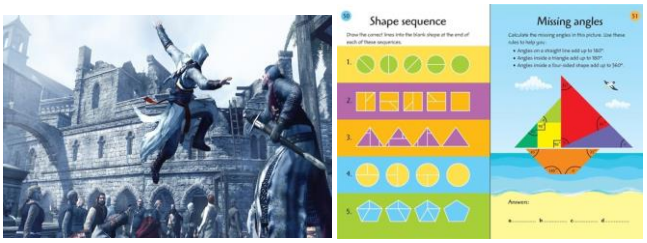

Figure 1: Examples of possible distraction techniques.

We presented UPs with screenshots depicting possible distraction techniques (Fig. 1). Most UPs (7/9) agreed that a game can be a viable distraction technique, with complex ones, that "*make your brain work hard*" (UP4) being preferred. As other distractions, UPs mentioned naming objects (e.g., animals, states), countdown from 100, multiplications, or simply visualizing names that pop up on a screen. We also asked our UPs where they would play the game, with home being the preferred location (5/9), followed by office (2/9) and commuting (1/9).

All UPs agreed with the progress feature as exciting - *"it would stimulate me"* (UP2). We also discovered that UPs are more interested in visualizing their progress in terms of physical rehabilitation and not lifestyle changes. As a goal,

UPs would mostly want to reduce their number of voids (6/9) and leakages (3/9). UP4 drew the progress feature as a bar chart [15], with both leakages and number of voids being represented. According to them, the progress should be shown daily and differentiate between working days and weekends. The number of voids and leakages could also be coded by sad/happy icons (e.g., a day in which the person has an increased number of leakages/voids can be categorized as a 'sad' day).

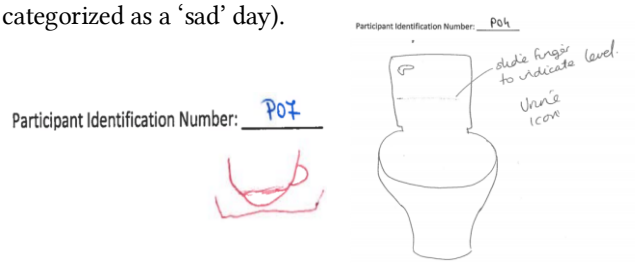

Figure 2: Fluid intake and voiding drawings made by UPs.

We also discussed the possibility of having a bladder diary and what representations would be best. For the fluid intake input, UPs indicated a mug (Fig. 2 left - UP7), whilst for the voiding one, a toilet representation (Fig. 2 right - UP4).

We also discussed the app icon and having security/privacy features. We presented UPs with various icons, some that aimed not to draw attention (Fig. 3 left) and some OAB related (Fig. 3 right). No major preference was found as four UPs would prefer the non-OAB icon and five the OAB one as "*you can say it's a water app.*" (UP6). However, 5/9 UPs would like a security feature such as a password (2) or quick lock (1). UPs' view varied from "*I would most probably delete the app if someone would take my phone and find it there.*" (UP2) to "*No extra level of protection. Keep it as simple as possible.*" (UP8).

Figure 3: Example of icon representations: non-OAB related icon (left) and slightly OAB related icon (right).

All UPs agreed with receiving PFM exercises reminders and 8/9 would also like an alert reminding them to drink more liquids. As a modality to receive reminders, vibration was chosen by all UPs, followed by sound (4/9) and silent (3/9). Confirming one of our initial hypotheses that people might perceive the app as being embarrassing, UP1 suggested hiding the reminder: *"Consider the fact that you are home and you have a visitor. You wouldn't like anything audio or with sound."*, with UP2 adding: *"No pop-up notification – What if your phone is in front of someone?"*. In addition to fluid intake reminders, we also wanted to understand UPs' view regarding the PFM reminder icon. We presented them with various screenshots (Fig. 4), from which Fig. 4 left (4/9) and Fig. 4 right (3/9) were the preferred ones by 7/9 UPs.

A new function was suggested by UP6, as an official permit to help people gain quick toilet access in public spaces. The motivation behind this is that certain public spaces (e.g., shops) do not allow non-customer toilet access.

Figure 4: Example of PFM exercises reminder screenshots: PFM related icon (left) and slightly PFM related icon (right).

Regarding the emotion wheel feedback, UPs mostly expressed positive emotions such as 'Relaxed', 'Calm' and 'Happy'. This suggests that interviews might be a suitable method for gathering requirements with participants suffering from a sensitive condition. During the third phase, we encountered 11 positive and 7 negative emotions. This might be because, although some UPs were pleased with their contribution *"I like drawing!"* (UP4), some did not like drawing: *"I don't like drawing things."* (UP9).

3.3 Design Decisions

Based on the design findings from this study, we developed the first prototype on a Samsung Galaxy S6 smartphone, with the following main functions:

Progress: Considering UP4's drawing and other UPs' comments, we decided to design the progress function by means of charts, with both happy and sad icons. Users would also have the option of setting up a goal in terms of the number of voids they would like to achieve in a day.

Reminders and Disguise: As no agreement was reached, we decided to re-visit these features during Study 2.

Distraction: We settled upon three techniques for distraction: two games and one non-game oriented. The first game was Tetris [21] (Fig. 5 right) as puzzle games increase users' level of attention [8, 13] and can be an ideal distraction technique. Tetris also proved successful when dealing with Post-Traumatic Stress Disorder as it requires attention and information processing [21] – which further strengthens its use as a way of distraction. Since multiplications were also suggested, we considered that the mathematical game 2048 [63] (Fig. 5 left) would be another suitable distraction. Finally, as UPs also suggested distractions that do not require any interaction and the fact that they wouldn't be able to play games all the time at

work, we implemented the concept of doing quick PFM contractions as a distraction.

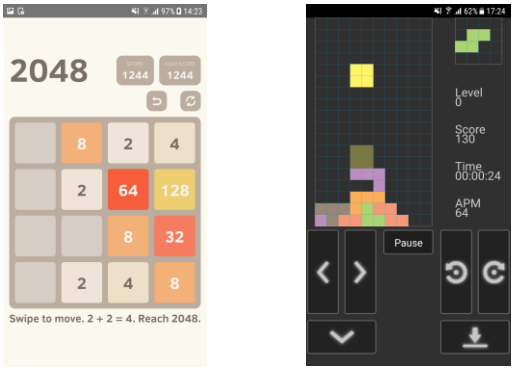

Figure 5: The two games proposed in the application: 2048 (left) and Tetris (right).

Map: The map feature is a customized version of the Google Maps application [24] that includes only the locations mentioned by UPs during the interviews (e.g., restaurants, bars) which might have toilets. The function also provides directions together with duration to reach the destination.

Bladder Diary: We decided to implement the fluid intake representation as in Fig. 2 left. UP4's suggestion was to design the voids screen as a toilet (Fig. 2 right). However, we felt as this representation would remind people of their condition and due to privacy concerns, we decided to use the same design as for the fluid intake screen (e.g., a mug). Precise urine quantities are required when filling in paper-based bladder diaries or in existing OAB apps [30, 57], forcing people to use a receptacle each time to measure the outcome. Intuitively, this becomes inconvenient when in public spaces or even at home. We, therefore, decided to use approximations to avoid users having to measure urine and instead implemented it as clickable images (Fig. 6 left). As in the paper-based diary, our representation also records when, their urge, and how much they urinated.

Treatment Description: This feature contains a description of the condition and its treatment, gathered from medical leaflets designed for people with OAB.

Toilet Pass: A simple screen with text and images, specifying the person has OAB and needs toilet access.

4 STUDY 2 – PROTOTYPE INTERVIEWS

After the development phase, we wanted to validate our prototype by interviewing again MPs and UPs. Both sets of interviews consisted of open-ended questions; data were analyzed in the same way as before.

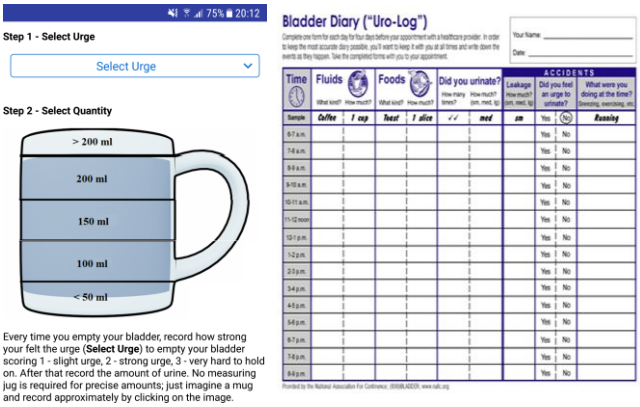

Figure 6: Our voids representation (left) as opposed to the paper-based bladder diary (right).

4.1 Medical Participants

4.1.1 Methodology. The app complies with UK OAB guidelines and we also confirmed with MPs that it is suitable for their patients. MPs were presented with the app installed on a Samsung Galaxy S6 device and asked to comment on the features. In total four semi-structured interviews were conducted with one medical consultant (MP2) and four urinary continence specialist nurses (MP3 - 6). MP2 and MP3 took part in Study 1 under the same MP number. MP4 and MP3 were partially interviewed together as MP4 had to leave during the interview. All interviews were conducted face to face and notes were taken down.

4.1.2 Findings. MPs agreed with the functionalities presented and provided suggestions on how to improve them. Regarding the progress, MP2 suggested providing only happy icons as positive reinforcement. Although the information provided in the treatment description was chosen from valid leaflets, providing images and links was suggested. In line with the literature stating that OAB is an embarrassing condition [10], two nurses suggested to not specify the name of the condition in the toilet pass due to confidentiality reasons or personal preferences "*People might not like that it states it's OAB.*" (MP5).

Contradictions were also found between the feedback provided in Study 1 and the findings of this study. For example, all MPs now agreed with the map feature with MP3 stating: *"Depends on the regime, I don't think it's a bad feature."*, whilst MP4 mentioned: "*I understand the contradiction as the map can increase the perception of going to the toilet. However, I agree with the feature as it reduces anxiety - it provides reassurance and helps people adjust to the regime better.*". Another contradiction found was regarding the bladder diary. Whilst two nurses emphasized the fact that precise urine quantities are needed otherwise the diary would be meaningless, MP2 agreed with using

approximations as "*Measuring urine is not easy and this would increase compliance.*".

4.2 User Participants

4.2.1 Methodology. As with the MPs interviews, UPs were presented with the updated app and asked to provide feedback. In addition, they were presented with possible embarrassing situations and asked if they might want the app to be discreet. We interviewed six people (UP9-14) with OAB symptoms of various ranges, five females and one male, age range 35 - 73, mean age 54.6. UP9 also took part in Study 1. All UPs either agreed or strongly agreed that they are confident using a smartphone. With respect to OAB apps, only one UP is using the Squeezy [55] app for PFM exercises. Only one interview was conducted face to face and all others via Skype. Among the online interviews, three UPs were presented with app screenshots as they did not own an Android OS device. As the purpose of this interview was to collect qualitative data regarding the app design, we felt that presenting the prototype in various ways did not influence UP's view. We recruited UPs via contact provided in an online bladder diary questionnaire.

4.2.2 Findings. All UPs agreed with the functionalities implemented. Several improvements were suggested such as displaying only one location at a time on the map "*because sometimes the icons are too close to each other*" (UP13) or to revise the urine quantity representation in the bladder diary. In line with the MPs' comments, two UPs suggested improving the treatment description with more information on the PFM topic. UPs would mostly play the games at home (5/6), followed by on the bus (3/6) and work (1/6). Nearly all UPs (5/6) mentioned the same locations for both games. Candy Crush [12] and Solitaire [54] were other games suggested. Some of the other distraction techniques, e.g., countdown from 100 and naming objects did not meet with much approval with half or less saying these were suitable. As for the MPs' feedback regarding the toilet pass, two UPs suggested changing the OAB terminology to "*sensitive bladder*" (UP11) because "*OAB symptoms seems like a medical term.*" (UP15).

The progress icons generated mixed feedback with one UP stating: "*The sad face shows you've failed but it might not be the case. For example, for me, the urge is worse when it's cold outside and it's not my fault.*" (UP10). Regarding the privacy aspect, only UP10 asked for a password to open the app. All other UPs suggested avoiding this functionality as: "*It would only overcomplicate things*" (UP11), "*It's not that sensitive info, it's not a major priority*" (UP13), and, "*It would be too complicated and if I have the urge an extra layer would annoy me.*" (UP14). All UPs voted for the same app icon (Fig. 3 right) as "*it's descriptive but doesn't offer too much info.*" (UP10).

Although all UPs agreed that it would be useful having a PFM exercises reminder, no agreement was achieved regarding the modalities by which to send the reminder, when to send it or its icon. Whilst two UPs did not want any icon, two preferred Fig. 4 left and two Fig. 4 right.

Contradicting the literature review and Study 1 findings regarding embarrassment and stigma, no ideas for making the design more discreet were generated or asked for by UPs during this study.

4.3 Design Decisions

We took on board the new suggestions and decided to implement several changes. Firstly, with respect to the *map*, we settled upon displaying only one location at a time, giving the option to users to see additional toilet locations if they wished. Secondly, the *progress* was changed to only show positive icons, which are generated based on the goal (Fig. 7). We decided to represent the first three days of the progress based on the data entered into the diary (as this is a common practice in the UK [20]). However, as people fail to fill in diaries, we felt it would be appropriate to automatically calculate the progress for the remaining days according to distraction techniques usage and other notifications sent by the app. Thirdly, small changes were made in the *bladder diary* function regarding the urine quantities. Fourthly, the text in the *toilet pass function* was changed based on recommendations.

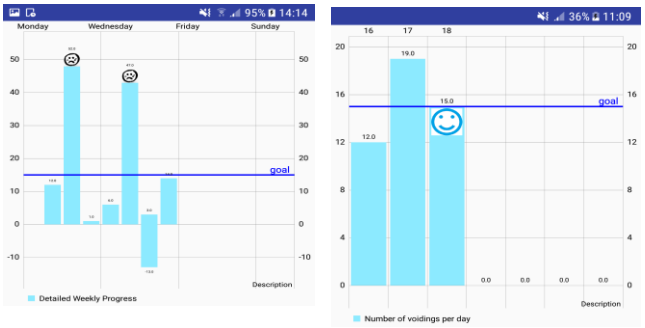

Figure 7: Original (left) and New (right) Progress Chart.

Lastly, we changed some information in the *treatment description* provided and added two videos. The only function remaining the same is the games as no changes were suggested. No privacy feature was implemented as no agreement could be reached during Study 1 and only one UP wished one in Study 2. Finally, we settled upon Fig. 3 right as the app's icon, Fig. 4 right as the PFM exercises reminder icon and letting users decide by which modality they wish to receive a reminder.

5 STUDY 3 – SHORT FIELD STUDY

Kjeldskov and Skov [47] and Baillie and Schatz [6] underline the importance of conducting short in situ evaluations as lab-based ones could leave usability or UX issues unrevealed. We, therefore, evaluated the app during a short field study with UPs. When evaluating an app for older adults with age-related macular degeneration, Hakobyan et al. [26] conducted a preliminary 7 days evaluation study before carrying on with a 6 weeks longitudinal field one. Previous sensor research [34, 39] found differences between weekdays and weekends and recommend undertaking a study which lasts at least a week (best 9-11 days) and collects both weekday and weekend data. Given this, we ran the study for 9 days.

5.1 Methodology

The study was divided into three phases (Table 3) and aimed to discover app usability issues, collect sensor data to understand how people interact with the app in the field, and understand if users' design decisions from previous studies hold when using the app in a real-life context.

Table 3. User Participants – Study 3 Structure.

Phase	Content
Phase 1 Set Up	App installation and usability evaluation.
Phase 2 Field Study	Nine days uncontrolled field study.
Phase 3 Uninstallation	App uninstallation and usability evaluation.

We started by posting invitations on social media and flyers around universities, libraries and leisure centers. We also emailed prostate cancer support groups. As people were not coming forward, we also advertised the study over the radio. We recruited six UPs (UP15-20), three males and three females, age range 26 – 66, mean age 54.6. Most UPs (5/6) agreed or strongly agreed they were confident using a smartphone. No UP was aware of other OAB apps.

The first phase was a face to face or Skype interview in which the app was installed on UPs' phone. After installation, UPs were asked to interact with the app by conducting tasks related to the features (e.g., set up the desired preferences, input data into the diary and inspect the map). After each task, UPs evaluated the workload using the standard NASA-TLX questionnaire [42, 27]. We provided UPs with tasks and NASA-TLX questionnaire as we wanted to evaluate the app and the mental load of the games (since we were using them as a suppression technique). This measure has proved successful when evaluating other mHealth apps [28, 38]. Again, we used the emotion wheel by Baillie et al. [5] to capture players' emotions regarding the games. We administered a wheel before playing the game to capture their initial emotions and a second one after to understand whether this type of distraction had an emotional impact on users.

The second phase was a 9 days field study in which UPs interacted with the app freely in the field. As suggested in [39], we collected sound, light and magnetic field data to capture environment data, WIFI (connected and visible hotspots name) to determine location and accelerometer to determine motion. Additionally, we collected app log data (number of accesses per feature and duration) from all UPs. We collected the environment and other data as we wished to investigate how an algorithm could be used to improve app functions such as distraction techniques durations and frequency of reminders. Data were automatically collected and uploaded to a server. No personal information such as photos, messages, and contacts was accessed or collected.

After the field study, UPs were asked to participate again in a short interview (Phase 3). As we wanted to determine whether using the app in the field has an impact on the way users perceive it, the same procedure as in the first phase was applied. Additionally, UPs were asked to fill in a SUS questionnaire [9] and answer additional questions, composed of 5-point Likert scales. These data were needed to understand whether the app was usable, if the UPs were satisfied with the features and if they would recommend the app to other people with OAB. At the end of the interview, the app was uninstalled from their phone. Apart from UP16 who owned a Huawei device, all other UPs owned a Samsung Galaxy smartphone, same as the device used for development. Full data (including sensor data) were collected from UP15, UP17, UP18, and UP19. Due to technical issues, only interview and app interaction usage data were collected from UP16 and UP20.

5.2 Findings

Although evaluated by only six UPs, the 85.8 SUS score indicates that the app usability can be classified as excellent [7]. This is also reflected in the fact that all UPs would recommend the app to other OAB people and all would like to be informed when the new app version is available. UP20 emphasized the benefits of using the app: *"The more I used the application, the better. I feel more relaxed about it. It helped me to take more control. I'm going to the toilet less,*

Distraction	UP	Location	Movement	Environment	Total No. Days	Total No. Accesses	Duration
2048	UP15	Home, Travelling	Still, On Foot	Quiet/Loud, Dark/Bright	1	4	1 – 8 mins
	UP17	-	-	-	1	3	1 min
	UP18	Home	Still	Quiet, Dark	8	33	5 – 41 mins
	UP19	Home	Still	Quiet, Dark/Bright	3	4	3 – 10 mins
	UP20	-	-	-	2	4	3 secs - 18 mins
Tetris	UP15	Home, Travelling	On foot, In Vehicle	Quiet, Dark/Bright	4	5	7 secs - 16 mins
	UP17	Home	Still	Quiet, Bright	3	3	2 mins
	UP18	Home	Still	Quiet, Dark	8	22	16 secs - 47 mins
	UP19	Home	Still	Quiet, Bright	3	3	2 – 3 mins
	UP20	-	-	-	7	16	1 secs - 22 mins
Quick Contractions	UP15	Home		Quiet, Bright	1	1	12 secs
	UP17	Home	-	Quiet, Bright	1	1	8 secs
	UP18	-	-	-	3	6	0 - 23 secs
	UP19	Home	-	Quiet, Bright	1	1	12 secs
	UP20	-	-	-	6	15	1 secs - 2 mins

Figure 9. Users' engagement with the distraction techniques.

am less anxious. I managed to drop 2 runs to the toilet per day. It helped me make a routine of avoiding going to the toilet, especially by doing the PFM exercises."

Progress: UPs mostly checked their progress at home, during the first three days and after entering voiding data into the diary. This could reflect the fact that people like to visualize their progress. The number of instances for checking their progress decreased significantly after the first three days in which they were asked to fill in the bladder diary (Fig. 8). This might mean that UPs questioned or did not understand the accuracy of the automatically calculated progress or perhaps more interaction is required to keep them motivated.

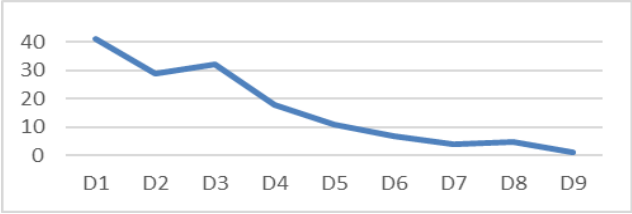

Figure 8: Total number of accesses per day regarding the progress feature over the course of the study.

UPs perceived the overall workload between 0%-5%, indicating that reading the progress chart was easy to do. Most UPs (4/6) were satisfied with the feature and 5/6 strongly agreed or agreed that seeing their progress was motivational. Regarding setting up a goal, all UPs strongly agreed or agreed it was motivational. Half UPs managed to achieve their goal, from whom two strongly agreed that seeing the happy icons in the progress was motivational: "*It made me aware that I made my target.*" (UP17).

Reminders: According to their preferred settings, 5/6 UPs consider the PFM reminder as being important and did not have an issue with the notification being displayed on their screen when the phone is locked. This finding contradicts the discreetness suggestions provided in Study 1. As previously found [38, 14], 4/6 UPs stated the reminders helped in adhering to their exercise and fluid intake regime: "*Think it is a good feature, it was helpful.*" (UP20), "*The whole app made me aware of the exercises and the fluids.*" (UP17). Only two UPs are not drinking the right amount of fluids per day and received the reminder. Among them, one mentioned it helped them drink a proper amount of fluids.

Distractions: All UPs agree or strongly agree when asked if they are satisfied with the games: *"Now I found I can*

distract myself-not totally, but I can take my mind out of the urge and go continue with other things." (UP18). The complexity of the games played an important role, as UP20 commented about the game 2048: "*I get totally caught into this. I find it very absorbing*." and added, "*Your games are complicated which is good on one hand."*

Most UPs perceived the mental workload on the NASA-TLX as being high (70%-90%) and showed an increased level of Frustration (e.g., 90%): *"It's not easy. I enjoyed playing this one but it's again frustrating."* (UP19 regarding 2048). For Tetris, the temporal demand and the level of effort were marked with a workload between 20%-100%.

The emotion wheels provided before and after playing the games show a change in emotions in 2/6 UPs (from Amused and Happy to Frustrated). Contradictions were also found between the feedback provided. UP19 felt approximately 30%-35% Frustrated but selected positive emotions (Relaxed and Amused) in the emotion wheel after playing 2048. UP18's emotions (Satisfied and Amused) are in contradiction with feeling 25%-30% Frustrated after playing Tetris. As games (especially Tetris) might cause anxiety in its players [13], we asked our UPs whether they encountered similar experiences. No UP mentioned that the games caused anxiety while playing. Although the feedback collected in the emotion wheels and the NASA-TLX questionnaire show some emotion changes, none of them relates to anxiety.

UPs' engagement with the games varies as some (e.g., UP18) played multiple times per day in 8/9 days of the study, whilst others (e.g., UP20 and UP19) played for two-three days. Location is also an important factor as all UPs mostly played the games at home. This is strengthened by UP19's comment that *"Games helped me. But they do not work when I am out and about and walking."* and UP20 who is *"More confident in using the distractions when at home or at work."*. Fig. 9 shows how each UP interacted with the distraction techniques during the study (UP16 only played Tetris once for 6 minutes).

Regarding the quick PFM contractions, UPs evaluated the overall workload between 0%-5%, indicating that reading the instructions is easy. This distraction met with higher approval among female UPs (2/3): *"The most successful in terms of, let's say discreet and less time required. It's quite efficient for me."* (UP20).

Map: UPs evaluated the overall workload of interacting with the feature to be low on all NASA-TLX scales (between 0%-10%). Contrary to our expectations, UPs did not use the feature at all during the field study. One reason for this might be the fact that UPs used the app for a short period of time in known locations and did not find themselves in a situation where they needed to use the map. Although nurses declared in Study 1 that a toilet map would stop people from adhering to treatment as it would facilitate toilet access, the feature is perceived as providing assurance: *"Like to know in the back of my head there is a toilet."* (UP20). So contrary to our original thoughts, the main function of the map could be reassurance, indicating that lack of interaction does not mean lack of user need for the function.

Bladder Diary: All UPs evaluated the overall NASA-TLX workload to be 0%-5%, indicating that inputting data is trivial. This is validated by the fact that all UPs strongly disagreed that inserting data was difficult. The following comment validates the literature [61] and Study 1-Findings and explains why UPs mostly inserted data when at home: "*I strongly agree it's difficult remembering to input data. I did best on my routine days but during weekends it's different. It's hard to remember to record something that is natural and not a big event*." (UP20).

Most UPs (4/6) filled in the diary only for the three requested days, although some did it for more days. For most UPs, the accuracy of the data inserted is questionable as the timings for inputting fluid and void data coincide. This is also reflected in the fact that UPs mostly inputted the data at home, which means it was not in real time. We wanted to make filling in the diary as easy as possible and decided to automatically save the time when users input data. However, our findings show that UPs would actually like altering the timings: *"The possibility of altering the time for the bladder diary as it's not always possible to record things straight away. I used to do a mental record and then fill it in."* (UP16). This might also be the reason why the timings for inputting fluid intake and void data coincide. Regarding approximating the urine quantity, 4/6 UPs strongly disagreed or disagreed it is difficult to do.

Treatment Description: All UPs evaluated the workload between 0%-5%. All UPs strongly agree or agree with the feature and found the information provided useful. Although it has been suggested to include videos, only one male UP watched the two available videos. UP17, already familiar with the exercises declared *"I didn't watch the videos as I am already doing them. Maybe to refresh but after 3 years I think I'm doing them right."*.

Toilet Pass: Half of the UPs strongly agree with it. Although it has been accessed multiple times, no UP used it in unknown places: *"It might be useful. I have a card in my wallet, but I would use that one first."* (UP16).

6 DISCUSSION

In this section, we discuss the outcomes from the three studies and how they address our research questions.

RQ1: *What key features should an OAB mHealth app have to support people during self-managed treatment?*

Progress: We wanted to understand whether we should allow users to set goals, show their progress and provide positive feedback when the goal is reached. Although the progress feature was met with high approval during the first two studies, we obtained mixed results during the field study. For the first three days, the progress was displayed based on the data inputted in the bladder diary. In the following six days, it was automatically calculated based on distraction techniques usage and other notifications sent by the app. In comparison to the first three days, we found that in this part of the study (in which no user interaction was needed) the progress checking dropped significantly. This seems to suggest that either UPs did not understand how the app was automatically calculating progress or that a minimal level of interaction is required, such as filling out the bladder diary daily in order to keep users motivated in tracking their progress. In our next app version, we will ask users to keep on entering data into the diary (as the findings showed this was quick to do and required low workload).

Reminders: Performing daily PFM exercises is an important part of the bladder retraining regime as well as drinking a proper amount of fluids per day. Our results show that reminders help people with their PFM exercise regime and in promoting a healthier lifestyle.

Distraction: We wanted to implement distraction techniques from going to the toilet when there is an urge to urinate. Mobile phone games have proved successful in promoting healthier lifestyles such as teaching people how to make healthier meal choices [25] or motivating them to have a healthy water intake [14]. On the other hand, interactive games did not prove successful in helping people quit smoking [46]. Given UPs' comments and interactions during the field study, our results tally with [25] and indicate that games could be a successful distraction technique, if users find it engaging. Given the high perceived workload in the Mental Demand scale measured using the NASA-TLX, playing mentally demanding games could also be a successful urge suppression technique. The NASA-TLX also showed that there was a high level of frustration after playing the games. However, the emotion wheel results indicate that users were amused and satisfied. This could suggest that designers should not rely only on the NASA-TLX questionnaire if they want to have a full picture of users' feelings towards a certain interaction.

Embarrassment: We wanted to know if the app needed to be disguised or have additional access permissions because of potential embarrassment concerns. Contradicting literature findings, our results show that embarrassment was not a major factor for our UPs. Whilst discreetness and increased privacy ideas were suggested during Study 1, UPs in Study 2 said that an additional level of security could over complicate things, causing annoyance when quick app access is needed. It is therefore clear there may be competing demands when it comes to an OAB app e.g., security could be an impediment to quick access.

Location: We investigated the possibility of having a map displaying the nearest points of interest that might have a toilet. Although contradictions were found between the two stakeholder categories, UPs emphasized the importance of having such a feature and therefore, we decided to implement it. Although UPs did not interact with it during the field study, we found that they said that it provided reassurance. We would like to dig deeper into this interesting aspect for design and re-evaluate the feature during a longitudinal field study.

Bladder Diary: A bladder diary is a form of assessment. During the field study, UPs tended to check their progress immediately after entering data in the diary. This might indicate that people like to track their symptoms. Therefore, we think that providing users with a direct interaction process that then is reflected in their progress may be important for a mHealth app and that graphical representations of the assessment data should be provided.

RQ2: *How might an OAB app help people self-manage their treatment and raise awareness of symptoms?*

One way of increasing adherence is by showing progress, providing reminders and allowing users to set goals [45, 38]. Our results show that these findings could also hold for embarrassing conditions. Previous research [45, 37] showed the importance of progress and positive feedback, such as scores or badges to help people adhere to treatment. However, although linked, the two are usually displayed on separate screens. Our results show that combining happy icons (the user reached their voids goal) and displaying them directly within the progress screen (number of voids in the past week) motivates people. Therefore, mHealth app designers could consider bringing together the progress and the goals onto the same screen.

Confirming other literature findings [38, 14], our data showed that reminders helped our UPs with their exercise regime and in consuming proper amount of liquid per day.

Although in previous research reminders were focusing only in one area (e.g., exercise adherence [38], or lifestyle changes [14]), we show that having more than one reminder type is not annoying and could encourage people with their self-managed treatment. Therefore, designers may consider using more than one reminder type.

During Study 1, it was suggested to us to include a treatment outline. This feature met with high approval during Study 2 and had a high number of accesses during Study 3. Moreover, given the fact that UPs stated the app made them more aware of their exercises and fluid intake, it can be concluded that the app also has the potential of increasing awareness of OAB symptoms.

RQ3: *Does context have an impact on how users engage with the app?*

As suggested in the literature [6, 47], both lab and field studies are needed to properly evaluate the usability of a mobile phone app. Our data validate this finding as we discovered design issues with some features (e.g., bladder diary, location map, and games) that were not highlighted during the first two studies. Our results also show that context plays an important role in the app interaction as our UPs mostly interacted with it at home. There are only a few instances where people used the app in different locations, such as being in a vehicle. This can reflect the fact that people would mostly use the app in a comfortable but also safe environment.

7 LIMITATIONS AND FUTURE WORK

One limitation of our work is the low number of UPs in our field study. Despite using all the usual routes and OAB association websites, we encountered major recruitment issues. As we are planning in our next studies to make the app freely available for download, we hope to achieve higher numbers. Our next step is to conduct a longer-term field study to evaluate if the app can increase adherence to self-managed treatment and raise awareness of symptoms.

8 CONCLUSION

This paper presents an exploratory study in which we co-designed and then evaluated with people with OAB and health professionals an OAB mHealth app. We commenced with an OAB and mHealth app literature review and used this as the basis for our requirements gathering interviews. Based on the data collected we designed the first prototype and validated it again with the same stakeholder categories. Given the second round of feedback, we improved the design of the app and evaluated it in a field study for nine days with people with OAB.

Our findings show that, visualizing progress and setting goals can be viewed on the same screen and could encourage people to continue using the app. Regarding reminders, having more than one type of reminder does not increase annoyance and could encourage adherence to self-managed treatment. Regarding games, users found them engaging and useful in their goal of suppressing the urge to visit the bathroom. We found that designers may want to consider using more than one technique when assessing the success of a game and its emotional impact on users. Contrary to the current research direction, we discovered that automatically calculating progress may be a detriment to app interaction. We found that an OAB mobile phone app has the potential to increase observance to self-managed treatment and raise awareness of symptoms.

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