DESIGN4 HEALTH

The role of micro-interactions in patient use of medication monitoring control devices and smart packaging

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ABSTRACT

Medication nonadherence is a common and increasingly recognised problem in health care delivery that is often linked with groups of people that face difficulties in managing their medication. This research explores the possibility of improving daily living of those people, by analyzing their interactions with smart devices and packaging that aim to monitor and control the management of medication (Granger and Bosworth 2011a; Naditz 2008) and more specifically by examining the design of micro-interactions that take place when patient users interact in such contexts with medication monitoring and control devices (Saffer 2013). The paper proposes a set of guidelines and design requirements for designing and evaluating such technologies. Finally, we present a case study of designing a smart medication monitoring and control device and outline our findings from the evaluation with actual users.

Keywords: Micro-interactions, visually impaired patients, elderly, smart devices, smart packaging, medication adherence, dosage, pills, RFID technology, smart home, connected healthcare

Introduction

Medication adherence is defined as the extent to which a person's behaviour corresponds to their healthcare goals. (Granger and Bosworth 2011b). People with cognitive and mental impairments, the elderly, the visually impaired and blind people, or people with other difficulties and physiological characteristics that prohibit them to manage their medication adherence, constitute an important part of our society which experiences such issues on a regular basis (Isaac and Tamblyn 1993; Zullig, Peterson, and Bosworth 2013a). The issue of adherence to medication regimens is quite serious because people with the aforementioned profiles run a higher risk of taking the wrong medication (medicine or dose) unintentionally (Checchi et al. 2014a; George, Elliott, and Stewart 2008; MacLaughlin et al. 2005a; Murray et al. 2004). An average of 50% of patients with chronic diseases do not follow their medication program as prescribed (Checchi et al. 2014b; Granger and Bosworth 2011b; MacLaughlin et al. 2005b). The rate of poor adherence has remained stable for over two decades with a 40% of patients failing to follow a prescription and over 50% discontinuing medications within a year (Granger and Bosworth 2011b). The responsibility for medication non adherence is shared by doctors, patients, clinicians, caregivers and of course the entire health care system (Granger and Bosworth 2011b; Zullig, Peterson, and Bosworth 2013b).

The first objective is to help patients understand what medications they take, how, when and why adherence is important for their health. Frequent patient counseling and accountability interventions are critical in reinforcing understanding and ensure sustained improvement. This can be peer-to-peer support, social support and telephone messages or live sessions. Also, self-monitoring is an essential tool that helps inform the health care team about a patient's behaviour and health needs. New technologies such as automatic pill dispensers or smart pill caps are used for that purpose, as well as collecting patients' biological data like blood pressure etc. Following this, patients can be informed by direct feedback and thus become aware if their treatment adherence is successful (Zullig, Peterson, and Bosworth 2013b).

To facilitate adherence, the medical costs must be reduced so patients can afford it. This can be achieved by coverage of prescription medications, reduced co-payments, and refill assistance. Regardless of the specific strategy used, increasing access to medication through logistical solutions which aim in reducing prescription costs is one of the most vital components of efficacious interventions to improve medication adherence. The strategy and technology used for every patient must be suited to their individual needs. Some patients require in-person counselling, others may require telephone contact while a large number of them may only need well-timed messages to remind them to take their pills (Zullig, Peterson, and Bosworth 2013b). Another way is to direct adherence through health information technology (HIT). This technology can remind patients to take their medication or even warn physicians in case of mistaken program (Checchi et al. 2014b).

Related work

Clinical trials of technology-based interventions can be broadly categorised into two groups: automated detection and reminder systems like telephone intervention via messages and in-person systems with an electronic component like a monitoring device with audiovisual alarm (Checchi et al. 2014b; Granger and Bosworth 2011b).

A feature common to all EMP (electronic medication packaging) devices is the recording and storage function. Their second most common feature is digital displays and audiovisual reminders. These displays use auditory beeps or flashing lights to inform about the last time the patient used it, for how long it was opened, or even the total number of times they opened it. It seems that when this feedback was combined with short message service text reminders there was a significant improvement (Checchi et al. 2014b; Laster, Martin, and Fleming 1996).

People over 65 are most prescription drug users. It has been proven that visually impaired people over 65 are two to three times more likely to need help in managing their medication (Crews & Campbell, 2004; Grindrod et al., 2014; Press et al., 2011). In addition, 1 out of 5 adults over 65 also experiences some cognitive dysfunction such as dementia (Graham et al., 1997, Grindrod et al., 2014, Prince et al., 2013). The problems these patients face are risk of getting the wrong medicine, wrong dosage or an expired drug, risk of not taking advantage of the drug , inability to replace an expired drug in time, loss of privacy, lack of full information on the side effects or doses of the medicine, decreased capacity to participate in decisions related to their treatment, high rates of being re-hospitalised, extra costs, increased mental load, inability to understand any possible mistake of the pharmacist (Granger and Bosworth 2011b).

Methodology

This study aims to examine micro-interactions that occur while patients interact with their drugs or medication monitoring devices. The interviews' purpose was to capture how patients move in their physical environments, how they recognise their medication, how they identify different drugs, the way medicine packs are placed, what techniques are used by each patient to differentiate drug packages themselves, how do they remember that she/he took his doses or at least the right drugs and which micro-interactions emerge during the interaction. At first, current micro-interactions had to be studied through interviews in fifteen patients. The participants ranged between 53 and 85 years old, and they were living with at least one more person. Some of them were also visually impaired for more than 3 years and with 80% or more blindness and not knowing the Braille alphabet. The process took place in the participants' houses. After observation and explanation of the medication system that every participant uses, the reviewer asked all the above and let patients discuss any problems or other difficulties they face in general. According to our research findings users incorporate a number of empirical methods and custom techniques in order to identify and keep track of their medication schedule. Participants distinguish their medicines according to their names, their packages' colour, and pill shape.

Figure 1: Empirical methods and techniques for identifying and keeping track of their medication schedule: Shape of the packaging or the pills, special label or other tangible characteristics, handmade sticker with custom notes.

For visually impaired patients, size and any special sign of the pill cardboard are also important. Some of them have their own bottles for every pill or stack paper letters in every different bottle, to separate them. All participants take their medication according to their daily activities. Patients store their pills mainly in the kitchen room. Some of the visually impaired patients also keep a specific series of the packages. All participants stated that they have consumed a wrong pill or dose or even a pill that has expired. Also, another main problem was that patients cannot be sure if they take their pills or not – common problem for those ages- after a while. Most of them – mainly hypertensive patients – mentioned that they can understand if they forgot any dose because of their subsequent symptoms, like headache. Also, three of them mentioned a specific technique which helps them understand if they took their pills or not, like rotating the bottle upside down after use. On average, they take 3 to 9 pills per day. Most of the users had a pill box to organise their daily medication and all the visually impaired patients had a "talking" handheld or some other assistive technology. Beside the main problem, there is also the possibility of forgetting a future dose or not taking the pill at the appropriate time or run out of medicines, which may be long-term but remains a major risk to the patient's health. Concerning the micro-interactions, a basic one is the upside-down placing of the bottle after use. Another similar trick consists in placing different drug pills in separate containers and putting rubber or Velcro on the packaging, cutting and sticking paper letters to containers or placing stickers on them. Yet another is arranging containers based on a particular order.

Methodologies for Interaction and micro-interaction design

Interaction Design is the design discipline that deals with the user activities and systems responces, the most appropriate workflow for achieving user goals, for identifying relevant information for each activity, and the processes of interaction (Kim Goodwin, 2009, p. 35). Micro-interactions are particularly important because they fill the gap between human and computer by directing all interactions. (Creative Bloq Staff, 2014). They provide users with feedback and understanding of process development, making the interface accessible, regardless of the complex logic behind it.

Dan Saffer has divided micro-interactions into four key parts: triggers, rules, feedback, loops and modes (Saffer, 2013b). Concerning this particular target group of patients, there is a special need for proper feedback to the user. The design starts with the lack of visual or hearing user-device communication and therefore the stimuli and feedback mechanisms should automatically trigger the rest of the users' senses in such a way that they do not become disturbing to them.

Concept

The system should operate autonomously, aiming to remove any cognitive load from the user while reassuring that they are properly following their medication. This case study refers to people aged 50 and older, with chronic health problems and hearing or visual impairments. The device must interact with the users and provide adequate information and guidance for medication adherence. It must be usable and accessible for the elderly. Instructions must be in a user-friendly format. It should present the ability to change the alert time, to store up to ten treatment medications and four universal medications, have a digital clock in a prominent place and connect to the network for treatment updates from doctors. It must afford sound recording/playback, proximity triggers, a notch in a suitable size to accommodate drug tabs and to identify the type of tabs.

Micro-interactions must be active or passive in each occasion, activated by a user's action, must have a maximum duration of four seconds and must require the least amount of effort., According to Saffer's guidelines for designing micro-interactions the design is controlled through rules which create a flow on users' actions. Feedback must be comprehensible from the user and it must not lead to interaction dead ends. Those feedback mechanisms should communicate a "message" to the user, so it has to transfer as much information as possible with minimal messages. Finally, loops must cease after a specific time and can stay open or closed depending on the characteristics of the specific case. Because of the specific cognitive, mental and physical characteristics of our target users the interface should remain minimal with simple steps for completing the different tasks. Moreover, the device must free the patient from the procedure of distinguishing the different drugs, to inform them for medication effect and expiration date, to log the patients' activities and keep doctors informed.

Prototype analysis

The primary aim is to free patients from drug management process. The only user intervention is to feed the device with the pill tabs through the acceptor located at the top. Tabs equipped with RFID technology provide all the necessary information including name, effect, expiration, side effects.

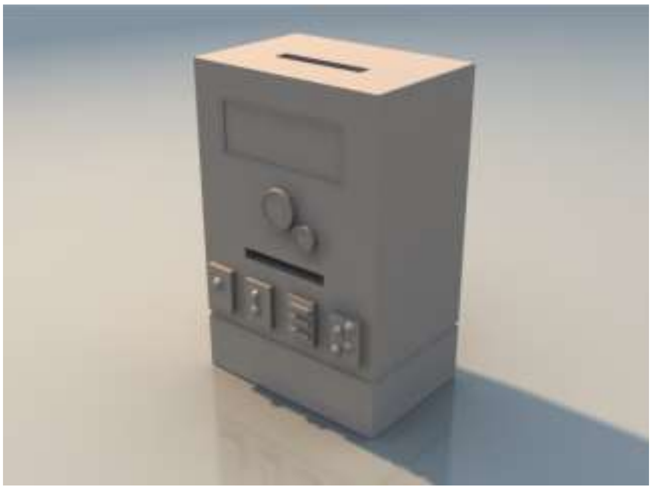

Figure 2: A three-dimensional representation of the low fidelity prototype of the smart device

The RFID reader retrieves appropriate information from the tabs and organises medication in the appropriate compartments. The actual medication schedule is provided by the doctor through the networked functionality and alerts the users on time. As an exception the users can request pills of frequent use by pressing the four lower buttons with the surface/tangible texture. Finally, users can postpone an automatic dosage notification at a future time if they are unable to take it on time and also provide feedback for the reason they do not adhere. If a dose is cancelled, the device can also be configured to either inform the health care provider or log the events and feedback from the patients.

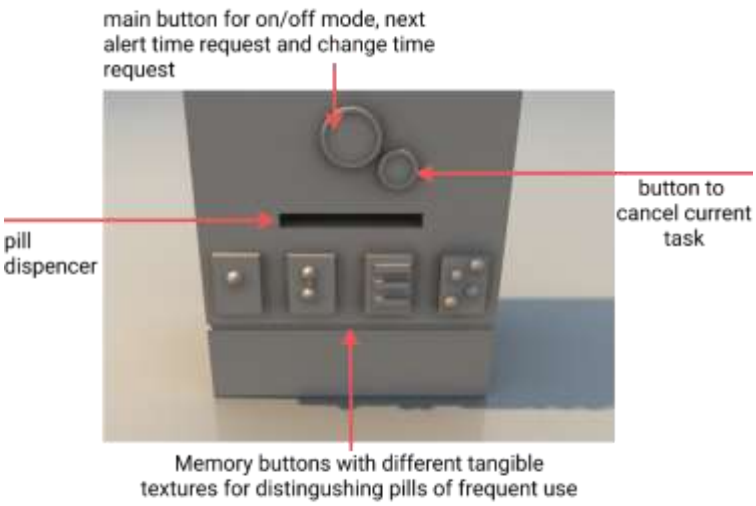

Figure 3: Details and functions of the devices' buttons and other components

The device consists of a part where the tabs are inserted and stored and the second one where the empty tabs are discarded. The device is portable with a rechargeable battery capable of around 48h of usage. The following micro-interactions are afforded: on/off, inserting medication tabs, update for the next dosage, postpone dose time and the request pills of frequent use.

Evaluation

After interacting with the device, users noted that it is quite effective and easy to learn. Most of our users easily identified the designed micro-interactions. All managed to turn on and off the device and identify the feedback mechanisms. Most users needed some initial assistance to feed the device with tabs, but managed to successfully complete the task in consequent scenarios. All users identified the next dosage alerts and with limited initial assistance managed to postpone a dosage.

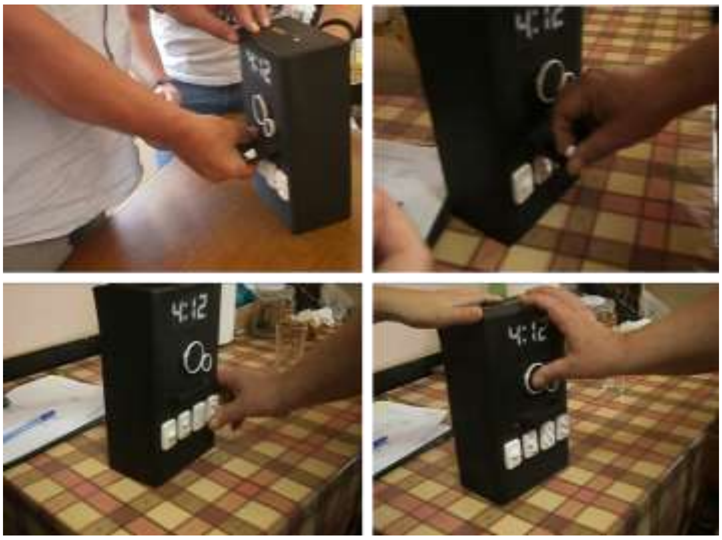

Figure 4: Actual users interacting with a low fidelity physical prototype during formative evaluation

People at the early stages of a disease found it particularly helpful and a very important companion especially in cases where the rest of the family, or the person responsible for taking care of them is not present. Three users mentioned pill different sizes should be considered and one user requested for an alert to feed the device before it get empty.

Conclusion and future work

Our evaluation sessions showed that the device considerably improved people medication adherence. Our current research is focused on a larger study with longer periods of application and testing, necessary to confirm our findings and provide us with valuable information regarding the design of the device, user habits and behavior and other requirements of the different stakeholders involved including medicine makers, suppliers, pharmacists , caregivers, doctors, family members. We plan to compare our design with other medication adherence devices and low cost solutions (Choudhry et al. 2017).

During the formative evaluation phases, we identified a number of improvements, enhancements and that can advance the overall quality of the design. Crucial notifications about expiration date or the current feed state of the device may take place when the user is in close proximity with the device and feed and pill identification mechanisms should be improved. To conclude, we also identified that patients with a complex medication regimen pose a special case where medication adherence becomes a difficult task as it requires more information to be captured (history of events), analysed and provide feedback to caregivers, doctors and patients.

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