Connecting the System to Enhance the Practitioner and Consumer Experience in Healthcare
E. Cummings et al. (Eds.)

doi:10.3233/978-1-61499-890-7-45

Adherence, Avatars and Where to From Here

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Abstract. Adherence to medication and treatment regimen continues to rank as one of the major clinical problems worldwide. Many of the currently available strategies lack the personalised interaction needed in order to effectively connect with the patients. Our solution is to develop an interactive avatar-based reminder application to simulate a human carer to provide customised conversations with the aim of improving adherence and satisfaction. The results of our initial trial showed that information and communication provided by the avatar were useful in reminding participants to take their health supplements. This paper discusses the importance of personalised communication and information in improving adherence and satisfaction, what we have learned from our initial trial with the avatar-based reminder application, and our proposed modifications for our next trial.

Keywords. Medication adherence, avatars, chatbot, patient communication

Introduction

Most medical treatments, especially long-term treatments for chronic illness, involve the prescription of a regimen of one or more daily medications [1]. Interrupted and inconsistent adherence behaviour can result in negative consequences to the patient and the healthcare system. Many factors can affect patients' adherence to medication and treatment regimen, and various strategies have been developed and tested in order to improve adherence. Most of the currently available strategies in the market use one-way communication and provide little to no personalisation. Our solution is to incorporate the use of an interactive agent in order to encourage and motivate users to adhere to their prescribed regimens through two-way personalised communication. Results from our initial trial shows that the personalised communication provided by the avatar led to improved adherence.

This paper first reviews some of the current issues of adherence, then identifies the importance between communication and adherence. Next, we describe our solution of using an avatar-based reminder application and the results of our initial trial, and finally discuss our plan for the next step based on analysing the results from the initial trial.

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1. Background

Adherence can be defined as the extent to which patients follow the instructions they are given for prescribed treatments [2]. The problem of non-adherence to medication and treatment regimens has received much attention worldwide, as it can lead to negative consequences to both the patients and the healthcare industry. The World Health Organisation identified medication non-adherence as one of the major causes of morbidity, mortality and health care costs [3].

Many reasons exist for non-adherence to medical regimens. The most common ones include complex medication regimens, fear of adverse effects, patient's diminished cognitive ability, lack of health knowledge and beliefs, patient-doctor relationship and many other factors relating to the patient and medication [4]. Various strategies have therefore been developed and applied in order to improve medication adherence. For example, the common use of a weekly pillbox that allow patients to put their medications into separate compartments [5], mobile phone based reminders such as SMS and reminder applications [6] and portable reminder devices such as an electronic pillbox, which are traditional pillbox with a built-in alarm function [7]. There had been some documented success with using these strategies, however many of them lacks personalised interaction and communication, which are considered to be a crucial aspect in improving adherence [8].

Patient-doctor relationship and communication is important in achieving such personalised interaction. One study shows that physician's initial communication style can positively influence client knowledge and initial beliefs about the medication, and that clients with more positive beliefs are more satisfied with their treatments [9]. Good communication skills in physician can improve the transmission and retrieval of important clinical information, which can allow patients to better understand the benefits, risks, and barriers to adherence [10]. The main goals of patient communication are to create a good trusting interpersonal relationship, facilitating exchange of information, and include patients in the decision-making process [11]. Burgoon et al. (1987) found that well educated patients that understand their condition and medication are said to be more willing to follow the prescribed regimen [12]. Therefore, well-educated patients with trusting patient-doctor relationship often resulted in improved patient knowledge and satisfaction, which in turn can positively affect their adherence towards medication.

2. Our Solution

Based on the limitations of the currently available reminder devices and applications on the market, we have come up with a possible solution of building an interactive avatar-based reminder application to be used on a mobile device. The aim of this application is to increase adherence and improve overall user satisfaction by simulating a human carer or a doctor through an avatar. An avatar is a life-like simulation of a virtual assistant created with computing technologies. Avatars are said to be persuasive, arousing, engaging and can elicit feelings of trust, and most importantly, they provide a sense of personalised experience [13]. Use of an avatar has proven effective in other areas such as interactive learning and teaching, and behaviour counselling. Adamo-Villani et al. (2016) found that by using an avatar to teach lectures, it led to an increase in subjects' content learning by 31% [14].

The avatar-based reminder application has been built using PhoneGap with JavaScript, Hypertext Markup Language (HTML) and Cascading Style Sheets (CSS). We have incorporated text-to-speech functionality by using an existing plugin available on the Internet. The application was designed to be used on iOS devices, and as a result iPads were used with the participants in the trial. The knowledge behind the avatar was scripted by researching online literatures on patient-doctor communication. Characteristics such as attentive, knowledgeable, smart/interactive, convincing and supportive are all found to be important aspects that an avatar need to have in order to simulate a human carer or a doctor to effectively communicate with patients. This can in turn result in improved attitude towards adherence and overall user satisfaction [15].

3. Initial Trial

The initial trial was completed with participants taking health supplements as a surrogate to medication in order to test the efficacy of the application in a low risk intervention. This trial was conducted with a simple version of the application that had limited interaction. Individual supplement information was loaded into the application before the iPad was given to the participants for the trial. The avatar verbally reminded the users when it was time to take their supplements and provided simple information related to the supplements they take with the click of a button. Participants were recruited within the university and consisting of both staff and students.

Out of the 43 participants registered, 4 did not match our inclusion criteria, 10 didn't respond, 2 left the university and 3 dropped out. In the end, 24 participants between the age of 18 to 70 completed the 3-week trial. Participants were required to first complete a one-week baseline pill count, which allowed us to gather their normal adherence rate before they were allocated their device to begin the trial. Participants were randomly allocated to either the control group or the intervention group. The control group was given an electronic pillbox with built in alarm functions and compartments for them to put their supplements. The intervention group was given an iPad with the application installed. Zip-lock bags were also provided to the participants in the intervention group for them to put their supplements in. During the trial, the participants were required to fill the pillbox and the zip-lock bags with one-week worth of required supplements. At the end of each week the participants were reminded to conduct pill counts to gather their adherence rate, and to refill their pillbox or zip-lock bags for the following week. Interviews were conducted before and after the trial with each participant, and both quantitative data and qualitative data were gathered throughout the trial.

Out of the 24 participants that completed the study, 11 were allocated the iPad and 13 were allocated the electronic pillbox through random allocation using Block Randomization technique. The uneven sample size between the groups were due to the dropouts from the study. However, we are satisfied that our results from the initial trial have provided us with useful input into the design of our second trial which will be discussed later in the paper.

4. Results and Discussion

The quantitative data gathered during the trial includes adherence rate, which was calculated on a weekly basis after participants conducted their pill count for the week.

The formula used to calculate the adherence rate was: ((pills at the start of the week – pills at the end of the week) / (pills at the start of the week)) * 100. Participants were also asked to rate the device out of 5 during the post-interview. The qualitative data gathered includes the face-to-face pre and post interviews with each participant. These qualitative data were then analysed using Quirkos, which is a qualitative data analysis software tool that help sort and manage textual data gathered from our interviews [16].

Out of the 11 participants in the intervention group, the average baseline adherence rate was 81%. At the end of the 3-week trial periods, there was an increased adherence of 17%, which resulted in an average adherence rate of 98%. For the control group, the baseline adherence average was 86%, and there was a 9% increase of adherence at the end of the trial, resulted in an average adherence rate of 95%. Based from the results, we can see that the participants that used the iPad intervention have a higher adherence rate improvement compared to those who used the electronic pillbox.

The majority of the participants in the intervention group reported that one of the main advantages they found when using the avatar-based application is that the avatar tells them both verbally and in written form exactly which supplement to take, and how much to take when the alarm goes off. The incorporation of personalised information proved to be favoured by most of the participants due to its usefulness and user-friendliness, i.e. avatar knows the participant's name and provide personalised supplement information based on the supplements each participant takes. One participant commented "I got a bit curious of the information button and find it very useful… and the best aspect is that it motivates you to take the supplements and it's hard to ignore it". On the other hand, the majority of the participants found that the iPad is too big to carry around with them. A technical issue encountered by participants was the text-to-speech plugin incorporated in the application will not work without internet connection, which meant the avatar will only provide verbally spoken information when the iPad was connected to the internet. Therefore, if there was no WiFi connection, participants had to rely solely on the text-based information provided within the application. As a result, 82% of the participants said that it will be better if the application could run on their mobile phones instead. However, technical issues can arise if we decided to install the application to participants' own mobile phones as the application only runs on iOS devices, so participants who uses other operating systems won't be able to run the application, and there is also the problem of incompatible iOS versions. Some participants stated that the verbal information provided by the avatar can be hard to hear or easily missed if there's distractions around, so it was suggested that text-based information should be provided together with verbal information. More than half of the participants stated that the talking avatar and text-to-speech functions were not significant to them and some even considered the functions as unnecessary, as what they found to be most important and attractive were the dialogue and interactions. One participant commented "the avatar became quite annoying since the second week and I think it will be better if there is the option of text-only reminder". The average score the iPad participants gave based on the usefulness and overall satisfaction was 4.5 out of 5.

The participants in the control group found the electronic pillbox to be small and portable as it includes compartments for them to put their supplements. However, despite the portability, 77% of the participants reported that the compartments are too small for their supplements, and as a result they still have to take their supplement bottle with them. Specifically, a participant commented "I can only fit one-day's worth of supplements in the compartments, and then have to refill every night, and this is too much trouble". The other major issue we found based on the post-interviews with the

participants, especially those that take more than one supplement per day, is that the electronic pillbox doesn't tell them which supplement they should take when the alarm goes off. This creates confusion for those that take multiple supplements, and it can possibly lead to health complications if it is used on participants that take more than one type of prescribed medications. Participants also noticed issues such as soft alarm sound which can be easily missed, and how it can be annoying as the alarm will beep every minute until a button is pressed, and then there's also the need to change batteries. The average score the participants in the control group gave based on usefulness and overall satisfaction is 3.5 out of 5.

From the results in the initial trial, we can argue that both the avatar-based reminder application and the electronic pillbox helped improve participants' adherence to supplements, and that the avatar-based reminder application is slightly better at improving adherence and had an overall higher user satisfaction compared to the electronic pillbox. The main advantage of the electronic pillbox is its portability, however participants noted issues such as lack of information, soft alarm sound, and the need to change batteries. On the other hand, the avatar-based reminder application was considered useful and informative, however negatives were that the iPad was too big to carry around and that the verbal information could be easily missed or misunderstood.

5. Next Step

A second trial was originally planned to include a more complex version of the reminder application, where the avatar would be able to interact with the user, answer questions and provide possible solutions and health suggestions. The user would also be able to use either text or speech recognition function to communicate with the avatar. However, based on the above results from the initial trial, our plan is to modify our second trial to allow the participants to use their own mobile phones. And in order to achieve this without limiting the participants to iOS devices, we have decided to incorporate the avatar knowledge scripts that was originally built for the complex version of the reminder application, into Facebook Messengers in the form of chatbot, using Facebook Messenger API. This means that the participants will be able to download Facebook Messengers into their own mobile phones and start interacting with the chatbot. Participants will have the option to use their mobile phone's existing voice recognition function to communicate with the chatbot. There will not be any verbal information provided by a talking avatar, just plain text messages and images, as what we found to be most important is the actual dialogue and interactions with the participants.

The Facebook Messenger chatbot will be able to remind the participants to take their supplements via Facebook Messenger notification, and participants will be able to ask health-related questions and interact with the chatbot, as we will be using the same scripts that were originally designed for the complex version of the application.

6. Conclusion

In conclusion, results from our initial trial showed that in comparison to the baseline supplement pill counts, both the avatar-based reminder application and the electronic pillbox resulted in improved adherence. The control group participants found the electronic pillbox to be portable with built-in compartments, but lacks the feature that

tells the user which supplement to take and how much to take when the alarm goes off, with the additional inconvenience and costly battery changes every few days to a few weeks. The compartments were also noted by most of the participants as too small. On the other hand, the avatar-based reminder application was considered informative and user-friendly as it resolved some of the issues encountered by participants in the control group by providing detailed supplement information such as dosage, instructions and information. However, it's limitation to iOS devices and the use of iPad for the trial made it cumbersome to carry around. We have therefore decided to modify our second trial to incorporate the use of Facebook Messenger chatbot to deliver reminders and health-related data to user's own mobile devices. It is hoped that in comparison to the results from our initial trial, the results from the second trial will show an even better adherence and overall user satisfaction by the participants in the intervention group.

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