Designing a system with persuasive communication to improve diet compliance for elderly users

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ABSTRACT

This paper introduces a system with persuasive communication to improve the diet compliance and adherence of participants of the PROMISS-project. For this persuasive communication different strategies and ways of personalisation are used, in accordance with existing literature. Furthermore, as the target group is elderly users, the design is tailored to their specific needs. A first prototype was created, based on seven functional requirements. During a pilot study, the prototype is evaluated with seven participants. Based on lessons learned during this pilot, as well as new requirements from the PROMISS dietitians, a refined design of the system was implemented. This refined design is briefly evaluated with four participants of the pilot during individual interviews. The changes made to the prototype were evaluated positively.

CCS CONCEPTS

• **Applied Computing** → **Health Informatics**; • **Human-centered computing** → **User studies**; **Usability testing**; Tablet computers; • **Software and its engineering** → Software development techniques;

KEYWORDS

persuasive communication, diet compliance, adherence, elderly

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1 INTRODUCTION

In Europe, 90-95% of the elderly people are living at home. Of these elderly, 21% is malnourished or at risk of being malnourished [1]. While ageing, the body composition changes, which increases the risk of malnutrition. However, there are many other factors contributing to the malnutrition of elderly people, resulting in various health risks and a decreased quality of life [13]. The PROMISS-project [1] aims to prevent malnutrition among elderly and to formulate recommendations for a healthy and active lifestyle. More specifically, they research a diet to improve the protein intake of elderly. A low protein intake is associated with frailty, as found in a research in Japan among elderly women [17]. Another research [15] supports this; it found a positive influence of protein intake on the physical functioning of elderly women. Physical functioning is important to maintain an active and healthy lifestyle for elderly, which is important since the majority of the elderly people stay at home. Research towards effective interventions, for which different forms are possible, is therefore useful.

In previous research it is shown that, comparing a smartphone, a website and a paper diary intervention, the adherence was the highest for the participants using the smartphone intervention [4]. Furthermore, other researches showed that a smartphone app improved the diet compliance of participants, e.g. [7].

In order to meet the specific needs of a target group, it is advisable to create a food journal design specific for this group, rather than a generic journal [6]. Therefore this paper describes the design and initial evaluation of a system with persuasive communication in order to promote diet compliance and adherence, to improve the protein intake of the elderly target group of the PROMISS-project.

Background literature about persuasive communication and application design for elderly users is discussed in Section 2. In order to develop the system a prototyping approach will be used. Section 3 discusses the prototype and its evaluation. A refined system is developed (Section 4) and re-evaluated with four participants (Section 5). Finally, in Section 6 discusses the current research and some possible extensions.

2 RELATED LITERATURE

As the goal of the system is to improve diet compliance and adherence by the means of persuasive communication, Section 2.1 describes related literature about persuasive communication in the health domain. Furthermore, as the target group of the application is elderly people, Section 2.2 will explain what aspects need to be taken into account when designing for this target group.

2.1 Persuasive communication

Persuasive technology aims to change the user's attitude or behaviour [14]. Computers have multiple advantages over human

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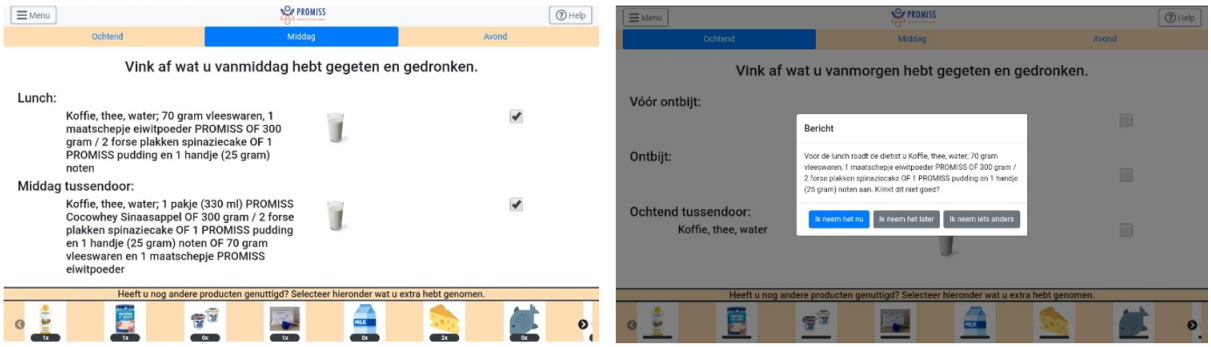

Figure 1: Screenshots of the initial version of the application

persuaders, among which are their anonymity, persistency, and the access to areas where human persuaders cannot come or are not welcomed to [8]. Furthermore, as shown in the introduction, smartphone applications are an effective means to increase participants' diet compliance. Being compliant to a diet often requires some form of behaviour change, persuasive communication is therefore useful in such an application. To study their compliance and behavior, users need to log their behavior in a system. In order to increase how often users log something in a system, notifications have found to be an effective method [3].

There are different ways in which messages can be tailored to improve their persuasiveness: framing, politeness strategies, and persuasion principles. Framing can be done in two ways: gain framing has the emphasis on the benefits, while loss framing has the emphasis on the costs. In a research towards the attention and response efficacy of participants for a prevention message, it was found that tailoring the type of framing used with the gender of the participant gives better results [5]. Gain framing was found to be more effective for female participants, whereas male participants responded more on messages with loss framing.

Messages should not only be persuasive, but also polite. In the research of [11] the politeness and persuasiveness of different politeness strategies is researched among an elderly target group. Among the tested strategies were *direct command*, *indirect suggestion*, and *questions*. *Questions* has the highest combined score, and can therefore be seen as the most polite and persuasive strategy.

Persuasive messages can be written taking into account Cialdini's six principles of persuasion [18]: *reciprocation, commitments and consistency, consensus or social proof, liking, authority*, and *scarcity*. The personality of a person can be described by using the Five-Factor Model [9], in which a personality is described by five traits: *agreeableness*, *conscientiousness*, *emotional stability*, *openness*, and *extraversion*. It has been researched what the influence of personality is on the effectiveness of healthy eating messages constructed using the Cialdini's principles using both positive and negative framing [19]. It is found that the *authority* principle is the most effective for most traits. *Consensus* messages are better for people with a low score on *conscientiousness*, while *commitment* messages work better for people with a high *conscientiousness*. Furthermore, people with a low *openness* prefer the *consensus* principle over *commitment*. In general, positive framing scored better compared to negative framing, but this was especially the case for people with a high *conscientiousness* or high *emotional stability*.

2.2 Application design for elderly users

In order to make a design that is suitable for the elderly target group, existing guidelines are researched. Tailoring the design to the elderly user group has found to be good for, among other things: the effectiveness, efficiency and user satisfaction [16]. This might however increase the task times for younger or more able people. Since there is a wide variety of elderly users and their experience with technology, it is important to find a balance when designing the application.

For the look and feel of a touch-based application it is important to have larger screens, with more space between buttons, and larger fonts [2]. Some other important things noted are using a separate keyboard and numpad in the application, using labelled icons, and using buttons instead of a menu structure.

When looking at the ways that elderly prefer to interact with touch-based applications it is found that they prefer tabbing over drag and drop actions [2]. Furthermore, it is important to have clear navigation in the application, which includes showing users where they are in the application and always giving them clear ways to progress, close, or go back through the interaction [12]. Because of the limited screen size of mobile devices, there is limited space for the needed information. For elderly it is important to show only relevant information on a page and also reduce scrolling to a minimum [12].

On a more general level, for no specific target audience, it was found in a qualitative research on using a smartphone application for diet and nutrition that users prefer quick and easy administration of their food intake, and the users want to be made aware of their intake and weight management [7].

3 PROTOTYPING PHASE

The development of the system starts with the prototyping phase. In order to get effective feedback, a first prototype of the system is created and evaluated during one of the pilots within the PROMISS-project. The feedback that is gathered during this pilot is than used in order to improve the prototype, which results in a refined system discussed in Section 4.

The prototype of the persuasive communication system is build as a tablet application. Based on the intervention designed in the PROMISS-project, the functional requirements (req.) of the prototype are the following:

(1) The system should give an overview of the personalised diet plan, per day. The diet plans are provided by the dietitians of the PROMISS-project. This diet plan is the same for each day.
(2) The user receives notifications as a reminder to take a meal from the diet.
(3) The user can enable a reminder for a notification that he/she has received.
(4) The user can enter whether he/she has followed an advice.
(5) The user can add extra items that he/she has consumed outside of the diet.
(6) The lay-out and user interactions are suitable for elderly users.
(7) The notifications are tailored to the personal characteristics of the user.

Figure 1 shows the prototype application. On the left is an example of the diet plan for a participant in the afternoon. The screenshot on the right shows a notification that is send to the user as a reminder for a specific meal.

3.1 Pilot study

The main goal of the pilot is to test the functioning of the application (e.g. find bugs and difficulties), as well as the interaction between the users and the system, and the user experience. In order to gain information about these aspects the participants received a Lenovo Tab4 10 (with an Android operating system) with the application, for the duration of three weeks.

With the use of logfiles from the application it is possible to study the user profiles by looking at the responsive and active interactions of users with the system. Due to time limits, the logfile functionality was only added for three of the participants, as it was still in development when the first participants started.

At the end of the pilot, the participants were asked to fill in a questionnaire, to collect data about the user experience. This questionnaire consisted of 24 statements that the participants had to rate on a 7-points Likert scale. The statements are about four different topics: effectiveness, messages, usability, and lay-out. Furthermore, participants could contact the researchers with questions or problems during the pilot. All the feedback given by the participants at the start, during and at the end of the pilot, is considered as feedback.

There were seven participants (four women, three men), with an age between 65 and 77 years old. Six of the participants filled in the questionnaire at the end of the pilot (three women, three men). One participant could not fill in the questionnaire due to time limits, however she did provide some general feedback.

3.2 Results pilot

3.2.1 Interaction. The logfiles from the tablets of the three participants that had a version with logging, were analysed. The first logfile showed that the participant used the application for 24 days and received 1888 notifications during this period. The participant responded on 15 (0.8%) of these notifications directly. Furthermore, the participant had 127 interactions on her own initiative. It needs to be noted that these logs sometimes overlap (for example entering and cancelling some intake, and adding an extra item multiple times which might be by mistake). In general, the log showed an usage pattern in which the participant updated her diet intake on a few moments a day (periodic recording).

The second logfile showed that the participant used the application for 33 days and received 1622 notifications during this period. The participant responded to 176 of these notifications directly (11%). The user had interactions with the system on her own initiative 51 times.

The third logfile showed that the participant used the application only for 8 days. According to the logfile the application was not always on, as it was not sending notifications for the whole day. This participant received 187 notifications, to 22 of these there was a direct response (12%). The number of user interactions that were logged that were on the participants own initiative is 5.

Figure 2 shows the active and responsive interaction rates of the three logfiles. Active interaction means that the user interacted with the system on its own initiative, whereas responsive interaction means that the user reacted on a notification or reminder send by the system.

3.2.2 Perception. Next to the logfiles, the scores on the questionnaires of the six participants have been analysed. In order to compare and combine the scores for the four aspects (effectiveness, messages, usability, and lay-out), the interpretation for all the scores needed to be made the same (namely: a higher score is better).

All the scores on the questions are combined per aspect, Figure 2 shows a boxplot for each aspect. The boxplot shows that for all the aspects the average score is around 4, which means neutral. However, the boxplot also shows that the scores vary a lot among the participants, especially for the usability.

Table 1 shows the average score for each statement and which topics (derived from the statements) have been evaluated positively (average ≥ 4) and which topics have been evaluated negatively (average < 4). Overall, 12 topics are evaluated in a positive way and 12 topics are evaluated in a negative way. Next to the questionnaires the participants also gave extended feedback. All comments that have been made regarding the application that can improve the user experience in the next design, are taken into account as feedback. An important remark that has been made by participants is that the system is not flexible enough, the eating times are for example the same for each participant and there are only limited options to enter your diet when you do not follow the diet advises exactly. Statements from the questionnaire that have been evaluated negatively are that the messages are not motivating and interesting. In the feedback, one of the participants mentioned that new facts about protein or the research, send in the messages every day, would motivate to use the application.

3.3 Lessons learned

The pilot has been very useful to identify possible pitfalls, and different user profiles. Based on the logfiles, two different usage profiles are identified: notification driven usage and active recording. In Figure 2, Participant 5 shows the active recording profile,

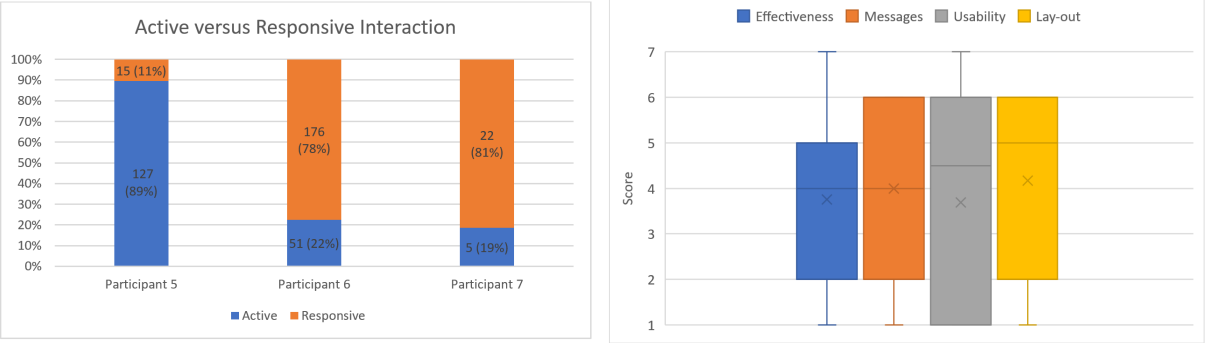

Figure 2: Rates of active / responsive interactions (left) and boxplot of questionnaires outcomes of six participants (right)

Table 1: Overview of positively and negatively evaluated topics with their mean score

	Positively evaluated topics	Negatively evaluated topics
Effectiveness	Motivation/help diet compliance (4.3)	Necessary functions available (2.5)
	Accuracy of the data (4.8)	Lives up to expectations (3.3)
Messages	Gentle tone (5.2)	Motivating (3.2)
	Not a compelling tone (5.2)	Interesting (2.8)
	Relevant for personal situation (4.5)	Problems the users experience (3.2)
	Believable/trustworthy (4.7)	Connection with perception and age (3.3)
Usability	Easy to use (4.2)	Irregularities (2.8)
	User friendly (4.2)	Would recommend the application (3.5)
	Easy to get along with (5.5)	Nice to use (3.3)
	Content with application and tablet (4.3)	Continuing to use (2)
		Pleasant to use (3.3)
Lay-out	Appealing (4.2)	Professional (3.8)
	Clear (4.5)	

characterised by a high percentage of active interaction, Participant 6 and Participant 7 show a notification driven profile, in which the user has a high rate of responsive interaction. Since there are only three logfiles available to analyse, it might be that there are more usage profiles.

A comment that was made in the pilot is that the eating times were too fixed. Furthermore, it was noted that it differs per diet advice which eating moments are used. Therefore, the next version needs to have more flexibility in showing the diet plans. There was also a lack of flexibility in how participants could enter their (protein) consumption. During the pilot it became clear that the diet advises had more options for each eating moment. Before designing the next version of the application it was therefore important to clarify, in collaboration with the dietitians, how the diet plans for the next study will be set up.

In the refined design the application needs to have a greater added value. As mentioned by a participant, the application was just a reminder to eat and a digital version of the diet from the dietitian. The statements of the questionnaire that have to do with continuing to use the application and the availability of all the desired functions scored, on average, the lowest.

Furthermore, it became clear that a careful re-evaluation of all the messages and texts, so that they match the perception and age of the participants is important. It is valuable to look at ways to make the messages more suiting the experiences of the users to make them more interesting and motivating.

4 SYSTEM REDESIGN

Since the set up of the diet plan in the final study changes, and as a response to the lessons learned, the function requirements of the system are refined in Section 4.2. Section 4.1 will briefly elaborate on the new diet plan structure. The final design will be discussed in Section 4.3.

4.1 Diet plans for final study

The diet plans for the final study need to be followed for around six months, while in the pilot this was only three weeks. The diet plans will be designed in a more flexible way, which is also in accordance with the lessons learned during the pilot. The dietitians create a diet plan set up in which people need to have an intake of a certain number of points for each eating moment (comparable to the system of Weight Watchers[1]). A product can be worth 0 - 8 points (with steps of 0.5), indicating a category of the grams of protein in the product. The goal of this system is to make it more easy for participants to variate their diet. They will still be provided with an example menu based on their own preferences, but this is just a guideline. Besides this they will receive a protein table containing various products and product categories, including the number of protein points they are worth per portion of the product. Furthermore, the protein list will contain a sign indicating which products are so called energy products, which means they contain more calories than average products.

The dietitians stressed the importance of using both household measures (e.g. a cup or a spoon) as well as exact measures (weight

[1]https://www.weightwatchers.com/nl/

or volume) for the input of the products a participant has eaten. The preference for one of these measures differ per participant. This contributes to the flexibility of the system.

Participants are also instructed to keep their intake at the requested level for each eating moment of the day. It is strictly advised to compensate for a meal where less than the requested level of proteins is consumed. However, it is not a big problem to consume too much protein now and then.

4.2 Extended function requirements

Some of the functional requirements described in Section 3 are refined as follows:

- Req. 1 is refined as: The system should give an overview of the personalised diet plan, per day, with the focus on the protein intake for each eating moment, expressed in protein points. There are sub requirements added:
  - The application must contain a suggested menu for each eating moment.
  - The suggested menu is first based on the diet plan of the dietitian, but during the study these suggestions will get tailored to the user.
- Req. 2 is extended with the warning to not send notifications too often (i.e. not every five minutes as in the prototype).
- The req. 4 and 5 are combined into one requirement: The user can enter the number of protein points for each eating moment. This can either be done directly or by entering the consumed products.

Furthermore, the following requirements are added to the list of requirements:

(8) The diet plan should be loaded in a dynamic way (i.e. the names, times and number of moments), to make sure that it can be tailored to every user.
(9) The system should take the diet rules into account e.g. the protein points.
(10) The user should be able to enter his/her meal using either exact measures (grams and millilitres) or household measures (e.g. cups or teaspoons).
(11) The user gets visual feedback on its intake compared to the requested intake.
(12) The user should be able to also enter intake on another day than today.

With these extended functional, the aim is to improve the added value of the application. This is mainly done by adding the functionality to enter all the products of a meal in the system and giving the user feedback according to the diet rules.

4.3 Refined design

In the refined design each eating moment has a threshold value, which is the recommended number of proteins for that advice. Furthermore, a suggested menu is available for each eating moment, that adapts to the preferences of the user (req. 1). The bottom right of Figure 3 shows such a suggested menu (on the left). The adaption is done as follows: if the user changes something in the suggested menu, this is stored and when this change has been made three times, the change will become part of the suggested menu. Names, notification times and the number of eating moments are now adapted to each specific user (req. 8), the top left of Figure 3 shows a part of a diet plan for a day.

The notifications and reminders (req. 2) are still send in the same way as in the prototype, but the user now has only two options (see the top right of Figure 3): enter the intake (req. 4/5) or enable a reminder (req. 3). Notifications are kept on the screen for around 15 minutes and a user receives 3 notifications per hours at most (req. 2).

Moreover, the messages are further tailored based on scores on the Ten Item Personality Measure (TIPI) questionnaire [10].

In accordance with the literature from Section 2.1 the participant receives a *consensus messages* when he/she scores low on *conscientiousness* or *openness*, *commitment messages* when he/she scores high on *conscientiousness*, and *authority messages* in all other cases.

New messages are written, keeping in mind the abovementioned Cialdini principles. Furthermore the messages are written both in a formal and informal way, which way participants prefer is asked during their intake. Two different framings are used to personalise for the gender of the participant: gain framing for female participants and the loss framing for male participants. The politeness strategy *questions* is used to make the messages polite and persuasive.

The user has the ability to add its intake in the number of protein points (see the bottom left side of Figure 3) or by entering the complete meal. When entering the meal the user can use suitable household measures or exact measures to indicate the amounts (req. 10). For showing alternative products to the user the diet rules are followed (req. 9). The products from the protein list are categorised in order to provide useful orderings in the application.

In Section 2.2 it was noted that it is important to have a quick and easy administration of the intake. When designing the system this has been taken into account in multiple ways. The user has two ways to enter the intake; directly via the points (see the bottom left of Figure 3), and by entering all the products consumed (req. 4/5), this is also called the meal adviser. The suggested menus adapt to the user's preferences, and lists of products to choose from get a shortlist with the users top five products.

To meet req. 11, scales are added to each eating moment to indicate the user's consumption for that eating moment, as well as for the whole day (see Figure 3). Each scale contains an indicator with the requested intake and, if the user has some intake for that moment or day, the scale is coloured to indicate this intake. The scales for the eating moments are coloured green when the user had the right intake, orange when the intake was 0.5 points less/more then the target, and it is red in all other cases. At the bottom of the home screen (see the top left of Figure 3), users have the ability to change the day they are entering their intake for up to three days ago and three days ahead (req. 12).

5 FIRST EVALUATION OF REFINED DESIGN

After implementing the refined design, the new version of the application is evaluated with four participants from the pilot, during individual interviews. The main goal of the interviews is to see whether the feedback received during the pilot is successfully used to improve the prototype.

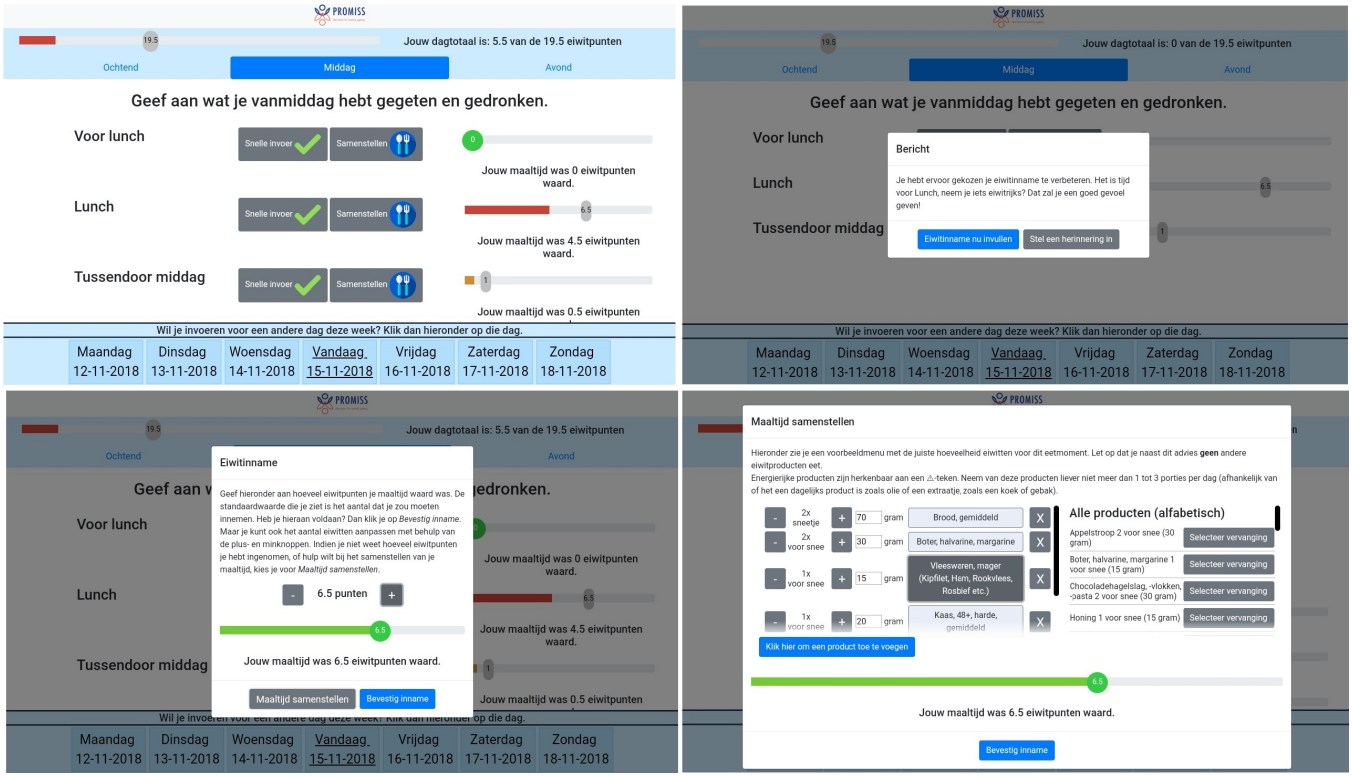

Figure 3: Screenshots of the final design. Top left: the main screen with the overview of the eating moments and the consumed protein points; top right: a personalised notification; bottom left: window to fill in the protein points; bottom right: window to adapt the current menu.

During the interview, the participants are asked to work with improved system. Together with the researcher the meal adviser is opened via a notification shown on the screen of the tablet. The participants are asked/explained how to select an alternative and how to add an item to the meal. The researcher assists the participants if needed and explains some of the features of the application (e.g. adaptation to the user and visualisation of the protein intake). The interaction between participants and the system is observed.

The participants are also asked to answer to some of the questions from the first questionnaire. Since the participants only have a short time to work with the application not all questions are relevant. Furthermore, open questions are asked about the improvements and the willingness to use the application.

5.1 Results from the interviews

Despite the low sample size, quantitative data from the questionnaires is analysed. Figure 4 shows the averages of the scores in the questionnaire of the prototype, both when including all questions in for this topic as well as only including the questions that have also been asked in the follow-up questionnaire. All topics are now scored with an average that is above the mean score of 4, which means all topics are evaluated positively. The highest average is for the lay-out. Open questions were also asked within the interviews. The comments made within these interviews are used to support the findings on all the topics from the questionnaires, as well as to get feedback on topics that were not in the questionnaire. In order to analyse those, they were combined based on their topic first and summarised in this analysis.

Figure 4 shows that all the topics have increased with at least two points. The highest increase (3.25) is for the effectiveness. This increase is also found for the question about whether participants wanted to use the application, which was slightly adapted from the question in the original questionnaire. The question about whether the participants could easily get along with the application had the smallest increase (0.5).

Participants further noted that the application had improved. The application was evaluated as more flexible, mainly due to the fact that you can enter your consumption more specifically and for multiple days at once. It was also noted that the lay-out was clean and professional. The adaptivity in the application was seen as a good addition that could also make it easier to work with the application. Finally, participants indicated that they would use the application because it provides an easier way to enter their daily intake. It was noted that it might motivate users with a lack of knowledge to help them with their diet. However, a participant noted that he might use the application less often once he was familiar with the diet. Another participant noted that she would not use the notifications, but would instead register on specific moment(s) of the day.

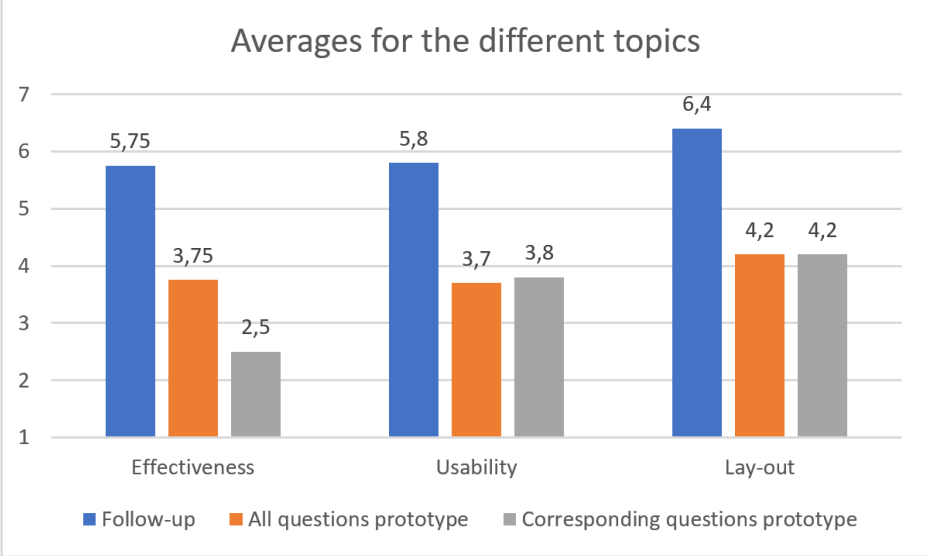

Figure 4: Graph showing the averages of the two questionnaires on different topics

The importance of good instructions was stressed by multiple participants during the interviews. They suggested a more extended instruction compared to the instruction with the prototype, as well as a good instruction manual.

6 DISCUSSION AND FUTURE WORK

The most important lesson learned during the development of the system is that both the system as well as the participants need to have flexibility. The system needs to be flexible in how the diet plans of the participants are written. The participants need to have the freedom to enter what they have eaten. The system enables them to enter their intake with multiple measures (protein points, household measures and exact measures). The efforts made to improve this flexibility are evaluated positively during the follow-up evaluation. However, there might be some limitations. The protein table might be limiting for users, as not all possible products are covered by this table, but it is more on a general level. Furthermore, the categorisation that is made for the products might not be the most optimal categorisation for each user. Products can only be found in one category, however they might suit multiple categories. Furthermore, the household measures are now set to specific exact measures, while this might be personal (e.g. different cup sizes). In a future version of the application more effort can be put in ways to make the search for a specific product more efficient and into personalisation of the measures used.

This pilot research was focused on the interaction that participants had with the system and the perception of the system of the participants. With the data collected in the current pilot it is not possible to draw any conclusions about the effect of the application on the compliance of the participants. In future research, as part of a larger study in the PROMISS project, this application will be used by a larger number of participants for a longer period of time. Within this research it will become clear whether the refined design improve the satisfaction of the users with the system. Furthermore, it will be possible to draw conclusions on the influence of the application on diet compliance. However, both the increase number of participants, as well as the increased duration of the study, will also give new insights in the user experience and interactions. It is expected that with this study it is possible to draw more general conclusions on design principles for persuasive communication systems to improve diet compliance for elderly.

Next to the refined design described in this paper, also a second version will be tested within the final study. This version will use gamification to increase the motivation of participants to stick to their diet plan. Which gamification techniques can be used to do so, and how this can be combined with the current system, will be investigated in another project within this research.

Beyond the scope of the existing project setup, further extensions of the system are also possible. The current version of the application uses simple thresholds to adapt the menu to each individual user. However, with the use of machine learning techniques the suggested menu items could be adapted more specific to not only the user but also to for example the day of the week or other eating choices made during the day. Using machine learning could also improve how efficient the users can navigate through the lists of possible alternatives or extra items, as it could create a smart fast choice menu instead of simply showing the most frequently chosen products on top. It might be possible to use the data gathered during the large experiment that will be conducted in the near future for designing such algorithms.

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REFERENCES

[1] [n. d.]. PROMISS. http://www.promiss-vu.eu/. ([n. d.]). Accessed: 2018-09-27.

[2] Muna S Al-Razgan, Hend S Al-Khalifa, Mona D Al-Shahrani, and Hessah H AlAjmi. 2012. Touch-based mobile phone interface guidelines and design recommendations for elderly people: A survey of the literature. In *Int. Conf. Neural Inform. Processing*. Springer.

[3] Frank Bentley and Konrad Tollmar. 2013. The power of mobile notifications to increase wellbeing logging behavior. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, 1095–1098.

[4] Michelle Clare Carter, Victoria Jane Burley, Camilla Nykjaer, and Janet Elizabeth Cade. 2013. Adherence to a smartphone application for weight loss compared to website and paper diary: pilot randomized controlled trial. *Journal of medical Internet research* 15, 4 (2013).

[5] Luca Chittaro. 2016. Tailoring Web Pages for Persuasion on Prevention Topics: Message Framing, Color Priming, and Gender. In *International Conference on Persuasive Technology*. Springer, 3–14.

[6] Felicia Cordeiro, Daniel A Epstein, Edison Thomaz, Elizabeth Bales, Arvind K Jagannathan, Gregory D Abowd, and James Fogarty. 2015. Barriers and negative nudges: Exploring challenges in food journaling. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*. ACM, 1159–1162.

[7] Steven S Coughlin, Mary Whitehead, Joyce Q Sheats, Jeff Mastromonico, Dale Hardy, and Selina A Smith. 2015. Smartphone applications for promoting healthy diet and nutrition: a literature review. *Jacobs journal of food and nutrition* 2, 3 (2015), 021.

[8] Brian J Fogg. 2002. Persuasive technology: using computers to change what we think and do. *Ubiquity* 2002, December (2002), 5.

[9] Lewis R Goldberg. 1993. The structure of phenotypic personality traits. *American psychologist* 48, 1 (1993), 26.

[10] Samuel D Gosling, Peter J Rentfrow, and William B Swann Jr. 2003. A very brief measure of the Big-Five personality domains. *Journal of Research in personality* 37, 6 (2003), 504–528.

[11] Stephan Hammer, Birgit Lugrin, Sergey Bogomolov, Kathrin Janowski, and Elisabeth André. 2016. Investigating politeness strategies and their persuasiveness for a robotic elderly assistant. In *International Conference on Persuasive Technology*. Springer, 315–326.

[12] Riitta Hellman. 2007. Universal design and mobile devices. In *International Conference on Universal Access in Human-Computer Interaction*. Springer, 147–156.

[13] M Hickson. 2006. Malnutrition and ageing. *Postgrad. Medical Journal* 82, 963 (2006).

[14] Wijnand IJsselsteijn, Yvonne De Kort, Cees Midden, Berry Eggen, and Elise Van Den Hoven. 2006. Persuasive technology for human well-being: setting the scene. In *International conference on persuasive technology*. Springer, 1–5.

[15] Masoud Isanejad, Jaakko Mursu, Joonas Sirola, Heikki Kröger, Toni Rikkonen, Marjo Tuppurainen, and Arja T Erkkilä. 2016. Dietary protein intake is associated with better physical function and muscle strength among elderly women. *British Journal of Nutrition* 115, 7 (2016), 1281–1291.

[16] Robert Johnson and Simon Kent. 2007. Designing universal access: web-applications for the elderly and disabled. *Cognition, Technology & Work* 9, 4 (2007), 209–218.

[17] Satomi Kobayashi, Keiko Asakura, Hitomi Suga, and Satoshi Sasaki. 2013. High protein intake is associated with low prevalence of frailty among old Japanese women: a multicenter cross-sectional study. *Nutrition journal* 12, 1 (2013), 164.

[18] Cialdini Robert. 1984. Influence: The Psychology of Persuasion. *William Morrow and Company, Nowy Jork* (1984).

[19] Rosemary Josekutty Thomas, Judith Masthoff, and Nir Oren. 2017. Adapting healthy eating messages to personality. In *Int. Conf. on Persuasive Technology*. Springer, 119–132.