

# InMyDay: a digital diary to promote self-care among elders

Marcelo Fernández<sup>1</sup>, Iyubanit Rodríguez<sup>2</sup> (0000-0003-0878-4076), Pedro O. Rossel<sup>1</sup> (0000-0001-5027-936X), Carolina Fuentes<sup>3</sup> and Valeria Herskovic<sup>2</sup> (0000-0002-2650-6507)

<sup>1</sup> Department of Computer Science, Universidad Católica de la Santísima Concepción, Concepción, Chile

<sup>2</sup> Department of Computer Science, Pontificia Universidad Católica de Chile, Santiago, Chile

<sup>3</sup> School of Computer Science, University of Nottingham, Nottingham, United Kingdom

mafernandez@ing.ucsc.cl, iyubanit@uc.cl, prossel@ucsc.cl,  
carolina.fuentes@nottingham.ac.uk, vherskovic@uc.cl

**Abstract.** Diaries allow users to record personal events and experiences, and are frequently used to collect participant data in user studies. Digital diaries have several benefits over traditional paper-based diaries, reducing respondents’ burden, administrative costs, and improving navigation. However, for elderly users, there are several challenges in the use of a digital diary: they may have cognitive and motor impairments, and fewer digital skills than other populations. We implemented a digital diary called *InMyDay*, specifically designed for elderly users. The goal of this diary is to promote self-care and self-reflection, by allowing users to register their activities and emotions. Ten elderly users tested the diary for five days, recording entries related to their days and how they felt. All of the participants used the diary every day and after the experiment, nine declared that they would use such an application at least once a week. We found that the diary promoted reflection, that users felt that this allowed them a moment of self-care during their day, and that they felt this was especially important for them as elderly people. Future work will focus on increasing the number of participants and emotions that may be reported and exploring new mechanisms of interaction.

## 1 Introduction

The world is aging; there will be approximately 2 billion people over 60 years of age by 2050 [1]. The additional burden this will cause on healthcare systems may be offset somewhat by the use of technology in home settings. Technology may be used to monitor, manage and motivate elderly patients in their own care [2]. Self-care is defined as “the ability of individuals, families and communities to promote health, prevent disease, and maintain health and to cope with illness and disability with or without the support of a health-care provider” [3]. Self-care

requires self-reflection and it involves strategies that help promote or maintain physical, mental, emotional and spiritual health [4].

Technologies for the self-care for elders have been proposed, helping monitor their activities [5] and their health, and remain independent in their own residences [6]. Additionally, health monitoring allows users to reflect on the collected data [6]. However, older adults are not usually involved in the design process of health and wellness applications [7], and their physical and neuro-degenerative limitations [8] may make it necessary to create and design technologies to suit their specific needs.

Diaries are books in which users may record personal events and experiences [9]. Diaries may be used to collect participant data (e.g. in user studies). However, motor problems in some elderly users impede writing, and carrying out challenging tasks interferes with journaling [10]. The use of digital diaries can reduce respondents' burden, administration costs and help the user to more efficiently navigate their digital memories [11]. However, the digital skills required to successfully record information in a digital diary may not be present in some elderly users, and their physical and cognitive limitations may further challenge their use of such a diary.

Therefore, the main research question guiding this research was: *does a digital diary allow older adults to record their activities and reflect on their emotional state?* This paper presents *InMyDay*, a digital diary for self-reporting emotions and daily activities for older adults. The diary was designed iteratively and refined using heuristics specific for elderly adults. To evaluate its use, we recruited 10 adults (over 60 years old), who each used the diary for 5 days and then participated in an interview.

This paper is organized as follows. First, we discuss related work, considering technology that supports self-care and self-reflection. Then, we describe the design and implementation of our prototype. Section 4 describes our methodology, then section 5 describes the results and section 6 shows the discussion. Finally, section 7 presents our conclusions and discusses possible avenues of future work.

## 2 Related work

Diary studies, or diary methods, are used to capture information about user experiences in their natural context [12]. For example, diary studies, used in combination with focus groups, have been found to provide a comprehensive view of elders' information [13]. Diaries have been used to record daily activities (e.g. [14]), diseases (e.g. pain [15]), and emotional state (e.g. [16]).

Diaries may be implemented through pen-and-paper, augmented paper or through technological means [12]. Web and mobile application versions have been found to provide better data quality than paper [11], as well as other benefits such as signaling, timestamps, flexibility in question presentation, data entry, management and accuracy, and taking into account the participant's schedule [12]. However, computer literacy, and the need of training for use, are limitations which still endure [12]. Elderly users have been found to prefer touchscreens over

RFID-based interaction in a digital agenda [17]. A recent study found elderly users were found to be able to successfully use a digital diary; even though they took a longer time to complete tasks (than on a paper form) and lengthy training may be needed to use the application [18]. However, few diaries have been proposed for the elderly, and generally, older users are not the target of design of mobile applications [19].

Some applications have been proposed to promote specific behaviors. For example, a diary application to control food intake stimulated self-control, behavior change and learning [20]. A reminder system for elderly adults found the importance of establishing a link between the reminder on paper and the reminder system, and then, imitating reminder strategies of users [21]. Diary applications have also been proposed for elderly users with specific impairments, e.g. an audio-based interface for users with visual impairments [22].

One of the challenges of applications that help the self-expression of older adults is that they should include support for reflection, interaction and review of activities [23]. This paper presents the design and evaluation of a digital diary that aims to allow elderly users to reflect on their activities and emotions, keeping a record of them for self-reflection.

### 3 InMyDay: Design and implementation of the digital diary application

We designed and implemented a digital diary for tablet devices called “InMyDay”, that allows self-reporting of emotional state and daily activities. The application stores daily entries in a pre-defined format, and these entries can be viewed again by the users. The application was implemented for the Android system, with local data storage.

The diary was adapted from a pen-and-paper version, which consisted of several pages with pre-defined questions about self-care and emotions, e.g. *Did I take care of myself today?*, with options such as: *Food intake: I ate / I did not eat*, and space for participants to explain their choices.

First, we implemented a direct replica of the paper version (Fig. 1(a) and (b)), for a Samsung Galaxy tablet device, trying to preserve as much of the original paper version as possible.

This first digital version incorporated a few features, such as creating an entry for a new day, reviewing past entries, viewing the next/previous pages, and saving the entry (Fig. 1(c)). We reviewed this application using heuristic evaluation, which is a usability assessment method that uses experts in usability to find problems in a system using usability principles [24]. We chose to use heuristics specifically designed to evaluate applications for older adults [25]. One expert conducted the evaluation, finding several problems (e.g. font could not be resized, no auditory response for certain cases, use of high-contrast combination of font and background, no feedback about the success or failure of the save task). The evaluation resulted in several changes: (1) font size and type and interface colors were changed to improve contrast, (2) icons were changed/improved and



**Fig. 1.** (a) Initial mockup of diary. (b) Final diary in paper format. (c) InMyDay, first version. (d) InMyDay, final version.

text was added to explain them, (3) a tutorial was added, (4) improvements in date selection, (5) diary pages were rearranged to improve readability, (6) error messages were improved, (7) save/delete functions were simplified. The resulting interface is shown in Fig. 1(d) and Fig 2. This interface was evaluated again using heuristic evaluation, finding no further usability problems.



**Fig. 2.** Final version of *InMyDay* diary application.

## 4 Methodology

### 4.1 Data collection

We collected participant responses from three standard questionnaires, selected to measure digital skills (DIGCOMP), anxiety and depression (GADS) and the usability of the application (SUS). Each instrument is described below:

1. System usability scale (SUS) is a Likert Scale which includes 10 questions and it is quick way to measure the overall usability of the system [26]. In this scale, scores over 80 indicate very good usability, while scores below 60 indicate poor usability [27].
2. DIGCOMP is an instrument to measure digital competences (set of knowledge, skills and attitudes needed today to be functional in a digital environment). Users are categorized into one of four possible groups, according to their digital skill levels: *none*, *low*, *basic* or *above basic* [28].
3. Goldberg Anxiety and Depression Scale (GADS) consists of two sub-scales: one of anxiety and another of depression; each sub-scale has 9 items to determine whether or not there is a mental disorder [29].

Information from the use of the diary application was recorded and used for analysis. Participants were interviewed, and the audio from these interviews was recorded and transcribed.

### 4.2 Participants

Our participants were 10 people (7 women, 3 men) over 60 years (average age: 65, SD: 4.12). Six were married and four were single. None of the participants lived on their own. Each participant signed an inform consent form for participating in the experiment.

**Table 1.** Description of study participants.

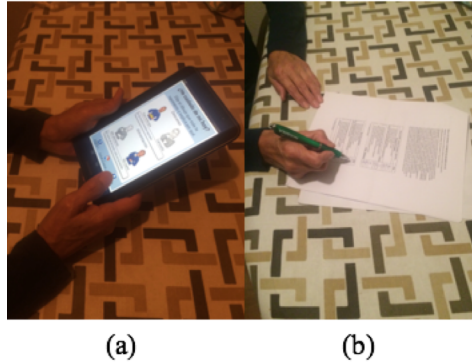
P	Age	G	Occupation	Impairment			Digital skills	Goldberg Scale	
				Visual	Auditory	Motor		Anxiety	Depression
P1	68	F	Housewife	•			None		
P2	61	F	Craftswoman	•			Basic	•	•
P3	61	M	Teacher	•	•		Basic	•	•
P4	60	F	Teacher	•	•	•	Above Basic	•	•
P5	72	F	Housewife	•	•	•	None		•
P6	66	M	Retired	•	•	•	Above Basic	•	•
P7	66	F	Merchant	•			Basic	•	•
P8	63	F	Merchant	•			Above Basic	•	
P9	70	M	Retired				Low	•	•
P10	60	F	House cleaner			•	Basic	•	•

Table 1 summarizes our study participants, displaying the age, occupation and gender of each, as well as whether they had visual, auditory or motor impairments (marked as •), their level of digital skills according to the DIGCOMP

questionnaire, and whether they had anxiety and/or depression according to the GADS questionnaire (marked as ●). Most participants had vision problems, and 7 out of 10 had depression or anxiety.

### 4.3 Experiment

To evaluate the prototype, each participant used the digital diary for five days, using the tablet device provided by the researchers. First, one researcher gave a brief introduction about the study and its purpose and the participants completed the DIGCOMP test and GADS survey. Then, the diary application was explained and each participant was given the tablet with the application installed and ready to use. The participant interacted with the application during five days in his/her house, with no researcher intervention (see Fig. 3.a). On the sixth day, the researcher conducted a brief semi-structured interview to assess user experiences. Finally, participants completed the SUS questionnaire (see Fig. 3.b). The evaluation was conducted between December 2016 and January 2017.



**Fig. 3.** (a) Participant trying out the digital diary application. (b) User filling out evaluation questionnaires.

### 4.4 Analysis

Interviews and information obtained from diary entries were analyzed using thematic analysis. The thematic map allowed us to see the topics emerge from interviews [30]. Some quotes from participants are provided in the results (translated from Spanish).

## 5 Results

### 5.1 InMyDay Usability Evaluation

The average SUS score given to the application was 63.5, which is neither poor nor good. However, we grouped the participants according to their digital skills, to analyze the average SUS score per group. Table 2 shows that, as digital skill levels increase, SUS score increased; i.e., the digital diary is more usable for people with higher digital competences. Although this is a natural phenomenon, we do believe this means that usability must be improved, especially considering users with low digital skills.

**Table 2.** Participants by digital skills and SUS score.

Digital skills	SUS
None	46.25
Low	57.5
Basic	64.38
Above basic	73.83
<b>Average</b>	<b>63.5</b>

Two main usability problems were mentioned by participants: first, choosing a date (see Figure 4(a)), because the dates on the calendar were too close to each other, and second, typing in the diary was considered to be a slow process (see Figure 4(b)), because of general difficulty with keyboards and the size of the keyboard, e.g. one participant stated: “*When writing, I took a long time and could not find the keys*”. People who mentioned difficulty in typing had on average a 43.3 SUS score, and those that mentioned keyboard size had 62.5, while those that did not mention any specific problems gave the application a 82.5 score. We found significant differences between groups *Keyboard typing* and *None* using Student’s t-test (level of significance = 0.05).

Regarding the usefulness of each of the pages of the diary, one section was the least useful. This page listed four emotions which they users could fill out to describe their day (*I laughed because.... / I cried because... / I was scared because... / I was angry because...*). Four users commented that the number of options per section should be increased (e.g. “*I thought some options were missing in some pages*”)

All of the participants filled an entry for each of the five days they had the diary. However, as this was what they were asked to do and they may have been filling the diary out of obligation, we asked them in the final interview how often they would use the digital diary if they were able to keep the device. Three participants responded that they would write everyday, three that they would write two times a week or more, three that they would write once a week, and one was unsure. One said: “*I would try to use it every day, because it is very important for us older people*”.



**Fig. 4.** (a) Choose the date problem. (b) Keyboard typing problem.

## 5.2 Supporting reflective processes through elicitation of emotions and activities of older adults

All participants mentioned that the digital diary allowed them to reflect on their emotions, specifically mentioning that they reflected more about the activities that they had done and their emotions “...you made me think about me and dedicate time to myself, which is something I never do... time is for those that surround me”.

The users effectively wrote about their emotions in the diary. Most entries were about being “happy”, especially related to sharing anecdotes, jokes, stories or being with loved ones (e.g. one response was “*I goofed around with my friends at the station*”). However, the participants also shared other types of emotions, such as being scared (“*I thought I had made a serious mistake at work*”) or angry (“*Sometimes I get angry when I lose in a card game*”). Five women indicated that they felt alone during the day, two of them on multiple days.

Participants also registered their daily activities, ranging from household chores such as cooking, cleaning and shopping in the mornings, resting, shopping and napping during the afternoons, and watching movies, talking and resting in the evening. Participants who were employed mostly reported being at work and afterwards resting and watching movies or TV in the evenings. The final questions in the diary asked users to reflect on their days (questions “What was the best thing that happened today?” and “These are the final reflections on my day”), and users provided their thoughts and reflections, suggesting self-reflection was happening. Only 10% of responses to the first question were blank, and 22% left the second question blank, suggesting that concrete questions may have better response rates. Users’ answers ranged from very brief and noncommittal (e.g. “*Good day*”, “*Typical day*”, “*I think nothing out of the ordinary happened*”) to reflective (“*I would like to go to the countryside and rest*”, “*I*



*can't run around as much anymore*") and profound (*"It was a tiring day and it reinforced that I don't want to work anymore"*, *"Tiring day but I could manage it when I thought that retirement is not too far away"* - these last two quotes are from two different participants' diaries).

## 6 Discussion

We created a digital diary with fixed questions and a limited number of emotions that could be reported. Participants used the diary, registering their activities and reflecting on their emotions. Some of the questions prompted reflection more than others, and it seems that asking a concrete question (such as "What was the best thing that happened today?") promoted more participation than more open questions (such as "These are the final reflections on my day"). Participants would have liked more options for reporting emotions, as they felt constrained by the few emotions that the diary held. A model of emotions could be incorporated into a next version of the diary (e.g. [31]). However, more options have to be included carefully, so as not to broaden the diary too much, provoking open questions that users do not feel inspired to answer.

We found responses that were superficial or noncommittal, as well as more profound reflections. Naturally, the participants knew that their diaries would be read by researchers, so many might have held back on expressing their feelings in more depth. However, all but one of the participants would like to write in such a diary at least once a week, so a more private setting for a digital diary may produce deeper reflection.

As a user experience research tool, we found that older adults are able to use digital diaries such as this one, and that special consideration must be taken with the size of the keyboards and the text on the screen. Previous research has shown successful interactions for older adults when paper and digital systems are linked [21]. In our case, the task was completely digital and users had the most difficulty with the tasks that were not easily comparable to paper tasks (e.g. choosing a date on a calendar). An avenue of further exploration of these issues would be to consider older adults using a digital stylus pen to input information, to provide a better reference to the physical world.

The Goldberg Anxiety and Depression Scale was applied in order to correlate its results with the diary data. However, only two participants did not have depression or anxiety, so it was not possible to find relationships between the reported data and these conditions. Although some studies have found that the prevalence of depressive symptoms is lower in older people [32], our study had a high percentage of participants with depression or anxiety.

Our proposal and preliminary evaluation have some limitations that we would like to acknowledge. First, the use of the diary did not focus on a specific context, so it was not possible to determine the motivation of use. Second, the sample of the study is small, so it is not possible to generalize our findings to the general population. Third, we used one set of heuristics to create the diary, but there are several other guidelines for designing interactive systems for elderly persons

(e.g. [33], [34]), and the variability of impairments that elderly people suffer may make it necessary to design diaries with specific heuristics to cater to these impairments.

## 7 Conclusion

This paper presented a digital diary for elderly adults to self-report their emotions, and an evaluation of this diary with 10 elderly adults (over 60 years old) in Chile. The digital diary allows to record the emotional state and the activities carried out on a daily basis.

We found that the older adults used the diary to reflect on their emotions, registering positive as well as negative emotions. Several users also provided deep reflections, and since all but one of the participants would like to write in such a diary at least once a week, we believe a more private setting for a digital diary may produce deeper reflection.

The next steps in this research will be to improve the diary, incorporating more possible emotions while maintaining its simplicity and directed questions, and exploring new mechanisms of interaction, such as stylus pens, which may be more familiar to elderly users due to their direct link with their physical counterparts, or voice dictation, which may help users with decreased motor skills. We will also increase the number of participants in future evaluations, to be able to understand users more thoroughly.

## Acknowledgments

The artwork was provided by artist Marcela Donoso (<http://www.marceladonoso.cl>). This project was supported partially by CONICYT-PCHA/Doctorado Nacional/2014-63140077, CONICIT and MICIT Costa Rica PhD scholarship grant, Universidad de Costa Rica and CONICYT/FONDECYT N°1150365 (Chile).

## References

1. World Health Organization: The worlds population is rapidly ageing (2017)
2. Coughlin, J.F., Pope, J.E., Ben R. Leedle, J.: Old Age, New Technology, and Future Innovations in Disease Management and Home Health Care. *Home Health Care Management & Practice* **18**(3) (2006) 196–207
3. World Health Organization: Self-care in the Context of Primary Health Care. Technical report, Report of the Regional Consultation (2009)
4. Mills, J., Chapman, M.: Compassion and self-compassion in medicine: Self-care for the caregiver. *Australian Medical Journal* **9**(8) (2016) 87–91
5. La, T.T., Valera, A.C., Tan, H.P., Koh, C.: Online Detection of Behavioral Change Using Unobtrusive Eldercare Monitoring System. In: *Proceedings of the 11th International Conference on Queueing Theory and Network Applications*. QTN'A '16, ACM (2016) 16:1–16:8

6. Caldeira, C., Bietz, M., Vidauri, M., Chen, Y.: Senior Care for Aging in Place: Balancing Assistance and Independence. In: Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing. CSCW '17, ACM (2017) 1605–1617
7. Davidson, J.L., Jensen, C.: What Health Topics Older Adults Want To Track: A Participatory Design Study. In: Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility, ACM (2013) 26:1–26:8
8. Li, Q., Luximon, Y.: Older adults and digital technology: A study of user perception and usage behavior. In: Proceedings of the AHFE 2016 International Conference on Physical Ergonomics and Human Factors. Volume 489 of Advances in Intelligent Systems and Computing., Springer (2016) 155–163
9. Ståhl, A., Höök, K., Svensson, M., Taylor, A.S., Combetto, M.: Experiencing the Affective Diary. *Personal and Ubiquitous Computing* **13**(5) (2009) 365–378
10. Dickinson, A., Arnott, J.L., Prior, S.: Methods for Human-Computer Interaction Research with Older People. *Behaviour & Information Technology* **26**(4) (2007) 343–352
11. Chatzitheochari, S., Fisher, K., Gilbert, E., Calderwood, L., Huskinson, T., Cleary, A., Gershuny, J.: Using New Technologies for Time Diary Data Collection: Instrument Design and Data Quality Findings from a Mixed-Mode Pilot Survey. *Social Indicators Research* (2017) doi:10.1007/s11205-017-1569-5.
12. Bolger, N., Davis, A., Rafaeli, E.: Diary Methods: Capturing Life as it is Lived. *Annual Review of Psychology* **54** (2003) 579–616
13. Koopman-Boyden, P., Richardson, M.: An evaluation of mixed methods (diaries and focus groups) when working with older people. *International Journal of Social Research Methodology* **16**(5) (2013) 389–401
14. Vrotsou, K., Bergqvist, M., Cooper, M., Ellegård, K.: PODD: A Portable Diary Data Collection System. In: Proceedings of the 2014 International Working Conference on Advanced Visual Interfaces (AVI-14), ACM (2014) 381–382
15. Lind, L., Karlsson, D., Fridlund, B.: Patients’ use of digital pens for pain assessment in advanced palliative home healthcare. *International Journal of Medical Informatics* **77**(2) (2008) 129–136
16. Morris, M.E., Kathawala, Q., Leen, T.K., Gorenstein, E.E., Guilak, F., Labhard, M., Deleeuw, W.: Mobile Therapy: Case Study Evaluations of a Cell Phone Application for Emotional Self-Awareness. *Journal of Medical Internet Research* **12**(2) (2010) e10
17. Iglesias, R., de Segura, N.G., Iturburu, M.: The Elderly Interacting with a Digital Agenda through an RFID Pen and a Touch Screen. In: Proceedings of the 1st ACM SIGMM International Workshop on Media Studies and Implementations that Help Improving Access to Disabled Users (MSIADU '09), ACM (2009) 63–70
18. Courbet, L., Bauchet, J., Rialle, V.: Evaluation of a digital diary for old people living in a retirement. *Gerontechnology* **15**(Supplement) (2016) 76s
19. García-Peñalvo, F.J., Conde, M.Á., Matellán-Olivera, V.: Mobile apps for older users – the development of a mobile apps repository for older people. In: Proceedings of the 1st International Conference on Learning and Collaboration Technologies (LCT 2014). Volume 8524 of Lecture Notes in Computer Science., Springer (2014) 117–126
20. Hakobyan, L., Lumsden, J., Shaw, R., O’Sullivan, D.: A Longitudinal Evaluation of the Acceptability and Impact of a Diet Diary App for Older Adults with Age-related Macular Degeneration. In: Proceedings of the 18th International Conference on Human-Computer Interaction with Mobile Devices and Services. MobileHCI '16, ACM (2016) 124–134

21. Williamson, J.R., McGee-Lennon, M., Freeman, E., Brewster, S.: Designing a Smartpen Reminder System for Older Adults. In: Proceedings of the CHI'13 Extended Abstracts on Human Factors in Computing Systems, ACM (2013) 73–78
22. Brewer, R.N., Cartwright, M., Karp, A., Pardo, B., Piper, A.M.: An Approach to Audio-Only Editing for Visually Impaired Seniors. In: Proceedings of the 18th International ACM SIGACCESS Conference on Computers and Accessibility. ASSETS '16, ACM (2016) 307–308
23. Brewer, R., Piper, A.M.: “Tell It Like It Really Is”: A Case of Online Content Creation and Sharing Among Older Adult Bloggers. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, ACM (2016) 5529–5542
24. Nielsen, J.: Finding Usability Problems Through Heuristic Evaluation. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. CHI '92, ACM (1992) 373–380
25. Silva, P.A., Holden, K., Jordan, P.: Towards a List of Heuristics to Evaluate Smartphone Apps Targeted at Older Adults: A Study with Apps that Aim at Promoting Health and Well-Being. In: Proceedings of the 48th Hawaii International Conference on System Sciences (HICSS 2015), IEEE (2015) 3237–3246
26. Brooke, J.: SUS-A quick and dirty usability scale. Usability evaluation in industry **189**(194) (1996) 4–7
27. Tullis, T., Albert, W.: Measuring the User Experience: Collecting, Analyzing, and Presenting Usability Metrics. Morgan Kaufmann Publishers Inc. (2008)
28. Ferrari, A.: Digital Competence in Practice: An Analysis of Frameworks. Technical report, Research Centre of the European Commission (2012)
29. Goldberg, D., Bridges, K., Duncan-Jones, P., Grayson, D.: Detecting anxiety and depression in general medical settings. *British Medical Journal* **297**(6653) (1988) 897–899
30. Braun, V., Clarke, V.: Using thematic analysis in psychology. *Qualitative Research in Psychology* **3**(2) (2006) 77–101
31. Russell, J.A.: A circumplex model of affect. *Journal of Personality and Social Psychology* **39**(6) (1980) 1161–1178
32. Christensen, H., Jorm, A.F., Mackinnon, A.J., Korten, A.E., Jacomb, P.A., Henderson, A.S., Rodgers, B.: Age differences in depression and anxiety symptoms: a structural equation modelling analysis of data from a general population sample. *Psychological Medicine* **29** (1999) 325–39
33. Jian, C., Shi, H., Schafmeister, F., Rachuy, C., Sasse, N., Schmidt, H., Hoemberg, V., von Steinbüchel, N.: Touch and Speech: Multimodal Interaction for Elderly Persons. In: Proceedings of the 5th International Joint Conference on Biomedical Engineering Systems and Technologies (BIOSTEC 2012). Volume 357 of Communications in Computer and Information Science., Springer (2012) 385–400
34. Nunes, F., Silva, P.A., Cevada, J., Barros, A.C., Teixeira, L.: User interface design guidelines for smartphone applications for people with Parkinson's disease. *Universal Access in the Information Society* **15**(4) (2015) 659–679