Context in designing and evaluating usability in eHealth technology for older adults

Marijke Broekhuis
Roessingh Research and Development, Enschede, the Netherlands
Faculty of Electrical Engineering, University of Twente, Enschede, the Netherlands
M.Broekhuis@rrd.nl

ABSTRACT
Technology for supporting older adults in healthy ageing has taken a flight in recent years. The implementation of eHealth technology could support older adults in monitoring and preventing age-related health conditions. When designing e-Health technologies, User-Centered Design (UCD) has received broad consensus over the years among researchers as a valid approach to design technologies that fit with the tasks and situations of the user. UCD states that in order to design effective technology we need to understand the context in which it is used for the design and evaluation of the technology. However, there are currently no standardized usability evaluation metrics for eHealth technology. In this thesis, I will explore the role of context in designing eHealth for older adults, and develop new usability metrics for assessing the usability of these kinds of technologies.

Author Keywords
eHealth; Older Adults; Healthy Ageing; Usability Evaluation; User-Centered Design; Context-of-Use.

ACM Classification Keywords
H.1.2 Information Systems: Human Information Processing; H.5.1: Multimedia Information Systems: evaluation/methodology; H.5.2 User Interfaces: Benchmarking, User-Centered Design; J.3 Life and Medical Sciences: Health, Medical Information Systems.

INTRODUCTION
Due to our increasing life expectancy [39] there is much attention for the application of eHealth technology for healthy ageing. To support older adults in healthy ageing, eHealth technology is upcoming [25]. It is applied to diagnose, prevent and treat age-related health conditions, but also to help and support older adults in becoming more resilient and skillful in managing their health. Examples of such eHealth technologies are virtual coaches that give nutritional or physical advice and platforms where people could set their own health goals and monitor their progress. This thesis focuses on eHealth technology that aim to support older adults in healthy ageing and in their general wellbeing.

In order for people to use eHealth technology, it is important that it is user-friendly. Although there exist many methods for usability testing there are no standardized methods or frameworks for eHealth technology. This is necessary because these generic usability instruments such as the System Usability Scale [4], do not take into account specific aspects of eHealth technology, such as improving self-care of health, improving, doctor-patient communication, health education and supporting treatment programs [26]. These generic instruments are not fully capable to evaluate usability for eHealth technology and specifically in the intended context-of-use.

User-centered design (UCD) processes take context-of-use into account [8]. Although UCD is a general approach for designing technology that fits with the goals and needs of the user, it does not provide specific methods or practical guides. For older adults, they need to incorporate eHealth technology in their usual daily life. The problem here is explained by van Gemert-Pijnen et al. [35]: *"People simply stop using technologies that do not correspond in any way with their daily lives, habits or rituals"* (p.2). This makes it quite challenging to gather contextual requirements for the design of eHealth technologies and to measure the effectiveness of eHealth technology in the context of the daily life. This thesis therefore focusses on studying context of use in the different stages of a UCD process.

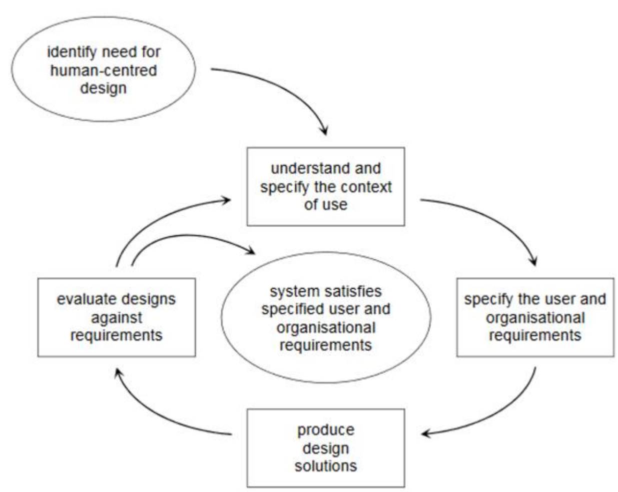

Figure 1. Illustration of the UCD process. From: Jokela et al., (2003), Figure 2, p. 55.

This work was selected for presentation at the NordiCHI'18 Doctoral Consortium, September 29, 2018.

The next paragraphs will give a short introduction in the two main research domains of the thesis, namely applying eHealth technology in daily life and usability benchmarking methodology for eHealth technology. Next, an overview of the studies will be provided. Lastly, the practical and academic implications of this research will be discussed.

Increasing attention on context-of-use

Identification of contextual needs, wishes and goals of your target audience has become essential in usability research and user-centered design processes. Recent developments in technology change how and when people use it since technology usage is becoming more intertwined with daily life. Instead of visiting a website for healthy nutrition while sitting behind their desk, they can watch recipe videos on a tablet whilst cooking, scan ingredients with their mobile phones in the supermarket or use social media to exchange recipe tips with their friends while waiting for the train. We need detailed information on these daily life situations to get insights on the context in which they would use eHealth technology and we need to apply these insights in the design and evaluation processes of eHealth technology.

As a starting point for identifying moments in the daily life of older adults where eHealth could support them in maintaining a healthy lifestyle, this research focuses on health information behavior (HIB) situations. We define this as situations where individuals actively search for, passively encounter, or consciously decide not to search for health information (HI). Most (health) information behaviour models focus on active information behaviour [13, 21, 30, 31]. This is limiting because it provides no information on reasons, motivations and factors that trigger active or avoidant HI behavior nor information on the actions people take after passively consuming health information. The model of Wilson [40] is hereby the exception, with clear distinctions between passive and active types of behaviour. However, this model does not explain which factors ‘trigger’ which types of behaviour.

We need to identify personal and contextual factors for the design of eHealth technology that supports older adults in living healthily. Also, we need to know if there are differences in personal or contextual factors in the use and evaluation of different eHealth technologies. For example, technologies that support older adults in maintaining an active lifestyle or for improving their quality of life. This information can be used for the design of eHealth technology, to provide its users with certain types of information at specific locations or time periods or to adapt motivational strategies based on the type of eHealth technology. Also, this information can be applied in the evaluation to measure if the technology takes these personal and contextual factors into account and how this affects the usability of the system.

Usability evaluation of eHealth technology

There are many ways of evaluating usability, such as heuristic evaluations, cognitive walkthroughs, focus groups, interviews, eye-tracking, thinking aloud, or surveys [33]. For quantitative usability evaluation there are usability benchmarking metrics (i.e. task completions, time on task, error on task) and standardized surveys, such as the System Usability Scale (SUS) [4], the Post-Study System Usability Questionnaire (PSSUQ) [23], After-Scenario Questionnaire [22], the Questionnaire for User Interface Satisfaction (QUIS) [6] and, specifically for the telemedicine research area, the Telehealth Usability Questionnaire (TUQ) [28].

These are all research methods or usability methods for generic usage, not specifically designed for eHealth. Although the latter, the Telehealth Usability Questionnaire, seems like a good option to measure usability in eHealth technology, this questionnaire is mainly developed for telehealth applications in which patient-clinician communication across digital devices is central. This limits its opportunities to measure the usability eHealth technology in which this relationship is not the main feature.

The problem with general and non-standardized methods for measuring usability is explained in the following case of serious games (SGs) for older adults.

The case of serious games

Recent studies on serious game evaluations show different methods to measure usability. Although some studies try to incorporate qualitative measures such as interviews, and focus groups to measure the effectiveness and usability of SGs [10, 12, 20], other studies show a variety of methods:

- Recording health or medical scores as a measure for effectiveness of the technology [2, 7, 24, 26, 35, 36, 37];
- Applying general usability and/or playability evaluation questionnaires [3,5, 18, 29]; and
- Focusing on individual elements such as enjoyment or engagement [1, 11, 32, 34].

The problems that arise from this overview are twofold. The first is that in clinical studies that examine eHealth technology, usability is not always taken into account. Health or performance indicators can be influenced by the usability of a technology. A low usability rating would result in lower efficiency, effectiveness and satisfaction of the system among the users and can thus affect their scores. Second, there are differences between commercial and serious games. While the first are intended for mass audiences, serious games are intended for specific target groups, such as rehabilitation patients or children, who often have specific health-related needs and sometimes cognitive and/or physical disabilities that eHealth technologies need to attune for 9, 17]. It is important to create a perceived task-technology fit between playing the game and the benefits of playing the game. This fit would enhance technology adoption especially among older adults [14]. Using generic usability questionnaires or only individual elements of such questionnaires, for evaluating the usability of serious games, is therefore not recommended.

This case illustrates the need for a suitable method to measure usability of eHealth technology within the context-of-use.

OVERVIEW OF STUDIES

This thesis will consist of five studies, all resulting in articles to be published in scientific journals. As this thesis investigates the role of context during the user-centered design process of eHealth technology, it seems like a logic choice to also take on this approach when developing a new usability benchmarking tool. Figure 2 gives a schematic overview of the outline of this thesis.

The first two studies will therefore focus on identifying health information needs and contextual factors in daily life that influence the usage of eHealth technology. The usability methodology studies will consist of a comparison between usability benchmarking tools when applied in the field of eHealth and a state-of-the-art survey study to examine the current state of usability testing in the field of eHealth. The fifth study will integrate the acquired knowledge in the development and validation of a new usability evaluation tool for eHealth technology. Next, each study will be briefly explained.

Study 1: Health information behaviour of older adults and chronic illness patients

We need to know in which daily life situations people engage in active, passive or avoidant HI behaviour, the social and environmental factors that influence their behavior, and the barriers they perceive while searching information. In a longitudinal diary study, we follow three chronic patient groups (seniors with age-related impairments, diabetes type 2 patients, and chronic pain patients) in three countries (Denmark, the Netherlands, United Kingdom) for four weeks. Each day, they received an online diary form on the type of health information situations they encountered, the factors that triggered this situation, and their behaviour in each situation. While writing this paper, the diary study was still continuing.

Study 2: Studying e-Health technology in daily life: the six dimensions of health

The new definition of health [15,16] emphasizes that 'health' is not just your physical and/or cognitive condition, but also includes other aspects such as quality of life and spiritual health. EHealth technology can be designed for each of these health domains. The purpose of this study is to uncover whether there are differences in personal and/or contextual factors between the acceptance of e-Health technologies for improving physical activity and, for example, for improving cognitive skills or quality of life.

Study 3: Evaluation of usability evaluation tools

A methodological study is being conducted in which a generic usability evaluation metric (the System Usability Scale (SUS)) and task-oriented usability metrics, are evaluated among three different e-Health technologies: a serious game, online health portal, and mobile app. A total of 55 respondents participated in this study. While writing this paper the results were under analysis. Goal of this study is to uncover which metric(s) is/are most indicative of eHealth usability.

Study 4: State of the art: current practices in usability evaluation in eHealth technology

Parallel to evaluating existing usability benchmarking metrics among eHealth technology, a review of usability testing in the field of eHealth is conducted. During a survey study, experts in the field of user experience and usability design and evaluation will be asked about their practices for usability testing in eHealth technology. The goal is to get insights on the usability metrics that are currently applied in usability testing of eHealth technology and the suitability and effectiveness of these metrics.

Study 5: Developing and validating a new usability benchmarking tool for eHealth technology

This final study focusses on developing and validating a new benchmarking tool for measuring usability of e-Health technology in the applied context. This study aims at psychometrically validating this tool by applying and testing it in multiple usability evaluation studies of eHealth technology.

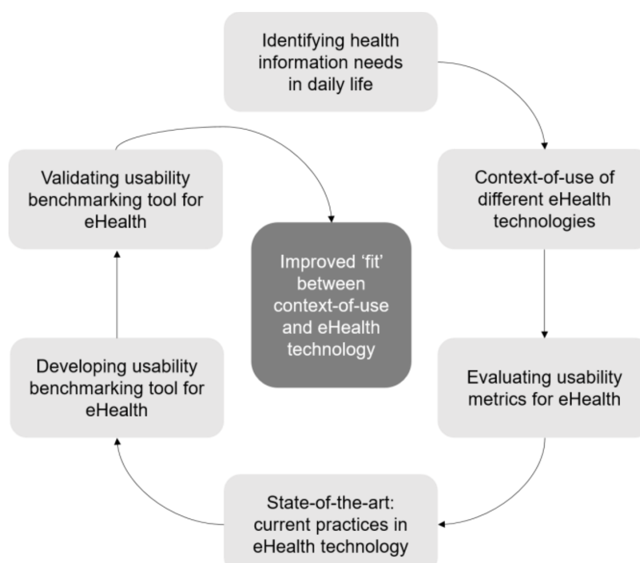

Figure 2. Illustration of research model. This follows the different steps of a UCD process, from identifying needs in daily life where eHealth technology could be useful to studying usability metrics and current practices towards the development and validation of a new tool. This will hopefully lead to a satisfactory usability benchmarking tool for eHealth.

PRACTICAL AND THEORETICAL IMPLICATIONS

This thesis will result in the following theoretical contributions:

- Insights in HIB among older adults that will enable us to developed a fine-grained model of HIB for the eHealth field
- Insights on (dis)similarities in personal and contextual factors between eHealth technologies for different health domains
- A theoretical framework for contextual factors for eHealth technology

Practical contributions will consist of:

- Insights in the suitability of popular usability metrics for the context of eHealth
- A usability benchmarking tool for eHealth

These theoretical and practical implications could improve the user-centered design processes of eHealth technology for usability engineers, designers and evaluators to detect in an early stage of development if the usability of the eHealth technology would fit with the context-of-use and to benchmark the usability of the final prototype. For example, to know already during the low-fidelity prototype phase, if a technology would be suitable for older adults to use in their daily life.

By tailoring eHealth technology to the daily lives of older adults and by evaluating its usability within this context with appropriate usability metrics, this thesis benefits future research on usability of eHealth technologies.

ACKNOWLEDGEMENT

This work is conducted within the context of the IMI SPRINTT (IMI-JU 115621) and Council of Coaches (GA #769553) projects.

REFERENCES

1. Agmon, M., Perry, C. K., Phelan, E., Demiris, G., & Nguyen, H. Q. (2011). A Pilot Study of Wii Fit Exergames to Improve Balance in Older Adults. Journal of Geriatric Physical Therapy, 34(4), 161–167. https://doi.org/10.1519/JPT.0b013e3182191d98
2. Bateni, H. (2012). Changes in balance in older adults based on use of physical therapy vs the Wii Fit gaming system: A preliminary study. Physiotherapy (United Kingdom), 98(3), 211–216. https://doi.org/10.1016/j.physio.2011.02.004
3. Boletsis, C., & McCallum, S. (2016). Smartkuber: A Serious Game for Cognitive Health Screening of Elderly Players. Games for Health Journal, 5(4), 241–251. https://doi.org/10.1089/g4h.2015.0107
4. Brooke J. SUS—A quick and dirty usability scale. In: Jordan PW, Thoma B, Weerdmeester BA, eds. Usability Evaluation in Industry. London: Taylor & Francis; 1995: 189–194.
5. Burke, J. W., McNeill, M. D. J., Charles, D. K., Morrow, P. J., Crosbie, J. H., & McDonough, S. M. (2009). Optimising engagement for stroke rehabilitation using serious games. Visual Computer, 25(12), 1085–1099. https://doi.org/10.1007/s00371-009-0387-4
6. Chin, J. P., Diehl, V. a, & Norman, L. K. (1988). Development of an instrument measuring user satisfaction of the human-computer interface. CHI '88-Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 213–218. https://doi.org/10.1145/57167.57203
7. Daniel, K. (2012). Wii-hab for pre-frail older adults. Rehabilitation Nursing, 37(4), 195–201. https://doi.org/10.1002/rnj.25
8. Endsley, M.R. (2011). Designing for Situation Awareness: An Approach to User-Centered Design, 2nd Edition. CRC Press, Inc: Boca Ration, FL USA
9. Flores, E., Tobon, G., Cavallaro, E., Cavallaro, F. I., Perry, J. C., & Keller, T. (2008). Improving patient motivation in game development for motor deficit rehabilitation. In Proceedings of the 2008 International Conference in Advances on Computer Entertainment Technology - ACE '08 (p. 381). https://doi.org/10.1145/1501750.1501839
10. Gerling, K. M., Schild, J., & Masuch, M. (2010). Exergame design for elderly users: the case study of SilverBalance. Proc. of the 7th International Conference on Advances in Computer Entertainment Technology. ACM, 66–69. https://doi.org/10.1145/1971630.1971650
11. Gerling, K. M., Mandryk, R. L., & Kalyn, M. R. (2013). Wheelchair-based game design for older adults. Proceedings of the 15th International ACM SIGACCESS Conference on Computers and Accessibility - ASSETS '13, 1–8. https://doi.org/10.1145/2513383.2513436
12. Glännfjord, F., Hemmingsson, H., & Larsson Ranada, Å. (2017). Elderly people's perceptions of using Wii sports bowling–A qualitative study. Scandinavian Journal of Occupational Therapy, 24(5), 329–338. https://doi.org/10.1080/11038128.2016.1267259
13. Glanz, K., Rimer, B., & Lewis, F. (2002). *Health Behavior and Health Education. Theory, Research and Practice.* San Fransisco: Wiley & Sons.
14. Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. MIS Quartely, 19(2), 213–236. https://doi.org/10.2307/249689
15. Huber, M., André Knottnerus, J., Green, L., Van Der Horst, H., Jadad, A. R., Kromhout, D., Smid, H. (2011). How should we define health? BMJ (Online), 343(7817), 1–3. https://doi.org/10.1136/bmj.d4163

16. Huber, M., van Vliet, M., Giezenberg, M., Winkens, B., Heerkens, Y., Dagnelie, P. C., & Knottnerus, J. A. (2016). Towards a "patient-centred" operationalisation of the new dynamic concept of health: a mixed methods study. BMJ Open, 6(1). Retrieved from http://bmjopen.bmj.com/content/6/1/e010091.abstract
17. IJsselstein, W., Nap, H. H., De Kort, Y., & Poels, K. (2007). Digital game design for elderly users. Proceedings of the 2007 Conference on Future Play, Future Play '07, 17–22. https://doi.org/10.1145/1328202.1328206
18. Jansen-Kosterink, S. M., Huis in 't Veld, R. M. H. A., Schönauer, C., Kaufmann, H., Hermens, H. J., & Vollenbroek-Hutten, M. M. R. (2013). A Serious Exergame for Patients Suffering from Chronic Musculoskeletal Back and Neck Pain: A Pilot Study. Games for Health Journal, 2(5), 299–307. https://doi.org/10.1089/g4h.2013.0043
19. Jokela, T., Iivari, N., Matero, J., Karukka, M. (2003). The Standard of User-Centered Design and the Standard Definition of Usability: Analyzing ISO 13407 against ISO 9241-11. *CLIHC '03 Proceedings of the Latin American Conference on Human-Computer Interaction Pages 53-60*, 53–60. https://doi.org/0.1145/944519.944525
20. Konstantinidis, E. I., Bamparopoulos, G., & Bamidis, P. D. (2017). Moving Real Exergaming Engines on the Web: The webFitForAll Case Study in an Active and Healthy Ageing Living Lab Environment. IEEE Journal of Biomedical and Health Informatics, 21(3), 859–866. https://doi.org/10.1109/JBHI.2016.2559787
21. Kuhlthau, C.C. (1993). A principle of uncertainty for information seeking. *Journal of Documentation*, *49*(4), 339–355. https://doi.org/10.1108/eb026918
22. Lewis, J. R. (1991). Psychometric evaluation of an after-scenario questionnaire for computer usability studies. ACM SIGCHI Bulletin, 23(1), 78–81. https://doi.org/10.1145/122672.122692
23. Lewis, J. R. (2002). Psychometric Evaluation of the PSSUQ Using Data from Five Years of Usability Studies. International Journal of Human-Computer Interaction, 14(3–4), 463–488. https://doi.org/10.1080/10447318.2002.9669130
24. Maillot, P., Perrot, A., & Hartley, A. (2012). Effects of interactive physical-activity video-game training on physical and cognitive function in older adults. Psychology and Aging, 27(3), 589–600. https://doi.org/10.1037/a0026268
25. Mugueta-Aguinaga, I., & Garcia-Zapirain, B. (2017). Is Technology Present in Frailty? Technology a Back-up Tool for Dealing with Frailty in the Elderly: A Systematic Review. Aging and Disease, 8(2), 2005. https://doi.org/10.14336/AD.2016.0901
26. Padala, K. P., Padala, P. R., Malloy, T. R., Geske, J. A., Dubbert, P. M., Dennis, R. A., Sullivan, D. H. (2012). Wii-fit for improving gait and balance in an assisted living facility: A pilot study. Journal of Aging Research, 2012, 597573. https://doi.org/10.1155/2012/597573
27. Pagliari, C., Sloan, D., Gregor, P., Sullivan, F., Detmer, D., Kahan, J. P.,MacGillivray, S. (2005). What is eHealth (4): A scoping exercise to map the field. Journal of Medical Internet Research. https://doi.org/10.2196/jmir.7.1.e9
28. Parmanto, B., Lewis, Jr., A. N., Graham, K. M., & Bertolet, M. H. (2016). Development of the Telehealth Usability Questionnaire (TUQ). *International Journal of Telerehabilitation*, *8*(1), 3–10. https://doi.org/10.5195/IJT.2016.6196
29. Reichlin, L., Mani, N., McArthur, K., Harris, A. M., Rajan, N., & Dacso, C. C. (2011). Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer. Journal of Medical Internet Research, 13(1). https://doi.org/10.2196/jmir.1519
30. Rogers, R. (1975). A Protection Motivation Theory of Fear Appeals and Attitude Change. *Journal of Psychology*, 93-114.
31. Rogers, R. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J. Cacioppa, & R. Petty, *Social psychophysiology* (pp. 153-176). New York: Guilford Press.
32. Rosenberg, D., Depp, C. A., Vahia, I. V., Reichstadt, J., Palmer, B. W., Kerr, J., Jeste, D. V. (2010). Exergames for Subsyndromal Depression in Older Adults: A Pilot Study of a Novel Intervention. *The American Journal of Geriatric Psychiatry*, *18*(3), 221–226. https://doi.org/10.1097/JGP.0b013e3181c534b5
33. Rubin, J., & Chisnell, D. (2008). Handbook of usability testing [electronic resource] : How to plan, design, and conduct effective tests (2nd ed.). Indianapolis, IN: Wiley Pub. https://doi.org/10.1007/s13398-014-0173-7.2
34. Schoene, D., Lord, S. R., Delbaere, K., Severino, C., Davies, T. A., & Smith, S. T. (2013). A Randomized Controlled Pilot Study of Home-Based Step Training in Older People Using Videogame Technology. PLoS ONE, 8(3), e57734. https://doi.org/10.1371/journal.pone.0057734
35. Soares, A. V., Borges Júnior, N. G., Hounsell, M. S., Marcelino, E., Rossito, G. M., & Sagawa Júnior, Y. (2016). Un jeu sérieux développé pour la réhabilitation physique des personnes âgées atteintes de syndrome de fragilité. European Research in Telemedicine, 5(2), 45–53. https://doi.org/10.1016/j.eurtel.2016.05.003

36. Szturm, T., Betker, A. L., Moussavi, Z., Desai, A., & Goodman, V. (2011). Effects of an Interactive Computer Game Exercise Regimen on Balance Impairment in Frail Community-Dwelling Older Adults: A Randomized Controlled Trial. Physical Therapy, 91(10), 1449–1462. https://doi.org/10.2522/ptj.20090205

37. Vallejo, V., Wyss, P., Chesham, A., Mitache, A. V., Müri, R. M., Mosimann, U. P., & Nef, T. (2017). Evaluation of a new serious game based multitasking assessment tool for cognition and activities of daily living: Comparison with a real cooking task. Computers in Human Behavior, 70, 500–506. https://doi.org/10.1016/j.chb.2017.01.021

38. Van Gemert-Pijnen, J. E. W. C., Nijland, N., van Limburg, M., Ossebaard, H. C., Kelders, S. M., Eysenbach, G., & Seydel, E. R. (2011). A holistic framework to improve the uptake and impact of eHealth technologies. Journal of Medical Internet Research, 13(4). https://doi.org/10.2196/jmir.1672

39. (WHO), W. H. O. (2017). World Population Prospects. Volume II: Demographic Profiles. 2017 Revision. Retrieved from https://esa.un.org/unpd/wpp/Publications/Files/WPP2017_Volume-II-Demographic-Profiles.pdf

40. Wilson, T. (1997). Information behaviour: An interdisciplinary perspective. *Information Processing & Management*, 551-572.