Adaptive Training for Older Adults Based on Dynamic Diagnosis of Mild Cognitive Impairments and Dementia

Anna Kötteritzsch[1], Michael Koch[1], and Fritjof Lemân[2]

[1] Universität der Bundeswehr, Werner-Heisenberg-Weg 39, 85577 Neubiberg, Germany
[2] FamilyVision, Trademark of VirtuoSys GmbH, Grainwinkel 8a, 82057 Icking, Germany
anna@koetteritzsch.net

Abstract. An increasing number of older adults with neurodegenerative diseases and a growing gap in healthcare services lead to a higher need of suitable means of prevention and intervention in order to support the maintenance of an autonomous life. Software for cognitive and psycho-motoric training has the potential to provide an adapted training that challenges without producing cognitive overload. To achieve this goal, the status of a person's cognitive and motoric abilities must be assessed. We propose a system that provides adapted training for older adults based on dynamic diagnosis of mild cognitive impairment and dementia. Within this contribution, a concept of content adaptation on the individual needs of a user and actual stage of development, a training application prototype as well as first results of user studies in a geriatric day clinic are presented.

1 Introduction

Neurodegenerative diseases, including Parkinson's and Alzheimer's disease, affect an increasing number of older adults in Germany. Symptoms of dementia, e.g. poor concentration, rapid exhaustion, and mental overload, restrain autonomy and quality of life. Continuous cognitive and psycho-motoric training in combination with social interaction increase the chances to delay mild cognitive impairments (MCI) and dementia as well as slow down the progression of dementia by addressing risk factors. However, care facilities cannot cope with the increasing need of means to prevent and intervene with cognitive and motor impairments and diseases.

Technologies in the area of Ambient Assisted Living (AAL) aim at supporting the autonomy of older adults in their home environment. Interactive systems have the potential to support people with age-related impairments by offering digital trainings and prevention activities. Furthermore, they may track a person's status and adapt to it based on the results. Considering rapidly changing and varying abilities in older adults with neurodegenerative diseases, it is important to provide dynamic adaptation of preventive measurements. By those means, mental overload can be avoided despite a challenging training. We present an approach to provide automatic adaptive cognitive and psycho-motoric training based on information entered by the user and information gathered from user interaction. The additional value of this approach is the

L. Pecchia et al. (Eds.): IWAAL 2014, LNCS 8868, pp. 364–368, 2014.

design of a complete user model based on the application domain and its usage in assistive technologies. In this contribution, we present first results of an adaptive training application for older adults based on measurements for dynamic diagnosis of MCI and dementia within the scope of the project FamilyVision.

2 Digital Therapy and Diagnosis of Dementia

Several assistive technologies offer cognitive and psycho-motoric training and the long-term diagnosis of abilities. Products include therapy applications as well as cognitive or motoric training games which adjust the level of difficulty based on limited user information. However, when not considering the cognitive or motoric state, a training effect may be decreased [2]. Research projects draw an increasing focus on adaptation of applications for older adults, providing an adaptation based on specific user requirements. Yet, these must me manually adapted [3] or consider single aspects of the user's abilities [4]. When focusing on older adults, all available information on context, abilities and impairments of the user might influence the user state. Some research projects track the usage context for adapting the system, yet do not take into account the user state [5]. Pielawa et al. [6] present a management system for long-term tracking of multi-morbid patients, providing modelling techniques that might be useful for training systems. Assistive technology for older adults with MCI and dementia must be adaptive in order to react to the rapidly changing needs and difficulties of the user [7]. Brouillette et al. show that a digital dynamic diagnosis application is feasible, reliable and valid when assessing levels of cognitive functioning [8]. Integrating dynamic diagnosis, advanced user modeling and adaptation techniques into the development of cognitive and psycho-motoric trainings may address the challenge of providing a suitable training for people with different abilities and requirements.

3 Dynamic Diagnosis and Adaptive Training

The aim of FamilyVision is to track and analyze short- and long-term user and usage information in order to adapt applications for prevention and intervention of MCI and dementia in its early stages. We developed a mobile software application combining dynamic diagnosis and an automatically adapted training for older adults with varying abilities.

3.1 Concept

Our approach supports older adults living in their own home environment by providing a tablet-based application for MCI and dementia prevention. Measurements addressing risk factors of dementia are automatically adapted, based on information about the user and his cognitive status.

Training of cognitive and psycho-motoric abilities requires an engaging training avoiding mental overload. Thus, training applications must be adapted to the abilities and impairments of the user. In order to adapt reliable diagnosis measurements into

our system, we compared the items of existing screenings for MCI and dementia (e.g. the Mini Mental State Test) and general geriatric instruments. We extracted seven categories of cognitive and psycho-motoric abilities that are analyzed by the screening instruments: 1. Orientation ability, 2. short-term memory, 3. attention, 4. calculation ability, 5. long-term memory, 6. executive functioning, and 7. logic / abstraction. These categories were integrated into our user model in addition to demographic information, areas of interest, preferences and past results of cognitive assessments. One to four items that diagnose the different abilities and are suitable for digital implementation were extracted for each category to be included in our prototype.

We conducted a preliminary qualitative study evaluating tablet applications in terms of usability and topics of interest with 12 patients (70 to 92 years; 8 f, 4 m) in a geriatric day clinic. The results showed common areas of interest of older adults concerning training applications and pointed out that different gestures are ineffective for older adults. The participants rated their enjoyment higher and challenge more adequate for contents that focused on the surrounding location, nature, and areas of interest (e.g. sports). Very difficult and very easy tasks were generally rated lower on the enjoyment scale then tasks with an adequate difficulty. These results stress the importance of adaptive technologies to engage older adults in training activities. We also analyzed and categorized existing trainings from research and practice. These trainings could supported one or more of the following user abilities: 1. Concentration and situation interpretation, 2. response, 3. short-term memory, 4. procedural long-term memory, 5. episodic long-term memory, 6. attention, 7. calculation ability, 8. Logical reasoning, 9. executive functioning, 10. abstraction and spacial imagination, and 11. fine motor skills. Based on existing literature and exercises, we developed one to eight training concepts for each of the training categories, taking into account design guidelines and requirements of the user group.

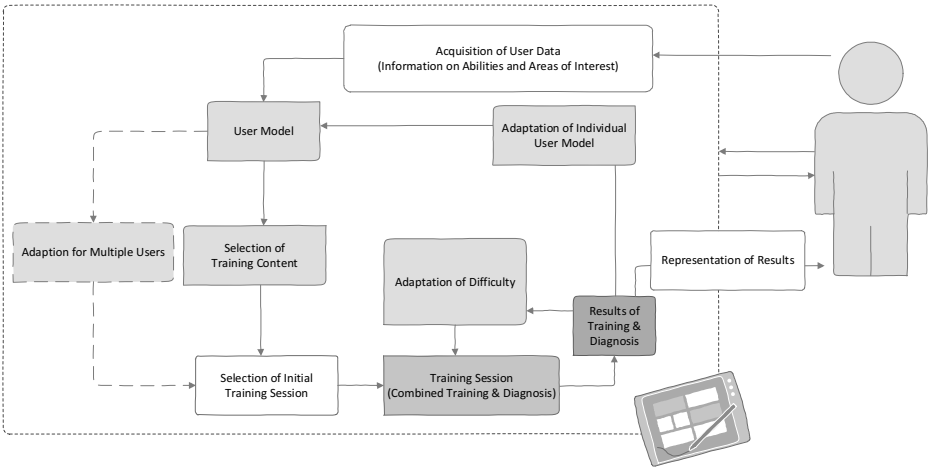

Fig. 1. Adaptation of cognitive and motoric training based on user and usage data

The diagnosis items and trainings were combined in an overall adaptive training concept. Using a playful approach, the users are guided through a 20 minute daily training session including all training and diagnosis categories. The results of the diagnosis and trainings are used to achieve a better adaption and selection of trainings as well as the customization of difficulty and help functions (e.g. repetition or highlight of items). Figure 1 shows the adaptation process of the self-adaptive training concept.

3.2 Prototype and Evaluation

In order to evaluate the concept with the user group, we developed a prototype of the proposed application. The prototype includes at least two items for each of the seven suggested diagnosis categories and five trainings that address eight of the eleven user abilities. A randomized training sequence consists of all trainings and one question of each diagnosis category. Figure 2 shows different screens of the diagnosis and training. When a user profile is created, difficulties are initially set. Based on the actual and former results of the trainings and diagnosis items, a value for each of the user abilities is calculated with every training reset. According to the values of user abilities, one of five levels of difficulty is set for the individual trainings.

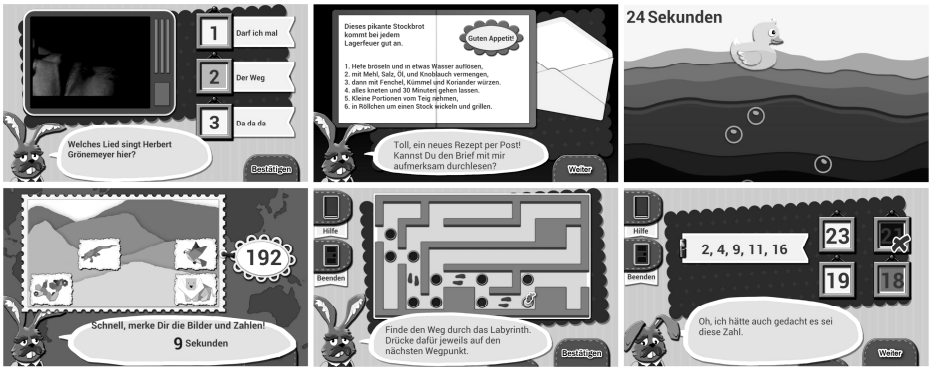

Fig. 2. Prototype of an adaptive training based on dynamic diagnosis (First row: Video quiz, sequence training, reaction game. Second row: Memory task, two dynamic diagnosis items)

The evaluation in a geriatric day clinic in cologne started in April 2014. Each patient is tested in three recorded sessions, including an interview, a training session and a standardized geriatric assessment. The results of the sessions give an insight into the validity of the diagnosis as well as the usability of the application. Furthermore, we evaluate the mental adequacy of the trainings in order to improve adaptation of the difficulties based on user abilities. First results indicate that heterogeneous users with varying abilities are likewise able to interact with the application. However, with declining cognitive abilities, the complexity of the proposed training is still too high.

4 Conclusion and Future Work

When developing prevention and intervention trainings for older adults, varying and changing abilities and impairments of the user must be considered. In order to provide challenge and avoid mental overload, we proposed an adaptation of trainings based on dynamic diagnosis of abilities on different scales. However, the developed prototype provides a limited adaptation mechanism and is based on a static calculation. A learning system will dynamically react to long-term changes as well as to the daily form. Thus, an advanced adaptation algorithm will be implemented into the prototype and tested in comparison to the simple adaptation. Furthermore, social interaction contributes in maintaining cognitive abilities. Therefore, we will face the challenge of implementing an adaptive multi-user training in our further research. In our future work, we will investigate how adaptation for multiple users with different abilities and impairments can be achieved. By means of providing adapted training based on dynamic diagnosis for older adults with varying abilities, our goal is to contribute to maintaining a long and autonomous life.

Acknowledgements. The research presented in this contribution is conducted as part of the FamilyVision project, which is funded by the EXIST program of the German Ministry of Economics (BMWi) and the European Social Fund (ESF) and by the FLÜGGE program of the Bavarian State Ministry of Education, Science & Art.

References

1. Garcia Marin, J.A., Lawrence, E., Felix Navarro, K., Sax, C.: Heuristic Evaluation for Interactive Games within Elderly Users. In: Proceedings of eTELEMED 2011, pp. 130–133 (February 2011)
2. Alcañiz, M., Botella, C., Rey, B., Baños, R.M., Lozano, J.A., de la Vega, N.L., Castilla, D., Montesa, J., Hospitaler, A.: EMMA: An adaptive display for virtual therapy. In: Schmorrow, D.D., Reeves, L.M. (eds.) Augmented Cognition, HCII 2007. LNCS (LNAI), vol. 4565, pp. 258–265. Springer, Heidelberg (2007)
3. Ma, M., McNeill, M., Charles, D., McDonough, S., Crosbie, J., Oliver, L., McGoldrick, C.: Adaptive virtual reality games for rehabilitation of motor disorders. In: Stephanidis, C. (ed.) UAHCI 2007 (Part II). LNCS, vol. 4555, pp. 681–690. Springer, Heidelberg (2007)
4. Vogt, J., Luyten, K., Van den Bergh, J., Coninx, K., Meier, A.: Putting Dementia into Context. In: Winckler, M., Forbrig, P., Bernhaupt, R. (eds.) HCSE 2012. LNCS, vol. 7623, pp. 181–198. Springer, Heidelberg (2012)
5. Pielawa, L., Helmer, A., Brell, M., Hein, A.: Intelligent environments supporting the care of multi-morbid patients: a concept for patient-centered information management and therapy. In: Proceedings of ISABEL 2011(15). ACM (2011)
6. Wolf, P., Schmidt, A., Otte, J.P., Klein, M., Rollwage, S., König-Ries, B., Dettborn, T., Gabdulkhakova, A.: openAAL - the open source middleware for ambient-assisted living (AAL). In: AALIANCE Conference, March 11-12, Malaga, Spain (2010)
7. Brouilette, R.M., Foil, H., Fontenot, S., Correro, A., Allen, R., Martin, C.K., Bruce-Keller, A.J., Kxeller, J.N.: Feasibility, Reliability, and Validity of a Smartphone Based Application for the Assessment of Cognitive Function in the Elderly. PloS One 8(6), e65925 (2013)