Effects of interactive storytelling and quests in cognitive rehabilitation for adults

Mareike Gabele[1,2], Andrea Thoms[3], Julian Alpers[1,],
Steffi Hußlein[2] and Christian Hansen[1]

[1] Otto von Guericke University Magdeburg, Germany
[2] Magdeburg-Stendal University of Applied Sciences, Germany
[3] HASOMED GmbH, Paul-Ecke-Straße 1, 39114 Magdeburg, Germany
mareike@isg.cs.uni-magdeburg.de

Abstract. Software-based training in cognitive rehabilitation is often perceived as boring when used over a longer period. This may negatively affect adherence and therefore reduce therapy success. Regular use is essential and should be continued after clinical stay. In this work, medically approved therapy software for cognitive training of divided attention in clinical use is extended with suitable gamification elements. Based on interactive storytelling, we created a main quest for single-player about two training sections and demonstrate a method by a prototype to wrap it around the therapy. Based on an exploratory study in Germany with patients (n=4) and a control group with healthy participants (n=6), we found a subjectively perceived motivational tendency for patients to use the software without being exhausted or losing concentration. Patients stated interest in further use. This work lays a basis to influence motivation, for further clinical evaluations, and shows important fields for future research.

Keywords: Interactive Storytelling, Cognitive Software Training, Gamification

1 Introduction

Software-based cognitive training is effectively used in clinical therapy in cognitive rehabilitation [1]. Among others, this is performed after strokes, which are the leading cause of acquired disability in adulthood [2]. Depending on which part of the brain is affected, there may be motor impairment, speech and language disorders and cognitive deficits such as in working memory, logical thinking, visual processing or in alertness. Relearning skills or compensation of cognitive impairments can take several months or years. Regular functional training is highly relevant and usually has to be continued at home after inpatient rehabilitation. An observational study in home training showed that compliance varies strongly among patients in cognitive therapy, with more than half of the patients training insufficiently [3]. Without control of the therapist, as in the clinic, the conduct depends on own engagement. The goal of the training is unambiguous, but it is limited to the functional execution of the task, without addressing the interest. Boredom may reduce the adherence and less or unfocused conduct of training may reduce the success of rehabilitation. In eHealth, even a substantial number of users

drop out before the application is completed [4]. This shows one of the main problems, which is maintaining long-term motivation. To interrupt the attrition rate and create a long-term motivation, we propose a combination of a cognitive software training with a gamification element appropriate to the training task.

The contribution of this paper is a method for combining gamification, here by means of interactive storytelling and a quest, and cognitive therapy. We implement the concept prototypically and evaluate the subjectively perceived effect of interactive storytelling and quests on patients in cognitive therapy during use. A control group with healthy participants shows whether the effect is general or if there are particularities of patients that need to be considered in game design. Based on this first explorative study, we identify the potential for further development for long-term use in home training.

2 Related Work

The term storytelling is interpreted differently depending on its field of application (e.g. as a therapeutic technique, narration or branding). In the following, we use it as mechanics for a fictional narration, with the extension to interact and intervene in the storyline [5] as a gamification element. These are elements that are typically used in games, but are inserted in a different, non-game context [6]. There are successful approaches for the integration of level, achievements and the collection of items in software-based cognitive therapy [7]. However, these short-term rewards should be avoided if the goal is long-term motivation [8]. Short-term rewards are rewards that are effective at the moment they are received. But they can be effectively integrated into overall motivation concepts if they promote a long-term goal [9, 10], which may last from hours and days to weeks, months or years if it is divided into several progress loops.

Based on an earnest topic, serious games are used. These are games that are developed for non-entertainment purposes and with a serious background [6]. This approach is taken up in rehabilitation in the serious game Re-Mission 2 [11], in which children in cancer therapy control an avatar through the body that fights cancer cells. Storytelling or the use of narrative elements can be found in many games [12]. On a theoretical level, it incorporates a pre-designed story, but also includes integration of the player and enables freedom of interaction during the action [13]. Interactive stories may create a connection to the storyline for the user by making their own decisions and completing quests, and can make them curious about further progress for more than one session. An example in the health and fitness area for the integration of a training task into a story is "Zombies, Run" [14]. There a story is experienced in real time and combined with real running training and current goals. The successful use of software-based cognitive training with integration of storytelling in serious games is also demonstrated by the training series "Meister Cody" [15]. It tells the story of a journey and promotes arithmetic training for children with dyscalculia. Storytelling can thus be used as motivator and provide a useful structure for attractiveness of the task to be performed [16].

The development of our concept to combine cognitive software training with interactive storytelling and quests is, among others, based on the self-determination theory.

It is an effective model to increase the motivation in cognitive training and psychotherapy [17, 18] and addresses the three psychological needs with regard to intrinsic motivation [19]: competence, autonomy and social relatedness. Stories support the autonomy with respect to the meaningfulness of goals [20]. A further aspect mentioned by Sailer is the possibility of decision freedom. This addressed the autonomy by interactivity in storytelling. It creates the feeling of competence and self-efficacy, which supports the change of one's own behavior [21]. In addition, quests offer the possibility within a story to clearly define the goal of the user's action [22]. Thus, a long-term goal is defined, and intrinsic motivation is addressed concurrently. This may be used experimental as a long-term factor to manipulate adherence [23]. These theories are relevant as a basis for developing motivation and combating attrition in digital self-improvement programs [24]. Surveys have shown that patients express general interest in the combination of training and play [25]. Numerous general research results have been reported on the individual game elements [26, 27], but their effect on patients in rehabilitation has so far been neglected [27]. In games, gamification elements are often combined, so that the effectiveness of the individual elements cannot be clearly evaluated. Other data are based on surveys [28, 29], which can show a tendency but not the actual effect.

3 Concept Development

For our prototype, we used an existing software for cognitive training of divided attention in rehabilitation [30]. According to the developer, it is a frequently used training program due to its relation to the everyday life of patients. The task is to drive a car on the screen (see Fig. 1c) and to react correctly to visual and acoustic environmental stimuli. In this way, patients learn to divide their attention between different tasks. We integrated two car drives into the prototype to show the connection within one long training session or between several short training sessions. An important concept design challenge is that the training should be motivating over several training sessions. A further requirement resulting from the use of training in therapy is that the existing task cannot be changed in order to maintain its existing effectiveness. These requirements were worked out in collaboration with the developers of the training and with neuropsychologists. Dividing the story into short sections can be used to adjust the duration of the training individually for each patient. Thus a story can last several training days.

Our target group are patients with limited abilities in divided attention who perform software-based training within rehabilitation. The risk of suffering a stroke doubles with every decade from the age of 45 [26]. However, accidents can also cause brain damage earlier. Problematic in the target group are the uneven prior knowledge of games and technology, age-typical differences in user types [31], personal abilities and strength of acquired cognitive limitations. For people without connection to technology and games, it is relevant to create realistic scenarios with easy access and handling to train at home [10]. In concept and interaction development, we oriented to the group with fewer skills and previous knowledge. At the same time, we chose a setting with criminal cases that is familiar to most users from books or films. This makes it possible to tell a completed story with a main quest and an arc of tension. At the same time it

offers the possibility to repeat the training (car drive) within one training session or in other criminal cases. As an employee in a detective agency, patients can solve several cases, depending on the duration of the therapy. Each criminal case has its own main quest. The main quests in the criminal cases consists of solving a mystery and do not build on each other. The prototype exemplary shows one criminal case to be solved.

The participant takes the role of a new employee in a detective agency and supports a senior detective (Fig. 1a) in solving a criminal case. It is possible to choose between a female and a male senior detective. In the game, the quest giver, a woman, calls the participant and tells about a mysterious note found on the doorstep. The participant selects one of two possible routes and drives with the car to the woman. The woman gives some clues to solve the case. One of two possible clues can be selected (Fig. 1b) and thus the participant choose the route to follow with the car (Fig. 1c). The story ends with a visit to a carrier pigeon breeder (Fig. 1d) whose pigeon has lost the note. In the end, the case turns out to be more humorous than expected. Finally, a hint about the next case to be solved is given. This is intended to arouse interest for the next session.

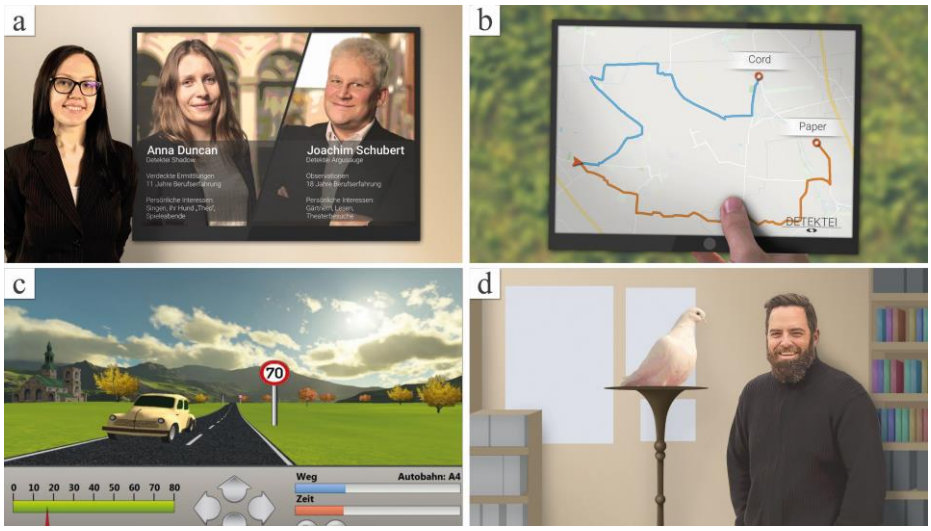

Fig. 1. Story and quest in which cognitive training is integrated: a) Selection of the detective to work with. On screen: Left: female, Right: male. b) Selection of the route to be driven. c) Task for cognitive training of divided attention by the means of a car ride. d) Resolution of the story.

The interactive story was created as one main quest with a simple fake choice architecture. The case is always resolved in the same way, but can be reached by variation at different turning points. The decision tree for the prototype was limited to three decisions, each with two options: the selection of the detective to work with, the route to the woman who called and the hint to follow. The structure of the story is based on a classical drama with exposition, climax and resolution. To this day, level structures and stories based on these are successfully used in game design [32]. Two car drives for training for divided attention are integrated. Thus, a connection between existing training (car drive) and gamification (interactive storytelling / quest) was created. It results

in a single-player game using the interaction with non-player characters. Because the goal is the training itself, it constitutes the largest part of the time (see Fig. 2).

A flat 2D representation with low complexity due to the limited cognitive abilities of the patients with focus on narrative dramaturgy was chosen. The focus is set on the elements relevant to the action in order to minimize the cognitive processing effort. We used a low level of detail in the illustration of the background and a higher level of detail in the visualization of the persons, objects and interactive elements that are important for telling the story. The selection of detectives is based on a resolute but friendly appearance. For the story we used a low fidelity click prototype, which was enhanced with audio files for speakers and background sound. This was combined with a Unity 3D [33] based version of the existing training for divided attention. Monitor, keyboard and mouse are used as input devices. These are known and do not influence the effect of the prototype.

4 Evaluation

The goals of the study were to analyze trends of possible positive and negative effects on physical and mental performance and the impact of interactive storytelling and quests on patients. Due to the qualitative explorative character of the study, we chose a small sample, which may provide starting points for further research. The study was conducted in Germany with patients in an outpatient clinic for cognitive neurology with heterogeneous causes of cognitive impairment (stroke, craniocerebral trauma, cerebral hemorrhage) and healthy participants in a control group to identify differences.

4.1 Participants

Two male and two female patients with cognitive impairment (n=4) in phases C and D, based on the German rehabilitation system, participated in the study. The average age was 44.5 years and the age range 31- 52 years. The control group consisted of two male and four female healthy participants (n=6) with an average age of 57 and the age range 51 - 66 years. All participants came from European cultures, took part voluntarily in the study and were not rewarded. In order not to influence the participants, they were not previously integrated into the design process. The age group is between 30 and 70 years. It was chosen because it includes both the age of patients with brain damage due to stroke and patients with brain damage due to an accident who tend to be younger than stroke patients. The average ages are this high, because experts stated that this corresponds to the distribution of patients with acquired brain damage with cognitive effects in the clinic. All patients suffer from cognitive impairments, are in rehabilitation and conduct cognitive trainings. They participated in addition to their standard therapy.

4.2 Methods and Material

The basis is the combination of interactive storytelling and quest with cognitive training for divided attention. This can influence the perception of training, the own physical

and mental performance and the interest in the training session. The prototype described in Section 3 was used in the study and a 30-minute training session was conducted. It was divided into two sections, which were carried out one after the other by the participants (see Fig. 2). This gives us an additional measuring point. The cliffhanger to the next section is generated when the caller shows the note that she has found.

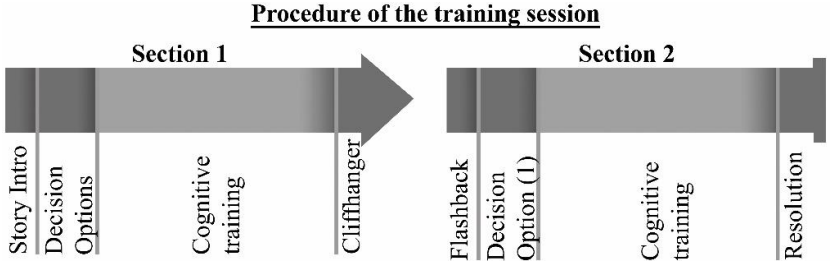

Fig. 2. Procedure of one training session with two sections based on the presented prototype and based on the combination of a cognitive training for divided attention, storytelling and quest

We asked questions about the training session and the own physical and mental condition, which were to be answered subjectively by the patients based on their personal perception. One part was to be assessed based on closed questions on a 5-point Likert scale. This provides the opportunity to give neutral answers, whereby ratings out of the neutral range can be considered more relevant. At the same time, it allows a comparison between the answers. The possible answers are divided into 1 (not at all), 2 (hardly), 3 (a bit), 4 (predominant), 5 (very). In another part, open qualitative questions were asked about the subjective experience of the training session. Thus, reasons for rating and feedback for optimization can be obtained without influencing the respondent with given answers. In the last part, participants were asked about their interest in further use. Three choices were offered: 1 (no), 2 (maybe), 3 (yes).

The structure was as follows:

a) After an explanation of the study, the participants gave their written consent.
b) Demographic data (including age, sex, education, experience in using computers, and neurological disease, if applicable) were collected.
c) Participants stated how motivated and exhausted they were before, between the sections and after the training session. They indicated whether they could concentrate on the task and stay focused. (closed questions)
d) After the training session, we evaluated the outcome regarding interest, perception of the interaction and combination of story and training and effects. (closed questions)
e) Participants were asked to describe in own words the task, the goal they had in mind during the training and aspects they liked and did not like. (open questions)
f) Finally, the participants stated whether they were interested in getting to know more cases of the detective agency and whether they would like to continue the training program at home. (closed questions)

4.3 Results

In the following, the questions we asked and the results are presented with regard to the structure presented in Section 4.2. Both the patients' and control group data are presented. Table 1 shows in relation to c) the progression from before the training, between the sections and after the training. Fig. 3 presents the results of the closed questions in relation to d). For this the Likert scale described in 4.2 is used. Further, conspicuous aspects of the data are described in detail. Afterwards, the results of the open questions in relation to e) are described text-based. Last Fig. 4 shows the results in relation to f).

Table 1. Subjective perception of the physical and mental condition before, in the middle and after the training session 1) of the patients and 2) of the control group.

1. Patients with acquired brain damages	**Training**		
Questions	before	middle	after
How motivated are you currently?	3,75	4,25	4,25
How exhausted are you currently?	3	3	3
Was it possible for you to concentrate and stay focused?	-	4,25	4,25
2. Healthy participants	**Training**		
Questions	before	middle	after
How motivated are you currently?	5	4,83	4,83
How exhausted are you currently?	1,66	2	2
Was it possible for you to concentrate and stay focused?	-	4,5	4,5

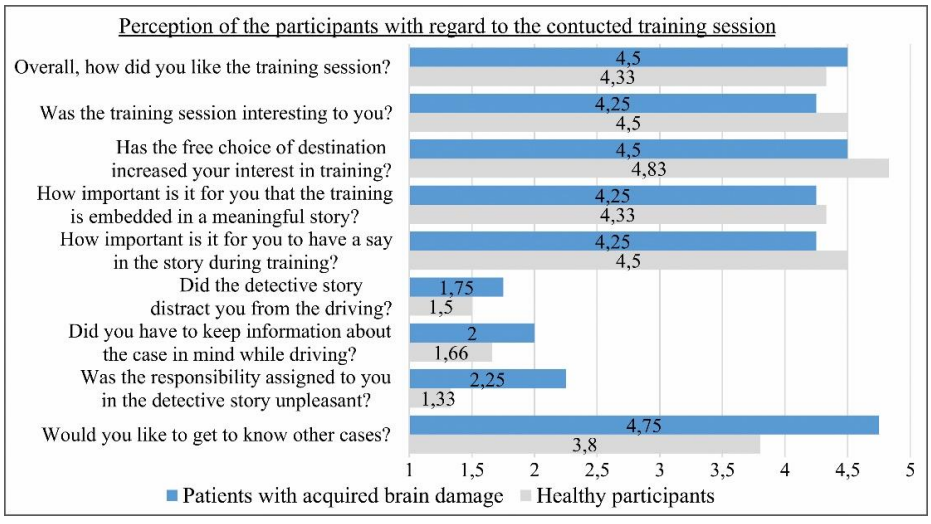

Fig. 3. Results of the questions after the explorative study with patients and control group

On average, the responsibility transferred to the patient by the quest was assessed as almost not unpleasant (2.25) on average. If the values are examined in detail, a wide range of ratings between 1 (not at all) and 5 (very) appears. In comparison, the healthy participants rated the transferred responsibility on average as not unpleasant at all (1.34) and in the distribution between predominantly 1 (not at all) to 3 (a bit) in one case.

On the basis of open questions e), participants were asked to describe in their own words the task they had carried out. Both the quest (solving the crime case) and the training (car drive) were indicated. The focus between the two varied among the participants. The same was shown with the goal that participants had during the task.

Overall, according to the trend shown in Fig. 3, the training sessions was also assessed positively in the open questions. In particular the combination between driving a car and solving the puzzle was mentioned as reason for this. With the patients, the focus was especially on the combination with the story. The reason stated for this was that the training is less boring. It has been reported from experiences in one's own environment that patients have lost their interest in training after several training sessions. It was suspected that the connection with the story may increase the motivation for the training. The control group, on the other hand, particularly focused on driving in the positive assessment. Concerning suggestions for improvement, the control group indicated that the story could even be closer to their own life. Both patients and control group expressed the wish that the difficulty could be higher. Participants were also asked about their interest in further use (Fig. 4): 1 (no), 2 (maybe), 3 (yes).

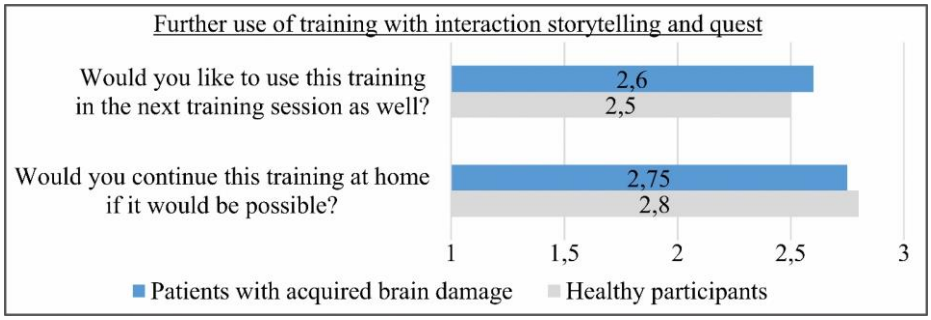

Fig. 4. Interest in further use of patients and control group in the clinic and in home training.

5 Discussion

In this work, we presented a method to combine a computer-based cognitive training for divided attention with interactive storytelling and quest, which led to a prototypical adventure game with a high driving share. We evaluated this exploratively on the effect on patients and a control group with healthy participants. Healthy participants were chosen to detect whether cognitive impairment may cause effects or whether effects also occur for healthy participants. However, this does not allow a comparison to the current training and level of possible efficacy. This will be tested in future steps. This work focuses on the subjectively perceived effects and whether they occur only with

patients. Due to the small number of participants, the results should be considered as a trend of the exploratory study and not be generalized. The results show starting points for further research focused on individual aspects. The study is a step to implement Killikelly's approach to use experimental factors to manipulate adherence [23]. It shows indications that interactive storytelling and quests may be a way to develop motivation and combat attrition. The results refer to patients with limitations in divided attention in rehabilitation phases C and D. For other limitations and other phases, they may differ.

The slight increase of motivation subjectively perceived in the course of the training c) might be due to the interest in combining training with interactive storytelling and a quest described in d), e) and f). It may also result from a comparison with other trainings known to patients which may be considered less interesting. In the control group, overall motivation is also very high, which indicates an interest in content. Nevertheless, it decreased slightly in the course of the study. This could be due to the fact that participants neither knew other training routines nor need the training they have performed, and are aware of it. This could also explain the slight increase in exhaustion. The fact that neither subjectively perceived exhaustion nor concentration decreased during the session is very relevant for the training. This indicates that there is no cognitive overload for patients that would reduce the cognitive abilities required for therapy.

Overall, the prototypical training session was assessed very positively. Due to the possibility to influence the storyline to solve the quest d) considered as relevant, a need for autonomy and relatedness in training may be assumed. This supports the selection of self-determination theory as the basis for the use of interactive storytelling and quest. [17, 18, 19]. However, its level in the current training and the needs have to be tested in corresponding questionnaires. The relevance of the meaningfulness of the embedding of the training [20] is also shown. In order to increase this and the level of relatedness, the patient could be involved in the development of new criminal cases. However, it should be critically investigated that some patients perceived the transferred responsibility as very unpleasant. This did not occur in the control group. The difference should be examined more closely with a higher number of participants. Interactive storytelling requires own decisions to solve the quest. If there are differences between healthy participants and patients, it should be investigated to what extent this is due to character traits or influenced by acquired brain damage. Interest in getting to know further cases confirms interest in this scenario, but leaves open whether interest in other scenarios would be higher or lower. It is particularly relevant that solving the case does not distract from driving and that not much information must be remembered. If this were not the case, other cognitive abilities than divided attention would have been addressed. According to experts, a combination of different trainings should be avoided.

With regard to e) patients have both training and story in focus during the session. This indicates that interactive storytelling with quest and training is not very distracting. The combination of the story and solving the quest was highlighted as positive by patients. Independently, it was assumed that this might increase the long-term interest of the training. This supports the intended use and shows the relevance of further research steps. The desire for a higher degree of difficulty can be based on the fact that the training in the prototype was set to a low level in order not to overstrain and thereby falsify the effect. This should be better adapted to the abilities of participants in future. The

desire for a closer connection to everyday life suggests that training might be adapted more to the rehabilitation goal of the patients. However, in the long term fun in training should also support this. It should be examined more closely which scenarios support the regular performance of the training. A free selection of a story may increase the interest in conducting training and the perceived autonomy.

The interest in using this in the next training session and independently at home underlines the positive evaluation and motivation shown above and supports further research steps. It should be considered how much the goal of the rehabilitation and how much the extension through storytelling and quest contribute to it. It is also interesting to note that healthy patients indicated that they will continue to use it. This indicates a high motivational factor due to the extension itself. Participants who indicated that they did not want to carry it out further expressed in e) at the same time that the level of difficulty should be higher. This could have had an influence on the decision.

In the present study no standardized questionnaires were used to adapt the questions to our prototype and to avoid additional cognitive effort by asking too many questions what may falsify the result. In following studies this may be changed for comparability.

Based on the presented method, the story can be extended to several training sessions by adding more content, or it can be divided into short quests depending on the patient's abilities. Currently, the session is designed not to be repeated. An adjustment of the structure for different dissolutions may be possible. This may increase the repetition of the training on different difficulty levels. In this situation, the question is whether a positive dissolution of the training session is necessary for motivating patients or not.

It should also be examined whether there is a different motivational effect on patients than by short-term gamification, like achievements and the collection of items [7, 8], and how they can be combined for which patients (e.g. for patients with limited memory). In this study, only minor differences between patients and healthy participants were found. However, it should be considered whether existing systems as well as those of the player types [34] are equally applicable.

The longer duration of the training with extension may be problematic for use in clinics. However, this probably does not influence the home training.

6 Conclusion

We demonstrated an approach to combine cognitive rehabilitation training for divided attention with interactive storytelling and quest as a gamification element and evaluated its effect on patients. The developed prototype was tested in an explorative study. Our results indicate that the subjectively perceived motivation of patients increases slightly during the training session. It was found that storytelling, quest as well as interactivity in combination with cognitive training are considered as meaningful by patients and that there is a high level of interest in their use. The combination shows potential for long-term and independent use in home training for patients. The assumption by patients that the expansion of cognitive training by storytelling and quest is more motivating in the long term than training itself supports the need for further research.

A possibility for flexible adaptation of the complexity and responsibility of content by decision possibilities for different patients can be created, as well as different resolutions of the story. It can also be further examined which topics are particularly suitable in terms of content for the development of scenarios in order to have a motivating effect. In addition, the difference between classic storytelling and interactive storytelling and quest can be considered in relation to the responsibility transferred to patients. The motivating effect of interactive storytelling and quests can be evaluated in a comparison group with classical cognitive training and a higher number of participants over several weeks. Furthermore, the effectiveness of the therapy can be evaluated and a clinical study can be conducted.

Acknowledgments. We would like to thank Juliane Weicker, Angelika Thöne-Otto and Michael Preier for the support in concept development and conducting the study. This work was funded by the European Regional Development Fund under the operation numbers ZS/2016/04/78123 and ZS/2017/01/83843 as part of the initiative ”Sachsen-Anhalt WISSENSCHAFT Schwerpunkte” and FEM-POWER under the operation number ZS/2016/09/81572.

References

1. Yoo C., Yong M., Chung J., Yang, J.: Effect of computerized cognitive rehabilitation program on cognitive function and activities of living in stroke patients. Journal of Physical Therapy Science 27(8), pp. 2487–2489 (2015).
2. Mendis, S.: Stroke disability and rehabilitation of stroke: World Health Organization perspective. International Journal of Stroke 8, 3-4 (2012).
3. Knop, A.: Hometraining kognitiver Störungen mit RehaCom. Präsentation, GNP-Tagung 2014. https://www.rehacom.de/fileadmin/user_upload/RehaCom/Mediathek/RehaCom-Hometraining-Anwendungsbeobachtung2014.pdf, last accessed 14.03.2018.
4. Eysenbach, G.: The law of attrition. Journal of Medical Internet Research 7(1) (2005).
5. Spierling, U.: Implicit creation non-programmer conceptual models for authoringin interactive digital storytelling. 1st Edition. Ph.D. thesis, University of Plymouth (2010)
6. Deterding, S., Khaled, R., Nacke, L., Dixon, D.: Gamification: Toward a definition. In: CHI 2011 Gamification Workshop Proceedings, pp. 12-15, Vancouver, Canada (2011).
7. Dobosz, K., Dobosz, M., Wojaczek, M.: Gamification of Cognitive Rehabilitation, In: Proceedings of 16th International Conference on Computers Helping People with Special Needs, pp 280-283, Springer Link, Linz, Austria (2018).
8. Nicholson, S.: A RECIPE for meaningful gamification. In: Gamification in education and business, pp. 1-20, Springer, New York (2015).
9. Gnauk, B., Dannecker, L. Hahmann, M.: Leveraging gamification in demand dispatch systems. In: Proceedings of the 2012 Joint EDBT/ICDT Workshops, pp. 103-110 ACM New York, NY, USA (2012).
10. Gerling K., Schulte, F., Masuch, M.: Designing and Evaluating Digital Games for Frail Elderly Persons. In: ACE’11 Proceedings of the 8th International Conference on Advances in Computer Enter-tainment Technology, (26). ACM New York, Lissabon (2011).
11. ReMission 2, http://www.re-mission2.org/ last access: 01.12.2018
12. Jenkins, H.: Game design as narrative Architecture. In: First person: new media as story, performance, and game, pp. 118-130, MIT Press, Cambridge (2004)

13. Simon, J.: Narrative, Games, and Theory. Game Studies - the international journal of computer game research 7(1), (2007).
14. Zombies, Run, https://zombiesrungame.com/, last access: 01.12.2018
15. Meister Cody, https://www.meistercody.com/, last accessed 01.12.2018
16. Reeve C.: Narrative-Based Serious Games. In: Serious Games on the Move, pp 73-89, Springer, New York (2009).
17. Cheek C, Fleming T, Lucassen MF, Bridgman H, Stasiak K, Shepherd M, Orpin P.:. Integrating Health Behavior Theory and Design Elements in Serious Games. JMIR Mental Health 2(2), article no. e11, (2015)
18. Ryan, R., Deci, E.: Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. American Psychologist 55, 68-76 (2000).
19. Ryan, R., Rigby, C., Przybylski, A.: The motivational pull of video games: A self-determination theory approach. Motivation and Emotion 30(4), 347-363 (2006).
20. Sailer, M. Ulrich Hense, J., Mayr, S., Mandl, H.: How gamification motivates: An experimental study of the effects of specific game design elements on psychological need satisfaction. Computers in Human Behavior 69, 371-380 (2017).
21. Bandura, A.: Self-efficacy: Toward a unifying theory of behavioral change. Psychological Review, 84 (2), 191–215 (1977).
22. Sailer, M., Hense, J., Mandl, H., & Klevers, M.: Psychological perspectives on motivation through gamification. Interaction Design and Architecture(s) Journal 19, 28-37 (2013).
23. Killikelly C., He, Z., Reeder, C., Wykes T.: Improving Adherence to Web-Based and Mobile Technologies for People With Psychosis: Systematic Review of New Potential Predictors of Adherence. JMIR mHealth and uHealth 5(7), 2017.
24. Birk, M., Mandryk, R.: Combating Attrition in Digital Self-Improvement Programs using Avatar Customization. In: Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems, Association for Computing Machinery, Inc, Montreal (2018).
25. Hung, Y., Huang, P., Chen, K., Chu, W.: What Do Stroke Patients Look for in Game-Based Rehabilitation: a survey study. Medicine 95(11) (2016).
26. Kelly-Hayes, K.: Influence of Age and Health Behaviors on Stroke Risk: Lessons from Longitudinal Studies. Journal of the American Geriatrics Society 58(2), 325-328 (2011).
27. Tăut, D., Pintea, S., Roovers, J., Mañanas, M., Băban, A.: Play seriously: Effectiveness of serious games and their features in motor rehabilitation. A meta-analysis. NeuroRehabilitation 41(1), 105-118, (2017).
28. Laamarti, F., Eid, M., El Saddik, A.: An Overview of Serious Games. International Journal of Computer Games Technology (2014).
29. Khaleel, F., Ashaari, N., Wook, T., Ismail, A.: Gamification Elements for Learning Applications. International Journal on Advanced Science Engineering Information Technology 6(6), 868 - 874 (2016).
30. RehaCom 2018, Therapy Module Divided Attention 2 (Geteilte Aufmerksamkeit 2), https://www.rehacom.de/geteilte-aufmerksamkeit-2.html last access 12.04.2018
31. Marczewski, M.: Considering Age and other factors in Gamification, https://www.gamified.uk/2018/06/20/considering-age-and-other-factors-in-gamification/, last accessed 2019/03/14.
32. Kampa, A., Haake, S., Burelli, P.: Storytelling in Serious Games. In: Entertainment Computing and Serious Games, pp. 521-540, Springer Verlag, Germany (2016).
33. Unity 3D, https://unity3d.com/de, last access: 21.12.2018
34. Tondello, G., Mora, A., Nacke, L.: Elements of Gameful Design Emerging from User Preferences, In: Proceedings of the Annual Symposium on Computer-Human Interaction in Play, pp. 129-142, ACM New York, Amsterdam, Netherlands (2017).