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Future Directions for ICT in Aphasia Therapy for Older Adults: Enhancing Current Practices Through Interdisciplinary Perspectives

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Summary

Growing numbers of older adults requiring aphasia therapy create challenges for the health care system. Information and communication technology (ICT) has the potential to provide computer-mediated, self-administered aphasia therapy that complements conventional therapy. We explore overlaps in ICT for older adults and aphasia therapy applications with the goal of integrating innovative ICT in aphasia therapy. Based on a case study, we explain how results of different disciplines developing ICT for older adults can be transferred in order to better support older adults with aphasia. We conclude with future directions for ICT in aphasia therapy by surveying interdisciplinary approaches that integrate best practices from conventional therapy, interface design, tracking technologies, user modelling, adaptation algorithms, playful design, user empowerment, and community interaction.

Introduction

Aphasia affects an increasing number of older adults in Europe (Steiner, 2011). Impairments that result from it include halting speech, struggles to find words, or incorrect changing of words or sentences (Schneider et al., 2012; Huber et al., 2013). Additionally, individuals may experience multi-morbid cognitive and physical decline resulting in poor concentration, rapid exhaustion, and mental overload (Freund, 2010). These aspects may lead to a loss of initiative, structure, and communication skills, thereby limiting social interaction and participation in work and private life (Steiner, 2011). At the same time, society faces a growing gap in healthcare services resulting from increasing medical needs and decreasing insurance coverage (Baron et al., 2005). Consequently, there is an increasing need of suitable means to facilitate healthy aging, including strategies to address age-related speech and language impairments. A variety of therapy measures has shown to influence aphasia

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symptoms considerably, but only if they are individualized (Graf et al., 2011) and conducted frequently (Sünderhauf et al., 2008). Studies underline that for achieving detectable effects on linguistic skills, an intensive therapy of at least five to ten hours each week for a minimum period of 11 weeks is necessary (Bhogal et al., 2003; Schneider et al., 2012; Grötzbach, 2010), especially in the first weeks after an incident. However, it is challenging for therapists to accommodate this increasing need of interventions means to support aphasia therapy. As a result of a lack of healthcare subsidies and an insufficient awareness of the importance of continuous therapy, only about a third of patients continue rehabilitation after stationary treatment (Schupp et al., 2006), even if explicitly advised (Rupp et al., 2008).

ICT has the potential to contribute in achieving a continuous and individualized training complementary to conventional therapy. In addition, data of the patients' progress can be gathered in order to facilitate long-term engagement with therapy. However, there are few examples where ICT has been implemented into aphasia therapy for older adults. For example, Martin et al. (2013) introduced a system for older adults with aphasia that provides short-term memory treatment. In a first evaluation with clinicians, it became clear that the interface and contents must be adapted to the user's needs and abilities in order to engage older adults in the training. This suggests that there is still huge potential for aphasia therapy in taking up innovative technologies and drawing from results of other disciplines where ICT-based therapy for older adults was successfully implemented. This article gives insights into recent ICT used in aphasia therapy as well as novel approaches in ICT for older adults that have the potential to enhance speech language therapy (SLT) for persons with aphasia. Based on a case study, we explain how technological innovations can be adapted, and argue that cooperation between different disciplines can provide benefits to create readily available, effective, and motivating aphasia therapy.

Current Approaches to ICT in Aphasia Therapy

Systems providing supportive ICT services are widely discussed, especially in the area of telehealth. Telehealth refers to the application of telecommunication technology for therapists and patients in order to provide healthcare services at a distance (Mashima & Doarn, 2009), e.g. to assist patient assessment and facilitate consultation (Baron et al., 2005). Telehealth applications have proven to be effective in a variety of settings, including aphasia therapy (cf. Rupp et al., 2008; Bilda et al., 2014).

Teleconsultation: Mediated Therapy

Patients and practitioners increasingly accept teleconsultation, an area of telehealth that refers to systems for mediating therapeutic sessions via ICT (Bilda et al., 2014). Research has shown that videoconferencing systems are a suitable means of providing SLT for a broad range of clients (Baron et al., 2005). Grogan-Johnson et al. (2010) compared videoconference-based therapy with face-to-face therapy for children with aphasia. They made similar progress with both methods. A comparative study of Gabel et al. (2013) confirmed these results,

showing that both means are similarly effective. These systems are usually deployed using stationary computers or tablet devices for connecting patients and therapists.

Many patients could benefit from mediating technologies, especially people with multiple impairments. For example, teleconsultation helps people with mobility issues to consult therapists without the need to travel, reducing time and financial effort (Baron et al., 2005). When considering the therapist's role in teleconsultation, an increased workload needs to be taken into account: Therapists need to learn how to use the system, monitor patient progress, and provide real time online consultation. As an additional effort to conventional therapy, spending multiple hours a week for teleconsultation with each patient is not feasible (Hall et al., 2013), but would be needed to fulfill the requirements of providing five to ten hours of therapy a week. In conclusion, teleconsultation offers advantages to patients and provides a valuable alternative for individuals with mobility impairments, but may be too time consuming for therapists, potentially reducing their willingness to adopt this approach.

Teletherapy: Digital Means for Intervention

Teletherapy, a term used for applications that provide in-home therapy, has shown to be effective to supplement conventional therapy (Rupp et al. 2008). Applications for teletherapy provide self-conducted training for patients and do not require a real-time supervision of therapists. Rupp et al. (2008) compared teletherapy to conventional therapy and to a group without therapy. Both types of therapy led to significant improvements in language skills, while there were no significant differences between groups, and the group that did not receive any therapy showing no improvement. Likewise, multiple projects including DiaTrain (Bilda et al., 2014) conduct ongoing research on long-term effects of self-conducted aphasia therapy.

Additionally, there is evidence that digital therapy had positive effects on aphasia symptoms. Studies on verb network strengthening treatment show improvements on lexical retrieval and single-word naming abilities. Increases in word output and decrease in typed neologisms could be achieved (Furnas & Edmonds, 2013). Further symptomatic therapy also showed to be effective: In a study on attention training for post-stroke aphasia symptoms, patients conducted three cognitive tasks on a computer in addition to conventional therapy. Patients with improved cognitive outcomes also showed an improvement of aphasic symptoms. These results show that computerized cognitive training is effective for aphasia symptoms for stroke patients (Graf et al., 2011), suggesting that teletherapy provides suitable means for aphasia treatment that can complement conventional therapy. Most tools are presented as web-based services on stationary computers or tablet devices, mainly focusing on in-home training. Hadood et al. (2010) successfully implemented naming practices into mobile devices. While most systems follow a one-size-fits-all approach, some applications allow speech therapists to adapt measures to individual patients. Still, this adjustment requires additional effort on behalf of therapists.

Teleassessment: Dynamic Diagnostics

Other effective methods in telehealth are store-and-forward technologies that trace information in one location and transmit it to a remote location (Baron et al., 2005). So-called teleassessment services are often combined with teletherapy. Thereby, therapists can monitor and adapt training remotely. This frequent diagnosis of a person's abilities enables therapist to diagnose a patient's progress by means of using quantitative assessments in addition to the interpersonal impression on a patient's abilities during therapy sessions (Vygotsky, 1978). Therapists receive a quantified patient profile (the health condition can be measured using different test batteries) and can compare how aphasia develops over time. Thereby, therapists receive long-term information on a patient's progress, which is helpful for face-to-face treatment (Sünderhauf et al., 2008), allowing SLT to be optimally individualized. However, a disadvantage of using teleassessment in terms of monitoring patients is an increased workload on behalf of the therapist. Transmitted data provides an overview over the SLT results, but systems do not analyze the aphasia status. The advantage that digital technology offers - to analyze and interpret information in addition to presenting it - is not yet integrated in aphasia teleassessment. To achieve a reliable analysis, standardized assessment batteries still need to be developed. Furthermore, while existing approaches require the approval for data transmission of the patient, technologies that record and transmit health data must consider all possible security issues when developing systems.

ICT in Aphasia Treatment for Older Adults

Even though there is an increased focus on ICT for aphasia therapy, older adults face various problems when interacting with them. One approach introduces memory treatment for older adults with aphasia. Within the first evaluation, the authors realized that in order to provide an effective and suitable training for older adults the system must be adapted. It requires elements for motivation and engagement, a proper representation of the user's state, more suitable (multimedia) contents, and it is too complex for the target group (Martin et al., 2013). These issues could also be observed in other approaches on ICT for older adults (cf. Burkhard & Koch, 2012), raising challenges for system designers when creating solutions that need to be accessible, useful, usable, and fun (Iwarsson & Ståhl, 2003). However, a lack of technology acceptance cannot always be ascribed to impairments of older adults. Rather than considering older adults as fragile and lonely individuals, the design of supportive ICT should acknowledge that ageing people have divergent interests and abilities, and are often times able to manage their well-being and impairments. Furthermore, numerous older adults actively contribute to society. Being a particularly heterogeneous audience, older adults are diverse in their expectations, experiences, abilities and needs, which challenges system designers to incorporate concepts such as customization and modularity of assistive system components (Durick et al., 2013). Therefore, applications in aphasia therapy that aim to address older adults must also consider adaptation mechanisms, especially when including people with co-morbidity. To this end, researchers and developers wishing to create systems for aphasia therapy for older adults can draw from existing work.

Approaches that SLT can take up from Other Disciplines

Research activities that individually support older adults implement a wide range of technologies, e.g. intelligent algorithms, sensor technology, or social network systems. Specific means include the enhancement of user experience, activity monitoring, user- and situation-based adaptation to individualize training, and approaches that increase well-being or activity motivation. In the following sections, we present examples of innovative technologies of ICT for older adults that open up future directions for aphasia therapy. Using a scenario-based design (Rosson & Carroll, 2001), we created a persona (Pruitt & Grudin, 2003) of an older adult, combining two real examples of older adults (91 and 65 years old) and taking into account the usual progress of post stroke aphasia (Schneider et al., 2012). Based on the case study of Paula, a woman living in a large town in Germany, we explain how approaches can be adapted.

Case Study

Paula is 75 years old and suffered a stroke five months ago. When she woke up after the stroke, she could barely understand what her son Martin was saying. She could not make up the sentences. When she tried to ask him about it, there was only quiet mumbling coming out of her mouth. Her doctors diagnosed global aphasia. During rehabilitation, she experienced rapid improvements, but these bad days, when no words seemed to be correct,really depressed her. With the support of Martin and a strong will, Paula managed to communicate in public again. While the words are mostly correct, sentence structures are still challenging for her - especially in situations when she needs to react quickly. Her speech therapist recommended her to practice at home. Thus, Paula is willing to try out technologies that may support her. In the last years, she used her mobile phone frequently and searched for information online on the tablet that Martin bought for her. Besides these two activities, she seldom used digital systems in her life. In addition, it is still hard for her to remember sequences of tasks. She gets confused when looking for information, or calling someone on her phone requires more than one single action.

Therapy Means and Innovative Interfaces

ICT is increasingly implemented in preventative and rehabilitative systems to address age-related impairments and support older adults. In gerontechnology, an interdisciplinary research field combining gerontology and technology, many innovative approaches were developed in the last decade, introducing a wide range of systems to support therapy and interaction paradigms that meet the needs of older adults. One area of interest is digital therapy or rehabilitation applications, transferring practices from conventional therapy or leisure activities of older adults. Such applications integrate multimedia content, and engage users, as for example demonstrated by Leirer et al. (2009) who implement auditory discrimination tasks to train cognitive functioning in older adults. Research also highlights the importance of designing content according to the user's interests. Studies on cognitive training with

older adults show that people are willing to conduct tasks by themselves when they are familiar with topics, e.g. certain sports, nature- or location-based topics (Kötteritzsch et al., 2014). Additionally, attempts have been made to model the interaction between users and ICT in order to ensure accessibility regardless of the impact of age-related changes. In order to facilitate interaction with ICT, research has explored movement of different parts of the body, speech and body signals (e.g. heart frequency of EEG activity) as input modalities. For example, gesture-based interaction has been applied in several rehabilitation applications for older adults (cf. Chen, 2013). Furthermore, spoken dialogue systems can be helpful for older adults (e.g., to manage appointments) if they are adapted to user behavior (Wolters et al., 2009). When planning interaction with digital aphasia therapy for older adults with varying abilities, novel approaches should be explored. Different means of interaction may be more or less suitable for individual tasks and users - for example, Curiel et al. (2013) found that older adults are faster using near field communication (NFC) tags while younger adults were faster with touch screens when using services on mobile devices. Generally, aphasia therapy applications could benefit from implementing these approaches of ICT for older adults. Figure 1 outlines a potential scenario in the context of our case study.

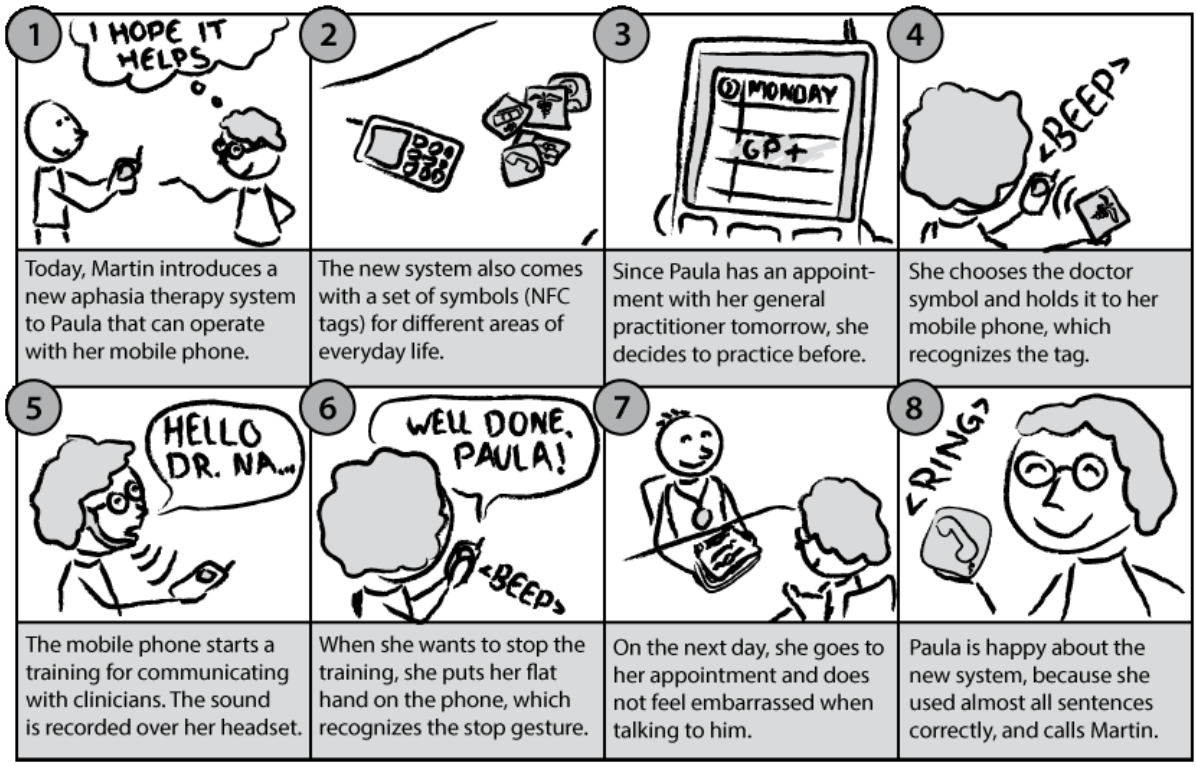

Figure 1: Scenario of location-based aphasia therapy using NFC tags and gesture-based interaction.

Knowledge Aggregation and Self-Adaptive Applications

Several assistive technologies provide support for diagnosis and therapy through the aggregation of knowledge and automatic adaptation. However, these tools can only be effective if they sufficiently consider impairments and needs of individual users. When offering services for older adults, there may be negative implications for therapy if accessibility goals are not met. For example, if an application fails to consider the cognitive state, therapy outcomes may decrease due to mental overload (Alcañiz et al., 2007). Research results stress the importance of adaptive technologies to engage older adults in training activities (Vera-Muñoz et al., 2009). Approaches that aim at enhancing well-being and autonomy of older adults increasingly recognize individualization of ICT. Research on user modelling, ambient intelligence, ubiquitous or pervasive computing, and internet of things (IOT) investigates how to create holistic patient profiles, and adapt applications based on specific user requirements. Novel sensor and tracking technology collects data that can be interpreted by intelligent algorithms (e.g. dynamic modelling and reconfiguration of user profiles). The information is used to trigger events in the system, e.g. alert a caregiver (Pielawa et al., 2013), automatically generate user interfaces (Abascal et al., 2009), or present individual information on large-screen displays (Yoon et al., 2007). One approach to adapt systems is the implementation of middleware platforms that aggregate sensor information and select services for the support of older adults based on it (Wolf et al., 2010). Furthermore, research on self-adaptive therapy systems for older adults demonstrated their effectiveness in several application contexts including cognitive (Kötteritzsch et al., 2014) and motor rehabilitation (Sisto et al., 2002; Smeddinck et al., 2013). Although these approaches have proven to be effective, they have not yet been implemented into aphasia therapy for older adults. With regard to the growing demand for readily available aphasia therapy, it is necessary that systems aim at creating a maximized outcome for the patient, but require minimal additional effort from therapists. Integrating dynamic diagnosis, advanced user modeling and adaptation techniques into the development of aphasia trainings may address the challenge of providing a suitable training for people with different abilities and requirements without the need of continuous supervision of therapists. The scenario in Figure 2 shows how an application for aphasia training could implement these technologies to track information and provide just-in-time therapy measures.

User Acceptance and Motivation

User acceptance and motivation are crucial when designing ICT systems for older adults, and an important step toward long-term engagement. Monotonous interaction and contents or unattractive design can result in high drop-out rates in the use of therapy applications, especially when the interaction itself is perceived as an effort that needs to be made before gaining access to any of the benefits therapy might offer (Romero et al., 2010). Lee (2007) conducted multiple studies on older adults' experiences with mobile phones, indicating that user satisfaction with a mobile phone was affected by perceived usefulness, ease of use and pleasure of use. For enhancing the user satisfaction and motivating older adults to

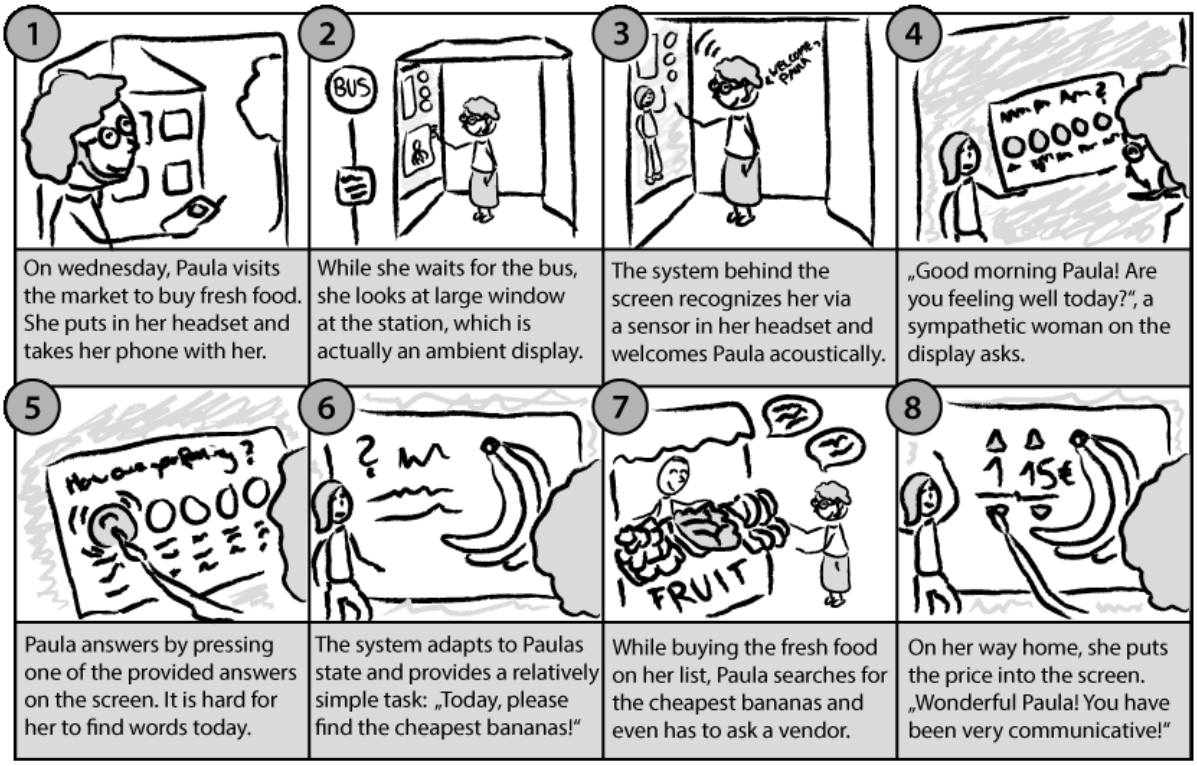

Figure 2: Scenario of adapting aphasia training based on the situation and user while interacting with ambient displays.

use a system, different approaches used gamification, which introduces game mechanisms or strategies into a serious application or context (Deterding et al., 2011). Often, systems for older adults apply scores, ranking lists, or awards to show that a user is making progress in an assigned task (Baumann et al., 2014; Vasconcelos et al., 2012). In contrast, serious games for older adults provide playful content and design in order to achieve serious goals (Connolly et al., 2012). Examples include the simulation of sports for rehabilitation (e.g., Connolly et al., 2012), virtual walks that engage older adults in social and physical activities (Gerling et al., 2011), memory games with pictures of relatives (Vasconcelos et al., 2012), and cooperative co-located and remote quiz games (Herrmanny et al., 2012). Playful approaches have shown to motivate older adults to engage in cognitive and physical activities (Connolly et al., 2012), increase a feeling of awareness (Hierhammer & Herrmanny, 2013) and overall well-being of older adults (Jung et al., 2009), and promote social interaction (Grimaldo et al., 2014). Another method to increase the acceptance of ICT for older adults is to provide transparent information and put the user into control. An example is the participatory telehealth platform introduced by Helal et al. (2012). The system collects information on the user, and represents the information to provide an overview of what is being transmitted. The user can control the tracking and transmission of information at any time. Other systems require explicit user actions to transmit data. A study by Zaad & Allouch (2008) shows that

perceived control over a system (asking for permission for transferring information gathered by the system) leads to a higher intention of using it. Finally, social community interaction and networking technologies can help to increase motivation in older adults, because they connect peers and enhance experience exchange. ICT can be used to share information on the own state, e.g. in video blogs after teletherapy sessions (Harley & Fitzpatrick, 2012), and talk about personal experiences with peers, for example, via smart TV applications (Alaoui & Lewkowicz, 2012). By integrating motivating elements, aphasia therapy applications for older adults have the potential to engage users and thus, ensure that patients receive a high frequency of aphasia therapy. A scenario on how these elements could be integrated is presented in Figure 3.

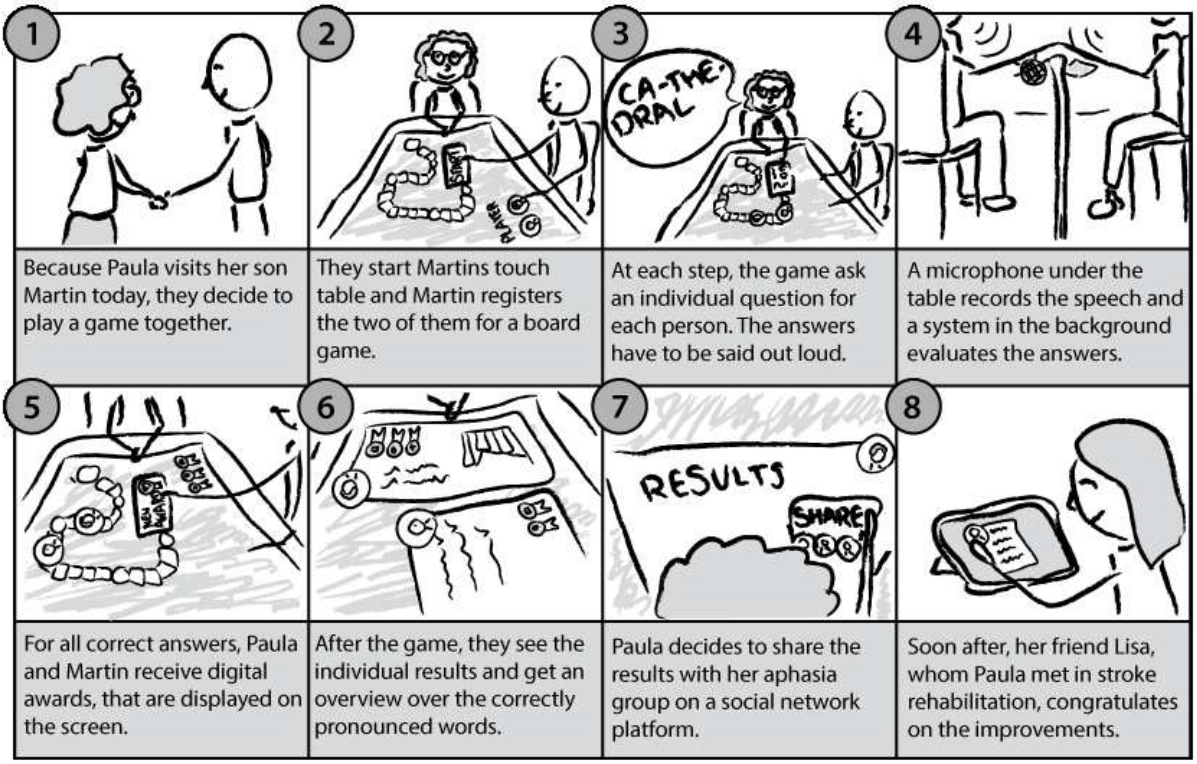

Figure 3: Scenario of a playful aphasia therapy that puts the user in control when sharing experiences with peers.

Future Directions: Interdisciplinary Approaches

ICT does not only provide possibilities for individualized complementary aphasia therapy, but offers potentials to integrate motivational and engaging elements for older adults experiencing age-related impairments. While the acceptance of ICT for complementary aphasia therapy grows - telehealth applications to assist face-to-face therapy are increasingly used in

aphasia therapy -, there is still a huge potential in taking up innovations from other research disciplines. Especially older adults who experience cognitive or motor impairments could easily practice their linguistic skills, with the therapist still being able to supervise the patient remotely. Additionally, the accessibility of therapy for patients with mobility impairments is increased, enabling them to conduct therapy continuously (Rupp et al., 2008). From the therapist's perspective, ICT would be beneficial as it could reduce workload by providing automatically processed analysis of information. Thus, there is an enormous benefit of implementing ICT in SLT for older adults with aphasia and therapists alike. Nevertheless, in order to benefit from innovative technologies and knowledge, research and development activities should strengthen interdisciplinary cooperation to leverage the full potential of therapeutic applications.

Interdisciplinary Activities

As stated in section 3, aphasia therapy for older adults could potentially benefit from applying approaches from different areas of computer science along with interdisciplinary research. Current interdisciplinary approaches already generate technological concepts and products for complementary aphasia therapy for older adults: Within a project of the Hogeschool van Arnhem en Nijmegen (HAN) and FamilyVision, an approach of using existing standardized assessments for providing adaptive dementia therapy (Kötteritzsch et al., 2014) was transferred to aphasia therapy (Peters et al., 2014). To this end, aphasia assessments (e.g. Aachen Aphasia Test) were analyzed regarding the required information for valid dynamic diagnostics, and evaluated in terms of feasibility for a digital therapy application. While the assessment of auditory comprehension, understanding the meaning of written text, cognition, categorization and association was easily integrated into the concept, assessment of written naming, writing from dictation, and writing neologisms from dictation provided challenges for technical accuracy. The results also showed that some assessments (e.g. spontaneous speech) were difficult to analyze using currently available technology. Nevertheless, parts of the analysis that can be automated could still lead to a reduction of workload in continuous diagnostics of aphasia. A second project (Schart et al., 2014) investigated assistive hints in SLT, which therapists apply when a patient is not able to manage a task. In a qualitative study, auditory, visual and tactile assistance measures (e.g., pointing on a picture) were analyzed with respect to frequency of use and the possibility to transfer them into a digital aphasia therapy. As a result, several auditory and visual hints were identified that could be integrated not only in digital aphasia therapy, but therapy and rehabilitation applications for older adults in general (e.g. limitation of answers, show an image, highlight or repeat parts of the task). Research by McGrenere et al. (2002) also underlines the importance of interdisciplinary approaches in ICT support for people with aphasia. The Aphasia Project conducted multiple studies in the attempt to explore alternative forms of communication using ICT. Based on the results, experts from computer science, psychology, audiology, and speech science cooperatively developed a PDA solution for communication support (Allen et al., 2007). Another alternative communication device successfully included context information gathered by sensor technology as well as speech and facial

recognition within an interdisciplinary approach (Kane et al., 2012). These activities show that approaches of creating solutions for people with aphasia can benefit from results from other research areas, and vice versa. Furthermore, Al Mahmud (2014) shares his experiences from two design research projects, providing recommendations on designing technology for people with aphasia. Thus, research on ICT in aphasia therapy for older adults should benefit from these experiences and take up research results in interdisciplinary approaches.

Summary and Conclusion

We summarized research efforts regarding ICT applications with a focus on supporting older adults, and described possible benefits of taking up innovations for aphasia therapy, which can be summarized as follows:

- **Content** for digital therapy has been generated in applications for older adults with cognitive impairments already. Due to overlaps in therapy objectives (e.g. training for cognitive functioning), these aspects could easily be applied to aphasia therapy.
- Guidelines for **user interface design** for older adults should be considered when developing aphasia therapy systems. Depending on individual needs, different interfaces may be suitable for providing intuitive interaction and should be further explored in the application context.
- **Tracking and interpretation** of user information is especially useful when systems have the goal to provide just-in-time support or are adapting to varying severity of aphasia symptoms.
- By integrating intelligent **user modeling and adaptation** techniques into tools for therapy, older adults with a range of abilities could be enabled to use these systems. Self-adaptive measurements for digital therapy at home complement SLT in providing continuous and highly frequent aphasia therapy means.
- **User experience** is important to engage patients to conduct aphasia therapy measures by themselves. A highly useful, usable and joyful system design can help patients to maintain engagement.
- Since play is a natural activity and spreads across all age groups, **playful approaches** in aphasia therapy have the potential to motivate older adults to accomplish different tasks without feeling a pressure to do so.
- It is important for applications that deal with health information to **empower users** to control gathered and shared data in order to avoid privacy issues. Easy to use and adaptable systems ensure that even people with little technology experience can keep track of system activities. The empowerment of people with aphasia by involving individuals in the system design process provides challenges for system developers (Galliers et al., 2012), but proves to be a key factor for the success of designing suitable solutions (Kane et al., 2012).

- By including peer groups and relatives into aphasia therapy, ICT for **connecting people** could increase social support, since aphasia rehabilitation requires a lot of energy and endurance from patients as well as patience and support from all people involved. In addition, communication, for which speech is essential, can be supported by shared practices.

This overview does not list all potential benefits of transferring ICT to complementary digital aphasia therapy. Further research approaches that apply ICT for supporting older adults offer many more perspectives. However, we were able to stress the importance of expanding the field of view when developing new concepts for aphasia therapy. To provide patient-centered, readily available and continuous SLT, research and practice must increase their efforts towards interdisciplinary approaches. When implementing advanced technologies, developers need to uptake the full potential of ICT and thus, consider information on the user and usage situation. With a cooperation of speech therapists, clinicians and system developers, these attempts have the potential to contribute in ensuring individualized and effective therapy.

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