Social Agency in an Interactive Training System

Norbert Reithinger and Ben Hennig

DFKI GmbH, Projektbüro Berlin,
Alt-Moabit 91c, D-10559 Berlin, Germany
norbert.reithinger@dfki.de

Abstract.
Interactive training systems often use avatars to depict an advisor that provides feedback on the exercise. In the framework of the SmartSenior project, which developed technologies for people with age related limitations, we realized an interactive trainer for stroke rehabilitation. The UI contained two avatars, one for the training person itself to provide feedback on her motion, and one for a physiotherapist, who guides the user through the exercises. In the study presented here, we looked especially at the social agency related aspects of this system. We tested the system using the AttrakDiff™ questionnaire and used the results to rate various aspects of social agentship.

Keywords: Interactive Training System, Social Agentship, Multimodal Interaction

1 Introduction

Interactive environments like games or training systems often use avatars that serve as communication partners in the flow of interaction. However, they are hardly explicitly developed with a focus on social agency.

In the context of the German SmartSenior[1] project we jointly developed different technologies to serve people with aged related limitations. With our partners Charité, Fraunhofer FOKUS, Nuromedia, Humotion, and Otto Bock we realized in the context of this project an interactive trainer – trainIT – for stroke rehabilitation [3,4]. During the development, the main emphasis was the clinical effectiveness of the training system. DFKI, the German Research Center for Artificial Intelligence, with its project office Berlin was responsible for the multimodal interface, and especially for the dialogic interaction.

The aspect of social agency of the system was only implicitly addressed at best. However, in the context of the EIT ICT Labs[2] activity "Computers as Social Actors" (CASA), we decided to conduct a separate study, especially looking into the hedonic

---

[1] http://www.smart-senior.de
[2] http://www.eitictlabs.eu

and pragmatic qualities that are good indicators for the social actorship of the system, independent of the initial target group of the system.

In the second section of this paper we give an overview of the trainIT system that we used for our usability test that is described in detail in section three. We use the AttrakDiff™ [3] questionnaire and website to measure the hedonic and pragmatic qualities of the system. In section four we present the categories for social actorship we agreed upon in the EIT ICT Labs CASA activity and rate our systems on the various dimensions.

2 Description of the system

2.1 System overview

The trainIT interactive training system integrates different sensor systems as well as multimodal input and output devices, controlled by a standard PC. To track the body movement we used in the tests a Kinect-based system, realized by Fraunhofer FOKUS. Additionally a custom-built inertial 3D-body sensor system was developed within the context of the project, which was not part of our test environment.

The body movements for the therapy exercises are mapped by a combination of both sensor types, Kinect and body sensors. The sensor data are analyzed in real-time and mapped to a body model displayed on the display in front of the user. Green, yellow or red lines mark the body's contours and provide immediate feedback for correct or incorrect movements. Additional comments are provided written and acoustically through the user's home TV. Figure 1 shows the basic building blocks of the system.

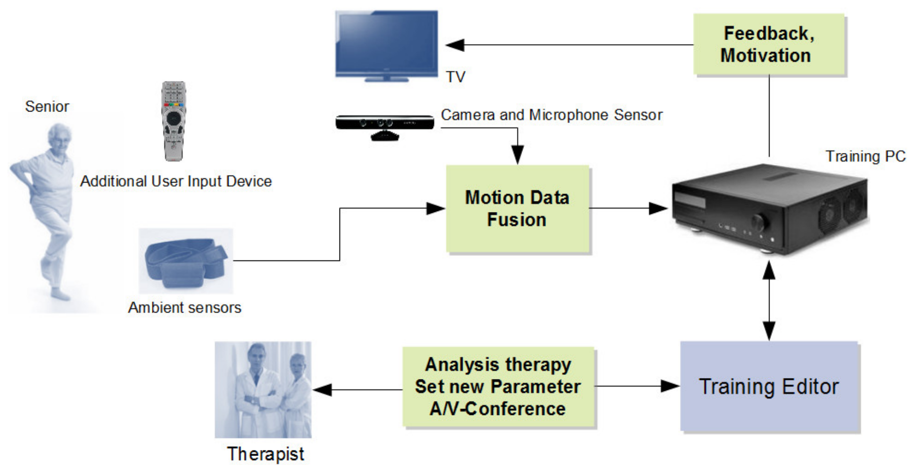

Fig. 1. Overview of the interactive training system

[3] http://www.attrakdiff.de/

Using a therapy editor, the therapist initially configures an individual training plan for the senior. Before starting a training session, the user gets her individual and actualized training plan from the online database, which is updated according to her personal training status. The database is located at Charité in Berlin, the largest geriatric clinic in Germany. After the training session, the training results are transmitted to the electronic health record in the safe and secure server back-end at the clinic. If needed, the system allows the patient also to get into contact with a therapist at Charité via A/V-communication as part of remote monitoring.

The design of the user interface including motivational elements is essential for user acceptance. To create familiarity with the training system in short time, we used an avatar-based approach, realized by Nuromedia. The therapist avatar talks to the user and visualizes reference movements. He or she – depending on the preferences of the user – provides personal interaction. The user avatar provides immediate feedback to her movements, functioning as a sort of mirror for the user. Immediate correctional feedback is provided through the color-coded body-parts (see above) and through comments from the therapist avatar.

The GUI is controlled by the "Interaction Manager" for user interaction and by the sensor engine for the animation of the user avatar (see [2,5,6] for some of the used technologies and approaches).

2.2 Related systems

For physical therapy, many projects exist to increase physical activity and to support motivational factors.

Within the project "GestureTek Health"[4] different gesture-control technologies exist for disability, hospital, mental health and educational sectors. For a virtual reality physical therapy, "GestureTek Health" developed a system called IREX™ (Interactive Rehabilitation and Exercise System). The system involves the user in a virtual game environment, where they are doing clinician prescribed therapeutic exercises. However it does not support a multimodal user interface.

The physical therapy system "Physiofun Balance Training" from Kaasa Health[5] is based on the Nintendo® Wii™ system. It uses the Wii console with a Wii Balance Board and a TV. A similar approach for a therapeutic balance test using comparable sensors is described by Dong et al. [1].

Ongoing projects for physical activities in rehabilitation are, e.g., PAMAP (Physical Activity Monitoring for Aging People)[6] and MyRehab[7], to name just a few. Our most

[4] http://www.gesturetekhealth.com
[5] http://www.kaasahealth.com
[6] http://www.pamap.org

recent search in German and EU project databases resulted in about 15 recently funded projects in that area. These systems usually analyze exercises and provide data for remote monitoring to be evaluated by a medical supervisor. They help patients to perform their rehabilitation and monitor their level of activity. Other projects[8] like Silvergame, age@home, KinectoTherapy, FoSIBLE, Eldergames, or Motivation also address the rehabilitation space. However all systems do not support a multimodal user interface, like ours does.

2.3 Scenario and Examples

To provide an insight in the interaction with the system, we will describe a short walk-through of the “One leg standing” training exercise for stroke patients.

The user starts the training system and is greeted by her virtual therapist. Then she is asked if she feels good or bad. The microphone is activated by the system, and she can reply, e.g., with “I'm fine”[9] or “I feel bad”. As an alternative to speech, she can also use the remote control: Button 1 for “I'm fine” or button 2 for “I feel bad”. The alternatives are presented on the screen clearly to address every available modality. In case the user feels bad, she is asked in the next step if she wants to be connected with her therapist. If the user wishes, a video call is initiated by the system. Otherwise, the system ends the training session. If the user feels OK, the exercise selection starts, which only shows the exercises that were previously selected by the therapist for the patient.

As an example, we describe briefly the therapeutic exercise "one leg standing" to improve the balance. All exercises, including the important posture parameters, were developed with physiotherapists. In that exercise the goal is to get the user to stand stable with a correct body posture on one leg. Here, the upper part of the body, the arms and the free leg should be kept stable. It starts in the upright standing. To stay in balance, the arms should be kept laterally with a small distance to the body. The next step is to pull up one knee, so that the angle between thigh and hip is 90 degrees. That position is to be held stable between 1 and 20 seconds, depending on the user's state of health. Right afterwards, she should repeat the procedure with the other leg. The evaluation during the exercise measures the upright posture without balance movements of arms, free leg or body, and the angle between thigh and hip. The described motion flow is used to specify the recognition, analysis and evaluation of therapeutic movements.

---

[7] http://www.first.fraunhofer.de/home/projekte/myrehab

[8] http://www.silvergame.eu/, http://www.joanneum.at/index.php?id=4243&L=0, http://www.kinectotherapy.in, http://fosible.eu/, http://www.eldergames.org/, http://www.motivotion.org/site/

[9] The German interactions are translated.

If the user has selected an exercise, it is explained, if desired. When an exercise is started, a start counter counts down, so that the user can prepare herself for the exercise. Then she follows the prescribed motion that is also visualized by the therapist's avatar (see fig.2, left). If the system detects a wrong move or a bad body posture, the user is immediately notified. We use different techniques simultaneously, voice announcement, acoustic signals and graphical feedback. When such an error occurs, the region with a bad posture is colored depending on the error level. The first error level is colored yellow.

For example, if the bearing of the upper part of the body is not correct, and the user leans back slightly, she immediately gets the friendly feedback not to lean back too far. If a critical error is detected, for example, if the user is almost falling down, the therapist gets a message to inform him about the critical event.

(a) One leg standing (b) Pass a river

Fig. 2. Example of a therapeutic exercise and the corresponding game

After an exercise, the user gets a break and then repeats the exercise. The therapist sets the break timing and repetitions in the therapeutic editor. In the end, the user receives an evaluation, which shows whether she has improved, or not.

Afterwards he has the opportunity to make another exercise or game (see fig.2, right). Motivation and retention to the training is of utmost importance. In addition to the training exercises we developed a game for each therapeutic exercise that takes up the theme of the therapeutic goal but has a more playful content. The following exercises including games are currently defined:

- Weight shift back and forth – Drive a motorboat
- Weight shift lateral standing – Slalom in standing
- One leg standing – Pass a river
- Weight shift lateral sitting – Slalom sitting

If no further exercises are scheduled, the therapist's avatar will initiate a dialog to terminate the session and the system shuts down.

3 Testing the system

3.1 Introduction and setup

As a result of discussions in the CASA goup, we decided to use the AttrakDiff™ questionnaire and website to measure the hedonic and pragmatic qualities of the system, using the results to infer the social attractiveness and agency of the system. To be perfectly clear about it: In this study we did not look into the effectiveness of the system wrt. stroke rehabilitation nor in the acceptance of the system in the initially targeted user group of the system! Our main goal was to measure the hedonic and pragmatic qualities of the system with persons from various backgrounds, thus gaining first insights in the overall user acceptance of our system. We used this opportunity also to get insights in the technical stability of the system, which worked without flaws during the tests.

AttrakDiff™ is an instrument for measuring the attractiveness of interactive products.[10] With the help of pairs of opposite adjectives, users (or potential users) can indicate their perception of the product. These adjective-pairs make a collation of the test dimensions possible. The following product dimensions are tested:

- Pragmatic Quality (**PQ**): Describes the usability of a product and indicates how successfully users are in achieving their goals using the product.
- Hedonic quality - Stimulation (**HQ-S**): People have an inherent need to develop and move forward. This dimension indicates to what extent the product can support those needs in terms of novel, interesting, and stimulating functions, contents, and interaction- and presentation-styles.
- Hedonic Quality - Identity (**HQ-I**): Indicates to what extent the product allows the user to identify with it.
- Attractiveness (**ATT**): Describes a global value of the product based on the quality perception.

Hedonic and pragmatic qualities are independent of one another, and contribute equally to the rating of attractiveness.

3.2 Participants and task

For our test we recruited 19 users from the Berlin region, either internally from the DFKI office in Berlin or externally. None of the subjects participated in the development of the system. The interaction sessions were either run at DFKI or at the homes of the users. The distribution wrt. age, gender and education is as follows:

[10] In this section we use and/or paraphrase graphical results and texts from the English report the website generates without special quoting. The evaluation was done in German.

Age	20 to 39	16
	41 to 60	2
	over 60	1
Gender	Male	13
	Female	6
Education	Lower Secondary Education	2
	Higher Secondary Education	2
	University	15

The tasks each participant had to fulfill was to perform one exercise and one game. All users were able to successfully perform their task.

3.3 Results and interpretation

In the portfolio-presentation, see fig. 3, the values of hedonic quality are represented on the vertical axis (bottom = low value). The horizontal axis represents the value of the pragmatic quality (i.e. left = a low value). The medium value of the dimensions are depicted with P and the confidence rectangle as . The confidence rectangle presents the users agreement in their evaluation of the product.

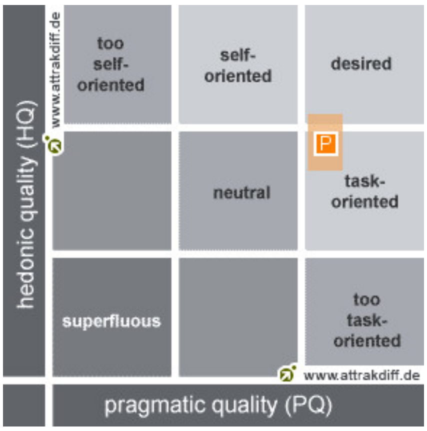

Fig. 3. Portfolio with average values of the dimensions PQ and HQ and the confidence rectangle of trainIT

Depending on the dimensions values the product will lie in one or more "character-regions". The bigger the confidence rectangle the less sure one can be to which region it belongs. A small confidence rectangle is an advantage because it means that the investigation results are more reliable and less coincidental. The bigger the confidence rectangle, the more variable the evaluation ratings are.

Overall, the trainIT system was rated as "*fairly practice-oriented*". The ***pragmatic quality*** is obviously high. The user is assisted by the system, and it is task oriented, but not too much. In terms of ***hedonic quality*** the character classification does clearly not apply because the confidence interval spills out over the character zone. The user is stimulated by the system, however the hedonic value is only slight above average. Since the confidence rectangle is small, the users agree in their evaluation of the system.

Detailed Analysis. The average values of the AttrakDiff™ dimensions for the system are plotted in fig. 4. In this presentation hedonic quality distinguishes between the aspects of stimulation (HQ-S) and identity (HQ-I). Furthermore the rating of product quality (PQ) and attractiveness (ATT) are presented.

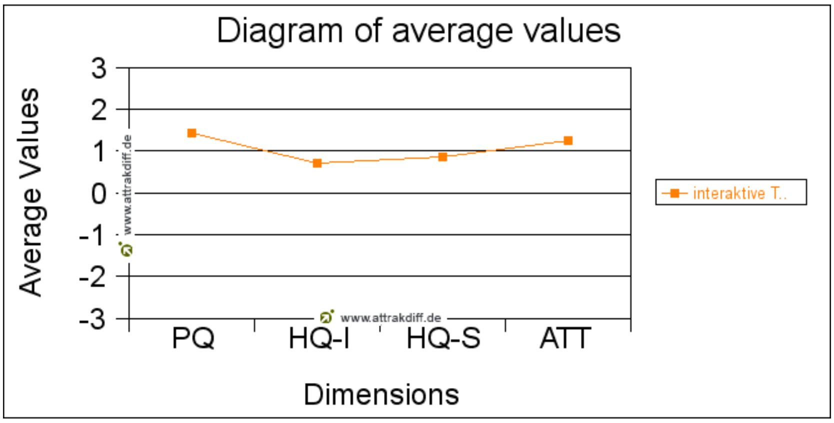

Fig. 4. Mean values of the four AttrakDiff™ dimensions for trainIT

With regards to hedonic quality – identity (HQ-I), the product is located in the average region. It provides the user with identification and thus meets well the standards. With regard to hedonic quality – stimulation (HQ-S), the product is also located in the slightly above average. The product's attractiveness value (ATT) is located in the above-average region, so the system is very attractive.

Description of Word-pairs. The mean values of the word pairs from the online questionnaire are presented in fig. 5. Of particular interest are the extreme values. These show which characteristics are particularly critical or particularly well resolved. Only on the world pairs "separates me – brings me closer" and "cautious – bold" are in the negative sector. The first value is obviously true: A training with a human person is more desirable than a training at home with remote interactions. The second word pair is actually good for this type of interactive system. Since the user should be cautious and should not overextend their training, this is a good indicator that we met one of the intended goals of the system.

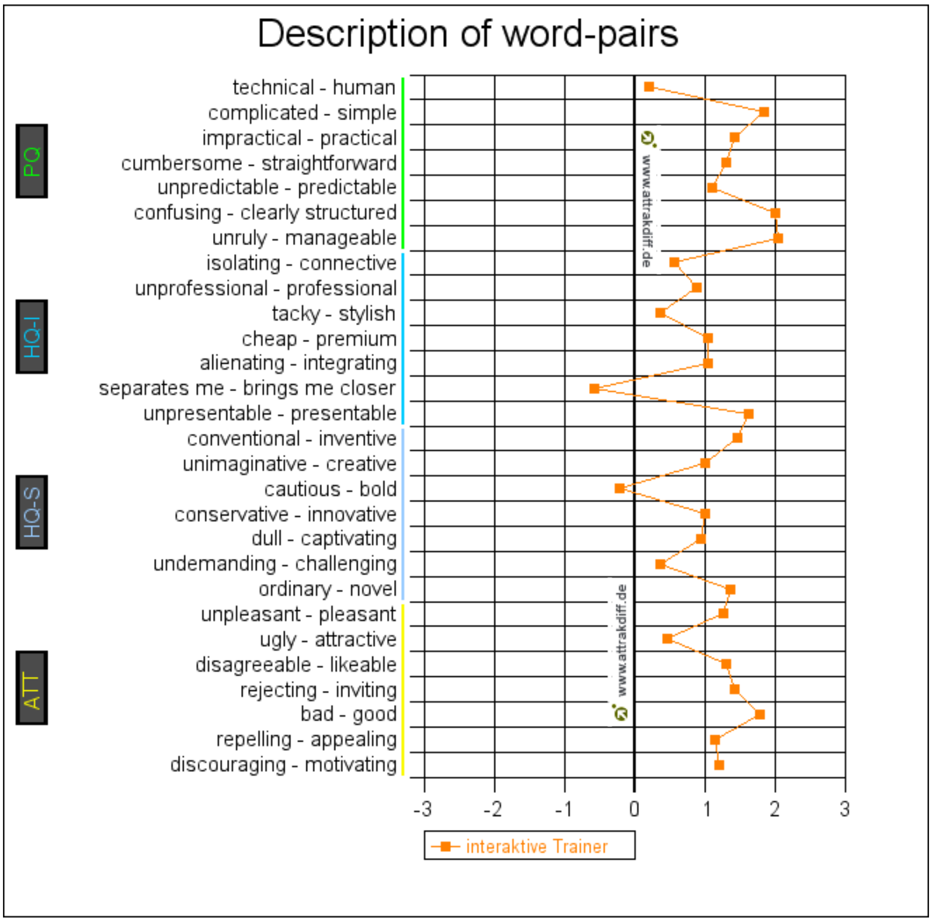

Fig. 5. Mean values of the AttrakDiff™ word pairs for trainIT

4 Social actorship in trainIT

Within the "Computers as a Social Actor" activity, we tried to come up with a common definition with some clear-cut criteria for social actorship. We developed the following definition of Social Actorship[11]:

> *Ability of the system to act in a **social context**, with **an implicit or explicit goal**. From the user perspective, Actorship is a characteristic of the system that makes the user **perceiving it as a human actor** to which s/he can direct*

[11] Source: Internal working document of the EIT ICTLabs Activity „Computers as a Social Actor", 2012.

their ***attention*** *and have* ***attention*** *in return (This can be explained by the Mirror Concept: the system that sense something and acts in response). Although, some systems could be seen as just a mediating actor, like mobile phone and ICT in general that fosters social interaction among people. In this case social actorship is seen as* ***the ability to influence and support the social life*** *of people.*

We agreed to focus on specific dimensions that define a system as a social actor. The dimensions are:

1. *Awareness*
2. *Intelligence=Intentionality*
3. *Embodiment: language, face, body*
4. *Social perception*
5. *Task/Goal of the system*
6. *Nature of the system: social tool-mediator-actor*

trainIT addresses most of the dimensions, defining actorship: it is aware of the user through the various sensors, it interacts intentionally, using a dialog strategy that reacts on the users' multimodal input, is embodied by an avatar, and has clear tasks and goals. In the above definition, we highlighted the main issues that are addressed by trainIT. The system was designed to act in the special context of rehabilitation, where people feel weak and sometimes out of touch with their usual social environment. The system's main goal is to engage the user in rehabilitation exercises. Through the use of a therapist avatar that is also talking to the user, the system creates the perception of a personal bond. The sensor feedback is also channeled through the avatar thus influencing the training exercise.

In detail we address:

- ***Social context****, with* ***an implicit or explicit goal****.*
  trainIT is tailored to help persons in a clear social context: being alone at home and getting back to be healthy again after a stroke. The explicit overarching goal is to go through a training plan set up by a physiotherapist, which broken down in various subgoals implicit in the various training sessions. This addresses especially dimension 5 (Task/Goal of the system). The test shows that the system has a pretty good pragmatic quality, i.e., that the users could interact with it successfully, even tough the test persons were
- *System that makes the user* ***perceiving it as a human actor***
  This goal is reached through, amongst others, a virtual actor that stands in as the person's physiotherapist. This therapist is able to carry out a spoken dialog about the training, supervises the exercises, as recorded by the sensors, motivates, and provides feedback. This addresses especially dimensions 6 (Nature of the system: social tool-mediator-actor), 2 (Intelligence=Intentionality) and 3 (Embodiment: language, face, body). The Hedonic Quality – Identity category in the tests relates to this dimension. As noted above the "*separates me – brings me*

closer" indicates that the non-human interaction is clearly noticed and valued negatively.

- *To which s/he can direct his/her* ***attention*** *and have* ***attention*** *in return*
  The person performing the exercise gets immediate attention to its performances, as measured by the sensors, both visually and through speech. E.g. corrections of the posture are signaled by sentences like "Please do not lean that far back". This addresses especially dimension 1 (Awareness). The word pairs from the Hedonic quality – Stimulation category in the tests show that the system stimulates mostly, even though the interaction is seen as *cautious*. Taking into account the target group of the system, namely mostly elderly people, this might actually be a good sign.
- ***The ability to influence and support the social life*** *of people.*
  Through the system the person gets immediate feedback to her performance and also can be sure that the performance results are channeled back to the telemedicine centre. Both the persons using trainIT and a supervisor at the centre can establish a direct interaction using a high definition videoconference solution built in the system. Thus the persons who have suffered a stroke and are not yet as mobile as before know there is a direct link that supports them, if necessary. As this group of persons often has problems taking up a normal life again, the system provides, besides the training, to support stability. This addresses partially dimension 4 (Social perception). The results in the Attractiveness category of the test mostly relate to this dimension: Only if the user considers the system positively in this category she or he might be willing to integrate the system in the daily life.

5 CONCLUSIONS

The study presented the trainIT interactive training system for stroke rehabilitation. We performed a reasonable sized usability test of the system using a standardized approach. We used it to categorize the social aspects of the system, which, on the one hand provides assurance in the work already done, and on the other hand, shows deficiencies that must be addressed in future versions of the system. As there is still no "standard" way to address social agency, usability tests like the one presented using more product oriented standard test tools are only a first step towards more elaborate testing schemes. Future activities continuing a CASA like theme could be very helpful in leveraging the results of this study and look deeper in the social aspects of personalized, interactive, agent based systems, which will become even more prominent in the immediate future.

The study shows that, even as a result of a research projects, trainIT is already desirable and attractive to a general audience, and thus, hopefully, also to potential customers. The system clearly was successfully tested on various categories that can be related to social actorship.

Acknowledgments

The work presented here was funded in parts by the German Federal Ministry of Education and Research under grant number 16KT0902 (Project SmartSenior) and in parts by EIT ICT Labs Activity 12124 (Computers as Social Actors). The responsibility for this publication lies with the authors. Thanks to Aaron Ruß for helpful comments.

References

1. Dong, L., Tan, M.S., Ang, W.T. and Ng C.K..: Interactive rehabilitation. i-CREATe'09 Proceedings of the 3rd International Convention on Rehabilitation Engineering & Assistive Technology (2009)
2. Gebhard, P., Kipp, M., Klesen, M. and Rist, T.: Authoring scenes for adaptive, interactive performance. Proceedings of the Second International Joint Conference on Autonomous Agents and Multiagent Systems, Second International Joint Conference on Autonomous Agents and Multiagent Systems (2003)
3. Hennig B., N. Reithinger: Development of a Multimodal Interactive Training System in Therapeutic Calisthenics for Elderly People. Proc. of KI 2012, Springer Verlag (2012)
4. John, M., Klose, S., Kock, G., Jendreck, M., Feichtinger, R., Hennig, B., Reithinger, N., Kiselev, J., Gövercin, M., Kausch, S., Polak, M. and Irmscher, B.: Smartsenior's interactive trainer - development of an interactive system for a home-based fall prevention training for elderly people. Advanced Technologies and Societal Change, 7:305-316 (2012)
5. McTear, M.F.: Spoken dialogue technology: Enabling the conversational user interface. ACM Computing Surveys (CSUR), 34(1):90-169 (2002)
   Nass, C., Steuer, J., and Tauber, E.R.: Computers are social actors. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '94). ACM, New York, NY, USA, 72-78 (1994)
6. Wahlster, W., editor. SmartKom: Foundations of Multimodal Dialogue Systems. Springer-Verlag, Berlin and Heidelberg (2006)