A conversational virtual human as autonomous assistant for elderly and cognitively impaired users? Social acceptability and design considerations

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Abstract: In this paper we explore how a conversational virtual human could be designed to be deployed as a socially acceptable autonomous assistive system for elderly and cognitively impaired users. In particular, we focus on a system's functionality in helping to maintain a well-structured daily life. We present initial findings from two types of studies: (1) Conducting interviews and focus groups considering users' attitudes and design considerations for assistance in maintaining well-structured daily routines and (2) analyzing interaction between the system and its users' while entering data into a calendar application. Analysis has revealed a set of design considerations for developing a socially acceptable system. Micro-analytic investigation of one user's concrete interaction with a Wizard-of-Oz version of the system has shown that a cognitively impaired person is able – by himself and only through interacting with the system – to gain insights into the system's possibilities and limits and to mistrust the system's competencies once the system initiates a repair sequence.

1 Introduction

In the last decade, the consequences of the demographic change towards a society with a growing number of elderly people have become a topic of general discussion: More and more people experience difficulties in realizing their everyday tasks due to increasing physical limitations and decreases in their cognitive abilities. Not only household activities become difficult, but also daily routines, such as reminding oneself of appointments, timely intake of medication and preserving structures of everyday life with regular meal-times etc. However, demographic studies forecast an increasing lack of human caretakers to handle these growing demands. Thus, the question arises in which ways these societal needs could be best supported. Enabling elderly (and also younger cognitivley impaired) people to lead, as long as possible, an autonomous life in their homes and social environment becomes an important task. A range of technical facilities have been developed to support such issues, and more recently, research has

begun to explore to which extent novel forms of autononous systems could be deployed. This leads to incertitudes among the prospective users, and concerns revolve, at first sight, around the fear of handling a novel technology, the role of sensors in home environments or the loss of social contacts. Thus, the central question arises how systems could be best designed to meet the users' needs in a way as to be socially acceptable. Given the increasing permeation of our daily lives with novel forms of technology, Harper et al. suggest that the typical research cycle of user-centered design needs to be complemented by an explicit consideration of ethical questions and a discussion about relevant societal norms and values [Ha08]. Thus, technological innovation needs to start from the users' needs and include a discussion about its social acceptability.

Against this background, the VASA project aims at developing assistance for maintaining a well-structured day and at exploring the dimensions of both its usability, social acceptability and effects on the users' daily routines. In particular, a system using a conversational virtual human is developed, which – in a first step – comprises a calendar application. It should allow the user to enter new appointments by means of natural communication [YKPK13] and provide reminders at predefined moments in time. To explore the scale of the users' needs with increasingly reduced capacities of working memory or concentration, two user groups are investigated: senior citizens and people with congenital or acquired cognitive impairments. At an early stage of the project, we aim at understanding the future users' needs and current practices in order to provide considerations for the system design. Thus, in this paper we address the following questions: (1) What actual needs of assistance occur in the participants' everyday lives? (2) What are the participants attitudes with regard to a virtual assistant and how should an assistance system be designed to be socially acceptable? Could we find any changes in the participants' attitudes once they have interacted with the system? (3) What competencies do users ascribe to the system? Would they eventually establish routines in interaction with the system?

In this paper, we present the background on social acceptance of assistive technologies, such as robots and virtual agents (section 2) and introduce our methodological approach (section 3). We present initial findings from two studies: In section 4, we investigate the users' attitudes towards a technical assistance systems exploring their actual suggestions, needs of support in handling daily routines of everyday life (section 4) and suggest considerations for designing a socially acceptable system. In section 5, we investigate the users' interaction with the system and how its conversational strategies might support the user in realizing and repairing problems of understanding.

2 Background

Applying autonomous systems – whether robots, virtual agents etc. – to the real world and the users' everyday life – does not solely induce issues of the system's functionality and usability. In addition the question arises how a system needs to be designed to be socially acceptable. In recent years, a range of studies investigated the users' attitudes towards modern technology and the social acceptance of autonomous systems. Meyer

explored – based on qualitative interviews and quantitative questionnaires – aspects that can increase or decrease the acceptance of service and social robots. Findings show that social robots are accepted more easily, if they have positive impacts on autonomy and self-determination of elderly people [Me11]. Both aspects, autonomy and self-determination, seem to be extensively relevant because they prevent the need of moving a stationary care facility. In what follows it has to be shown which influencing factors on acceptance of a virtual assistants were already mentioned. Krämer finds [Kr08] that an agent is accepted more easily by ist users when he has a specific role. As Perez et al. found through qualitative interviews with participants that live in their own home it is conceivable that robots for instance could remind people of medication, cleaning or fitness workout [PKE12]. So the purpose of technology is one aspect of acceptance. Another aspect of acceptance concerns the physical appearance of technology. The theory of the „uncanny valley“ assumes that the extent of anthropomorphic design influences the users' perception [Ma05]. An autonomous system should not be too humanlike or it will cause irritation and frighten its users. Meyer's study [Me11] shows that elderly participants indeed would be frightened by social robots that are too humanlike. Krämer [Kr08] finds that the appearance of a virtual agent has an impact on the users' perceived efficiency and acceptance of the system. However, her findings show, on the contrary, that a more humanlike interface gains more trust by the user. A system that behaves in a more humanoid way made the user act more humanly. Krämer concludes that the presence of a socially acting system seems to cause similar emotional reactions as in human-human-interactions.

Furthermore, Meyer shows [Me11] that a robot has to respect the individual intimacy of its users and should not be an omnipresent entity. Therefore, a robot has to knock before entering a room. The presence of a virtual assistant is conducted on screen, since it is not physically mobile. The GUIDE Project [Gu11] found that avatars should disappear in problem-free interaction, but should automatically reappear when a task problem was detected. This means that both, robot and agent, should not be present all the time. Meyer further concludes that a system has to be reactive and is only allowed to talk, when the user recommands talking [Me11]. This brings us to issues on concrecte interaction (for this term see critically Krummheuer [Kr10]) between the system and its users. Krämer underlines the relevance of modalities like gaze and gestures [Kr08.] for acceptance of an autonomous system. She reveals that when an agent gazes at the user, he is more easily convinced of the system's competences and gazes at the agent more often. This relevance of mulitmodality is consistent with the results of Williamson et al. [WMB12]. They conclude that the participants generally prefer interaction (in which the system reminds them of something) to be initiated in an unimodal but continued in a multimodal way if more information was required. There is a lack of data showing concrete interaction between both user groups, the elderly and the cognitively impaired people, and a technical system that offers a capable dialogue system, since most of the reported research focuses on technical systems with limited dialogue capabilities.

Conceptualizing social acceptance, Heerink et al. propose the 'Almere model' [HKEW10] based on the enhanced Unified Theory of Acceptance and Use of Technology [VMDD02]. The 'Almere model' reveals the correlating constructs: Anxiety, Attitude towards technology, Facilitating conditions, Intention to Use, Perceived

adaptiveness, Perceived Enjoyment, Perceived Ease of Use, Perceived Sociability, Perceived Usefulness, Social Influence, Social Presence, Trust, Use. Heerink et al. showed that it depends on the context, the system and to the purpose of use, to which extent these conditional constructs influence processes of acceptance [HKEW10]. In addition, it was found that attitude towards technology has impacts on acceptance as it affects the intention to use the system. Although findings of Heerink et al. give detailed illustration about the factors that could determine processes of acceptance and how they influence each other, it lacks issues that can be seen on the surface of concrete interaction. Also, the interactive abilities of the technical systems deployed (iCat, RoboCare, Steffie) were restricted and did not concern the users' needs in everyday life. Maybe thus, they could be regarded as less relevant by participants. In sum, related work has shown the relevance of these topics and the concept of (social) acceptance is currently investigated in HCI research from various perspectives. But only very few papers assessing social acceptance do take user studies, quantitative and qualitative instruments (especially focus groups) into account similarly. Also, there is need of research exploring the progression of social acceptability – especially if a virtual assistant is introduced into everyday life – and its influences on the participants' daily routines and activities.

3 Method: Integrating participatory design with micro-analysis

To investigate how the users' everyday lives are organized and what their actual needs of assistance are, a stepwise process has been adapted: (1) To gain some first insights into the ideas and attitudes of elderly people, guided interviews – as reported by Meyer [Me11] or Pérez et al. [PKE12] – with a few senior citizens were conducted. Based on these experiences, (2) an adapted participatory design was developed by engaging focus groups – as reported by Williamson et al. [WMB12] or (for a closer methodological view) Morgan [Mo02] – in a continuum of discussions and integrated system trial. Since it is not yet well understood how dialogue and multimodal conversational behaviour must be structured and presented on the part of the system in order to maximize effectivity of the interaction between user groups and a virtual agent this is combined (3) with micro-analysis of video recordings of system trials as conducted by Krämer [Kr08] or Heerink et al. [HKEW10].

3.1 Initial interviews: "I don't need help, but I know someone who does"

We conducted guided interviews with about ten (7 female, 3 male) elderly people between 72 and 89 years of age from the researches wider social environment, so that easy access and a basic trust were guaranteed. They were chosen based on the criteria of being at least 70 years old, retired from professional (mid-class) work life, mentally sane and living in their usual home environment. According to our two-fold understanding of 'social acceptance' we wanted to know: (1) Which assistive needs do elderly people have and how should technology be designed to best meet these needs and achieve a good level of social acceptance? (2) How would applying a virtual assistant to people's everyday lives affect the users' lives and daily routines? Thus, the interview-guideline contained three main sections: (a) everyday practices, physical or mental sanity and

actual needs, (b) affinity, experience and attitudes regarding technology and (c) expectations on technological progress and use of technology. Preliminary analysis of the interview data revealed the following issues (systematic analysis is ongoing):

- Participants mainly named physical problems but could rarely imagine further concrete wishes for assistance
- Participants were unwilling to delegate duties due to principles by which they were raised and educated.
- Participants approved the virtual assistant to be indeed useful as well as helpful for other people but not for themselves.

While these initial observations are revealing and systematic data analysis is ongoing, it became obvious that we could not expect detailed comments and ideas about the assistive technology we were developing, although assistance in structuring daily life had been reported as a central concern by professionals in the domain.

3.2 Participatory design: Involving focus groups in different stages of development

Based on the insights and experiences gained from the initial guided interviews, we enlarged our methodological instrument and developed the following approach based on the idea of participatory design consisting of four steps, whereby each of the following four partial-studies took place at one specific date.

(1) Firstly – to gain insight into the user's personal needs, attitudes and technical affinities – two **focus groups** were organized. The observation from the guided interviews, that elderly participants were highly innovative when thinking about others' needs as opposed to their owns, led us to invite participants to discuss the case of a fictional elderly person (which the moderator briefly introduced at the beginning) in one separate focus group. In another focus group caretakers for people with cognitive impairments were invited to discuss about real potentially suitable participants living in their institution. (On the recommendation of the caretakers, we conducted individual interviews with the cognitively impaired participants themselves including their personal situation and conditions instead of conducting another common focus group.) In both cases we expected that communication about a fictive third person's problems and needs would implicitly induce participants to reveal thoughts about their own problems and needs as well as about their clients. To help overcome technological barriers and to stimulate concrete ideas we provided a range of material props, which the users could play with and manipulate. The research questions for both user groups focus on the same five main topics: (a) possible current and future needs, (b) actual assistance that people receive by living within the institution, (c) solved and persisting problems of everyday life, (d) helpful benefits of using a technological system & calendar issues and (e) issues of usability and participatory design of virtual assistants.
(2) Secondly, the **system was demonstrated** to the participants and they were invited to afterwards name and discuss their first impressions of the virtual assistant.
(3) Thirdly a **Wizard of Oz study** was conducted in which the users interacted with a

virtual agent and were asked to enter appointments into the system's virtual calendar (5.1). Afterwards they were interviewed about usability, functionality and design.

(4) Fourthly, a **debriefing focus group** was conducted to learn about the user's reactions, new impressions and experiences with the prototype system. In this last step of the participatory design process, ideas and thoughts that appeared afterwards were to be examined. Furthermore trust and social bonds to the participants were to be established for further studies.

3.3 Micro-analysis of the user's interaction with the system

On another analytical level, we are interested in understanding more closely the ways in which the users actually interacted with the virtual assistant ‚Billie' within the wizard of oz study and how the system's communication strategies might support the user in realizing and repairing the occurrence of potential interactional problems. Since misunderstandings by technical systems are inevitable, a key sub-question is how users react to misunderstandings of the assistant and whether specific interaction strategies of the agent can help them to spot and repair them in a way suited to their cognitive limitations. Therefore, video recordings of the human-agent interaction are analysed on the micro-level using the analytical tools derived from Conversation Analysis [Te99]. CA focuses on the collaborative processes between interacting co-participants, how their embodied actions and verbal utterances react upon each other and the resulting sequential structures.

4 Study 1: User attitudes and design considerations for assistance in maintaining well-structured daily routines

To ensure that the functionalities and design of the assistant would meet the intended users' needs and address their ideas of a socially acceptable autonomous system, we started by exploring how the daily routines of the participants are organized, which assistive needs occur and their ideas about the system's design and its acceptability.

4.1 Study design and participants

We have conducted a study with the user group of elderly people involving all 4 consecutive stages of the focus group based participatory design as described in section 3.2. The focus group consists of six participants aged between 76 and 85 years, two of whom live in a residential care home and thus have the experience of daily contact with caretakers. The remaining four participants live in a so-called 'assisted living environment' connected to the residential care home and organize their lives autonomously, but have the prospect of assistance in case of need. With regard to their technical experiences, four participants are interested in technology, and three of them use mobile phones regularly. Two participants stated to not use any technical devices. For the user group of cognitively impaired people data collection is ongoing. The focus group consists of three cognitively impaired people aged between 36 and 53 years who are clients of a profes-

sional care service provider. Their personal situation ranges from living in an own apartment to a shared apartment, both located within the institutions' central building. All three participants suffer from epilepsy. Additionally, they have either a learning disability, psychic strain, a psychomotor retardation leading to global uncertainty, or an impaired short-term memory. The first stage has been conducted in two interrelated sessions: On the one hand, a focus group consisting of 8 caretakers was asked to discuss to which extent their clients (a group of 10 pre-selected participants) could potentially benefit from technical assistance. On this basis, three focus clients were chosen, who, on the other hand, were then interviewed about their personal situation. All three participants use mobile cell phones and computers for different primarily purposes. One participant plays video games but does not use the Internet. One participant uses the computer to check information on the Internet, another uses Skype technology to communicate with relatives. However, this is not generally representative of all ten clients of the user group. The technical affinity of each user is quite individual.

4.2 Potential areas and functions of assistance

To determine the users' needs and derive a set of guidelines for the design of the virtual assistant, the analysis is based on the first three steps of our participatory design and contains results from the initial focus groups with both mentioned user groups. In the first session, participants were invited to talk about current needs and in which way a novel assistive technology could be helpful for them. Elderly participants envisaged a technical system to be helpful with regard to a range of activities. Firstly, assistance in handling their daily structures was found to be relevant. This includes being reminded of regular and time-consistent intake of food and liquid as well as of taking their medication. Secondly, reminders of appointments that take place away from home were stated, such as doctors' visits. Thirdly, the system should be able or read the newspaper aloud and provide little games – like chess, e.g. – that allow to train or maintain participants' cognitive functions. For the cognitively impaired participants, a system was envisaged to be helpful, that could remind them of taking their medication. Also being reminded of outward-appointments is as relevant as for the elderly people. Additionally the system should be able to awaken participants. Apart from this, the virtual assistant should memorize information that participants dictate, so that shopping lists or other relevant information could be stated for both, the participants and their caretakers.

4.3 Current practices of organizing everyday routines

We wanted to know how the participants' currently organize and structure their daily lives and routine activities. The participants of the elderly focus group currently structure their days autonomously. In doing this, their primary resource consists of calendars to remember birthdays, visits to the doctor's etc. (stated by four participants). To do so, two participants reported to use a daily pocket calendar with a daily view, while two other participants choose a desk calendar with a weekly illustration. In total, four participants generally prefer wall calendars showing a monthly view indeed. For the cognitively impaired participants the caretaker focus group stated that most of their clients organize their daily structures by themselves. However, it could not be ruled out, that there were

problems in doing so. Hence, an important amount of clients does need support in form of well-timed reminders for an upcoming activity, e.g. and their assistive solutions are highly individualized as well as closely adapted for the individual's current circumstances. Nevertheless, a set of cross-cutting practices can be found. Usually, if necessary, clients bring new appointments in form of paper based post-it-notes to a meeting with their caretaker who possibly can transfer information into an EDP-supported client-specific personal documentation and sometimes additionally into the caretakers' own calendars. This way, caretakers keep track of their client's appointments and remind them individually of each appointment. Therefore – at the time of our studies – 6 of 10 clients have already been reminded of appointments by phone calls. 4 of 10 participants are consistently reminded of intaking medication. 3 of 10 clients have to be awakened by phone calls to ensure that they indeed get out of bed. Importantly, for many clients, their success in keeping appointments is highly influenced by the relationship between client and caretaker. If, at some point, this relationship is emotionally affected negatively, the risk is high that the client – although being reminded of an appointment – does not realize the activity.

4.4 Users' suggestions and design considerations

From the illustration of the two user groups, we can derive a set of suggestions and design considerations for the development of a virtual agent, which should assume the role of assisting in organizing daily routines and singular appointments. While showing a range overlapping suggestions, the two user groups open up the range of functions which go along with different types of assistive needs and stages of autonomy. In this sense, we do not consider these as specifically related to the respective user groups, but rather consider them as diverging points on a scale of needs. Participants might ‚wander' along this scale over time, depending on their changing life and health situation, so that in the long run, an assistive system should be adaptive to changing needs. The issues brought to light in the focus groups can be grouped along the following categories:

Mentioned Issues	Elderly People	Cognitively Impaired People
Device	Stationary device (+ additional mobile)	Mobile device (+ Stationary at home)
Access to the calendar	Only accessible by users	Users + optional virtual access for caretakers
Calendar design	Monthly view as default calendric illustration (+ additional options)	Daily view (+ additional options)
	Pictographs for appointments, meaningful colour discrimination	
	Large font	
Entering appointments	Several input modes	
	Unique appointments and recurring appointments	
Reminder function	Modifiable self-assigned	Immediately when imminent
Pro-active/reactive agent behaviour	Reactive unless a reminder is required	

Figure 1: Mentioned Issues

Device: While elderly people tend to organize their days around a stable home base, at which they spend increasingly more time and from which they start their activities, the cognitively impaired (younger) people spend an active work life and undertake a range

of social activities. Thus, the virtual assistant for the elderly should be realized as a stationary device integrated into the home environment. For the cognitively impaired people, on the contrary, an additional mobile device would be required to match their life style. In particular, reminders need to be given while they are on the go, and new appointments might come in at any time of the day. Also, they easily become sidetracked while they are on their way to an appointment, so that – at moments – it might be helpful to provide additional assistance along the way to an appointment.

Access to the calendar: While in the case of the elderly user group access to the calendar should be restricted to the owner of the calendar, for some cognitively impaired people it might be necessary to allow the caretaker to access the client's calendar. If agreed with the client, the caretaker might also enter or edit a client's appointments.

Calendar design: As primary design of the system's calendar the elderly people would choose a monthly calendar view. In sum, participants stated that the calendar's view should be modifiable and illustration should be neatly arranged. For the cognitively impaired people the caretakers in contrast generally considered a daily illustration helpful weekly or monthly structure would be too demanding to handle. Both focus groups suggested the implementation of additional selective illustration possibilities. In general, the visualisation of displayed pictures that represent an appointment's content was thought to be useful.

Entering appointments: The system should contain several input modes. While entering a future appointment the according day should be displayed. When an entry is finished, the default illustration should automatically be restored. There should be the possibility to enter unique appointments as well as recurring appointments. Additional data fields are required, e.g. to note if transportation or the company of a caretaker is required for a particular appointment.

Reminder function: The elderly users would like to be reminded at a self-assigned time that has to be modifiable at any time. The cognitively impaired users should be reminded immediately when an appointment is imminent, including potential transit time. For the concrete process of being reminded (on the stationary system) the increasing priority of an appointment could be signaled, e.g. by colours or blinking. When a reminder has to be performed, the focus group shows that the virtual assistant should establish attention first by playing a pleasant and non-annoying unique sound. Afterwards the virtual assistant should verbally address the user by calling the user's name and then wait for a response. At that point interaction merely proceeds, if the recipient signals attendance by verbally responding. If the system cannot detect any reaction, the reminder should be postponed. For the cognitively impaired users caretakers suggest that it is important to have a reminding function for people 'on the go'. Thus, the idea arose to include the users' cell phones as all three participants stated to currently use one (s. 4.1).

Pro-active/reactive agent behaviour: The focus groups stated that the system's behaviour should principally be reactive unless a reminder needs to be issued. If there is nothing the user has to be accordingly reminded of, the system should rest on standby. Billie should react only when explicitly addressed by the user and otherwise be imperceptible.

4.5 Issues of applying the system to the participants' environment and daily lives

One major issue of social acceptability consists of applying an autonomous system to the user's everyday life and residential environment. The system should be integrated into the existing furnishings. Ideally, the television and the assistant's platforms should be contained within the same device (although switching between the assistant and television has to be organized). However, if a technical system is planned to assist in organizing daily structures, applying sensors or cameras to the users' homes is inevitable. At the same time, users should not feel (nor be) restricted in their privacy. Thus, one type of sensors should only detect the user's presence; video cameras should only observe a predefined restricted space when the user has 'turned on' the system and when they are essential for interacting with the system. The placement of cameras and microphones has to be considered (functional for the system vs. comfortable usage of the system from usual seating facilities), whether an additional mobile device could be used and what the presence of additional people might mean for the system's behaviour.

4.6 Users' attitude towards the system improves after the first system trial

According to the subsequent stages in the participatory design method, users were initially asked about their attitudes towards an autonomous system, then were given the opportunity to interact with the system and, at a later date, again asked about their attitude towards the system. Comparison of their evaluation reveals a slight positively improvement. In particular, users considered the system more helpful for other people and even themselves after interacting with it. In fact after the interaction four participants could imagine to use Billie in the future and only two participants still declined to use it.

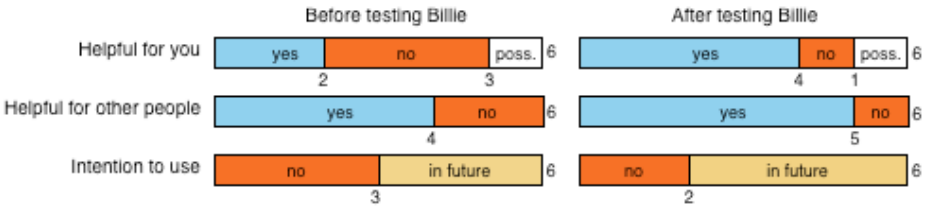


Figure 2: Attitudes towards Billie before and after testing the system

On the one hand, these results are encouraging. On the other hand, the question arises what actually happens during the users' interaction with the system. This will be explored in the following section.

5 Study 2: Interaction with the system: Developing media competency

In a second study we investigated how cognitively impaired users interact with the system. In particular, we were interested in what happens when the system produces misunderstandings, how users would repair them and what impact this would have on the users' trust in the system. Here, we investigate how one user organizes the interaction with

the system, how its strategies might support him in realizing and repairing the occurrence of a problem/error and – over the course of subsequent data entries – appears to develop an understanding to which extent he could trust the system and where checking is required. Therefore, video recordings of the human-agent interaction are analysed on the micro-level using the analytical tools derived from Conversation Analysis (s. 3.3).

5.1 Study design

We conducted a study, in which a Wizard-of-Oz [Ri12, YKPK13] version of the future autonomous system (being developed in parallel) was deployed with a group of cognitively impaired people. The users were recruited from a professional service provider for cognitively impaired people and regarding their impairments are comparable to the user group described in section 4.1. The system was set up to enter appointments into a virtual calendar, which was presented on the screen in form of a weekly view and accompanied by a virtual human assistant, called Billie (Fig. 3). The entry of appointments was provided in a multimodal fashion: In the calendar iconic visualization and highlighting was used; the virtual human used talk, gaze, head movements and deictic gestures when verbally naming a piece of information and referring to the calendar.

Figure 3: Cuecards and the system's screen showing ongoing interaction

Participants were seated in front of the agent and instructed to verbally request the system to insert seven appointments into the system's virtual calendar by naturally talking to the system. The system was explained as displaying an avatar able to engage in schedule-related dialog in spoken language. All appointments were given in form of seven cuecards (Fig. 3), on which the day, time, and the description of the event were given along with an iconic representation of the topic. Appointments were designed to contain events from the typical week of the users but declared to be fictional and explained individually beforehand. The wizard made the agent introduce itself and then verbally describe two items already entered in the fictional schedule, highlighting them on the virtual calendar board. The participants were then asked to start entering their 7 appointments. To explore how users would deal with the system's misunderstandings of a data entry, the agent would proceed with a predefined scheme of introducing errors: for cards 1, 4 and 5, no error would be introduced; for cards 2 and 7 the time would be misunderstood; for card 3, the topic would be altered to a similar-sounding incorrect one; for card 6, both time and day would be altered. All items and errors were presented both

verbally by the agent and graphically in the calendar. For this two different strategies were realized: a global and a local condition, for which the system's local repair strategy shows a slight (though not significant) better performance for the users' success rate in repairing the ‚problematic' slots [YKPK13]. In the example presented in the following, the system performs the global strategy, in which the assistant summarized items in one coherent utterance ("So you will go shopping, Wednesday at 9?"), visually displays the whole appointment at once and waits for the user's feedback.

5.2 From trusting the system to realizing its fallibility

When entering the first, initial appointment, the user reads the information from the cuecard and Billie repeats it correctly. After Billie has finished repeating, the user checks the cuecard by looking at it (visible as the user's gaze) and ratifies the summarized information verbally. When Billie has affirmed successful entry, the user proceeds with the second task. For the second task Billie produces an error in understanding the time of the second appointment. The user does not react to it, but keeps focusing on the screen, and finishes the activity. For the third task, the system again repeats the correct information. Thus, the user seems to establish an initial routine of entering data into the system, does not suspect it to produce any errors and trusts the system's entry of information without double checking them. It is only during the fourth task that the user realizes the system's fallibility. He reads the appointment from the cuecard (see above Fig. 3) „on wednesday seventeen to nineteen o'clock paint with light photography in the dark" (in the transcript: line 01). Similar to the previous data entries he looks at the cuecard while reading the information (line 01, #Img. 1, @cuecard1) and only looks up to the screen after he has finished reading (line 02, #Img. 2, @billie).

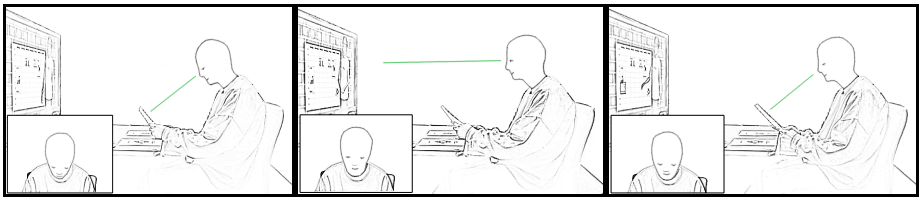
```
01      U:      (2.5) am mittwoch s=siebzehn bis neunzehn=uhr=hm. (-)|
                      on wednesday seventeen to  nineteen o'clock
        U-gaz: @cuecard1-------------------------------------------------------
        U-act: (takes_cuecard1)                                          |#Img.1

02      U:      malen mit l=licht (-) fotographie im dunkeln.|
                paint with light      photography in  the dark
        U-gaz: ----------------------------------------@billie-------------
                                                                 |#Img.2
```

The system then responds by naming the correct activity, but produces errors for the information concerning day and time: „so have you on monday at fifteen o'clock the class paint with light photograph in the dark" (03). Once the system has named the faulty day, the user now immediately gazes down to the card (03: @cuecard1) and then looks back to Billie (03: @billie) and thus appears to doublecheck the information.

```
03      B:      (1.2) also haben sie am mon|tag um fünfzehn uhr     den kurs
                      so   have you  on monday at   15  o'clock    the class
        U-gaz: --------------------------|@cuecard1~~~~~~~~~~~~~~~@billie-
                                         |#Img.3

04      B:      malen mit licht fotographie im dunkeln.
                paint with light photograph in the dark
        U-gaz: ----------------------------------------------------------------
```



Img. 1 Img.2 Img.3

While the system's summary of the appointment has caught the user's attention, he initially does not further act upon it. Rather, the system explicitly invites the user to doublecheck „is that correct?" (05) and thereby offers to treat its utterance as potentially problematic and thus initiates a repair sequence.

```
05      B:      (2.5) ist das so richtig,
                      is that so correct?
    U-gaz: ------@cuecard1---------@billie-----------------------------

06      U:      (---) am mittwoch. ja,
                      on wednesday yes
        U-gaz: ----------------------@cuecard-----------------------------
```

Now, for the first time, the user reacts by correcting *one* of the two faulty pieces of information by repeating the correct day „on wednesday yes" (line 06) and gazes back to the card (06: @cuecard). In the following (no further transcript provided due to space considerations) Billie accepts this repair and feedbacks it by including the corrected day (still with the wrong time): „ok you have then on wednesday at fifteen o'clock the class paint with light photography in the dark". When Billie begins to utter this the user looks at the screen again, and once the system has named the day „wednesday", the user gazes down to the card again and subsequently alternates his gaze between the screen and the cuecard. He then *self*-initiates a repair sequences by giving the correct time and „from seventeen to nineteen o'clock no" and simultaneously gazes at the screen again. Again Billie reformulates the whole information with the corrected information for both day and time. During this the participant gazes at Billie but looks down to the card once again for a short period of time and then back to the screen. After waiting for a response for 1.2 seconds, Billie closes the sequence with „alright I enter that". During this the user looks down to the desk and begins to manipulate the next card initiating the upcoming task. Thus, a change in the user's conduct occurs during the course of the interaction with the system from initial trust over realizing that 'something is odd' to undertaking a repair. This detailed analysis of the interactional conduct reveals that the user develops an understanding of the system's possibilities and limits and how to best deal with them. In other words, interacting with the system establishes as a routine. When entering the fifth appointment into the system, the user carefully doublechecks - given that the system now presents a correct data entry - the system's understanding already *at the moment* when Billie repeats the information. Hence, during the first trial with the system, he develops – by himself and without any guidance – a novel form of media competency only through interacting with the system. For future analysis, a central analytical and conceptual issue needs to revolve around the questions, to which extent the system's conduct provides orienting devices, which invite the user to indeed check the appoint-

ments' correctness. Thus, the question arises, how the system can invite its users to adopt a critical attitude and check information at particular moments in time and how an optimal initiation of repair sequences has to be designed multimodal to reliably focus the user's attention at the right time. Therefore, it has to be figured out at which precise moments users generally come to realize a problem.

6 Summary and Discussion

The combined approach of participatory design involving focus groups in different steps of the design process and micro-analysis of the users' interaction with the system has shown that the users – senior citizens and cognitively impaired people – are not generally afraid of autonomous systems. In fact we can conclude, that users' attitudes actually improve after interacting with the system. Further we were able to pinpoint more precise ideas. As design considerations for a system that would be socially acceptable, we revealed that the system should generally behave reactively and should be unobtrusively integrated into the user's home environment. Sensors should only be used to detect the users' presence. The system should only initiate interactions when reminding the user (by first playing a sound signal waiting for the user to respond). Cameras and microphones should be in standby mode until activation is admitted. The system should furthermore be customizable considering issues like time of reminder, design of the calendar, etc. Additionally analysis has revealed that a cognitively impaired person is able to gain insights into the system's possibilities and limits and discovers how to deal with them. The participant establish a differentiated mistrust considering the system's competencies. This results in routines in the user's conduct. The user develops a novel form of media competence by himself and only through interacting with the system. Future work will focus on exploring in greater detail and on a larger data basis the users' interaction with the system, the differences between local and global repair strategies and how this could transfer to the autonomous system and to a real world situation.

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Transcripton Conventions

The transcription arranges related and continuous segments while the actual segments display the interactional behaviour of either the virtual assistant Billie (B) and the user (U) as well as the user's gaze (-gaz) and hand actions (-act), that are listed only when an action occurs. The GAT conventions have been applied to their verbal utterances [Se09].

(.) represents a minimal pause, (-) and (---) represent two different lengths of short pauses less than one second. Exact pauses are denoted with a time designation. The direction of gaze is displayed with (@) and sequentially aligned with utterances and images (#).

References

[Gu11] GUIDE Consortium: User Interaction & Application Requirementes, Deliverable D2.1, 2011.

[Ha08] Harper, R.: Being Human – Human-Computer Interaction in the year 2020, Microsoft Research Ltd, England, 2008.

[HKEW10] Heerink, M.; Kröse, B.; Evers, V.; Wielinga, B.: Assessing Acceptance of Assistive Social Agent Technology by Older Adults – the Almere Model. In: Int J Soc Robot, 2, 2012; S. 361-375.

[Kr08] Krämer, N.C.: Soziale Wirkungen virtueller Helfer – Gestaltung und Evaluation von Mensch-Computer-Interaktion, Kohlhammer, Stuttgart, 2008.

[Kr10] Krummheuer, A.: Interaktion mit virtuellen Agenten? Zur Aneignung eines ungewohnten Artefakts, Lucius & Lucius, Stuttgart, 2010.

[Ma05] MacDorman, K.F.: Androids as an experimental apparatus: Why is there an uncanny valley and can we exploit it? CogSci-2005 Workshop: Towards Social Mechanisms of Android Science in Stresa, Italien, 2005; S. 106-11.

[Me11] Meyer, S.: Mein Freund der Roboter. Servicerobotik für ältere Menschen – eine Antwort auf den demografischen Wandel?, VDE Verlag, Berlin, 2011.

[Mo02] Morgan, D.L.: Focus groups interviewing. In: Handbook of interview research: Context and method, 2002; S. 141-160).

[PKE12] Pérez, J.G.; Karreman, D.E.; Evers, V.: Contextual analysis of the need of elderly for independent living – Is there a role for robot physical therapy?, IROS 2012 – Workshop on Motivational Aspects of Robotics in Physical Therapy, October 12, Portugal, 2012.

[Ri12] Riek, L.: Wizard of oz studies in HRI – A systematic review and new reporting guidelines. In: Journal of Human-Robot Interaction, 2012; S. 119-136.

[Se09] Selting, M. et al.: Gesprächsanalytisches Transkriptionssystem 2 (GAT2). In: Gesprächsforschung, 10, 2009; S. 353-402.

[Te99] Ten Have, P.: Doing Conversation Analysis - A practical guide, Sage publications, London, 1999.

[VMDD02] Venkatesh, V.; Morris, M.G.; Davis, G.B.; Davis, F.D.: User Acceptance of information technology. Toward a unified view. In: MIS Quarterly 27(3), 2003; S. 425-478.

[WMB12] Williamson, J.R.; McGee-Lennon, M.; Brewster, S.: Designing multimodal reminders of the home – pairing content with presentation. In: Proceedings of the 14th ACM international conference on Multimodal interaction (ICMI '12), New York, 2012; S. 445-448.

[YK12] Yaghoubzadeh, R.; Kopp, S.: Towards a Virtual Assistant for Vulnerable Users – Designing Careful Interaction, In: Proceedings of the 1st Workshop on Speech and Multimodal Interaction in Assistive Environments, Association for Computational Linguistics, 2012; S. 13-17.

[YKPK13] Yaghoubzadeh, R.; Kramer, M.; Pitsch, K.; Kopp, S.: Virtual agents as daily assistants for elderly or cognitively impaired people – Studies on acceptance and interaction feasibility. In: Proceedings of the IVA '13 Conference in Edinburgh, 2013, (in press).