Smart Homes for People with Alzheimer's Disease: Adapting Prompting Strategies to the Patient's Cognitive Profile

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ABSTRACT
Smart home technologies constitute a potential solution to allow people with Alzheimer's disease (AD) to remain in their home. These intelligent houses contain technological devices aiming to provide adapted cognitive assistance (prompts) when needed. However, a literature review of the field revealed a predominant use of verbal prompts with little knowledge about their real effectiveness. To contribute solving this important issue, we propose, in this paper, comprehensive guidelines to help smart homes researchers to maximize the efficiency by adapting the form of prompts to the specific cognitive profiles of patients with AD. First, we identify the main deficits of AD that influence the effectiveness of prompts. Second, we details which prompting strategy to use accordingly. Third, we propose an experimental protocol, based on a well-known test, and a new prompting software, which allows to validate the proposed guidelines. Finally, we present the preliminary results of a first experiment conducted in our lab with participants having mild to moderate AD.

ACM Classification Keywords
K.4.2 Social Issues (*Assistive technologies for persons with disabilities*)

General Terms
Documentation, Experimentation, Human Factors

Author Keywords
Smart Homes, Alzheimer's disease, Prompts, Efficiency, Guidelines.

1. INTRODUCTION
The aging population will bring increased number of case of dementia [1] because age is the main risk factor [2] for this cognitive impairment. The main cause of dementia is Alzheimer's disease (AD) [2], which can be defined as a neurodegenerative illness characterized by a progressive and irreversible decline in cognition [3]. Deficits in cognition are memory impairments, problems in executive functions, aphasia, agnosia and apraxia [4] resulting in the need for assistance in performing activities of daily living (ADL) [5] (e.g., eating, bathing, dressing). People with dementia need a lot of help from their caregivers and this need increases with the progression of the disease (i.e., with the decline of the skills). Most patients move in institutions where the help given by professionals can be 24 hours a day [2] because of the growing charge and stress on caregivers. However, seniors want to stay home [6] and families generally prefer to keep people with AD at their residence as long as possible [2]. Also, governments want to extend the time elders can remain in their house for economic reasons [6] (e.g., costs for the management of the patient) and social reasons (e.g., lack of medical staff) [7].

Assistive technologies such as smart homes [8] constitute a potential solution [9,10] to allow people with AD to remain in their house. Intelligent homes contain technological devices to capture the actions of the residents (sensors) and to provide them punctual assistance when needed (prompts). Prompts in smart homes are hints, suggestions and reminders to help the resident to complete a task [11]. There are four main categories of prompts: auditory, pictorial, video and light [11]. **Auditory prompts** can be verbal (e.g., step by step instructions, feedback, questions), sound (e.g., alerts, reminders) or music. They require the use of equipment such as speakers, portable audio devices, headphones and handheld systems [11]. **Pictorial prompts** may be photographic (e.g., colors, shapes, images, pictures) or textual (e.g., keywords, sentences, textual descriptions) and require the use of projectors, screens, computers or handheld systems [11]. **Video prompts** are pictorial (i.e., pictorial prompt and auditory prompt together) or modeling (i.e., video of a person performing a task) and require the use of the same equipment as the auditory and pictorial prompts [11]. **Light prompts** are variations of the intensity, color and blinking of a light bulb or a laser pen [11]. A deep research revealed a predominant use of verbal prompts in assistive technologies for people with AD [e.g., 1,12]. Lack of knowledge about the real effectiveness of these prompts significantly affects their efficiency by providing cues that are not adapted to the user's profile [11]. For example, the verbal prompt may be less effective for a person with Wernicke's aphasia (which is a disorder of language comprehension) because s/he could not understand it. To provide help that is appropriate to a person with AD, it is important to consider that each patient presents a different profile within the usual symptomatology (i.e., some spheres being more affected than others) that cannot benefit from an approach "one-size-fits-all" [13].

In order to contribute solving this important issue, we propose, in this paper, comprehensive guidelines to help smart homes

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researchers maximizing the prompting efficiency by personalizing prompts according to the specific cognitive profiles of the patients with AD. Our multidisciplinary contribution takes several forms. First, we identify the main deficits of AD that influence the effectiveness of each specific prompt (see Table 1). Secondly, we present a set of comprehensive guidelines (see Figure 1), which were defined by combining the knowledge and experimental results gathered from many paradigms (e.g., psychology, computer science, medicine, education). We then details which form of prompts to use according to each particular cognitive trouble and explain why. Third, we illustrate these guidelines by modelizing it into a decision tree, which is a flexible tool that can directly be implemented into an algorithm. Its use is therefore easier for computer scientists and engineers. Fourth, we propose an experimental protocol, based on a well-known test, and a new prompting software that we developed in order to be able to validate the proposed guidelines. Finally, we present the preliminary results of a first experiment, conducted with participants with mild to moderate AD, where we tested three different forms of prompts.

2. GUIDELINES TO PERSONALIZE PROMPTS ACCORDING TO THE SPECIFIC DEFICITS OF AD

Alzheimer's disease (AD) is characterized by a progressive and irreversible decline in cognition [3]. The first cognitive symptom to appear is often memory problems [2,3] that manifest as forgetfulness of general knowledge (semantic memory) and events experienced personally (episodic memory). Another important cognitive sphere that is altered in AD is executive functions. Deficits in these functions are problems in planning, sequencing and attentional control [5] that are significant and affect several ADL. In addition, cognitive deficits extend to the fields of language (aphasia), recognition (agnosia) and movements (apraxia) [3]. Aphasia is a trouble of expression or comprehension of spoken or written language. Agnosia is a disorder of recognition by the senses (i.e., the patient perceives the visual or auditory stimuli but does not recognize them). Apraxia is the inability to perform voluntary movements. It makes the patient unable to remember the sequence of movements required to achieve his task. To establish a diagnosis of Alzheimer's disease, the person must have memory problems accompanied by one or more cognitive deficits named above. The cognitive symptoms should not be due to other diseases of central nervous system, to general conditions that can cause dementia, to infections caused by a substance or to a delirium [4]. Another diagnostic criterion is that cognitive deficits must be the cause of impairment in social and occupational functioning of the person.

The majority of people with AD are elders because age is the main risk factor [2]. In that sense, seniors with AD may have sensory problems usually associated with aging such as hearing and visual troubles. Even if they are not necessarily part of the AD, it is important to consider these sensory disorders because they affect two sensory modalities (auditory and visual) which are widely used while carrying out everyday tasks. These sensory deficits can significantly affect the efficiency of the prompts that are mainly presented in auditory modality (auditory and video prompts) and visual modality (pictorial, video and light prompts). Although other types of prompts exist (such as olfactive, tactile, etc.), we will concentrate our paper on auditory and visual prompts (and deficits affecting them) because they are more commonly available in smart environments. Deficits that we will consider are: memory impairments, deficits in executive functions, aphasia, agnosia, apraxia and sensory problems (see Table 1). We will elaborate more on these deficits in the next paragraphs. Here is a table based on the interpretation of data found in the literature and summarizing these deficits and the kind of prompt they affect.

Table 1. Deficits affecting auditory and visual modalities of prompts.

Deficits	Modalities of prompt affected	
	Auditory	Visual
Memory disorders	Depends on how the prompt is used	
Executive functions		
Comprehensive aphasia	Spoken language	Writing
Agnosia (visual or auditory)	Verbal or non-verbal sounds	Writing, objects (pictures or not)
Apraxia	Depends on how the prompt is used	
Sensory problems (visual or hearing)	All type of sounds	All type of images

All these deficits affect the effectiveness of prompts in one way or another. The following figure (see Figure 1) represents a visual synthesis of the prompts that are effective for each of the specific deficits named above. It was obtained by combining knowledge and experimental data from litterature with our own experimental results (see validation section). It is modelized as a decision tree which is a flexible tool that can directly be implemented into an algorithm thus, facilitating its use by computer scientists and engineers. Moreover, it can be used in part or in whole, depending of the scope of the assistive system we want to design. These guidelines will help smart homes researchers to personalize prompts according to the specific deficits of the people with AD. This is a novelty in the fields of prompts and Alzheimer’s disease. It opens up new horizons for this area of research. In the next paragraphs, we will detail, in order, each branch of the guidelines tree stated on Figure 1.

2.1 Memory Impairments

Memory impairments are a well known symptom of the Alzheimer’s disease [2]. It manifests as forgetfulness of general knowledge (semantic memory) and events experienced personally (episodic memory). For example, a person with a **deficit of semantic memory** may not remember what is a jar (semantic aphasia). In that sense, if we send a prompt asking to take a jar to this person, it will be less effective because s/he will understand it (i.e., s/he knows that s/he has to look for a jar) but s/he still not knows what it is. So, verbal prompts are not the best if the problem is semantic memory [14]. The same phenomenon occurs with the textual prompts. Furthermore, music and sound prompts are too implicit and indirect to be used in such situations. Indeed, prompts more direct and implicit as a blinking light pointing the object in question, would be more effective [14]. Also, photographic prompts may be effective because images facilitate access to semantic memory [15]. Thus, pictorial video prompt would also be effective. Moreover, modeling video prompt would

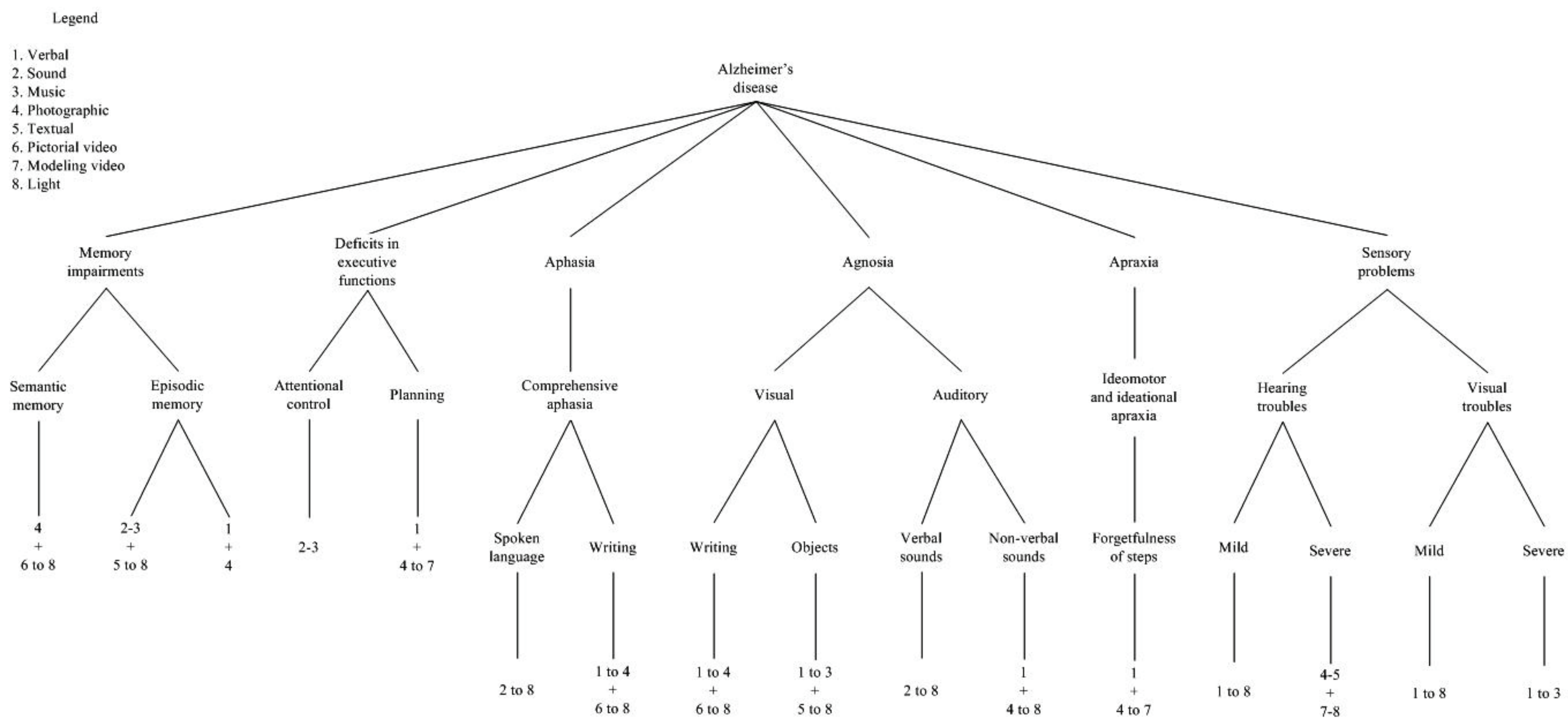

Figure 1. Prompts that are effective for each of the specific deficits.

be useful to show the person how to use the object. However, understanding video prompt may be an additional charge in memory [7, 5]. So, there is a need for more research on video prompts. Generally, troubles of semantic memory are preceded by deficits in episodic memory (memory of events experienced personally in a place and at a given time). **Deficits in episodic memory** (particularly in short term memory) can make the person forgets what she was doing. It may affect verbal memory or nonverbal memory. If verbal memory is affected, it would be better to use an auditory or a visual prompt that does not refer to language (sound, musical, photographic, pictorial video, modeling video or light) and that the person may well understand. In contrast, if non verbal memory is affected, it would be better to use a prompt that refers to language (verbal or textual). Encoding disorders associated with memory problems are also important in AD. However, they do not directly affect the effectiveness of prompts and therefore, will not be discussed further in this article.

2.2 Deficits in Executives Functions

Executive functions generally show a decline in normal subjects aging. In AD, the executive functions are also affected, but more importantly and more frequently than in normal aging. Deficits in executive functions of people with AD mainly manifest as problems in planning and attentional control that increase the need for assistance in performing ADL [5]. **Planning** of an action or a task require step by step assistance that can be achieved with various prompts (see Figure 1). However, a step by step guidance is not possible with sound, music and light prompts. For the **attentional control problems**, a verbal prompt can be effective to restore the purpose of the task [14] but people with AD do not respond optimally to such guidance [7]. It is possible to use a verbal prompt saying the name of the person to get his/her attention before using the prompt that will guide her [7]. Opinions are different from one author to another for the prompt that guide the person. The modeling video prompt is the most effective for people who lack of attention [11] (i.e., regardless of the other deficits that the person may have). However, a video prompt (pictorial or modeling) or a pictorial prompt (photographic or textual) could distract the person from the visual part of the task [5]. The light prompt can be effective even when the resources of the person are used somewhere else to get her attention but it is only moderately effective compared to the sound prompt [11].

2.3 Aphasia

Language disorders are salient features of Alzheimer’s disease. Aphasia is a disorder of speech or comprehension of spoken or writing language. The expressive aphasia does not affect the effectiveness of prompts but comprehensive aphasia does. This type of **aphasia** manifests as a difficulty to understand spoken or writing language. The verbal prompt may be less effective with a patient who has a comprehension of spoken language aphasia. Video prompts can be effective with that patient if the auditory part of the prompt is not only verbal. What is important is that the prompt does not only refer to spoken language (see Figure 1) because the patient has difficulty understanding it. For the patient who has a comprehension of written language aphasia, it is important that the prompt does not refer to written language (see Figure 1). So, the textual prompt is less effective for that patient. The pictorial video prompt can be used if the pictorial part of the prompt is not textual.

2.4 Agnosia

Agnosia is a disorder of recognition by the senses. The patient perceives the stimuli but does not recognize them. There are several types of agnosia whose visual and auditory. The **visual agnosia** is a disorder of recognition of visual stimuli. It may be a problem of recognition of writing or objects (pictures or tangible objects). Often, these two types of visual agnosia coexist. However, for practical purposes, we consider that it may exist individually. According to this information, it is possible to make the following conclusions. Textual prompts are less effective for patients with a disorder of writing recognition and pictorial video prompts can be effective with these patients if the visual part is not textual. What is important is that the prompt does not refer to writing (see Figure 1). For patients with a disorder of recognition of objects, the important is that the prompt has to be more explanatory. Indeed, a visual prompt (photographic or pictorial video) of an object would be less effective if it does not explain how to use the object. Pictorial video prompt can be effective if the visual part is not an object. This visual part should be textual (e.g., sentences or textual descriptions explaining the procedure). However, modeling video prompt would be useful to show the person how to use the object that s/he does not recognize. Some other prompts could also be effective with these patients (see Figure 1) and should be tested. The **auditory agnosia** is a disorder of recognition of auditory stimuli. The patient can not recognize the verbal or nonverbal sounds. So, the verbal prompt is less effective for a patient with agnosia of verbal sounds and if we use a video prompt with this patient, the auditory part should not be verbal (it should be sounds or music). For the agnosia of non verbal sounds, sound and musical prompts are less effective and if we use a video prompt with these people, the hearing part should not be one of these two types of prompts. It should be verbal. Other prompts can be effective with both populations (see Figure 1).

2.5 Apraxia

Apraxia is the inability to perform voluntary movements. The patient doesn't remember the sequence of movements required to achieve his task (ideomotor and ideational apraxia). Indeed, people with AD often forget steps when they perform a task. For people who forget steps of a task (i.e., not just those with AD), modeling video prompt seems to be the most effective [11]. For a prompt that is effective for people who forget steps when they accomplish a task, it is important that guidance be given step by step. This type of guidance can be accomplished by the sound, music or light prompts but it is less effective. Some other prompts are more effective for step by step assistance (see Figure 1). There are several other types of apraxia but they do not directly affect the effectiveness of prompts. The assistance provided by the prompts overcomes these types of apraxia. Therefore, these other types of apraxia will not be discussed further.

2.6 Sensory Problems

Elders with AD may have sensory problems usually associated with aging such as hearing and visual troubles. Thus, aging may results in **hearing troubles** among the patients with AD. Often mild hearing loss can be corrected with hearing aids. Although auditory prompts may not be most effective for people with mild hearing loss, they can still be used. However, it is recommended to use a male voice for the verbal prompt because, the female voices are more acute and therefore more difficult to hear [1].

For people with severe hearing problems, it is recommended to use visual prompts (photographic, textual, modeling video and light). The pictorial video prompt would be useless because its auditory part would be ignored by the patient and its visual part is already done by the photographic prompt. Then, it is well known that aging can lead to a decreased vision in older people. **Visual troubles** can be corrected using visual aids (e.g., eyeglasses, contact lenses). So, even if visual prompts (photographic, textual, pictorial video, modeling video and light) may be less effective in people with mild visual problems, they can still be used. In the literature, there are guidances for the environmental management of older people with vision problems (e.g., use warm colors, have a good light, accentuating the contrasts, use larger images) (e.g., [16]). These suggestions could be used by those who would test visual prompts with people who have mild visual problems. For people with severe visual problems, the best prompts would be auditory ones (verbal, sound and musical) (see Figure 1). Verbal prompt is the most effective because it is more direct and explanatory than sound and musical prompts.

2.7 How to use the proposed guidelines

Of course, all these deficits usually coexist. Thus, there is a set of inter-influence between these deficits on the effectiveness of prompts. For example, if a patient has a disorder of visual recognition of writing (agnosia), the guidelines provide the use of all prompts except the textual prompt. However, this patient may also have trouble understanding spoken language (aphasia) for which the guidelines provide the use of all prompts except the verbal prompt. In that sense, if the patient has these two deficits, one must understand that the use of verbal and textual prompts is prohibited. This applies even if the patient has a third deficit (e.g., a disorder of semantic memory). In that case, the decision tree provides the use of photographic, video (pictorial and modeling) or light prompts. So, these are the four prompts that we should retain for that patient. Further experiments will be needed to determine with more precision which of these prompts would be the most effective in each situation.

3. VALIDATING THE PROPOSED GUIDELINES: EXPERIMENT WITH MILD TO MODERATE ALZHEIMER PATIENTS

The Laboratory of Ambient Intelligence and Activity Recognition (LIARA) aims to develop technologies to support people with AD, their caregivers and health professionals. The ultimate goal is to maintain people with AD at home using ambient intelligence. The laboratory has a complete cutting-edge home automation infrastructure. It includes an apartment (see Figure 2) that allows capturing the actions and localization of its users and to assist them in the performance of their ADL (if needed). Thus, this apartment is equipped with pressure mats and movement detectors that allow us to be informed of the actions and locality of the resident. We also have Radio Frequency Identification Data (RFID) tags on objects indicating their position and electromagnetic contacts on the cabinet doors. Temperature and light sensors allow us to maintain a proper atmosphere. All these devices send information to a main computer where all can be managed. Also, we have a prompting system (with auditory, pictorial, video and light prompts) that can be controlled remotely and be sent for punctual assistance for the residents when needed. Each room of the apartment is equipped with prompts. Auditory prompts (verbal, sound and music) can be sent through Internet Protocol (IP) speakers. Pictorial (photographic and textual) and video (pictorial and modeling) prompts may be sent using a television screen or an IPad located on the refrigerator door. We have set of lights that we can vary the intensity and blinking. So, all the necessary equipment to conduct experiments are available. Moreover, our synergic multidisciplinary team (computer scientists, neuropsychologists and engineers) has good collaborations with organizations (i.e., local Alzheimer Society, regional hospitals, nursing homes for elders) and health facilities to recruit participants.

Figure 2. Overview of our infrastructure.

3.1 Experimental protocol

Recently, our laboratory conducted an experiment with people with mild to moderate Alzheimer's disease to evaluate the effectiveness of three main types of prompts (i.e., verbal, modeling video without sound and modeling video with sound) according to the neuropsychological profile of the participant (memory impairments, deficits in executive functions, aphasia, agnosia and apraxia). This experiment was conducted as part of a doctoral project. It has been approved by the ethical committee and we got certifications. This experiment consisted of two parts: a neuropsychological evaluation of the patient at home and the experiment in our laboratory. The neuropsychological evaluation includes tests detecting memory impairments, deficits in executive functions, aphasia, agnosia and apraxia. For the experiment, a new protocol was designed for the purpose of testing. It is based on the Naturalistic Action Test (NAT) [17]. This test evaluates the performance of individuals with neurological afflictions (stroke, traumatic brain injury, progressive dementia) in everyday actions. It has been slightly modified by our team to be used with prompts. The protocol works as follow. The participant is asked to make 1) a toast and a coffee and 2) to pack a gift (one task at a time). S/he sits on a chair and all necessary equipment for the performance of the task is on the table in front of her/him. S/he is free to use whatever s/he wants to complete the task and may do so in the order s/he likes. A prompt can be sent using a software developed for this experiment (see next section) if the participant needs it (e.g., s/he forgets a step) at any moment by a research assistant. There is no time limit [18]. Each test is videotaped and timed. The videos are framed so as to preserve the anonymity of the participant (the faces are not shown on the video) (see Figure 3). Also, we developed a score sheet to record the order in which the different stages of the task were performed.

Figure 3. A participant doing a toast and a coffee.

3.2 Developped software

For testing purpose, a new prompting software has been developed (see Figure 4). This software has been programmed with Visual Studio 2010 using C# language, which allowed a rapid development of the software and its interface. It was designed according to the chosen experimental protocol. Each activity of the NAT is encoded and the software proposes a step by step visual representation of the task (see left part of Figure 4). It allows an assistant to send from a distant computer a prompt if required (e.g., if the participant uses the wrong ustensil). With a simple click on a button, a chosen form of prompt (i.e., verbal, modeling video without sound or modeling video with sound) can be sent for a specific step of the task through a computer screen and speakers placed in front of the participant.

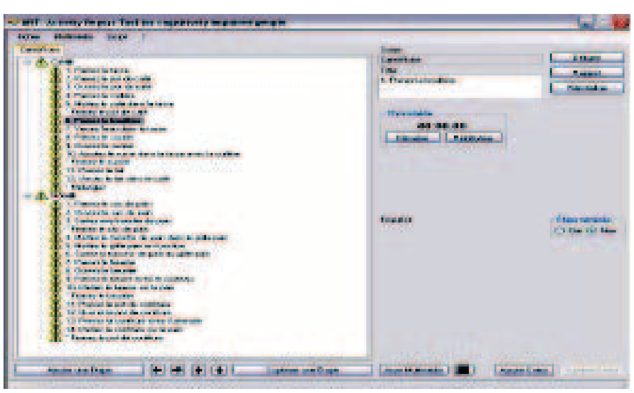

Figure 4. Our developed prompting software.

The software also allows to note the results, the number of erroneous steps, the type of problem (e.g., omission, inaction, substitution) and the percentage of task completed. Moreover, it allows us to save each session separately, the type of prompt sent, the completion time of the task and other notes that are relevant. Finally, it should be pointed out that the software uses a wired connection between computers in order to avoid security issues.

3.3 Results, analysis and discussion

Some participants have already completed the first phase of the experiment. Therefore, we can give first results. The participants of this experiment are stage 4 and 5 of the Global Deterioration Scale (GDS) [19]. They all had low scores at the Mini Mental State Evaluation (MMSE) [20]. Also, they showed deficits in verbal episodic memory, lexical access and reactive mental flexibility. Moreover, some participants had deficits in planning/organization of visual-spatial tasks, visual agnosia, ideomotor apraxia, low speed of information processing or ideational apraxia.

On average, participants completed the task of coffee and toast in 35.9 (± 4.7) steps and they completed the task of packaging a gift in 18.6 (±2.1) steps. The average is 1.9 (± 0.8) errors by participants for whom about 8 prompts were sent for the task of coffee and toast. For the task of packaging a gift, an average of 1.6 (± 1.2) errors was observed and about 10 prompts were sent. Trends indicate that verbal prompt and modeling video with sound are effective (see Figure 5). The verbal prompt has an efficacy rate of 51% on average. The modeling video prompt, meanwhile, has an average efficiency of 58%. These two types of prompts showing a difference of efficiency of 7%. Also, results indicate that the modeling video without sound is less effective for participants encountered.

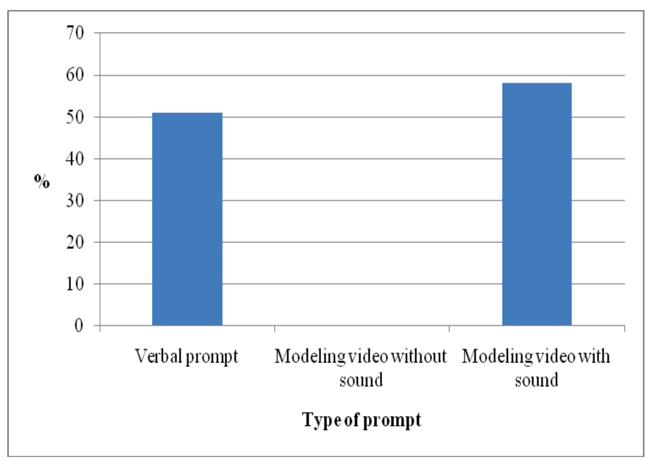

Figure 5. Efficiency of prompts.

Several hypotheses could explain these trends. First of all, the effectiveness of verbal prompt could be due to the fact that it is accessible and does not require attentional disengagement from the task. Indeed, the participant may continue the implementation of the current task while listening to the instructions given. Secondly, the efficiency of the modeling video with sound may be due to the combination of advantages of auditory and pictorial prompts. In addition, modeling video with sound are dynamic and familiar. Finally, the low efficiency of the modeling video without sound may be caused by several factors. When a participant is engaged in a task of visual nature (e.g., meal preparation, packaging of a gift), the presentation of a prompt using the same sensory modality requires an interruption of the current task and an attentional disengagement while increasing cognitive load. Moreover, the modeling video without sound in the experience was preceded by an audible signal to alert the participant. When the signal was sent, participants ignored it because they were not able to locate the source and to understand the purpose of such an indicator. We have not advised them that assistance could be given through the screen in front of them. So, they did not look at the screen. Therefore, they did not benefit fully from the modeling video without sound and it is difficult to rule on its effectiveness by now. A similar phenomenon occurred with the modeling video prompt with sound because it happened that participants did not look at the screen and therefore only benefited from the verbal part of the prompt. Other limits were noted in the protocol. Some participants did not understand that the verbal prompt was sent to them and when they understood, they had already missed part of the message. Indeed, some participants asked to hear the message again because they did not understand it. For all these reasons, it is difficult for us to give you more precise results regarding the effectiveness of prompts depending on the deficits of people with AD. However, the protocol was revised in order to aleviate these limitations in the second experimental phase that should start soon. We decided to continue the experiment with more participants to see if these trends are statistically significant. Other and more precise results are yet to come, but we think that the promising results we obtained so far are already very useful for researchers working on smart home technologies [11].

4. CONCLUSION

In the last few years, smart home technologies have become a very active research trend bringing hope in the effort to postpone the institutionalization of the persons with Alzheimer disease. However, to be effective, a smart home has to compensate the deficits of its users by exploiting their remaining strengths [11]. The actual predominant use of verbal prompts [e.g., 1, 12] seems to be a standard in the smart homes field and other assistive technologies. Lack of knowledge about the real effectiveness of these prompts significantly affects their efficiency by providing cues that are not adapted to the user profile [11]. In order for prompts to be appropriate for a person with AD, it is important to consider that each patient is different and that it can not be an approach to one-size-fits-all [13]. To contribute solving this important issue, we proposed, in this paper, comprehensive guidelines to help smart homes researchers to personalize prompts for patients with AD. This was accomplished: i) by identifying the main deficits of the illness that influence the effectiveness of specific prompts (see Table 1); ii) by developing comprehensive guidelines that indicate which form of prompts to use according to these specific deficits (see Figure 1), iii) by designing a new experimental protocol based on a well-known cognitive test allowing to validate the proposed guidelines, iv) and by presenting the preliminary results of a first experimented conducted in our smart home infrastructure with several participants with mild to moderate AD, using a new prompting software that we developed. The guidelines that we introduced allow orientation of the research in development of assistive technologies. It was modelized as a decision tree, which is a flexible tool allowing the guidelines to be directly implemented into an algorithm. Its use is easy for computer scientists and engineers. It should be noted that this research is only a step toward the development of adapted assistive devices for people with AD. The deficits of a person with AD are not the only factor to consider for the optimization of the efficiency of prompts. Other factors, such as the nature and characteristics of the task are also important to consider. For instance, we know that the familiarity (i.e., familiar or unfamiliar), the complexity (i.e., easy or complex) and nature (i.e., manual or cognitive) of the task also have a significant impact on the prompting efficiency [11].

With the rapid development of assistive technologies, there is a real need for more experiments on the efficiency of prompts so that patients with AD may eventually benefit of the full potential of assistive devices and smart homes. Therefore, our team plans to conduct further experiments that will verify with more precision the efficiency of each type of prompts separately, according to the specific deficits of the AD. Our multidisciplinary work will be beneficial for smart homes researchers who want to maximize the prompting efficiency. At term, we hope that our work will contribute to bring a new quality of life to patient with AD and their caregivers.

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6. REFERENCES

[1] Mihailidis, A., Barbenel, J.C., and Fernie, G. The efficacy of an intelligent cognitive orthosis to facilitate handwashing by persons with moderate to severe dementia. *Neuropsychological Rehabilitation, 14,* 1(2004), 135-171.

[2] Alzheimer's Association. Alzheimer's Disease Facts and Figures. *Alzheimer's & Dementia, 7*, 2(2011).

[3] Gouvernement of Quebec (2009). Relever le défi de la maladie d'Alzheimer et des maladies apparentées. Une vision centrée sur la personne, l'humanisme et l'excellence. Rapport du comité d'experts en vue de l'élaboration d'un plan d'action pour la maladie d'Alzheimer. Accessed July 7, 2011 from http://publications.msss.gouv.qc.ca/acrobat/f/documentation/2009/09-829-01W.pdf

[4] American Psychological Association. (2000). *Diagnostic and statistical manual of mental disorders* (4e éd.). Virginie: APA.

[5] Wherton, J.P., and Monk, A.F. Technological opportunities for supporting people with dementia who are living at home. *International Journal of Human-Computer Studies, 66*, (2008), 571–586.

[6] Pigot, H., Lefebvre, B., Meunier, J.-G., Kerhervé, B.,

Mayers, A., and Giroux, S. The role of intelligent habitats in upholding elders in residence. *In Proc.* 5th international conference on Simulations in Biomedicine, Slovenia, April 2003. pp.497-506.

[7] Bouchard, J., Bouchard, B., Potvin, A., and Bouzouane, A. L'intelligence artificielle au service des personnes Alzheimers et de leurs proches. *Revue Québécoise de Psychologie* (RQPSY), to appear in décembre 2011, pp. 1-25.

[8] Augusto, J. C. and Nugent, C. D (2006). Designing Smart Homes: The Role of Artificial Intelligence. *Lecture Notes in Artificial Intelligence, 4008,* Springer.

[9] Mihailidis, A., and Labelle, K.-L. The Use of Automated Prompting to Facilitate Handwashing in Persons With Dementia. *American Journal of Occupational Therapy, 60,* (2006),442–450.

[10] Pigot, H., Mayers, A., and Giroux, S. The intelligent habitat and everyday life activity support. *In Proc.* 5th International conference on Simulations in Biomedicine, Slovenia, April 2003, 507-516.

[11] Van Tassel, Bouchard, Bouchard, and Bouzouane. Guidelines for Increasing Prompt Efficiency in Smart Homes according to the Resident's Profile and Task Characteristics .*In Proc.* 9th International Conference on Smart Homes and Health Telematics, Montréal, June 2011, 112-120.

[12] Lancioni, G.E., La Martire, M.L., Singh, N.N., O'Reilly, M.F., Sigafoos, J., Pinto, K., & Minervini, M.G. Persons With Mild or Moderate Alzheimer's Disease Managing Daily Activities via Verbal Instruction Technology. *American Journal of Alzheimer's Disease & Other Dementias, 23,* 6(2009), 552-562.

[13] Mihailidis, A., and Fernie, G.R. Context-aware assistive devices for older adults with dementia. *Gerontechnology, 2,*2(2002), 173-188.

[14] Wherton, J.P., and Monk, A.F. Problems people with dementia have with kitchen tasks: The challenge for pervasive computing. *Interacting with Computers, 22*, (2010), 253–266.

[15] O'Connor, M.K., and Ally, B.A. Using stimulus form change to understand memorial familiarity for pictures and words in patients with mild cognitive impairment and Alzheimer's disease. *Neuropsychologia, 48*, (2010), 2068–2074.

[16] Jones, G.M.M., and van der Eerden, W.J. Designing care environments for persons with Alzheimer's disease: visuoperceptual considerations. *Reviews in Clinical Gerontology, 18*, (2008), 13–37.

[17] Schwartz, M. F., Segal, M., Veramonti, T., Ferraro, M., & Buxbaum, L. J. (2002). The Naturalistic Action Test: A standardised assessment for everyday action impairment. *Neuropsychological Rehabilitation*, 12(4), 311-339.

[18] Laprise, H., Bouchard, J., Bouchard, B., and Bouzouane, A. Creating Tools and Trial Data Sets for Smart Home Researchers: Experimenting Activities of Daily Living with Normal Subjects to Compare with Alzheimer's Patients. *In Proc.* 2nd IADIS International Conference e-Health, Germany, July 2010, 143-150.

[19] Reisberg, B., Ferris, S. H., de Leon M. J., & Crook, T. (1982). The Global Deterioration Scale for the assesment of primary degenerative dementia. *American Journal of Psychiatry, 139*, 1136-1139.

[20] Folstein, M. F., Folstein, S. E., McHugh, P. R. (1975). "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research*, *12*(3), 189-198.