Guidelines for Increasing Prompt Efficiency in Smart Homes According to the Resident's Profile and Task Characteristics

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Abstract. Smart homes provide a technologically enhanced environment that helps user's complete activities of daily living, thus increasing their autonomy. However, predominant use of verbal prompts in smart homes, with little knowledge of their effectiveness, affects significantly their efficiency by providing prompts that are not optimized with the profiles of the users and the characteristics of the tasks. In order for prompts to be effective, they have to compensate the deficits of its users by exploiting their remaining strengths. To contribute solving the issue, we present, in this paper, basic guidelines that are useful for increasing prompt efficiency in smart homes. We identify relevant significant individual profiles and task characteristics that affect prompt efficiency and how to use prompts accordingly. In addition, we illustrate our efforts to validate the proposed guidelines by giving preliminary results from our ongoing experimentations and by presenting the experimental protocol and software application being used.

Keywords: Smart Homes, Prompts, Efficiency, Guidelines, Individual Profiles, Individual variables, Task Characteristics, Task Variables.

1 Introduction

A smart home can be defined as a technologically enhanced environment that helps its resident in the achievement of his activities of daily living, thus increasing their autonomy [1,2]. However, predominant use of verbal prompts in smart homes [3], with little knowledge of their effectiveness, affects significantly the efficiency of these technological tools by providing prompts that are not optimized with the profiles of their users and the characteristics of the tasks. For example, while verbal prompts are effective for normal functioning individuals, they are highly ineffective for individuals with severe deficits in verbal comprehension [4,5]. In order to maximize its potential, it is essential for smart homes to compensate the deficits of its users by using prompts that exploit their remaining strengths [1,3,6,7,8]. Moreover, the prompts in these homes, while simultaneously accommodating the profiles of its users, also have to be compatible with the characteristics of the tasks currently in progress [3]. Such accommodation and compatibility can only be achieved by having

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a greater knowledge of individual profiles and task characteristics related to prompt efficiency and by increasing the variety of prompts used [6]. However, due to the prevalence of research in the smart home paradigm being mainly directed towards sensory devices and behaviour recognition, such information is relatively scarce [1,2,9]. Consequently, the literature on which prompt to use is limited and, as a result, the proportion of individuals that fully profit from the great potential of smart home technologies is reduced [6].

In an effort to contribute solving this important issue, we propose, in this paper, basic guidelines that are useful for increasing prompt efficiency in smart homes. Our contribution takes several forms. Firstly, we describe thoroughly and synthetically prompts that can be used in smart homes (see table 1). Secondly, we present major individual profiles and task characteristics that significantly impact prompt efficiency (see table 2). Thirdly, and most importantly, by synthesizing and vulgarizing crucial data on prompt efficiency found in the literature of numerous paradigms (e.g., psychology, education, medicine), we offer essential guidelines that indicate which forms of prompts to use according to significant individual profiles and task characteristics (see table 3). Finally, we illustrate our efforts to validate the proposed guidelines by giving preliminary results from our ongoing experimentations and by presenting the experimental protocol and software application being used.

2 Overview of Prompts Compatible with Smart Homes

Prompts can be considered as hints, suggestions and reminders that increase the probability of a desired behavioural outcome [10]. As shown in table 1, we can identify 4 main categories of prompts that can be used in smart homes: auditory, pictorial, video and light. By far the most used in smart homes, **auditory prompts** offer a number of options that increase autonomous behaviour [1]. These prompts, which require devices such as speakers and headphones, can be used as a verbal, sound or musical form. Verbal prompts, which consist mostly of verbal step by step instructions, are an easy and interesting option for increasing task completions in smart homes [4]. Both sound prompts, which consist of different kinds of sounds, and musical prompts, which consist of different types of music, provide content free information that increase autonomous behaviour in a non-intrusive way. **Pictorial prompts** are a relatively cheap option for providing visual instructions. They can be used in a photographic or textual form. The photographic form can be described as a combination of colors, shapes, images and pictures often used to visually demonstrate a sequence of step by step instructions. The textual form, by using the alphabet in a number of ways, describes, amongst other possibilities, step by step descriptions in a visual and textual manner. **Video prompts**, by requiring electronic devices such as computers, gives the possibility to combine the advantages of auditory and pictorial prompts (i.e., a picture of an object with a verbal instruction) [4]. Video prompts can also be used in a modeling form, which provides, with the help of a model performing a task, dynamic visual and auditory step by step instructions [10]. **Light prompts**, which require a light bulb or a laser pen, offer a number of minor but essential benefits (e.g., increasing attention by directing where to focus one's energy) not seen with other prompts [1]. These

advantages are made possible by varying the intensity or color of the lighting and by using the light for pointing objects or for flashing.

Table 1. Portrait of prompts compatible with smart homes

Type of prompts	Devices necessary for prompt use	Different forms of prompts	Description of forms
Auditory	Speakers Portable audio devices Headphones Handheld systems	Verbal	Step by step instructions Feedback Questions
		Sound	Alerts, reminders
		Musical	Music
Pictorial	Projectors Screens Computers Handheld systems	Photographic	Colors Shapes Images or pictures
		Textual	Key words Sentences Textual descriptions
Video	Projectors Screens Computers Handheld systems	Pictorial	Same as pictorial, but with auditory
		Modeling	Video of a model performing a task
Light	Light bulbs Laser pens	Light	Intensity Colors Flashing Pointing

All these prompts can be used to help a resident carrying out tasks and activities of daily living. A task can be defined, in the smart home paradigm, as a sequence of steps organized within a time-frame [1]. Given that a task is composed of several steps, each requiring instructions that fit their own characteristics, it is essential to use a combination of prompts that accommodate the particular characteristics of each steps. This strategy is particularly important with tasks that are composed of steps that differ in nature. For example, certain steps are of a cognitive nature (e.g., counting eggs) and others of a manual nature (e.g., stirring hot sauce). Steps that are verbal in nature require visual instructions that do not interfere with the step currently being done. The same phenomenon is observed with steps of a visual nature as they require instructions of a verbal nature in order to minimize interference [9]. Furthermore, a sequence of prompts closely or simultaneously used in a task also has to differ in their nature in order to minimize interference. For example, the near or simultaneous use of verbal prompts giving instructions for cooking pasta can confuse the individual and consequently make him forget or mix up the information.

3 Which Variables to Consider before Choosing a Prompt?

There are two main factors that significantly affect the efficiency of prompts and, as a result, are crucial to consider: individual profiles and task characteristics [5]. The

effect of these factors on the efficiency of prompts is cumulative [3]; therefore, it is essential when choosing a prompt to at least take into consideration individual and task variable described in table 2. Other individual variables (e.g., preferences, age, intelligence, etc.) and task variables (e.g., number of steps, length) also have an incidence on prompt efficiency. However, given the scope of the paper, they will not be discussed here in order to focus on the most relevant variables to consider.

Table 2. Significant individual and task variables that affect prompt efficiency

Factors that affect prompt efficiency	Sub-categories of factors (individua and task variables))	Description of sub-categories
Individual profiles	Diagnostics (general cognitive deficits associated with pathology)	Alzheimer's disease Traumatic head injury Intellectual disability
	Personal abilities	Verbal or visual ability
	Specific cognitive deficits (specific difficulties with tasks associated with a particular individual)	Lack of initiative Forgetfulness of steps Inaccurate task completion Lack of attention
Task characteristics	Task familiarity	Familiar or unfamiliar
	Task complexity	Easy or complex
	Nature of task	Manual or cognitive

As seen in table 2, there are three **individual variables** that have a significant impact on the efficiency of prompts: diagnostics (i.e., Alzheimer's disease, traumatic head injuries and intellectual disabilities), personal abilities (i.e., verbal and visual) and specific cognitive deficits (i.e., lack of initiative, forgetfulness of steps, inaccurate task completions and lack of attention). As regards to **diagnostics**, Alzheimer's disease is the most common form of dementia and the leading cause of cognitive impairment [6]. Individuals diagnosed with this disease progressively suffer from memory loss, aphasia, agnosia, apraxia and executive dysfunctions [8]. These deficits affect the efficiency of every prompt, but we can reasonably assume that the presence of memory loss, aphasia and executive dysfunctions particularly impacts auditory prompts. Traumatic head injuries are an acquired injury to the brain that can result in a number of deficits (e.g., memory, attention, abstract thinking, etc.), which, depending on the severity and type of deficits, generally affects equally the efficiency of each prompts [6]. Intellectual disabilities are a developmental disability defined by significant shortcomings in adaptive behaviour and intellectual functioning [6]. Deficits associated with this disorder affect the efficiency of every prompt, but its influence, due to the high prevalence of language deficiencies, is particularly felt with auditory prompts [5]. Regarding **personal abilities**, individuals who possess strong visual abilities have an aptitude to visually represent, amongst other possibilities, the sequence of steps in a task. Conversely, individuals with strong verbal abilities have an aptitude to symbolically represent the sequence of steps in a task. Due to their iconic nature, visual prompts are the most effective prompts when used with individuals possessing strong visual abilities. In contrast, auditory prompts, given their symbolic nature, are the most effective prompt when used with individuals who possess strong

verbal abilities [4,5]. As for **specific cognitive deficits**, individuals who lack initiative, forgets steps or inaccurately complete tasks, performs efficiently with the guidance of video prompts, and to a lesser extent, auditory and pictorial prompts [10]. Regarding those that lack attention, their performance is optimal when paired with video prompts and adequate with auditory and light prompts [4,12].

There are three main **task variables** to consider before choosing a prompt: **familiarity** (i.e., familiar or unfamiliar), **complexity** (i.e., easy or complex) and **nature** (i.e., manual or cognitive). Individuals who are unfamiliar with a task are less likely to have verbal labels defining each of its steps. Consequently, auditory prompts, in contrast with visual prompts, are less effective with this type of task [5]. Also, presuming that complex tasks are generally more difficult to label verbally, the use of visual prompts is slightly more effective than auditory. As for the nature of task, due to the reduction of interference, those that are cognitive are more effective with visual prompts while those that are manual are more effective with auditory prompts [9].

4 Guidelines for Using Prompts According to Significant Variables

Based on these facts, it is now possible to propose guidelines indicating which form of prompts to use according to those variables. These guidelines are synthesized in Table 3, which illustrates the efficiency of each form of prompts according to significant individual profiles and task characteristics. As we can see, the efficiency of **verbal prompts** is moderate to effective when used with individuals suffering from Alzheimer's disease, traumatic head injuries and intellectual disabilities [4,9]. Given the great compatibility, they are effective to highly effective with individuals possessing strong verbal abilities [5]. Furthermore, their efficiency for manual tasks is effective to highly effective. **Sound prompts** are moderately effective with individuals suffering from traumatic head injuries. This can be explained by the capacity of these prompts to compensate the attention deficits from these individuals. For the same reason, the content free nature of sound prompts is moderately effective when used with tasks in which individuals lack attention [12]. **Musical prompts**, due to their capacity to compensate attention and motivation deficits, are moderately effective for individuals suffering from intellectual disabilities. For these reasons, they are effective with individuals that inaccurately complete tasks and lack attention. However, given that the information provided is content-free, musical prompts are mostly effective in situations in which the person has a near mastery of the task needing to be done [10]. **Photographic prompts** (iconic or photographic) are usually effective when used with individuals suffering from Alzheimer's disease, traumatic head injuries and intellectual disabilities given that visual abilities generally deteriorate at a slower pace than verbal abilities [4,9]. They are also effective for cognitive tasks [9]. Due to their significant compatibility, the use of photographic prompts with individuals who possess strong visual abilities is effective to highly effective. These prompts are moderate to effective for individuals that inaccurately complete tasks or forget steps and moderate with complex and unfamiliar tasks [4,5]. **Textual prompts**, which require sufficient verbal abilities in order to be successful, are moderate to effective when used with individuals suffering from Alzheimer's disease or traumatic head injuries; effective with those possessing strong verbal abilities and moderately

effective for those that lack initiative or forget steps due to their capacity to provide written reminders and detailed instructions [8,12].

Table 3. Prompt efficiency according to significant individual profiles and task characteristics

	Alzheimer's disease	Traumatic head injuries	Intellectual disabilities	Strong visual abilities	Strong verbal abilities	Lack of initiative	Forgetfulness' of steps	Inaccurate task completions	Lack of attention	Unfamiliarity with task	Complex tasks	Manual tasks	Cognitive tasks
Verbal	M/E	M/E	M	M	E/ HE	M/E	M/E	I/M	M/E	I	I/M	E/ HE	I
Sound	I/M	M	I/M	M	M	I/M	I/M	I	M	HI	HI/I	M/E	I
Musical	I	I/M	M	M	M	I/M	I	E	E	HI	HI	M/E	I
Photographic	M/E	E	E	E/ HE	M/E	I/M	M/E	M	I/M	M	M	I/M	E
Textual	M	M/E	I/M	M	E	M	M	I/M	I	I	I/M	I	I/M
Video pictorial	E/ HE	E/ HE	E/ HE	E/ HE	E/ HE	E/ HE	E	E	E	E	M/E	M/E	M
Video modeling	E/ HE	HE	HE	HE	E/ HE	E/ HE	E/ HE	E/ HE	E/ HE	E/ HE	E	M/E	M
Light	I/M	I/M	I/M	I/M	I/M	M	I/M	I/M	M	HI	HI/I	I/M	M/E

Legend : HI = highly ineffective; I = ineffective; M = moderate; E = effective; HE = highly effective

Video prompts of a pictorial nature and **modeling prompts** are the most effective prompts in smart homes. This can be explained by their capacity to reinforce desired behaviours while being used; by their capacity to simultaneously use multiple prompts; by their dynamic nature which increase concentration and by their tendency to be the preferred prompt [4]. In addition, by providing instructions in different ways, they can exploit the strengths of almost every individual by accommodating their deficits [6]. As a result, they are moderately to highly effective with every variable seen in table 2. However, modeling prompts, due to increased familiarity and attention, are even more successful than video prompts of a pictorial nature [11]. It can be assumed that **Light prompts**, due to their content free nature, are ineffective to moderate when used with individuals suffering from Alzheimer's disease, traumatic head injuries or intellectual disabilities. However, it can also be presumed that the use of numerous lighting techniques (e.g., flashing) can render these prompts useful for individuals lacking initiative and attention.

5 Experimentations: Validation of the Guidelines

In order to empirically validate the proposed guidelines our multidisciplinary research team designed an experiment, currently in progress, which evaluates prompt efficiency according to individual profiles and task characteristics. The experiment,

which began in the fall of 2010 and should end in the summer of 2011, is approved by the ethical committee. Its aim is to evaluate the efficiency of three prompting forms (i.e., verbal, pictorial and video) according to the relative neuropsychological profile (e.g., memory, apraxia, etc.) of individuals suffering from moderate stages of Alzheimer's disease. Several participants have already completed the experiment.

The experimentation is based on a well established cognitive test: the Naturalistic Action Test (NAT). This test is conceived to evaluate the performance of individuals with neurologic afflictions in common kitchen tasks. The NAT used in this experiment is slightly modified in order to better evaluate the performance of the participants. The experimental protocol works as follow: the participant sits in front of a table that has all the items needed for the completion of the task (see figure 1, left). A computer screen and speakers are positioned in front of him. The participant is free to use anything he wants to complete the task and can do so in the order that pleases him. Each trial is recorded on video and timed. When needed, an assistant sitting at the back of the table sends prompts (audio, pictorial or video) by the means of a software application developed purposely for this experiment (see figure 1, right). With a simple click of a button, a chosen form of prompt can be sent to the participant for a specific step. The assistant then notes the results (e.g., type of problem, number of wrong steps, percentage completed, etc.) using the software. It allows the saving of each session separately, with the prompts sent, the timing, the notes, etc.

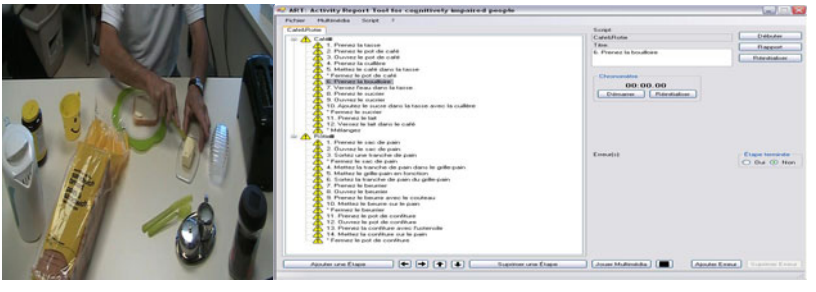

Fig. 1. Ongoing experimentation and developed prompting software

Though the experimentations are not completed, preliminary results indicate that video prompts are the most effective prompts. Auditory prompts seem to be ineffective most of the time while pictorial prompts do not seem to help with the attention deficits of the participants, and thus seem to be also ineffective. Other and more precise results are yet to come.

6 Conclusion

In order for the smart home paradigm to be effective, prompts in these homes will have to compensate the deficits of its users by exploiting their remaining strengths [1,3,6,7,8]. However, predominant use of verbal prompts in smart homes [3], with little knowledge of their effectiveness, affects significantly the efficiency of these technological tools by providing prompts that are not optimized with the profile of its

users and the characteristics of the tasks. To contribute solving the issue, we proposed, in this paper, basic guidelines to follow in order to increase prompt efficiency in smart homes. This was accomplished: i) by detailing the type of prompts that can be used in smart homes (see table 1); ii) by presenting major individual and task characteristics that can significantly impact the efficiency of prompts (see table 2); iii) by illustrating thoroughly and synthetically guidelines that indicate which form of prompts to use according to major individual and task characteristics (see table 3) and iv) by describing an experimentation currently in progress in our laboratory which aim to validate the proposed guidelines. Since the literature on prompt efficiency is still in its early stages, the need for further research in regards to prompt technologies, individual profiles and task characteristics is much needed. Therefore, we plan to conduct further experiments that will verify with greater precision the efficiency of each types of prompt according to significant individual profiles and task characteristics. Our work will be beneficial for increasing the compatibility between prompts, tasks and the individuals that use these devices.

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References

1. Giroux, S., Leblanc, T., Bouzouane, A., Bouchard, B., Pigot, H., Beauchet, J.: The Praxis of Cognitive Assistance. In: Gottfried, Aghajan (eds.) Behaviour Monitoring and Interpretation, Ambient Intelligence and Smart Environments (AISE), pp. 183–211. IOS, Amsterdam (2009)
2. Laprise, H., Bouchard, J., Bouchard., B., Bouzouane, A.: Creating tools and trials data sets for smart home researchers. In: Proc. IADIS e-Health, Germany, pp. 143–150 (2010)
3. Mihailidis, A., Fernie, G.R.: Context-aware assistive devices for older adults with dementia. Gerontechnology 2(2), 173–188 (2002)
4. Lancioni, G.E., O'Reilly, M.F.: Self-management of instructions cues for occupation: review of studies with people with severe or profound developmental disabilities. Research in Developmental Disabilities 22, 41–65 (2001)
5. Nailos, M.A., Whitman, T.L., Maxwell, S.E.: Verbal and Visual Instructions with Mental Retardation: The Role of Subject Characteristics and Task Factors. Journal of Behavioral Education 4(2), 201–216 (1994)
6. Lopresti, E.F., Bodine, C., Lewis, C.: Assistive Technology for Cognition: Understanding the Needs of Persons with Disabilities. IEEE Engineering in Medecine and Biology Magazine 27(2), 29–39 (2008)
7. LoPresti, E.F., Mihailidis, A., Kirsch, N.: Assistive technology for cognitive rehabilitation: State of the art. Neuropsychological Rehabilitation 14(1/2), 5–39 (2004)
8. O'Neill, S.A., Mason, S., Parente, G., Donnelly, M.P., Nugent, C.D., McClean, S.: Video Reminders as Cognitive Prosthetics for People with Dementia. Ageing Int. 1, 1–16 (2010)
9. Wherton, J.P., Monk, A.F.: Technological opportunities for supporting people with dementia who are living at home. Int. J. Human-Computer Studies 66, 571–586 (2008)

10. Post, M., Montgomery, J., Storey, K.: A decision tree for the use of auditory prompting strategies. Journal of Vocational Rehabilitation 31, 51–54 (2009)
11. Mcgraw-Hunter, M., Faw, G.D., Davis, P.K.: The use of video self-modelling and feedback to teach cooking skills to individuals with traumatic brain injury: A pilot study. Brain Injury 20(10), 1061–1068 (2006)
12. Fish, J., Evans, J.J., Nimmo, M., Martin, E., Kersel, D., Batemen, A., et al.: Rehabilitation of executive dysfunction following brain injury: "Content-free" cueing improves everyday prospective memory performance. Neuropsychologia 45, 1318–1330 (2007)