SuperAssist: Supervision of Patient Self-Care and Medical Adherence

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Abstract

Due to significant aging trends in coming decades, health care service in western countries is no longer able to satisfy the national care needs. Patients are increasingly expected to perform Self-Care, facing them with severe medical adherence problems. We are exploring the possibilities of personal virtual assistants in the supervision of Self-Care. Because this is ethically complicated, we first observed healthy participants caring for an online patient. We took into account the level of commitment and participation in the development of the care plan. Additionally, we looked at the participants' personal profile. Analysis did not show a significant effect of level of commitment and participation on the performance of care and level of medical adherence. The participants did express a strong preference for a cooperative supervision condition in which they were involved in the scheduling of the care tasks and able to manage the care plan. The results offered good footing to progress in our development of supervision of patient's Self-Care.

Keywords: Supervision, Virtual assistants, Self-Care, Medical adherence, Personal profile, Health-Pal

1. Introduction

Among western countries, Europe will experience the most significant ageing trends up to 2050 and the rate of the 60+ age group will be around 37% [1]. Because of the aging, it can be expected that in European countries such as the Netherlands health care needs will increase substantially in the coming decades [2].

Patients are expected to act more empowered and self-supporting. This implies patients' involvement in the care plan and execution of Self-Care, management of a computer-based patient record (CPR), operating domestic medical instruments, and communication with location-dispersed medical and technical specialists.

Development of personal virtual assistants based on Multiple Agent System (MAS) technology offers interesting opportunities for the supervision of these complex tasks (Fig. 1). Within the framework of the SuperAssist project, TNO, Delft University of Technology, and Leiden University Medical Center are developing models for the supervision of complex task environments by deployment of personal assistants. The project's business partners Philips Research,

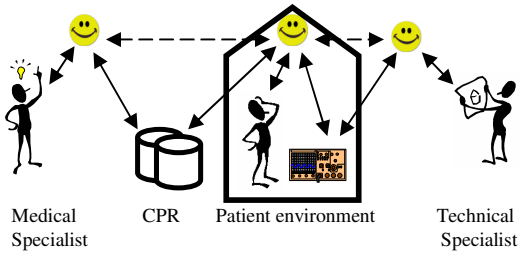

Fig. 1: Personal virtual assistants for supervision of complex task environments

Pemstar, Science & Technology, and Sigmax, bring in their technology and contribute to the development and validation of SuperAssist elements [3].

In a first study on supervision of complex task environments, we studied in which user-assistant collaboration condition performance of maintenance and troubleshooting of medical instruments is most effective, efficient, and satisfactory. We observed the effect of a manual, cooperative, and autonomous collaboration condition on their performance and personal preference for the collaboration condition. In the manual collaboration condition the user worked with the official manual. In the cooperative collaboration condition the assistant was oriented towards interaction with the user. In the autonomous collaboration condition the assistant relieved the user of its tasks within its capacity. The manual collaboration condition appeared the least suitable. The cooperative collaboration condition appeared most suitable for an optimal performance and it was also considered the most preferred. Examination of personal profiles showed that education level and reading skill explained variance in observed errors. Locus of Control and computer experience explained variance in preference for collaboration condition.

In our current and a second study, we are focusing on supervision of patients' Self-Care. Important bottleneck with Self-Care is the low level of medical adherence. We designed a scenario in which a patient using an electronic agenda is supervised by an intelligent virtual assistant, called the Health-Pal.

We are examining the effect of the level of user-assistant supervision on performance of Self-Care and enhancement of medical adherence. We look at the preference for supervision condition and at the influence of different personal profiles on the performance. Because the supervision of patients is ethically complicated, we want to be sure that the deployment of the Health-Pal fits our requirements concerning accurate observation, usability of the system, and obtaining empirically insights in the factors that influence Self-Care and medical adherence. Consequently, we are first testing the Health-Pal with healthy participants who have to care for an online patient. For a next experiment we planned to have actual patients participate who will care for themselves.

In the next chapter we give a summary of a literature research on Self-Care and medical adherence and pose our research questions. In the third chapter we discuss our research design and in the fourth chapter we discuss our results. Finally we discuss the implications of the results and our future research.

2. Literature review

2.1 Self-Care

The World Health Organization defines Self-Care as "activities individuals, families, and communities undertake with the intention of enhancing health, preventing disease, limiting illness, and restoring health" [4]. Extensive report on the importance of Self-Care with chronic patients has been done by [5] and an interesting categorization of Self-Care is proposed by [6]. The authors define four types of Self-Care: Regulatory SC including routine health maintenance activities, Preventive SC, including practices like exercising, dieting, self-examination, Reactive SC, including self-initiated responses to symptoms that have not yet been labeled by physician as illness, and Restorative SC, which is compliance to a professionally prescribed medication regimen.

In our model of the SuperAssist, the assistant will supervise these four categories. This will take place through:

- Monitoring the patient personal profiles, CPR, and routines medical activities;
- Stimulating and facilitating Self-Care tasks such as diets, exercise, and medication;
- Offering support for better understanding of practical implications of Self-Care.

2.2 Medical adherence

Medical adherence is generally defined as the extent to which a patient's behavior (in terms of taking medications, following diets, or executing lifestyle changes) matches with medical or health advice. The average rate of adherence across diseases and medications is just 50%, underlining the gravity of this problem [7,8]. Different factors are said to influence medical adherence, e.g., desire in participation in medical decision-making, locus of control, self-efficacy and personality traits.

In their article [9], the authors state that the patient's participation in medical decision-making can improve its self-care. This concerns the desire for discussion with the physician and the desire for receiving information from the physician.

A study on the role Locus of Control (LOC) [10] on medical adherence showed that people with an

internal locus of control believe that their own tasks determine the rewards that they obtain, while those with an external locus of control believe that their own behavior doesn't matter much and that rewards in life are generally outside of their control. The authors found that poorer adherence to a diabetic regimen were related to higher level of external LOC beliefs.

Different studies [e.g.,11,12,13] examined the influence of self-efficacy on medical adherence in patients and data suggests that efforts to improve self-efficacy could have medical and psychological benefits. Studies on the influence of personality traits on medical adherence [14] showed that the trait conscientiousness is highly relevant to an enhanced self-care because of its predicting value concerning medical adherence.

2.3 Research questions

Following the discussed literature on Self-Care and medical adherence, we hypothesize that an increasing amount of commitment with and participation in the care plan will positively influence the quality of care. Therefore participants in a supervision condition during which they cooperate actively with their virtual assistant will perform better on the care of their online patient than in a condition in which the assistant performs autonomously.

Additionally, we expect that the discussed personal profiles, i.e. desire for participation in medical decision-making (DPMD), self-efficacy (SE), locus of control (LOC), and personal traits will explain some variance in performance of care for the online patient (Table 1).

Table 1: Effect of personal profiles on the performance of care

Moderators	**Effect**
Desire for participation in medical decision-making (DPMD)	Variance in performance of care
Self-efficacy (SE)	
Locus of Control (LOC)	
Personal traits	

3. **Research Design**

Following a scenario-based design approach [15] we developed a prototype of an electronic agenda in which the patient maintains its schedule. A virtual assistant, we call the Health-Pal, supervises the patient by monitoring its personal profile, including the agenda, data from linked medical instruments, the computer-based patient record (CPR) with somatic aspects (complaints, medical data) and preferences. Accordingly, the assistant determines the patients care plan, including time schedule and Self-Care tasks, and adds it to the patient's agenda.

The participants could access their electronic agenda and online patient on the Internet. This enabled us to objectively observe their behavior in a non-laboratory environment. This is the first time we applied this electronic agenda with a virtual assistant. Therefore we asked participants to care for an individual assigned online patient instead of themselves. For a next experiment we planned to have actual patients participate who will care for themselves.

Corresponding to the fist experiment, the Health-Pal and the patient supervise the care either in a cooperative or an autonomous way:

- The cooperative assistant supervises the patient's profile and suggests care tasks to improve the online patient's health. The participants were free to deviate from the care plan and modify the tasks if they feel they can improve the health with other care tasks.
- The autonomous assistant supervises the patient's profile and decides on the ideal care tasks to improve the online patient's health. The participants were obligated to follow these tasks.

For example, on Wednesday a participant in the autonomous condition had to instruct the online patient to perform the fixed tasks "average exercise" and "play a game". A participant in the cooperative condition could instruct the online patient to perform the tasks "light exercise", "have a snack", and "have conversation" (which the participant chose in advance based on the suggestions of the assistant) or he could deviate from it, if he felt other tasks would improve the patient's health.

Twenty-eight persons (male: 14, female: 14) participated in our experiment. The participants were aged between 36 and 59 (mean: 47.21). Twenty-three persons were employed (fulltime: 11, part-time: 12). We surveyed the participants' educational level which varied between a university degree and lower general secondary school degree. We surveyed computer skill which varied between low ("I almost never work with computers.") and high ("I work with computers daily."). Afterwards we surveyed the preference for supervision condition, concerning commitment to and

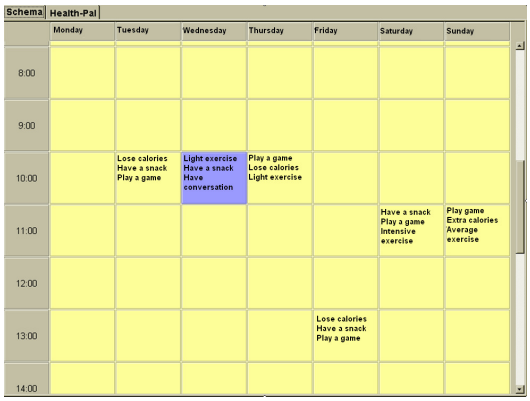

Fig. 2: The online schedule screen with care tasks and current time (the dark square)

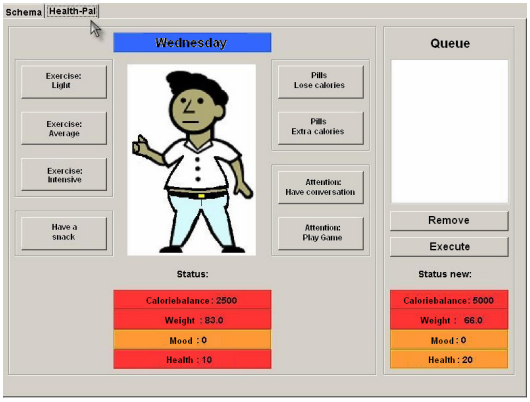

Fig. 3: The online patient screen.

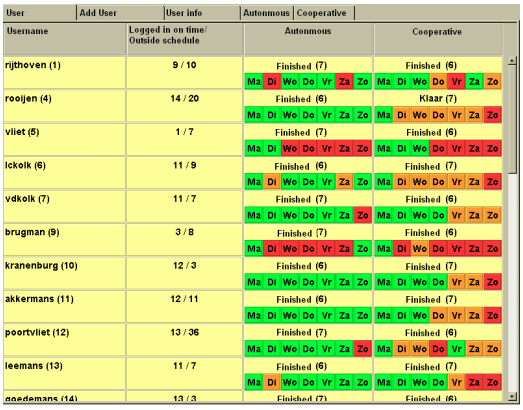

Fig. 4: The administrator and monitoring screen

involvement in the care plan, caring for an online patient, and caring for one-self.

The participants were asked to care for their online patient for two weeks. The patient is overweight and has to perform care tasks, i.e. dieting, exercise, medication and receiving attention, to get back into shape. One week the participants received cooperative supervision and the other week they received autonomous supervision. The second week the patient's health state was restored to its initial (unhealthy) state and we randomized the condition order to prevent a learning effect.

At the beginning of the week the participants had to make a schedule of that week. In the schedule they had to indicate for each day at what time they would care for the online patient and the schedule was copied in the online schedule (Fig. 2). An important constraint was that instructing the patient to perform care tasks was only possible if the participants logged in at the time indicated in de online schedule.

In the patient screen (Fig. 3) the participants could care for the online patient. To care for the patient meant that they had to instruct the patient to perform the care tasks (do exercise, take a snack, take medication) and give it attention (play a game or have a conversation) by pushing the regarding buttons (Fig. 3). After a task is selected it appears in the queue at the right. Bellow the queue the future status of the patient is calculated based on the task in the queue. Tasks can also be removed form the queue. When all desired task are in the queue the participants has to push the "Execute button" to definitively instruct the patient to perform the care tasks.

In the autonomous supervision condition the tasks were fixed. The participants could only push the buttons that were indicated in the schedule. In the cooperative supervision condition the participants had to read guidelines on how to get the online patient back into shape and indicate what care tasks they wanted the patient to perform on beforehand. During the week all the buttons were active and the participants were free to deviate from the scheduled tasks if they felt this could improve the health of the patient. With the use of the future status the participants could proactively select the tasks they wanted the patient to perform.

In the administrator screen (Fig. 4), the experiment leader can add users and manage their profiles, online schedule, and supervision condition. Furthermore, he could monitor the participants' performance, concerning the times participants logged in according their schedule, the performance of the care tasks, and the health of the virtual patient.

5. Results

Participants felt most committed to the cooperative supervision condition (Table 2). We sent out an online survey among the participants from whom 21 responded. Twenty respondents indicated to feel more committed to both the schedule itself (Commit1) ($\chi^2(1)=17,19$, $p<.001$) and the care for the online patient (Commit2) ($\chi^2(1)=17,19$, $p<.001$) if the virtual assistant only suggested care tasks and the participant was free to deviate from the self-selected care plan.

The participants' experienced clear distinction of commitment with the different supervision conditions. Nevertheless, a paired sample T-test indicated no significant evidence for the fact that the supervision condition influenced the performance concerning the adherence to their online schedule. Subsequently, we found no moderation of the discussed personal profiles, i.e., desire for participation in medical decision-making (DPMD), self-efficacy (SE), locus of control (LOC), and personal traits in the performance of care for the online patient.

There was a strong preference for the cooperative support condition (Table 2). In a survey, twenty respondents expressed preference for supervision in the cooperative condition (Pref1) ($\chi^2(1)=17,19$, $p<.001$). Moreover, 18 respondents indicated that if they were caring for themselves, they would also prefer selecting their own tasks and have the possibility to deviate from it if they feel it would improve their health (Pref2) ($\chi^2(1)=17,74$, $p<.05$).

Table 2: χ^2 test statistics on commitment (Commit 1, Commit2) and preference (Pref1, Pref2) regarding supervision condition

	Observed N	**Expected N**	**Residual**
Commit1			
Cooperative	20	10.5	9.5
Autonomous	1	10.5	-9.5
Total	21		
Commit2			
Cooperative	20	10.5	9.5
Autonomous	1	10.5	-9.5
Total	21		
Pref1			
Cooperative	20	10.5	9.5
Autonomous	1	10.5	-9.5
Total	21		
Pref2			
Cooperative	18	10.5	7.5
Autonomous	3	10.5	-7.5
Total	21		

6. Discussion

The system with the electronic agenda and the Health-Pal assistant proved to be a suitable tool. With the tool we successfully obtained an accurate observation of the participants' adherence to the care plan and their performance of care for the online patient. It gives us a good overview of the adherence to the care plan, the managements of the care tasks, and the overall health of the online patient. In addition, we successfully deployed two dissimilar types of supervision conditions concerning the commitment with the care in general.

According to literature, commitment and participation in the plan improves medical adherence and the overall Self-Care quality. Although there was a distinct difference between the conditions concerning experienced commitment and participation, we did not find significant differences in the performance of care.

The lack of significant results is almost certain attributed to a ceiling effect. During the experiment, we observed a generally high commitment in general causing the participants to score at best. We assume that the effect of the supervision condition on performance was therefore masked. We expect that with Self-Care over a longer period of time and with a larger number of constraints we will find a significant variance in medical adherence and quality of Self-Care. Real life issues such as the complexity of the Self-Care and a bigger weight of personal trade-offs on medical adherence will be further studied in our next experiment with actual patients.

Additionally, during the improvement of our system we should rethink the influence of the supervision condition on the performance of care and medical adherence with different personal profiles. Not only the level of commitment and participation and the patient's personal profile, concerning desire for participation in medical decision making (DPMD), locus of control (LOC), and self-efficacy (SE) are of importance. We must also anticipate to factors we currently did not take into account. Important social issues are conformation and peer support, and the patient's desire preservation of their quality of life (QOL). QOL concerns the patient's satisfaction of his or her life position in relation to specific medical goals, expectations, and values..

In our next experiment we will reconsider the influence of factors such as the duration of care, personal preference for condition in relation to performance. We will aim at using the system in a field

experiment over a longer period of time (e.g., two months) with patients performing Self-Care and look at improvements in their medical adherence. Besides the patient's personal profile, we will take into account social influence and preservation of QOL.

Conclusion

This paper summarizes the evaluation of a system consisting of an electronic agenda and a personal virtual assistant. These were designed to supervise patients' Self-Care and improve their medical adherence. We successfully observed participants' performance of care for an online patient in a non-laboratory environment and were able to manipulate the supervision condition, concerning the level of commitment and participation in the medical decision making.

There was no significant effect of the supervision condition on the performance of care. We did find a strong preference for a cooperative supervision condition in which the participants were involved in the scheduling of the care tasks and able to manage the care plan during the week. Commitment and participation is essential for medical adherence which is currently a severe problem in Self-Care. Based on our findings we will further develop the system to enhance the supervision of patient's Self-Care.

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