

# Utilizing Human Computer Etiquette to Encourage Human-Machine Therapeutic Alliance

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**Abstract.** A new design paradigm is needed for technologies designed to aid those with traumatic brain injury. We describe a holistic approach to augment sensor data with user feedback to more accurately represent user state and actions. To motivate human-machine collaboration we utilize a computational model of human-computer etiquette to generate interactions. By quantifying and allowing machines to exhibit appropriate behaviors, we can manage user expectations and embed user reporting so the system is viewed as a cooperative ally instead of intrusive or contributing to reporting burdens. In this paper, we briefly describe a smart home prototype system called Sensing using Physical and Psychological Observations for Rehabilitating Troops (SUPPORT) and provide two use cases describing the proposed functionality of the system.

**Keywords:** Assistive Technologies, Human-Computer Interaction, Cognitive Orthotic, Smart Home, Computational Etiquette, Politeness, Planning, Traumatic Brain Injury, Formal Models

## 1 Introduction

Those with Traumatic Brain Injuries (TBI) often experience challenges with memory, attention, problem solving, visuospatial tasks, and communication [3] which can have detrimental effects on their independence. These challenges are compounded by the diverse set of individual abilities and limitations that require customized treatment and assistance [4]. To encourage and enable a patient's independence, innovations in monitoring systems and cognitive prosthetics are necessary.

We describe a holistic approach to augment sensor data with user feedback to more accurately represent user state and actions. To motivate human-machine collaboration, we utilize a computational model of human-computer etiquette to generate interactions. In this paper, we briefly describe the designs of a smart home prototype system called Sensing using Physical and Psychological Observations for Rehabilitating Troops (SUPPORT) and provide two use cases describing the proposed functionality of the system.

## 2 The SUPPORT System

The SUPPORT system will consist of a small number of sensors, such as motion and noise detection, provide dynamic human-machine interactions, and use intelligent scheduling capabilities to optimize the delivery of cues and reminders. Information from the sensors will be cross referenced with direct feedback from the user so the system can build a more accurate user model. This system will use temporal relative constraint and soft constraint event planning, and a dialog system derived from an etiquette model to dynamically calculate and present appropriate interactions using a probabilistic model. See Figure 1 for a screen capture of the main user interface.

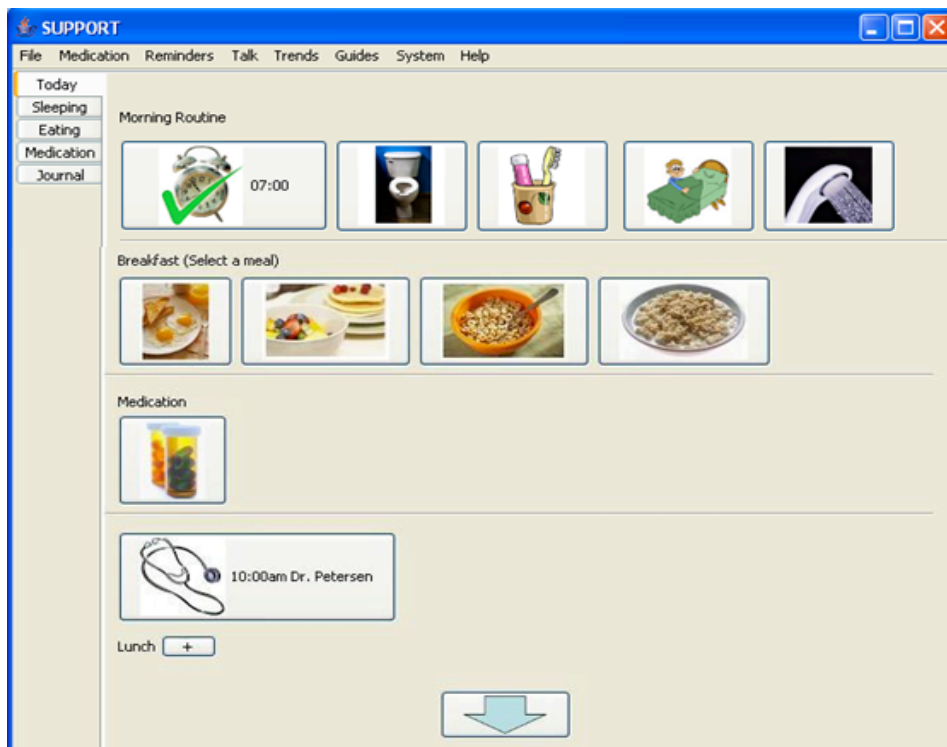


Figure 1. Screen capture of main user interface.

### 2.1 The Importance of User Feedback

Research (see [5] for an early example and also [1]) shows that in many domains users like to “talk back” to their machines, are motivated to use them more extensively if such feedback is accepted and come to see them as more responsive, more accurate, more trustworthy and, less stressful to interact with than when such

feedback is denied. We will combine user feedback with the user's daily plan to improve the system's performance over time.

## 2.2 The Use of Relative Temporal and Soft Constraints

To increase system flexibility we use temporal and soft constraints. Our reminder generator first enumerates temporal constraints associated with the user's routine: the ideal and acceptable times for doses of medication and their times relative to other activities etc.. To form a quality reminder plan for a given day, the generator treats this enumeration as a set of soft constraints, where the quality score gained for satisfying some constraint is balanced against the score lost for violating others. For example, there may be little gain in issuing reminders for activities which are seldom forgotten by the user, but substantial loss in quality for omitting reminders of activities which occur on an infrequent or irregular schedule, or are of high priority.

## 2.3 Computational model of human-computer etiquette

A theory of the role of politeness in human-human interactions, and a specific model of how to construct utterances that will be regarded as more or less polite in context was previously developed [2]. This was used to produce a model and algorithms to select the most appropriate utterances to motivate human-machine collaboration [6]. The model states that the amount of face threat (during social interactions the threat to the speaker's autonomy or the threat of not being highly regarded by others) in a communication exchange is a function of the contextual values as follows:

$$W_x = D(S,H) + P(H,S) + R_x .$$

- $W_x$  is the 'weightiness' or severity of the threat
- $D(S, H)$  is the social distance (roughly, the inverse of familiarity) between Speaker (S) and Hearer (H)
- $P(H,S)$  is the power difference that H has over S
- $R_x$  is the ranked or raw imposition based on the content of the message to be delivered.

The amount of threat must then be redressed, or mitigated by using politeness strategies.

## 3 Use Case 1: Medication Event

The following use case demonstrates the basic functionality of different components of the proposed SUPPORT system as they relate to a medication event. In the given scenario the user needs to take medication three times a day, after meals. The times and options for these medication events are entered into the system by the user through SUPPORTS customization process. This provides the initial requirements for medication adherence.

The user has been using the system for five weeks. During this time the system has been able to develop a user model through the collection of statistical information

about how often the user forgets to take medication and how the user responds to medication reminders. The current user model includes a default rule for medication that states "medication event to follow a meal event (3 a day) with a threshold of 30 minutes." The system is able to use collected information to determine the percentage of time medications are missed and the number of reminders needed. Finally, the user model includes interaction history (human-system familiarity, last redress level of medication reminder).

Currently, the user is preparing a meal in the kitchen. The system is aware of this activity because the kitchen motion and refrigerator sensors have been triggered. The system accesses the user model to determine if a medication reminder should be generated. Because the user has only been missing medications 10% of the time lately, the reminder generator has calculated that the cost of interrupting the user's current task is higher than the benefit of issuing a reminder. Thus the reminder generator will not issue a reminder.

Two hours later, the user has finished preparing and eating the meal, but no medication event has been detected via the sensor in the medication caddy. During this time the system has detected triggered motion sensors in the bathroom and living room. The rule regarding medication after meals initiates a missed medication event; therefore the request generator creates a request for user feedback on medication. The system scheduler may choose to schedule the message to be delivered now, or later with other messages, such as a daily interaction session.

The scheduler examines the user's schedule and predicts that the user is currently available (i.e. not sleeping, not in the middle of an activity such as preparing a meal or getting ready to go out). The cost of interrupting the user is low, and the need for the system to know whether medication was taken is high. Thus, the scheduler sends a message for a user feedback request to be delivered now. The message can be sent aurally via the telephone or visually via the device screen as preferred by the user.

The exact utterance delivered to the user is based on the user's familiarity with the system and recent interactions. Using the etiquette model the appropriate redress is calculated. Some of the choices include:

- Hello, this is <avatar's name> from the SUPPORT system. I believe you have a scheduled medication event after each meal, but I couldn't detect whether you took your medication after lunch. Have you taken your medication?
- Hey buddy it's me. Hope you had a good lunch. Did you take your pills after your lunch just now?
- Hi <user's name>. Just checking in to see if you took your afternoon meds. Did you?

The user may respond with one of several choices, followed by the system's response, see Table 1.

Table 1. Example user and system responses.

User Response	System Response
Yes, I've already taken them	Sorry, my mistake then, I'll check it off the list. You've been doing great with your meds, keep up the good work! Talk to you later.
No, I'll take them now	Alright then. Glad we caught that one. By the way, you've been doing great with your meds, keep it up! Talk to you later.

No, I'm going to skip them	You've been doing so well, you know they make you feel better, why do you want to skip them?
No, I'm out of medication	Oh did we forget to refill the prescription? I can put it on your to do list and remind you later.
No, other reason.	

## 4 Use Case 2: Self Report and Noise Detection

Use case 2 demonstrates the usefulness of different types of sensors and user interaction with the system. From the noise sensor log the system identifies that a noise occurred at 2 a.m. The noise dissipated immediately and was recorded as being too loud for normal activities during this time period (sleep), but not loud enough to initiate an immediate call to identify the cause. This system decision was made based on the calculation of the costs and benefits associated with calling. In this instance the cost of interrupting sleep was deemed to be greater than the benefit of identifying the noise. During the next conversation between the system and the user, the system will ask about the noise if the user indicates not sleeping well, see Figure 2.

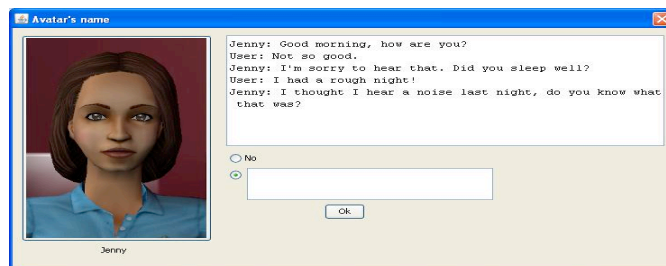


Figure 2. Morning conversation between a user and avatar.

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## References

1. Bickmore, T., Cassell, J.: How about this weather?" Social Dialogue with Embodied Conversational Agents. Proceedings of the AAAI Fall Symposium on Socially Intelligent Agents. North Falmouth, MA, (2000)
2. Brown, P., Levinson, S.: Politeness: Some Universals in Language Usage. Cambridge Univ. Press; Cambridge, UK. (1987)
3. Cicerone, K.D. et al.: Evidence-Based Cognitive Rehabilitation: Recommendations for Clinical Practice. Arch Phys Med Rehabil, 81, pp. 1596-1615 (2000)

4. Cole, E.: Cognitive Prosthetics: An Overview to a Method of Treatment. *NeuroRehabil*, 12, pp. 39-51, (1999)
5. Miller, C.A., Hannen, M.D.: User Acceptance of an Intelligent User Interface: A Rotorcraft Pilot's Associate Example. In *International Conference on Intelligent User Interfaces*, Redondo Beach, California, pp. 109-116. (1999)
6. Miller, C., Wu, P., Krichbaum, K., Kiff, L.: Automated Elder Home Care: Long Term Adaptive Aiding and Support We Can Live With. In *proceedings of the AAAI Spring Symposium on Interaction between Humans and Autonomous Systems over Extended Operation*, Stanford, Palo Alto, CA. (2004)