

## **Relational Agents in Clinical Psychiatry**

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## **Abstract**

Relational agents are computational artifacts, such as animated screen-based characters or social robots, that are designed to establish a sense of rapport, trust, and even therapeutic alliance with patients, using ideal therapeutic relationships between human counselors and patients as role models. We describe the development and evaluation of several such agents designed for health counseling and behavior change interventions, in which a therapeutic alliance is established with patients in order to enhance the efficacy of the intervention. We also discuss the promise of using such agents as adjuncts to clinical psychiatry in a range of possible applications, and some of the challenges and ethical issues in developing and fielding them in psychiatric interventions, before speculating on possible directions for future research on relational agents in healthcare .

## **Keywords**

Relational Agent, Embodied Conversational Agent, Therapeutic Alliance, Automated Counselingt

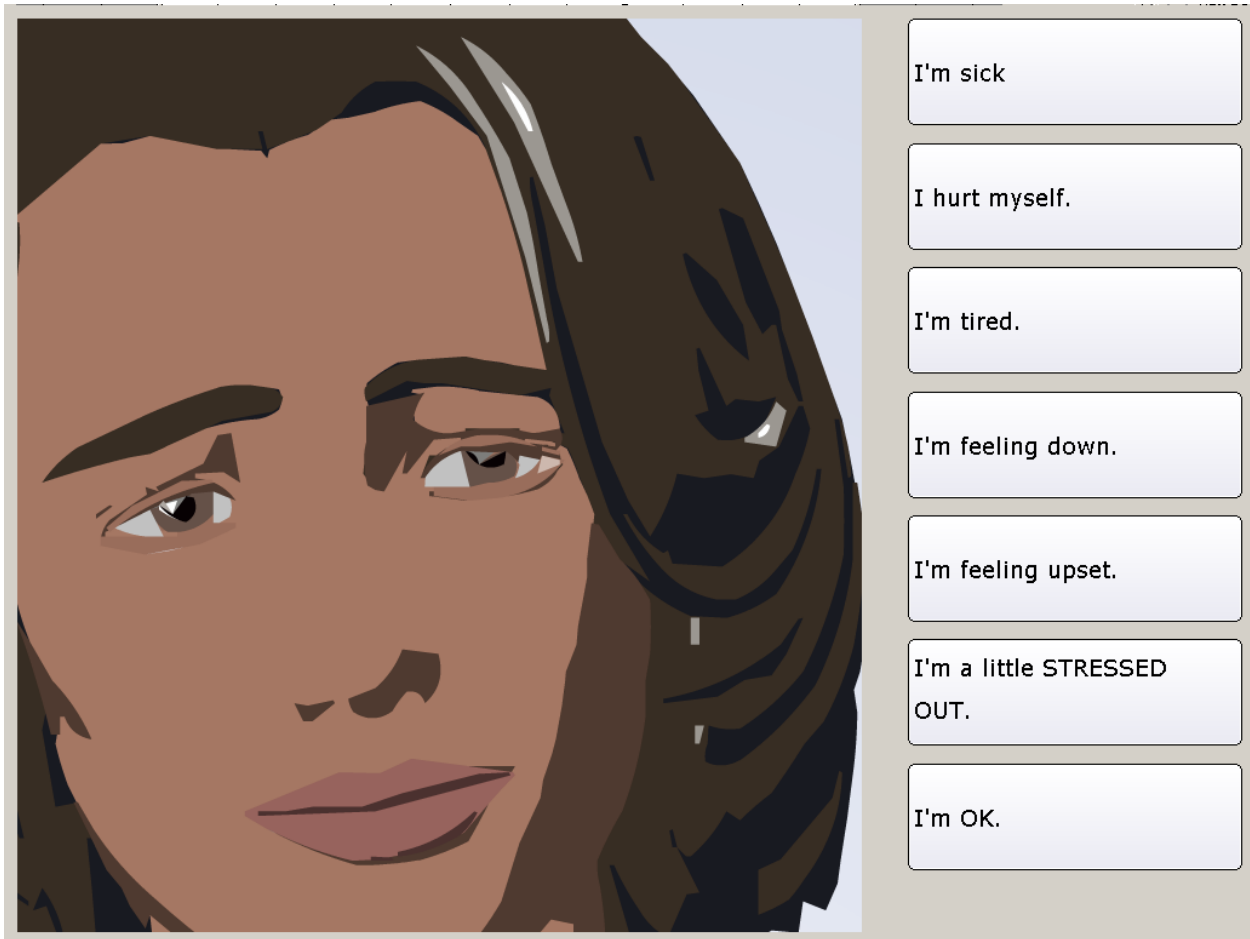
## **INTRODUCTION**

Relational agents (RAs) are computer programs designed to build a sense of relationship with people over time, including therapeutic alliance. Our objective in writing this article is to inform psychiatrists about the development of RAs and describe their capabilities in enough detail that psychiatrists can envision how RAs might be beneficial in their practices.

In this article, we discuss what a relational agent is, and how to build an effective one. This is followed by a description of the small number of studies using relational agents in health care applications. Next we explore the potential benefits of relational agents in clinical psychiatry, followed some speculation about directions for future research on RAs in psychiatry.

## **WHAT IS A RELATIONAL AGENT?**

Relational agents are computer programs that have conversations with users in an effort to create a relationship with them. Since the primary site of human relationship building is face-to-face conversation, most of the research to date has focused on the development of relational agents in the form of humanoid animated agents (Figure 1) or robots that simulate face-to-face conversation with people. Simulation of face-to-face conversation involves modeling both what people say to each other (via a “dialogue system”) and the nonverbal behavior that accompanies the speech, such as hand gestures and facial displays of emotion (via an “embodied agent” interface).



**Figure 1. Relational Agent Interface**

One of the first dialogue systems designed to have conversations with users was ELIZA, a simulated Rogerian therapist.<sup>1</sup> ELIZA exchanged typed text messages with a user, and used a number of tricks to make users believe they were having a natural conversation with a person. ELIZA was not designed to do therapy, but two dialogue systems based on ELIZA technology were,<sup>2,3</sup> although these were not very effective, mainly because of the computer's inability to adequately understand unconstrained text entered by the user. Subsequent work in modeling therapeutic conversation has moved away from unconstrained input (for example, requiring users to select their utterances

from menus, as in Figure 1), but has sought to incorporate more sophisticated models of the structure of conversation, both within a session and over repeated sessions, to allow tailoring of a conversation based on context, prior conversations, and information about the user.<sup>4</sup>

Research into embodied conversational agents has focused on how to model conversational nonverbal behavior in an animated character or robot, and use this behavior to communicate information to the user (e.g., pointing at something being talked about), to regulate the flow of conversation (e.g., using eye gaze to signal turn-taking), and to express emotion and attitude (e.g., using facial display).<sup>5</sup> One product from this body of research that has now been used in several counseling systems is the “BEAT” text-to-embodied-speech system.<sup>6</sup> BEAT takes the text that an agent is to speak as an input and generates synthetic speech with “visemes” (mouth shapes corresponding to phonemes), synchronized facial movements, and other non-verbal behaviors that are communicative and social and relational in nature, such as head nods.

It may at first glance seem difficult to create a relationship between a computer and a person, and to many the very notion may be suspect. However, people tend to anthropomorphize many inanimate things like stuffed animals, and seem to be especially predisposed to do so with things that move or make sounds such as robotic toys like Furby. It is well established in the fields of human-computer interaction and communication that people tend to anthropomorphize computers and complex

technology, and demonstrate social attitudes and behaviors towards them.<sup>7</sup> This has also been demonstrated in automated health counseling interventions. For example, in a qualitative study of user perceptions of an automated telephony-based health behavior change system, Kaplan et al. found that users not only talked about the system using anthropomorphic terms (e.g., using personal pronouns), they described the system in ways indicative of having a personal relationship with it (e.g., “friend”, “helper”, “mentor”) and seemed to be concerned about impression management (e.g., choosing to only interact with the system on days in which they met the system’s health behavior goals).<sup>8</sup>

The development of relational agents for healthcare applications is limited. Over the last decade a series of these agents have been developed for a variety of applications in health counseling and education, with development and maintenance of a therapeutic alliance over time being a central concern. A number of empirical studies have been performed both in and out of the lab on the impact of specific design features that seem to foster an alliance, and to assess the efficacy of counseling systems designed with these features.

Relational agents could provide a unique role in health care at this time. In an effort to reduce costs, health care providers are being pressured to spend less time with patients. Relational agents may be able to augment the health care provider’s time by increasing the patient’s understanding of and compliance with instructions, and aiding the patient in accomplishing health-related behavior change.

## **KEYS TO BUILDING AN EFFECTIVE RELATIONAL AGENT**

Designing a relational agent is a lot like training a psychotherapist. Relational agents are modeled after human interpersonal interactions that promote working alliances and build trusting relationships in general. In addition, relational agents designed to perform specific counseling tasks must also model the interactions of humans performing those tasks well. In the course of developing relational agents, several design studies have been conducted to evaluate techniques for establishing a sense of trust and therapeutic alliance between a person and an agent.

Strategies for forming a strong therapeutic alliance are generally those that enable the user to respond to expected human social behaviors.

**Verbal behaviors** that can be used by a relational agent to establish and maintain a therapeutic alliance with users include: expressing empathy for the user, social dialogue, reciprocal self-disclosure, humor, meta-relational communication (talk about the relationship), expressing happiness to see the user, talking about the past and future together, continuity behaviors (appropriate greetings and farewells and talk about the time spent apart), and reference to mutual knowledge. Specific language constructs such as inclusive pronouns, politeness strategies and greeting and farewell rituals indicative of a close relationship are also used. Many of these behaviors require a database of information about the user and prior interactions with them to be kept between sessions. Bickmore demonstrated that a relational agent that uses these

verbal behaviors, in conjunction with the nonverbal behaviors below, is more effective at establishing a therapeutic alliance with users compared to an equivalent agent that does not use these behaviors.<sup>9</sup>

**Nonverbal behaviors** that can be used for relationship-building include "immediacy" behaviors--close conversational distance, direct body and facial orientation, increased and direct gaze, smiling, pleasant facial expressions and facial animation in general, nodding, and frequent gesturing--which project liking for the other and engagement in the interaction, and is correlated with increased solidarity.<sup>10</sup> Agents can also use facial displays of emotion to signal attitude towards the patient, such as concern for empathic dialogue.

**Interruption** by an agent is less annoying when the agent uses human social conventions. This is important for reminder agents that need to alert users, for example for medication taking. Two studies have demonstrated that users are less annoyed and choose to continue working longer with an agent that repeatedly interrupts them when the agent uses social behavior, such as apologizing for the interruption and empathizing with the user.<sup>11, 12</sup>

**Animation** is more effective for portraying relational agents than text alone or a static image. Users seem to prefer animation in their agent companions just as they do in their human companions. In a comparison of different ways to present relational agents to users—using text-based dialogue only, a static agent image plus text dialogue, and



animated conversational nonverbal behavior plus text dialogue—it was found that animation contributed significantly to the establishment of a working alliance in a brief interaction between users and agents on handheld devices.<sup>13</sup>

Empathy is a key element in forming strong helping relationships. Empathy can be expressed using verbal and non-verbal cues as described above, and the studies below emphasize its importance.

**Empathy promotes alliance.** Two studies have now demonstrated that empathy alone, when used by a computer agent, promotes user liking of the agent, reduction of user frustration, and desire to continue working with the agent.<sup>14, 15</sup>

**Agent empathic accuracy is more important than user expressivity.** Given the current state of dialogue systems technology, when developing counseling dialogue for relational agents, designers are forced to choose between (a) allowing users to freely express their feelings, but having the agent provide imperfect empathic responses, or (b) greatly restricting how users can express themselves (e.g., through multiple-choice input), but having the agents provide reasonably accurate empathic feedback. One study found that in a brief comforting interaction with a relational agent, agent empathic accuracy was more effective in terms of actually comforting users and increasing their satisfaction with the agent.<sup>16</sup>

Maintaining relationships with agents over months or years requires additional strategies.

**Variability** in agent behavior is important to maintain a long-term alliance. Users who must continue to work with an agent over long periods (e.g., in a longitudinal behavior change intervention) need to see changes in agent behavior over time. One study demonstrated that simply manipulating variability in an automated exercise counselor's behavior (wording, visual appearance, social chat topics) was effective for increasing how often study participants chose to talk to the agent over time.<sup>17</sup>

**Self-disclosure** by an agent is important to maintain a long-term alliance. There has been a running debate among developers of embodied agents as to whether they should present themselves as humans, with personal, human, autobiographical back stories, or whether this constitutes some kind of deception. One study compared an automated exercise counselor that told personal narratives during social chat as events that happened to "a friend" (third person) with an equivalent agent that told the same stories as happening to itself (first person). Participants hearing first person stories reported enjoying their interactions with the agent significantly more and completed more conversations with the agent over time, compared to participants in the third person condition, while ratings of agent dishonesty were not significantly different between the groups.<sup>18</sup>

**Referencing knowledge of prior interactions** is important to maintain a long-term alliance. Health-related behavior change typically requires many interactions over a period of weeks to months or longer. In order to maintain a relationship over time it is necessary for an agent to develop a history with its user, so that each interaction does not seem isolated, but is placed in the context of previous interactions. This requires the agent to maintain a persistent database of information about previous sessions, and mechanisms for referring to past conversations and tailoring the current conversation accordingly.<sup>4</sup>

## **RELATIONAL AGENT INTERVENTIONS AND CLINICAL TRIALS**

There are few relational agents that have been developed for healthcare applications, and even fewer of these that have made it to clinical trials. Here we briefly review all of the relational agent-based health interventions that have been evaluated and reported in the literature to date.

### Medication compliance - Anti-psychotic medication in patients with schizophrenia

Of most interest to psychiatrists is a study done to improve medication compliance.

Medication adherence in general is a significant problem, with many studies indicating that adherence rates of 50% are common across many conditions and treatments.<sup>19</sup>

The incidence of medication non-adherence in schizophrenia approaches 50% the first year and 75% the second year, leading to higher rates of hospital re-admissions and greater number of inpatient days, higher health care costs and reduced work productivity. Contributing factors to the low adherence rate include medication side effects, psychotic symptoms, insufficient social support, and a lack of understanding of

the role of medication for preventing relapse.<sup>20, 21</sup> In addition, a positive interpersonal relationship with a health care provider has been shown to lead to improved adherence rates.<sup>22</sup>

To address this challenge, a home-based relational agent was designed to promote antipsychotic medication adherence among adults with schizophrenia and evaluated in a quasi-experimental pilot study.<sup>23</sup> The system runs on a laptop computer as a stand-alone system, and is designed for a one-month, daily contact intervention (Figure 1). The agent tracks each patient's medication taking behavior for a single antipsychotic taken by mouth in pill or capsule form based on self-report, but it also reminds patients to take all of their other medications as prescribed. In addition to medication adherence, the agent promotes physical activity (walking) and talking to the agent every day. For each of these three behaviors, the agent first asks for a self report of the behavior, provides feedback, and negotiates a new behavioral goal.

There are several other unique aspects of the medication adherence dialogue used by the agent. Since the system is not networked to a central server, it asks the patient whether or not their prescription has changed at the start of each conversation, so that the agent does not promote an incorrect regimen. The system also keeps track of refill schedules and reminds patients to get refills before they run out of their tracked medication (including problem solving, such as recommending that a friend drive them to the pharmacy if they don't have transportation). Finally, the system uses a form of "direct observation" – a technique used in human medication adherence interventions in

which a health provider watches while the patient takes their medication. To accomplish this, the patient is asked to conduct their chats with the agent at one of their prescribed medication taking times. When the agent asks patients about their medication taking behavior it asks whether they have taken their dose for the current time of day yet (e.g., “Have you taken your evening Prolixin yet today?”). If they have not, the agent asks them to go ahead and take it while it waits.

Towards the end of the intervention, the agent begins instructing patients in techniques for behavioral self-maintenance. It starts by asking patients to obtain a multi-compartment pill box and calendar for self monitoring, then asking patients about this during every conversation until they do so. Once the patient has obtained these, the agent reviews techniques for self monitoring at periodic intervals until the end of the 30-day intervention period.

The agent dialogue and nonverbal behavior were tailored specifically to interact with individuals with schizophrenia, according to the literature on mental health nursing<sup>27</sup>. Extended time was spent during orientation and termination phases of the intervention schedule to help patients ease into and out of their working relationship with the agent. The first several days were spent only on relational behavior and visit adherence before discussions of medication, exercise and schizophrenia were started. The last several days were spent preparing patients for termination, addressing their feelings about ending their daily conversations with the agent and focusing the counseling on promotion of self-maintenance behaviors. The dialogue scripts were reviewed to

ensure that simple, direct language was used throughout by the agent, and its nonverbal behavior was simplified by removing conversational “gaze aways” that patients may take as a cue of untrustworthiness.

The pilot study involved twenty participants, aged 19-58, recruited from a mental health outpatient clinic who met the DSM IVR criteria for schizophrenia, were on any antipsychotic medication, and had two or more episodes of non-adherence in the 72 hours prior to recruitment. Sixteen participants (80%) completed the study and, of these, one participant expressed concern that the program was relaying their personal information to others, but the study nurse was able to re-orient them to continue the intervention. Another participant developed paranoia and stopped using the agent after a few days and could not be convinced to continue.

**Results:** System logs indicated that participants talked to the agent an average of 65.8% of the available days, with nine of the participants talking to the agent at least 25 times during the 30 day intervention. Self-report ratings of satisfaction averaged 4.0 on a 1 (“not at all”) to 5 (“very much”) scale. Self-reported medication dose adherence was 89%. Satisfaction was rated an average 4.5 on a 1=“not at all” to 5=“very much” scale. These results indicate that patients with schizophrenia largely accepted and regularly talked to the agent, and were satisfied with their daily counseling conversations.

Health-Related Behavior Change - Increasing Exercise in Young Adults

One of the earliest relational agents developed was the FitTrack system, featuring “Laura” the exercise advisor (Figure 1). Laura was designed to have daily conversations with sedentary adults on their home computers to attempt to motivate them to do more walking. The exercise promotion system has been evaluated in two studies to date.

FitTrack was first evaluated in a three-condition randomized trial with 101 young adults from a college community in order to test the ability of the agent’s relational behavior to foster a sense of therapeutic alliance in study participants over 30 days of brief daily counseling.<sup>9</sup> The counseling included behavioral (e.g., positive reinforcement), social cognitive (e.g., problem solving to develop self-efficacy) and cognitive behavioral (e.g., promotion of positive thoughts about exercise) techniques. One group of participants (RELATIONAL) interacted with a version of Laura in which all of her relational behavior (social dialogue, empathy, nonverbal liking behavior, etc.) was enabled, while a second group interacted with the same agent in which these relational behaviors were removed (NON-RELATIONAL). A third group acted as a non-intervention control and simply recorded their daily physical activity (CONTROL).

**Results:** Participants in the RELATIONAL condition reported significantly higher Working Alliance scores on the Bond subscale of the measure compared with subjects in the NON-RELATIONAL condition, both at one week, and at the end of the four-week intervention (the Bond subscale assess the trusting, empathetic dimension of the alliance, in contrast to dimensions that assess agreement on the tasks and goals of therapy<sup>24</sup>). Several other self-report and behavioral measures indicated that relational

bonding with the agent was significantly greater in the RELATIONAL group compared to the NON-RELATIONAL group. Participants in the RELATIONAL and NON-RELATIONAL groups combined, increased the number of days per week that they engaged in at least 30 minutes of moderate or more vigorous physical activity significantly more than subjects in the CONTROL condition. However, there were no significant differences between the RELATIONAL and NON-RELATIONAL groups with respect to gains in physical activity, likely due to the short duration of the intervention. These results could be interpreted as meaning that the effects of relational behavior alone on outcomes in agent-based health behavior change interventions are only seen after an extended period of time. In fact, more recent studies indicate that one of the real advantages to engaging users with relational agents may be retention in long-term interventions <sup>18</sup>.

#### Increasing Exercise in Older Adults with Limited Computer Literacy

A modified version of the FitTrack system was evaluated with 21 geriatrics patients in order to determine how approachable and effective the system was for individuals with low computer literacy.<sup>25</sup> The randomized trial compared older adults who interacted with the agent daily in their homes for two months with a standard of care control group who were only given pedometers and print materials on the benefits of walking for exercise. Participants ranged in age from 62 to 84, were 86% female, and 73% were African American. Eight (36%) had never used a computer before and six (27%) reported having used one “a few times”.



**Results:** All participants using the agent found the system easy to use, rating this an average of 1.9 on a 1 (“easy”) to 7 (“difficult”) scale. Satisfaction with the overall intervention was very high. At 8 weeks, the agent group showed a net mean increase of 2611 steps per day compared to controls. Two-thirds of agent subjects averaged over 5,000 steps per day at 8 weeks while two-thirds of controls remained below the 5,000 steps/day threshold considered to reflect a sedentary lifestyle. Between-arm slope comparisons based on daily recorded pedometer steps demonstrated that those in the agent group increased their daily step count significantly compared to controls ( $p=.001$ ). In addition to demonstrating the ability of the agent to motivate behavior change, the primary result from this study was that populations with low reading literacy and very low (or nonexistent) computer literacy find relational agents approachable and usable.

### Increasing Exercise with a Portable Relational Agent

A relational agent designed to increase exercise was also deployed on a PDA with an integrated accelerometer, which acted as a pedometer (Figure 2).<sup>26</sup> Such portable agents provide an automated counselor that can go everywhere with a patient, providing information and counseling whenever and wherever the patient needs it. Coupled with sensors, such as the accelerometer, these agents can also provide proactive suggestions, for example alerting the patient when it is time for a medication dose, when the patient is about to enter a risky situation (e.g., based on location), or when the patient appears to be making a decision about whether to engage in a

particular behavior (based on sensed patient behavior). Such systems must be adept at knowing not only how, but when to interrupt a user in order to maximize long-term compliance with a therapeutic regimen.



**Figure 2. Portable Relational Agent**

A preliminary field study has been conducted using this handheld relational agent.<sup>26</sup> The study evaluated the impact of automatically triggered counseling by comparing an agent that could sense whether the user was walking at moderate intensity or not and proactively providing feedback to them whenever they finished a walk (AWARE), with an agent that the user had to explicitly tell when they were starting or ending a walk

(NON-AWARE). Seven participants carried these computers continuously for 8 days, experiencing each condition for 4 consecutive days (counterbalanced).

**Results:** On relational measures, participants rated themselves as having a significantly closer relationship with the AWARE agent compared to the NON-AWARE agent ( $p < .05$ ). However, contrary to expectations, participants did significantly more walking in the NON-AWARE condition of the study ( $p < .001$ ). There are several possible reasons for this, including several problems with the reliability of the walking bout detection, a one-minute delay between completion of a walk and positive reinforcement in the AWARE condition, and effects of an implicit behavioral “contract” with the agent in the NON-AWARE condition when participants explicitly told it they were going for a walk <sup>29</sup>.

#### Health-Related Behavior Change - Improving Diet

“Autom” is a non-mobile interactive social robot designed to promote diet tracking among overweight users.<sup>27</sup> Autom was programmed to use a few of the relational behaviors described above in its daily conversation with users, such as appropriate greetings and limited social chat. In a 6 week study, 45 participants who were class I or II obese (BMI range of 25 up to 42) interacted with either the robot, a touch screen computer, or used a paper diary to record their eating behavior daily.

**Results:** Participants rated the robot significantly higher on Working Alliance compared to the touch screen condition. In addition, participants who interacted with Autom continued recording their diet behavior significantly longer than those in the computer or

paper diary conditions. There were no significant differences in actual weight loss between groups. These results provide further evidence that patients find anthropomorphic agents more engaging than equivalent systems that are not personified. Whether a robotic embodiment is more effective than an equivalent screen-based animated agent at engaging users or motivating behavior change has yet to be demonstrated.

#### Inpatient Education and Counseling - Virtual Hospital Discharge Nurse

Relational agents have also been used in inpatient settings for bedside patient education. The “virtual discharge nurse” (Figure 3) is designed to counsel patients on their self-care regimen before they are sent home from the hospital.<sup>28</sup> A particular focus in this work has been the development of a relational agent that can explain written hospital discharge instructions to patients with low health literacy. To develop this agent, several conversations in which nurses were explaining discharge instructions to patients were videotaped and analyzed to develop models of the verbal and nonverbal behavior used by the nurses. This agent is wheeled up to a patients’ hospital bed before they are discharged from the hospital, and spends a half hour (on average) reviewing this material with them, testing for comprehension, and flagging any unresolved issues for a human nurse to follow up on.



**Figure 3. Virtual Nurse for Inpatient Education**

**Results:** Two rounds of pilot studies were conducted to assess acceptance, usability and satisfaction with the system. Results indicate that patients found the system easy to use (average 6.8 on a 1="difficult" to 7="easy" scale), reported high levels of satisfaction (6.7 on a 1="not at all" to 7="very much" scale), and 74% said they preferred receiving the discharge information from the agent over their doctor or nurse. Patients also expressed appreciation for the time and attention provided by the virtual nurse, and felt that it provided an additional authoritative source for their medical information. Patients who interacted with a version of the virtual nurse agent that used relational behavior reported feeling that the agent cared significantly more about them compared to patients who interacted with the same agent that did not use relational behavior. A

randomized clinical trial involving 750 hospital patients is underway. The results demonstrate that a wide range of patients, including those with low health literacy, find relational agents easy to use, and most patients (regardless of literacy level) appreciate the ability to have their health questions answered in a low pressure interaction, even if it is by an automated nurse.

## **BENEFITS OF RELATIONAL AGENTS IN PSYCHIATRY**

### Treatment of Mental Illnesses

Relational agents could provide high-quality computerized cognitive-behavioral therapy (CCBT). Numerous studies have demonstrated that CCBT, especially when delivered in conjunction with care or direction from a health care provider, is effective in the treatment of a wide range of mental illnesses including: unipolar depression, generalized anxiety disorder, and panic disorder with and without agoraphobia<sup>29-32</sup>. In addition, CCBT has been shown to be a cost-effective treatment option because the time required by the health care provider, typically a general practitioner, per patient is considerably smaller than treatment as usual.<sup>33</sup>

Most of these interactive CCBT programs have not employed relational agents.

Relational agents hold the promise of developing a therapeutic alliance with patients that can boost retention in an intervention, provide motivation to do the homework required for successful CBT, and improve outcomes. If relational agents were used, we would predict that the percentage of patients who successfully complete these CCBT programs would rise significantly. We would also predict that the amount of provider

time required to produce good outcomes would substantially decrease. If CCBT delivered by relational agents leveraged provider time it would enable many more patients to benefit from CBT directed by trained cognitive-behavioral therapists. It would also make it possible for the many patients living in areas where there is a shortage of trained cognitive-behavioral therapists to receive CBT, one of the only non-pharmaceutical evidence-based therapies for many mental illnesses.<sup>34, 35</sup>

Relational agents that provide CCBT can help psychiatrists provide treatment for those patients who cannot or will not come to our treatment facilities for face-to-face therapy. General studies of the prevalence of mental health in various populations estimate that up to 40% of those with mental illnesses do not seek professional help. These patients include those with physical obstacles like illness or remoteness, and those with mental obstacles like agoraphobia and the perception that seeking mental health care is stigmatizing.<sup>30</sup>

Web-based relational agents could communicate with a patient's health care providers using dedicated web sites accessible only by the patient's health care providers. Information transmitted might include information about adherence to medication and rehabilitation regimens, and patient-reported symptoms that could indicate medication side effects or relapse. This sort of information would enable health care providers to intervene with those patients who were at risk of relapse, ideally preventing emergency room visits and hospitalizations, and enabling patients with chronic illnesses to live independently at home for a longer time. Patients might also elect to have the relational

agents send information to a dedicated website to which only their independent caregivers had access. Knowing that the relational agent is having regular interactions with the patient, and has the capability to communicate the substance of these interactions with them and their health care providers may reduce the stress on informal caregivers.

Psychiatric patients who develop a positive, trusting, working alliance with a relational agent may receive benefits beyond treatment of the acute illness episode. First, the cost of allowing a patient to continue interacting with a relational agent is small, making it possible for the relational agent and the patient to continue working together to achieve adherence to medication regimens and to monitor the patient's symptoms for signs of relapse on an ongoing basis. If successful in increasing medication adherence and detecting relapses, these ongoing interactions should decrease unnecessary emergency room visits and hospital admissions. Second, if there is a relapse or the development of another illness that can be managed by the relational agent, the therapeutic relationship is already established so that treatment can commence quickly and effectively. Third, psychiatric patients who are very isolated may receive meaningful social benefits from interactions with the relational agent. Also, because the relational agent is connected to the internet, it can help the patient stay in contact with family and friends by helping them send and receive email, text messages, and internet phone calls. Fourth, the patient's relationship with the agent may compensate for the lack of a long-term ongoing relationship with an individual provider, as these sorts of relationships are becoming less common as patients are managed by teams and



patients begin to form relationships with healthcare facilities rather than with individual healthcare providers. And fifth, access to data provided by the relational agent by different members of the patient's health care team may help maintain continuity of care.

### Health-related Behavior Change

Relational agents can be a tool for health-related behavior change. There have been many interactive programs designed to help people change unhealthy behaviors. The studies discussed above demonstrate that the relational agent is able to create a therapeutic working alliance with the patient, a pre-requisite for a being a successful agent of change.

Psychiatrists are experts in behavior change. Motivational interviewing is a practice commonly used to help patients, at various stages in deciding to change a behavior, to address their ambivalence about making a change, and move them closer to the state where they are ready to take action to achieve a behavior change. Using motivational interviewing techniques allows patients to convince themselves that they want to change their behavior, which has proven much more effective than counseling patients to change their behavior<sup>36</sup>. Specifically, psychiatrists treat patients who suffer from diseases resulting from unhealthy behaviors, like substance abuse, smoking, eating disorders, and primary insomnia. Psychiatrists deal constantly with medication adherence because our patients are among the most non-compliant. More generally,

non-pharmaceutical approaches to treating most mental illnesses also involve promoting behavior change.

Behavior change is key factor in improving mental health and it is increasingly recognized that it is a key factor in improving physical health as well. Improving our ability to change lifestyle health behaviors like exercise and diet is critical because they are leading causes of chronic diseases and death in the United States. The treatment of these chronic illnesses consumes a significant portion of the health care budget. We must maximize our ability to promote behavior change both to prevent chronic illness and also to manage it effectively. Managing chronic illnesses involves helping patients to adhere to lifestyle changes like diet and exercise, as well as to adopt medication, rehabilitation, and symptom and physiologic monitoring regimens. As in psychiatry, non-compliance with prescribed medication is the single most common reason for relapse or decompensation in those with chronic illnesses.<sup>19, 37</sup> Efforts are underway to develop counseling dialogue systems for relational agents that facilitate the creation of systems to address additional health-related behaviors. The key concept is that the underlying specific counseling techniques can be modeled so that they can be re-used.<sup>38</sup>

### Facilitating Communication

Relational agents may prove useful to psychiatrists and other physicians to improve the effectiveness of communication with patients. Due to the limited time health care providers are allotted to interact with patients, it is becoming increasingly common for

patients to leave their physician's office, the emergency room, or the hospital without understanding what they are supposed to do to follow-up. Failure to communicate well with patients, especially patients with low health literacy, often results in poor outcomes. There have been many protocols, including some computerized interactive ones, for patient education that have been designed to address these failures of communication. Relational agents have the capability to continuously evaluate comprehension enabling them to pursue communicating the important points until the patient has demonstrated understanding and willingness to comply with home care instructions <sup>39</sup>.

### Outcomes Research

A final benefit of relational agents is that in the process of performing their task, they store all the information required to do outcomes research. In order to sustain long-term working alliances, relational agents need databases containing information about previous interactions with patients, which include records of the patients' progress. In this way, relational agents automatically document their actions and measure their effectiveness. The data required for outcomes research is built into these systems and needs only to be analyzed to reap its benefits.

### Ethical Considerations

Although relational agents have the potential to be of great benefit in psychiatry, there are a number of issues that should be addressed before they can be deployed in clinical settings. Presenting a computer program as a (simulated) person raises several ethical concerns that may be especially important when dealing with mental health patients.

Even if they are clearly told that they will be interacting with a computer program (and are frequently reminded of this fact by the agent), some patients may become confused and think they are interacting with a real person instead of an agent. Some researchers have also argued that anthropomorphic interfaces in general can confuse users by raising their level of expectations regarding the abilities of the agent, ultimately resulting in user frustration and anxiety<sup>40</sup>. The use of relational behavior to draw users into trusting relationships with agents may also heighten concerns about promoting social isolation if users become too dependent upon their artificial relationships.

There are also a number of ethical issues that are common to the use of any technology in treatment. One is ensuring the safety and accuracy of any advice provided by the agents, especially if they are not being monitored closely by health care personnel. The ethics of persuading users to change their behavior, even when it is for their own health benefit, seems even more critical when it is an automated system doing the persuading<sup>41, 42</sup>. Finally, as with any technology that is assisting in the treatment of (potentially) remote patients, there are issues of confidentiality, privacy, security, and provider liability, as well as issues of competency and licensure of clinicians who prescribe the technology.<sup>43-45</sup>

## **LOOKING TOWARD THE FUTURE**

Work to date has only explored a tiny amount of the space of possible interventions that could be developed with relational agents, and there are many open research questions and avenues for future exploration.

### Improvements in alliance management

As relational agents are used by more patients and over longer periods of time, the data obtained will drive the development of more complex relational models and relationship maintenance through detection and management of ruptures in the alliance. In addition, relational agents developed to date have been focused on establishing the “bond” (emotional) dimension of the therapeutic alliance. Future research is needed to understand better methods of modeling negotiation of the goals and tasks of therapy.

### Anywhere, anytime portability

As described above, portability provides a unique set of affordances to relational agents, and the very act of carrying them around all day may promote social bonding. As more and more of our computing migrates from our desktops to our pockets, it is likely that the best medium for deploying relational agents will be on portable devices such as cell phones. As it becomes easier to integrate sensors with these devices and to incorporate data, such as a user’s schedule, it will become possible to time interventions so that they are most useful to the user.

### Emerging technologies will extend the abilities of relational agents

There are a number of technologies still in the development stage that may prove useful in making relational agents more effective. Some of these technologies will provide more accurate information about the emotional state of the user, enabling the relational agent to display more nuanced expressions of empathy. Some of these technologies

can be used to augment the information available to a computer or PDA-based relational agent. For example, speech prosody sensors <sup>46</sup> may help a relational agent assess the user's emotional state. Several computer vision-based systems have already been developed in research labs that can detect posture and facial expression <sup>47</sup>, both indicators of the user's emotional state. Improved computer vision will also enable relational agents to monitor gaze and detect whether the user is returning the agent's eye contact and responding to gaze cues provided by the agent<sup>48</sup>. Wearable sensors can measure many variables which, when transmitted wirelessly to the relational agent, will provide the agent with even more sensitive data about the user's emotional state, based on measurements such as heart rate, breathing rate, and heart rate variability (a measure of stress).<sup>49</sup>

The ability for users to speak to agents, rather than select an answer using a touchscreen or mouse, is not essential for relational agents to accomplish their therapeutic tasks, but would make interacting with them even more similar to interacting with other people. However, the ability to conduct effective, natural and safe conversations with an agent using unconstrained speech or typed text input remains a distant possibility. Counseling and relational dialogue topics span the breadth of human experience, thus requiring human level commonsense knowledge to automatically process. In addition, mis-understandings of users' utterances in the context of many health-related conversations (e.g., medication adherence) represent real and unnecessary safety risks. Finding more expressive user input methods that avoid these serious issues is an open area of research.

### Mobile robots as relational agents

Mobile, anthropomorphic robots capable of social interaction with people can provide additional unique affordances for relational agents: they can physically find and approach a patient; and they can bring the patient things associated with caring such as medication, food and drink. The preliminary work with the Autom robot discussed above<sup>50</sup> demonstrates the promise of this direction of research, although Autom is not mobile and thus does not demonstrate the real affordances that mobile robots can provide over screen-based relational agents.

A mobile robot is uniquely equipped to locate a patient in their home and initiate an interaction with them. The robot can move right up to the patient in a socially appropriate manner, observing human social standards such as maintaining a comfortable interpersonal distance and politely interrupting only when necessary. The ability to proactively engage the patient could enhance the agent's effectiveness, especially at behavior change tasks and in cases where the patient is lonely or depressed. Frequently users choose not to interact with a relational agent when they haven't done what they agreed to do, like exercise. In many healthcare applications, it's important to be able to engage the patient even when they'd prefer not to, for example if they haven't taken their medications, done their rehabilitation exercises, or even taken a walk if that was prescribed by their physician as part of a disease management regimen.

Relational robots could also bring things to patients, like medications, food and water, and self-care materials. People tend to associate being brought things with being taken care of (instrumental support), and in this way robots may provide some of the comfort and security associated with human caregivers. Similarly, many patients who are depressed or lonely may experience social benefits from interacting with a relational robot, since it can provide the experience of being visited or having someone living with them.

#### Relational Agents in counseling research

Empirical research on psychotherapy needs to move beyond small, one-off, poorly controlled studies in order to establish an evidence base for what really works in a counseling session. To do this requires that the patient experience be as tightly controlled as possible, eliminating biases due to experimenter effects, and making counselor behavior (including all nuances of verbal and nonverbal behavior) as precisely repeatable as possible. Relational agents can provide an ideal platform for this kind of research, by presenting precisely repeatable conversational behavior to a patient, free from experimenter bias and subjectivity.

#### Expanding range of interventions incorporating relational agents

Relational agents could play a role in a broad range of mental health interventions, and especially those in which the therapeutic alliance is known to be important or in which maintaining long-term patient retention and engagement is key for patient improvement. Programs utilizing relational agents could be developed for additional applications, such



as monitoring physical rehabilitation programs under the guidance of physical therapists, screening patients for various illnesses, promoting adherence to a regimen of diagnostic monitoring for the purposes of the management of chronic illnesses, monitoring mental status, maintaining orientation and a regular schedule in patients with cognitive impairments, and providing social benefits for patients who are isolated. Even in interventions involving only patient education, relational agents can make the experience more enjoyable and engaging for the patient and thereby potentially improve retention. There is work underway to make counseling dialogue systems in general, and relational agents in particular, easier to develop through the use of re-usable software constructs.<sup>38</sup>

## **CONCLUSION**

Relational agents are not replacements for psychiatrists. We will not be able to replicate the knowledge, expertise and real compassion of such highly trained experts in the foreseeable future. However, as adjuncts to clinical psychiatry, in well-defined and narrowly scoped roles such as in promoting compliance with medication or lifestyle health behavior regimens, relational agents may represent invaluable allies in the treatment of mental illness.

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