

# Augmenting Group Medical Visits with Conversational Agents for Stress Management Behavior Change

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**Abstract.** Individuals with chronic stress can improve their overall wellness by making lifestyle changes. We describe the design and evaluation of a computer-animated conversational agent that is used in conjunction with Integrative Medical Group Visits (IMGV) to help individuals with chronic pain and depression manage their stress. The agent coaches patients in between group visit sessions, reviewing how to manage stress using non-pharmaceutical techniques (e.g., mindfulness, meditation, yoga self-massage). We conducted a longitudinal clinical trial with 154 participants in which patients in the intervention group interacted with the conversational agent at home on a touch screen tablet to reinforce what they learned in group medical visits. Results from the trial indicate that the conversational agent, in conjunction with medical group visits, leads to significantly more positive stress management behaviors in patients compared to outcomes that arise in usual care, after 9 and 21 weeks.

**Keywords:** conversational agent, health behavior change, meditation, stress management, complementary and alternative medicine.

## 1 Introduction

Group medical visits, also known as “shared medical appointments”, are an increasingly popular way of delivering medical care and behavioral interventions for chronic health conditions in a more economical way than one-on-one medical appointments [1]. In these visits, patients receive individualized care, but also participate in group health education and self-management instruction, as well as social time with other patients. Typically, 8-12 patients meet with one or two clinicians for 2 hours on average. These visits are not only cost effective, but they allow patients to share stories, tips, and accomplishments with each other and to provide mutual social support to promote empowerment [2,3]. Despite their advantages, patient adherence to recommendations for self-care tasks such as stress management techniques (mindfulness and meditation) are rarely followed exactly between group visits, especially over the long term. Automated systems may be able to bridge the time between group visits by reinforcing information delivered during visits, guiding patients through self-care practices and procedures, motivating adherence to the overall integrated intervention, and providing a source of social support.

“Chronic stress” is the chronic overactivity or ineffective managing of adaptive processes in people, and can predispose individuals to be more susceptible to acquiring new disease or exacerbate their existing diseases [4]. Standard treatments for chronic stress and associated symptoms include: medications, exercise, counseling, teaching coping skills. Increasingly, mindfulness-based approaches to stress management—including meditation and yoga—are being recommended to individuals who suffer from chronic stress.

Beginning in 2010, Boston Medical Center began an experimental program called Integrative Medicine Group Visits (IMGVs) to provide non-prescription self-management techniques and health services to patients who had been diagnosed with chronic pain. Individuals with chronic pain and depression typically have chronic stress as one of the primary symptoms they have to manage. IMGV contains 8-10 weekly clinical appointments where patients meet with doctors and health professionals, and are taught how to care for themselves. This program combines Mindfulness-Based Stress Reduction (MBSR) with patient education and integrative medicine therapies. Patients attend facilitated discussions about numerous health topics relevant to their care such as nutrition and physical activity in 2.5-hour visits. The visits also involve instruction in self-care management topics, spanning mindfulness-based stress reduction (meditation), and complementary non-medical pain therapies (exercise, self-massage, yoga [5]).

In this paper, we describe our work in designing, developing, and evaluating a conversational agent that assists patients with stress and chronic pain in conjunction with the weekly group visits. A conversational agent is a computer animated character that interact with users with simulated face-to-face conversation, including nonverbal behavior such as hand gestures and facial displays. Patients interact with the conversational agent at home during the intervention, and use it to review the material covered in each visit in more detail, as well in order to practice self-care skills such as meditation and yoga.

First, we will review the related work, and then describe the design of the conversational agent to help patients to better manage their stress. Next, we will present the results of a randomized clinical trial, before concluding.

## **2 Related Work**

Numerous technologies have been developed to promote healthy behaviors such as physical activity, healthy eating and stress management. Here we briefly review related work in technologies for stress management, including prior research on conversational agents.

### **2.1 Technology Promoting Stress Management**

A wide range of technologies, from internet-based programs to mobile applications and virtual reality, have been designed to promote stress management and related behaviors [6]. For example Gaggioli et al. developed a mobile platform to help users

by tracking their stress, via heart rate and self-reports, and providing relaxing multimedia [7].

Several games have also been designed to promote stress management by providing stress-related biofeedback in an entertaining way [8]. A few interventions have also been developed for promoting mindfulness or relaxation, using techniques from complementary and alternative medicine. Gromala developed “The Virtual Walk” to teach users mindfulness-based stress reduction using VR [9]. RelaWorld is a neuroadaptive virtual reality meditation system that provides a relaxation experience by adapting the VR elements to the user’s brain activity level [10]. Finally, Rector describes a system to provide yoga coaching to blind users [8].

## **2.2 Conversational Agents for Health Behavior Change**

A growing body of research investigates the role of embodied conversational agents as virtual health coaches to engage users in persuasive and motivational interactions. Several agent-based systems have been developed in recent years to assist patients in managing their health problems in general, and to enable chronic disease self-care in particular [11]. Researchers have shown the positive effects of interaction with conversational agents on health behavior change. Agents developed in the past provide one-on-one counseling for patients and consumers for motivating exercise promotion [12], weight loss [13], breastfeeding [14], insomnia therapy [15], and preconception care [9], with generally positive results.

Bickmore et al. demonstrated that utilizing relational skills such as empathy and social dialogue in health behavior change interventions can significantly improve the users’ experience and desire to continue over multiple interactions [16]. However, Schulman found that social dialogue actually made a health counseling conversational agent less persuasive [17]

Beun et al. developed a sleep-care e-coach mobile application that enhanced users’ adherence for sleep behavior change by providing just in time, personalized feedback. They reported that increasing motivation plays a key role in coaching systems [2]. Shulman, et al, examined the effect of using motivational interviewing techniques in a conversation on users’ self-efficacy [18].

Several conversational agents have also been developed specifically to help individuals manage chronic health conditions. Monkaresi, et al, developed the “IDL coach”, an embodied conversational agent that helps individuals with diabetes manage prescribed exercise, nutrition, blood glucose monitoring, and medication adherence, although no evaluation studies are reported [19]. Bickmore, et al, developed an agent to help individuals with schizophrenia to manage their condition, to increase physical activity, and continue to take prescribed antipsychotic medication, and promising results from a quasi-experimental pilot evaluation have been reported [20]. ICT’s SimCoach is an embodied conversational agent that was designed to address depression and/or post-traumatic stress disorder (PTSD), although results from a large randomized controlled trial with 333 patients failed to find any clinically significant benefits of using SimCoach [21].

### **2.3 Conversational Agents for Stress Management**

Conversational agents have also been developed specifically to help users manage their stress. Hudlika developed a virtual coach that provides mindfulness meditation training and the coaching support necessary to begin a regular meditation practice [22]. Shamekhi describes a conversational agent that played the role of a meditation coach, using information from a respiration sensor to tailor its feedback to users [23].

Stress management education also has been shown to be more effective when a conversational agent is used. Results of a study by Jin indicates that the presence of a conversational agent causes significantly higher engagement and enjoyment in an stress management education system, and this engagement mediates learning outcomes [24].

All of these prior efforts seek to provide automated support for a single technique for stress management; none provide an integrated intervention that incorporates several best practices such as meditation, yoga, self-massage, and nutrition. In our intervention design, we seek to provide such an integrated intervention, with a conversational agent as a persistent, unifying persona across all of these activities.

## **3 Design of the Agent-based Intervention for Stress Management**

The conversational agent-based intervention was designed with monthly input from a patient advisory group (PAG) of patients, suffering from chronic pain and depression, who, at the time, were already participating IMGV at Boston Medical Center. The PAG provided input on how best to deliver and facilitate the IMGV, as well as the interaction features, intervention media, and dialogue content for the conversational agent; the PAG continued to provide guidance during the pilot studies and clinical trial whenever new challenges emerged.

### **3.1 The Conversational Agent “Gabby”**

The conversational agent used in our work named “Gabby” was designed based on feedback from the PAG, and a pilot study [25], and focus group interviews. The agent is animated and rendered in the Unity game engine using custom animation software, running on a dedicated-use 8” Dell touch screen tablet computer (Fig. 1). The agent’s appearance was designed to appear to be a racially ambiguous female in her mid-forties. The agent speaks using synthetic speech from a commercial Text to Speech (TTS) system with synchronized nonverbal conversational behavior. The agent’s nonverbal conversational behavior is generated using BEAT [26], and includes beat hand gestures and eyebrow movements for emphasis, as well as a range of iconic, emblematic, and deictic gestures, alterations in the agent’s gaze for signaling turn-taking, and posture shifts to mark topic boundaries, synchronized with speech. Additional media elements, including images and video clips, are also integrated into the agent’s environment for pedagogical purposes. Dialogues are scripted using a



**Fig. 1.** Touch Screen Tablet Computer with Conversational Agent custom hierarchical transition network-based scripting language. User input is obtained via multiple choice selection of utterances on the touch screen [27].

### 3.2 Intervention Design

The agent-based intervention was designed to guide users through nine weeks of new material along with the weekly group visits, followed by an arbitrary number of weeks of “maintenance”, in which patients can continue to review material learned in the group visits. During this intervention, patients also have the option of completing practice activities with the agent (Fig. 2). The IMGV model utilizes principles of adult learning and engagement to allow for experience and knowledge sharing. This collective experience empowers and motivates patients to create an individualized treatment plan for their pain. This model aims to promote behavior change by providing a learning environment for the principles of principles of Mindfulness Based Stress Reduction, enriched with reinforcement. Each week, following a group visit, the agent reviews the new material just learned, walks patients through practice sessions, and allows them to review material covered in prior weeks. Home practice topics include meditation, self-massage, acupressure, and yoga. The agent also reviews educational information on nutrition, physical activity, pain, stress, sleep, and depression.

The first conversation with the agent starts with Gabby introducing herself and then summarizing the various services she can provide. Each subsequent conversation starts with a greeting, followed by two questions about how the participant is doing mentally (mood) and physically (how comfortable they are). They are then asked whether they have already reviewed the past topics or not, followed by a question about how their practices are going. Based on their responses, they are offered either to review past sessions or go through the new content in coordination with the material covered in the group that week. Gabby's talks are designed to be interactive and user-directable. The final coordinated session is allocated to behavioral goal setting, wherein patients can set new goals, review their goals or check their goals. The system is also designed to detect multiple logins per day. When a user returns to



**Fig. 2.** Screenshots of Gabby guiding a chair yoga (left) and a meditation session (right) talk to Gabby in less than six hours, she skips the greeting and asks if the user wants to continue from where he/she left off

In order to induce the feeling of a personal interaction, Gabby calls users by their given name, and asks questions such as, “How is your Wednesday going?”. In addition, to avoid repetition in conversations, in several dialogue scripts, including greetings, farewells, and other dialogue that is frequently used, the system randomly selects agent utterances among several options for each interaction.

### **Mindfulness-based Stress Reduction**

Mindfulness Based Stress Reduction (MBSR) is a set of techniques that incorporate mindfulness to assist people with chronic pain to manage their self-care by practicing exercises such as mindfulness meditation, body awareness and mindful yoga[28]. The main curriculum consists of nine weekly group visits guided by a trained instructor, which the last session is more focused on mindfulness practice. MBSR has been proven to have positive effect on stress reduction[29], anxiety and depression[30].

In the intervention design we paid particular attention to the incorporating MBSR techniques into the system. The agent is designed to guide users through several meditation practices and a yoga session (Fig. 2). To increase the efficacy of these sessions guided by Gabby, we manipulated Gabby’s voice and visual and acoustic background while she was leading the user through a meditation. Since mindfulness activities require participants to be focused and mindful, any distraction can disrupt the process. The instructor’s voice is a potentially crucial element when people are trying to concentrate. Thus, we used speech synthesis markup language (SSML) to make Gabby’s voice as natural and calming as possible. Calming music was also added as a background sound during these sessions to improve the experience. Based on feedback from the patient advisory group, we also decided to display a calming background picture while users are meditating. To generate visual variety, Gabby selects a random picture for each meditation session. from a set of 15 pictures. Gabby also guides a chair yoga session. All instructions were designed to be most effective for the target population with chronic pain.

## 4 Stress Reduction Intervention Clinical Trial

In order to evaluate the fully-developed system and examine how the conversational agent influences patient performance and satisfaction, a longitudinal between-subjects randomized clinical trial study was conducted. The patients in the control group received the usual care (non-IMGV) for chronic pain and depression. They attended regular meetings with their primary care physician, while those randomized to the intervention condition attended group medical visits for nine weeks, and were provided with Gabby on a tablet computer which they took home for 21 weeks (12 weeks after the group visits have ended), as well as with access to a website with review materials.

**Group visits structure:** Groups are led by a clinician facilitator and a co-facilitator, who use a facilitative leadership style as part of the group. Each session follows the same structure each week. In each visit new material about stress management, physical activity or nutrition are reviewed by the facilitators. Part of the visits are also allocated to the stress reduction exercises such as mindfulness meditation or yoga.

### 4.1 Participants

Study participants were recruited through flyers, placed in the family medicine and adult medicine departments of three study sites, and through Primary Care Providers (PCP), who referred patients for the study. Participants were required to be suffering from chronic pain and depression, 18 years of age or older, and English-speaking.

A total of 338 patients were screened across three sites, among whom 160 participants were enrolled. Six patients have withdrawn to date, resulting in 154 participants (75 in the intervention group, and 79 in the control group) enrolled. Participants are 22 to 84 years old (mean=51 SD=12.3), 86% female, 58% African-American, 29% white.

### 4.2 Measures

Besides sociodemographic we also assessed the stress management skill development by asking participants what they have done to relax or manage their stress in the past, at baseline, 9 weeks and 21 weeks. They were asked about the different types of stress management or relaxation techniques they used including both positive (e.g. deep breathing and walking), and negative behaviors (e.g. smoking and drinking alcohol). This question was presented as a 10-item checkbox that they could select as many items as they want. The participants' impression of the whole system and Gabby were assessed through a 17-item self-report measures. Participants were asked to fill a questionnaire on their perception of Gabby and her role in improving their health behaviors such as stress. The questionnaire contained four 7-point likert scale items on Gabby and stress, nine 7-point likert scale items on Gabby herself, a few open-ended question about users' experience with Gabby and a yes/no questions regarding whether they use Gabby's suggestion to manage their stress or not.

## Results

The analysis of log files from tablet computers suggests that intervention participants interacted with Gabby an average of 105 minutes, with the average number of 8.8 logins, over the first 9 weeks they had the system.

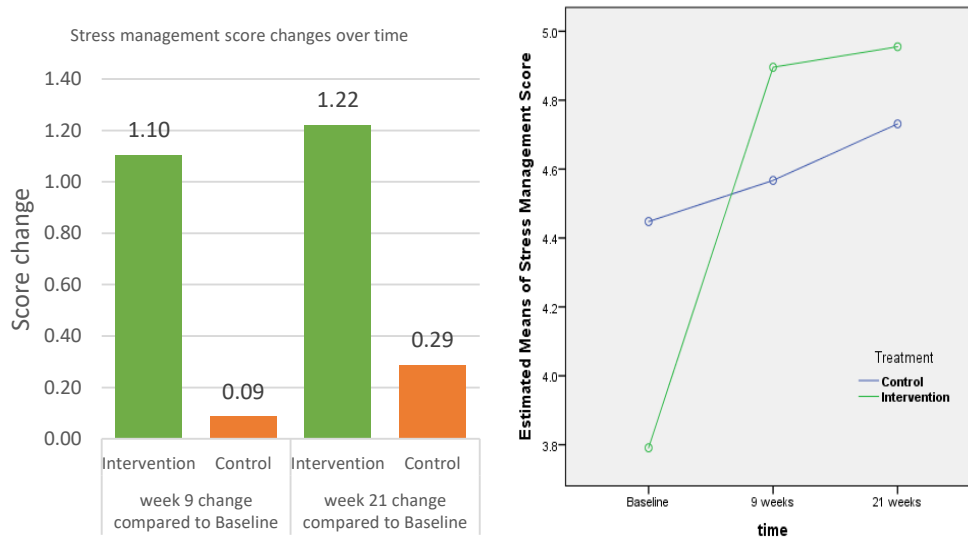
**Stress Management:** We categorized the ten behaviors under two groups: positive behaviours, and high-risk negative behaviors. We coded the checked positive behavior as +1 and checked negative behavior as -1 (Table 1).

**Table 1.** Stress management responses coding

Stress management behaviors	Positive behavior (Deep breath, Exercise, listening to music, praying, spending time friends, shopping, walking)	Negative behaviour (Drinking alcohol, smoking cigarette, smoking marijuana)
score	+1	-1

Adding up the coded scores, we came up with three total scores for each participant, at baseline, 9 week, and 21 week assessment.

In order to compare the improvements, we calculated the changes in stress management scores after 9 weeks and 21 weeks ( $21\text{week\_change} = 21\text{w\_score} - \text{baseline\_score}$ ,  $9\text{week\_change} = 9\text{w\_score} - \text{baseline\_score}$ ). Results of a T-test for independent samples showed that participants who used Gabby and the OWL website along the group visits ( $M=1.1$   $SD=1.6$ ) had a significantly higher improvement than control group ( $M=0.09$   $SD=1.58$ ) in managing their stress after 9 weeks,  $t(136)=3.74$ ,  $p < 0.0001$ . There is also a significant difference in the score changes for intervention



**Fig. 3.** Results of a t-test on independent samples to compare the control and intervention (left) and the changes of both groups over time (right)



(M=1.22, SD=1.86) and control (M=0.29 SD=1.34) after 21 weeks  $t(136) = 3.42, p=0.001$ .

**Gabby Evaluation:** 81% of participants declared that they used at least one of Gabby’s suggestion to reduce their stress. Table 2 and Table 3 show the average responses to each item by 68 participants.

**Table 2.** Self-report rating of Gabby in helping users to manage their stress (N = 68), single sample Wilcoxon signed ranked test demonstrates ratings were significantly greater than neutral.

Question	Anchor 1	Anchor 7	Week 9	p-value	Week 21	p-value
How satisfied were you with talking to Gabby about reducing stress?	Not at all	Very satisfied	5.21(1.6)	<.001	5.55(1.5)	<.001
How helpful was Gabby in relieving your stress?	Not at all	Very satisfied	5.14(1.6)	<.001	5.25(1.7)	<.001
Do you think that you will use some of Gabby’s suggestions to improve your health in the future?	Not at all	Very much	6.28(1.1)	<.001	6.08(1.4)	<.001
How confident do you feel that you can continue the changes you made based on Gabby’s recommendations after this study is finished?	Not at all	Very much	5.76 (1.2)	<.001	5.52(1.3)	<.001

**Table 3.** Self-Report ratings of Gabby at 9 weeks and 21 weeks points (N = 68), single sample Wilcoxon signed ranked test demonstrates most of the ratings were significantly greater than neutral.

Question	Anchor 1	Anchor 7	Week 9	P value	Week 21	P value
How easy was it to talk to Gabby?	Very difficult	Very easy	5.66(1.6)	<.001	5.66(1.7)	<.001
How much do you trust Gabby?	Not at all	Very much	5.95(1.3)	<.001	5.66(1.5)	<.001
How well did Gabby answer any questions that you had?	Not at all	Very well	5.47(1.5)	<.001	5.54(1.5)	<.001
Did you feel like Gabby provided feedback and information that was specific to you?	Definitely no	Definitely yes	5.62(1.5)	<.001	5.42(1.8)	<.001
Did you feel like Gabby provided support and encouragement to reach your goals?	Definitely no	Definitely yes	5.89(1.3)	<.001	5.69(1.6)	<.001
How did you feel about the amount of time that you spent with Gabby?	Too little	Too much	3.86(1.6)	.475	3.66(1.6)	.075
Would you like to interact with Gabby again?	Not at all	Very much	6.15(1.5)	<.001	5.89(1.5)	<.001
How much would you have preferred talking to a doctor or nurse than to Gabby?	Definitely prefer doctor/nurse	definitely prefer Gabby	4.00(1.9)	.975	3.85(2)	.377
How likely is it that you would recommend Gabby to someone you know?	Not at all	Very likely	6.17(1.3)	<.001	6.14(1.3)	<.001

**Qualitative Results:** Overall participants found Gabby as a very useful complement for the material covered during group visits. Many of them stated that Gabby provided the opportunity to review the class lessons and more detailed information at any time, and anywhere they wanted, without limitation. They felt that they had more time to review and understand the lessons with Gabby than they did during the group sessions. Here we report some comments from participants in regards with the stress management capabilities of Gabby. Most of the participants found the meditation, yoga and mindful sessions very “*useful*” and “*relaxing*”. Many participants found

Gabby very effective in motivating them to practice the mindfulness exercises. For example, P1 said that *“I was able to incorporate meditation in my life which is extremely important to me as I age. Before Gabby I felt like my heart was racing all the time with relationship issues. Just everything. It really calmed me down.”*. P55 added *“Gabby got me motivated. The exercise the deep breathing, she would tell me to calm my nerves.”* Participants also found themselves “much calmer” and could “take life with less stress” than they used to, by practicing mindfulness with Gabby. Particularly P41 mentioned that *“Gabby improved it in terms of stress because of her calming voice and it was something out of his norm. Spoke nice and easy and allowed him to take the time”*

Participants were also asked about the difficulties of interacting with Gabby and what they would like to improve in the interaction. Consistent with the self-report data some participants reported that they did not have enough time to interact with Gabby. A few participants also said that they would like to be able to ask a “specific question” and “go beyond what was available”. Some of them also reported facing difficulties using the program: *“hard to log onto because not as computer savvy”*. We believe that this kind of issue might give rise to stress that could also negatively impact their satisfaction with Gabby.

## **5 Conclusion**

We have demonstrated that a home-based conversational agent can be effective, when used in conjunction with medical group visits, in promoting stress management techniques over a 21-week period of time. The agent was well-accepted by patients, and appears to have helped reinforce the material taught during the group visits. We have demonstrated this with a cohort of patients with chronic pain and depression from a safety net hospital, where most patients are low income, disadvantaged minorities. Previous studies have found low levels of computer literacy in these populations [31], indicating that conversational agents are a good delivery medium for disadvantaged populations. Our study indicates that although individuals who have little experience with technology had some difficulties using the tablets, they find the conversational agent an acceptable and effective medium for receiving healthcare counseling and information.

Limitations of our study include the relatively small sample from health centers in the Boston area. We also are unable to disentangle the effects of the face to face weekly group visits from those of the home-based conversational agent, and plan future studies to tease these apart.

### **5.1 Future Work**

Our future work includes conducting a longitudinal study with a control group attending the group visits without any technology and the intervention group using technology such as conversational agents, and compare the changes in outcomes to investigate the specific role of technology in such an intervention. We are also

exploring the use of a variety of sensors to assist Gabby in helping patients through self-care practices, such as respiration sensors to help with meditation [23], and Kinect to provide more tailored yoga coaching. Finally, we are exploring ways in which the agent can more interactively demonstrate skills, such as yoga positions.

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