Can Software Agents Influence Human Relations? - Balance Theory in Agent-mediated Communities -

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ABSTRACT

We sought to create a social embodied conversational agent to support group interactions, using 'balance theory' from social science research on human-human relations. We conducted an experiment to evaluate the social ECA's effectiveness in a group situation, depending upon how strongly it mediated the conversation among group members. First, we confirmed that it could win favorable feelings from subjects by showing an agreeing attitude to them and, conversely, unfavorable feelings by showing a disagreeing attitude. Next, we validated balance theory as a rule governing both agent-human relations and human relations if the social ECA highly mediated the conversation. We found that the social ECA's effectiveness was very low if it did not control turn-taking, and if the human pair had a chance to converse extensively with one another. Conversation analysis corroborated these results.

Categories and Subject Descriptors

I.2.11 [**Artificial Intelligence**]: Distributed Artificial Intelligence; H.5.1 [**Information Interfaces and Presentation (I.7)**]: Multimedia Information Systems - *Artificial, augmented, and virtual realities.*

General Terms

Design, Experimentation, Human Factors

Keywords

Embodied conversational agents, social ECAs, balance theory, virtual environments, virtual communities, agent-mediated communities.

1. INTRODUCTION

Our research group is building embodied conversational agents (ECAs) to support human-human communication and relationship building in virtual environments. We have created an online digital city resource for real-life inhabitants of Kyoto, including virtual reproductions of parts of the city itself, which people can log into to explore and converse [7]. We believe ECAs can play important roles in this online community, providing assistance and information, helping to direct the flow of visitors to this online world, and assisting in making connections between these virtual Kyoto citizens. In online worlds, such agents can have special information and knowledge, and powers of movement and activity that can complement the abilities and powers of actual human visitors. We believe novel, blended interaction styles and relationships will form in these contexts. We call such environments 'agent-mediated communities'. Within agent-mediated communities, we believe ECAs could be quite powerful-even going so far as to influence visitors' opinions of one another as well as of the ECA.

Shared virtual environments with ECAs are becoming increasingly common (for a large-scale commercial example, see [11]), and we (and others-see [19]) see this as an important application area for ECAs. There is already evidence that non-embodied software agents that communicate with human users in text-chat virtual worlds are engaging [2]. Some would argue that ECAs could play a vital role in shaping community in online virtual worlds [8]. However, this belief presumes that ECAs can in fact be influential members of such communities.

Yet the ECAs' effectiveness will depend upon their ability to work with visitors not just as individuals, but as members of conversational and other groups (such as crowds or tour groups), within the environment. Techniques for interacting with small or large groups socially can be very different than those used in one-on-one conversations and relationship formation. For example, an ECA might try to completely align its opinions with any individual it is working with, in a one-on-one situation. However, in a group, it needs to be careful of how it uses such agreement with each person, in order to preserve the harmony of the group, and avoid inconsistency or perceived favoritism. There are many findings of this nature in the social sciences, about the workings

of groups. Developers of ECAs need to take these findings into account when designing for these contexts.

In our own efforts, we are focusing on crafting group interaction skills and competence for ECAs, so that they can have a role in supporting and sustaining human-human relations. We call an agent with such skills a social ECA. In this paper, we present preliminary studies that use principles from the study of group communication dynamics in the social sciences to craft charismatic and effective social ECAs.

2. SOCIAL EMBODIED CONVERSATIONAL AGENTS

2.1 Related Works

Much research has explored creating embodied conversational agents for one-on-one interaction applications, such as tutoring [9], training [17], and sales [1]. Less work has been done to investigate how best to create ECAs for group contexts. As far as documenting practical effectiveness of ECAs, there are as yet few results even in one-on-one application contexts (Lester et al's results are a notable exception [9]), and only one that we know of for group contexts [6].

There are, however, research findings about the general social effectiveness of one-on-one ECAs. People respond to the facial expressions, gaze, head movements, and gestures of agents as if they were human beings [1] [18]. There is a body of work (summarized in [16]) that demonstrates that people will respond similarly to characteristics (such as gender cues) and interpersonal tactics (such as flattery or reciprocity) coming from computers and ECAs as they do toward other people. Researchers have also demonstrated that people will behave in a familiar social science task (the prisoner's dilemma) with ECAs similarly to how they'll behave with a human partner in a videoconferencing system [14].

Our research follows this approach-building ECAs that use strategies and cues known to be effective in human interaction situations, and confirming their effectiveness in the agent-human interaction. We are interested in cues and tactics that enhance or dampen persuasiveness and charisma in our agents, in a group context.

2.2 What Makes a Persuasive and Effective Social ECA?

In an earlier study [6], we noticed an interesting effect—an ECA that made itself disagreeable to both conversation partners in a group (by bringing up an embarrassing subject), tended to cause them to have a more interesting and engaging experience, and to have more positive impressions of their conversation partner. Upon investigating the literature on impression formation, we learned of a social science theory that may help explain this effect, called balance theory. Balance theory, formulated by Heider [4], states that people prefer to have harmoniously aligned attitudes toward a third party or object. For example, if I dislike a third person, I will feel more in balance with you if you feel the same way toward this person. Such an alignment can cause the kinds of positive feelings and outcomes that we observed in this prior study, and is used in advertising contexts to elicit positive impressions of products [15]. We felt this would be a helpful tactic for a social ECA to use in group situations, to drive human interaction partners toward forming particular impressions of one another, and of the agent itself.

We were also interested in what factors would affect the ability of the social ECA to influence people in this manner. In human conversation, a person's power in a group situation can be gauged by looking at how much he or she holds the conversation 'floor'. A person who maintains a higher degree of control over the interaction will tend to have more influence [13]. From this, we drew the conclusion that the more our social ECA could control the floor by mediating the conversation, the more effective it would be at driving peoples' impressions of it and of the other conversation partners. Conversely, allowing the human interaction partners to control the floor more would inoculate them against influence from the social ECA.

2.3 Our Hypotheses

We set up experiments to investigate whether we could replicate balance theory effects with our social ECA, and whether we could modulate the effects based on control of the conversation. Our hypotheses were:

1. A social ECA can create balance theory effects.
2. Widening the conversational channel (reducing the social ECA's mediation) between the human conversation partners will lessen the conversational control of the ECA, and correspondingly lessen its effectiveness.

In order to test hypothesis 1., we needed to be able to manipulate the participants' attitudes toward the social ECA, so that they could then be in alignment (or not in alignment). To do this, we manipulated whether the social ECA held the same opinion as the participant—a common and effective tactic in persuaders' attempts to influence [20]. Thus, we include two additional hypotheses:

3. A person will like the social ECA more if it shares his/her opinions, and will dislike it more if it does not.
4. A person will assume that his/her conversation partner likes the social ECA more if it shares that person's opinion, and will assume that s/he dislikes the social ECA more if it does not.

3. PROTOTYPE OF SOCIAL ECA

3.1 The Art of Agreement (or Disagreement)

In prior work, we developed a conversational mechanism through which a social ECA could build common ground among human conversationalists by highlighting agreement or disagreement among their opinions [6]. This social ECA was able to 'break the ice' among new conversation pairs using this technique. We adapted this social ECA's behavior repertoire to create our balance theory interactions.

In our experiments we created three types of social ECA behavior as shown in Figure 1. The agreeing ECA finds topics that people share opinions about, and expresses that same opinion. The disagreeing ECA finds such topics and expresses the opposite opinion. The unfair ECA finds a topic that people do

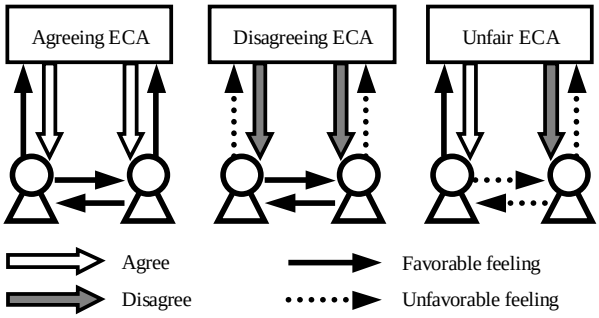


Figure 1. Three types of social ECAs and two humans

not see eye to eye on, and sides one way or the other between the participants, to create asymmetry. The idea of balance theory is that either consistent condition will create harmony for the human participants. If they both like the agent, everyone can feel part of a team with one another. If they both dislike the agent, the team just doesn't include the agent. However, if the agent agrees with one and disagrees with the other, it will pull them apart and cause less positive reactions.

Pretests showed that, as in real life, an ECA that always agreed was a bit suspicious. Thus, in the agree and disagree conditions, we included a couple of counter-trend responses to make the social ECA's behavior more plausible.

In actual virtual environment contexts, social ECAs could use semantic web searches or other techniques to learn about the opinions and preferences of human visitors without even asking. Or, they could enquire tactfully of the participants during the encounter, and react accordingly.

In the present experiments, we used both methods in the low-mediation condition. We made use of a questionnaire given to participants beforehand, to find topics of agreement and disagreement. And also we used the conversation mechanism developed for our prior experiment to elicit opinions and adapted the social ECA's behavior accordingly.

3.2 Experiment Design

To test our hypotheses (listed in Section 2.3) about social ECAs and balance effects, we conducted an experiment in which the ECA's task was to interact with two people who were meeting for the first time, in a virtual environment. Figure 2 is a picture of the experimental setup, in the low-control condition (where participants could chat using audio and video). After participants completed their conversation, each filled out a questionnaire (items discussed in more detail below).

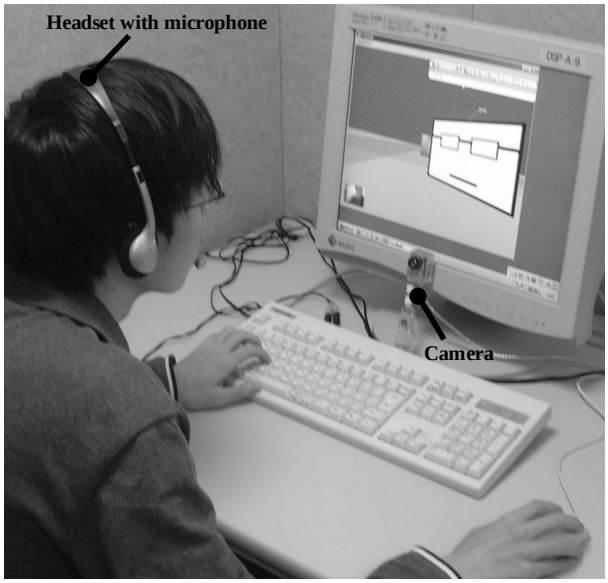
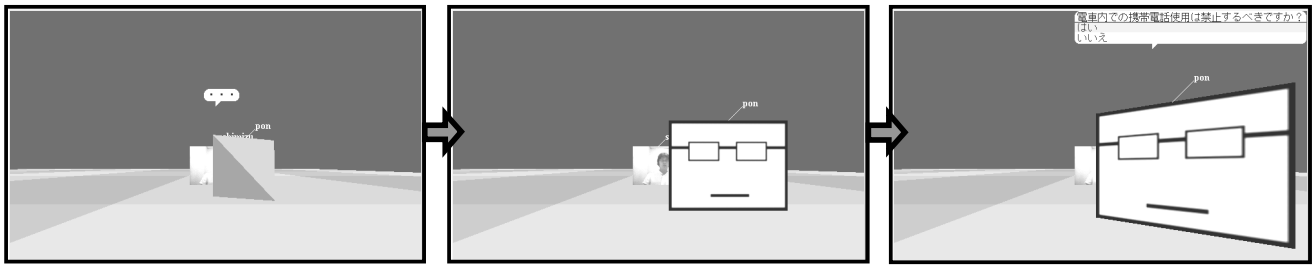


Figure 2. Experimental setup

We investigated two ways that the conversation channel could be reduced, using a two-factor, four condition (2x2) between-subjects experimental design. The first factor was whether the ECA controlled conversation or not. In the low-control condition, subjects could freely talk with one another through the video and voice communication channels of our virtual environment *FreeWalk* [12] during their virtual meeting with the ECA. In the high-control condition, participants could see each other, but could not talk with one another, and were simply participating in the menu-based question-and-answer conversations illustrated in Figure 3 and 4. The second factor was whether the ECA fully mediated the conversation or not. In the low-mediation condition, the ECA formed a circle with the participants to be a member of their conversation group (see Figure 3—the ECA and other participant are facing this participant, who is answering a

(a) (b) (c)

Figure 3. Low-mediation condition. (a) The ECA displays a balloon of the question to ask you, and you click one of the menu items displayed below the question to answer. (b) The ECA asks your partner. You can see the question balloon to know what question the ECA asks. (c) When your partner answers the ECA, you can see his answer in a small balloon.



(a) (b) (c)

Figure 4. High-mediation condition. (a) The ECA talks to your partner. You can see that they are talking but cannot read the text in the balloons. (b) After the ECA finishes talking, it leaves from your partner and comes close to you. (c) The ECA begins talking with you. It asks you several questions.

question from the ECA.). In the high-mediation condition, the ECA traveled between the participants to repeat a one-to-one interaction with each of them standing far from one another (see Figure 4). In this condition, agent-human conversations were hidden from the other person. In a follow-up conversation with another ECA that asked about feelings toward the ECA, participants then realized they either concurred or differed in their feelings toward the ECA, which were formed independently.

In each condition, balance theory effects were measured by how clearly the four balanced triads appear as shown in Figure 5. In this figure, 'shared' means that the subject and his/her partner share feelings toward the agreeing or disagreeing ECA and 'like' means that the subject develops a favorable feeling toward the agreeing or unfair ECA. In the questionnaire, we asked subjects about the degree of similarity and attraction in their feelings

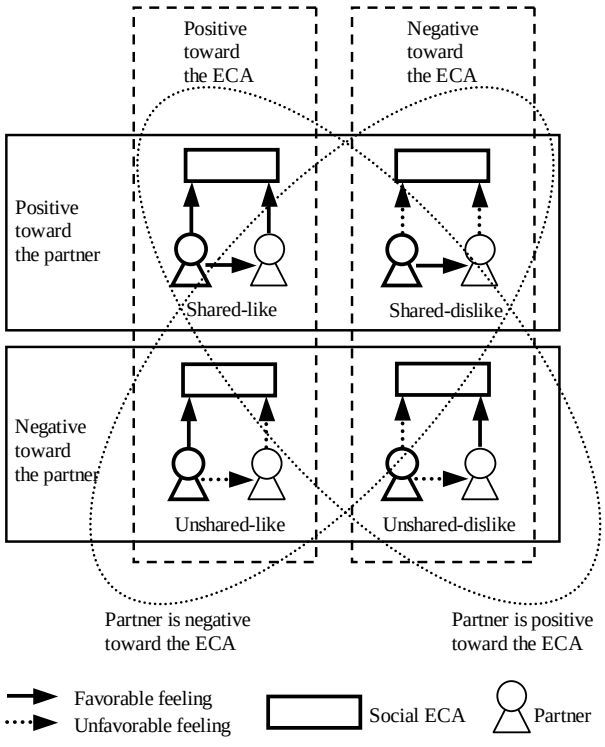


Figure 5. Four balanced triads

toward their partner and the ECA, and also in their partner's feeling toward the ECA. Positive or negative trend in these three feelings distinguishes the four triads. Thus, in each feeling, we have eight cells that are the two trends by the four conditions. A total of 185 university students (113 male and 72 female) participated in our experiment to provide twenty data sets for each cell (ten data sets for each triad in each condition). Figure 6 represents the whole design of the experiment.

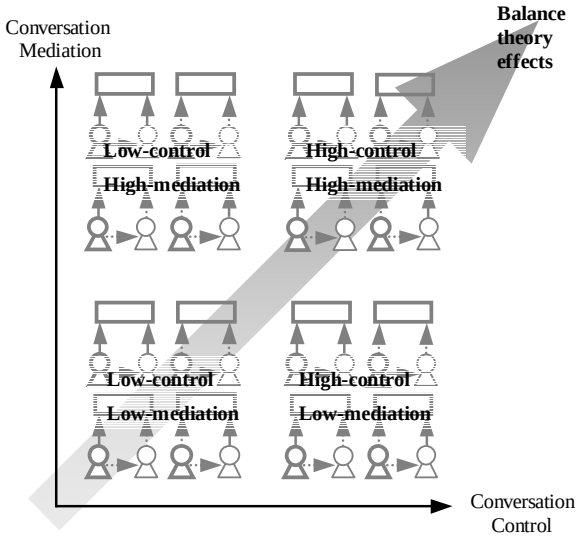


Figure 6. Design of the Experiment

4. RESULTS

4.1 Questionnaire Data

We ran statistical analyses of the effects of the three independent variables—level of conversation control (*Control*), the level of conversation mediation (*Mediate*), and the feeling trend predefined by the balanced triads (*Trend*)—on participants' answers to questionnaire items. Table 1 summarizes the main effect of Trend and how this interacted with the other two variables in the results of a 2x2x2 ANOVA. In this table, many significant differences were observed in the two indices of the three feelings. Since both the similarity index (Similarity) and the attraction index (Attraction) are formed by three questions,

we confirmed their reliability by calculating *Cronbach's alpha* for each set of itmes, which are ranged from .76 to .95.

Table 1. Summary of three-way ANOVA

Feeling toward	Index	*Trend*	*Trend*Control*	*Trend*Mediate*
ECA	Similarity	146.9***	1.3	4.0*
	Attraction	25.5***	1.3	7.2**
ECA from the partner	Similarity	162.1***	0.6	0.1
	Attraction	36.0***	5.2*	4.7*
Partner	Similarity	17.1***	5.6*	1.9
	Attraction	7.4**	11.4**	0.5

*p<.05, **p<.01, ***p<.001 (df=1, 72)
Trend: feeling trend predefined by the balanced triads
Control: level of conversation control
Mediate: level of conversation mediation

4.1.1 A Social ECA Creates Balance Theory Effects

Significant differences found in all the six dependent variables of the main effect of *Trend* in Table 1 shows our social ECA could successfully influenced the subjects' feelings. All the means of the variables in Figure 7 are consistent with the balance theory.

- The ECA could win a favorable feeling from the subjects by agreeing with them and win an unfavorable feeling by disagreeing.

  When the agreeing or unfair ECA agreed with a subject (the shared-like and unshared-like triads in Figure 5), he/she thought that the ECA was more similar (*F(1,72)=146.9, p<.001*) and more attractive (*F(1,72)=25.5, p<.001*) to him/her.

- The ECA could make the subjects assume their partners' reactions to be the same way.

  When the agreeing or unfair ECA agreed with the partner of a subject (the shared-like and unshared-dislike triads), the subject thought that the ECA was more similar (*F(1,72)=162.1, p<.001*) and more attractive (*F(1,72)=36.0, p<.001*) to his/her partner.

- The ECA could influence human relations among the subjects.

  When the agreeing/disagreeing ECA agreed/disagreed with both of a subject and his/her partner (the shared-like and shared-dislike triads), the subject thought that the partner was more similar (*F(1,72)=17.1, p<.001*) and more attractive (*F(1,72)=7.4, P<.01*) to him/her.

4.1.2 Widened Conversation Channel and Reduced Mediation Lessens the Effects

Interaction between *Trend* and *Control* was found in the feeling toward the partner. This interaction plotted in Figure 8 shows that the ECA became less influential in human relations when it did not control conversation. When the subjects could talk with one another, similarity differences between the shared and unshared triads disappeared (*F(1,72)=5.6, p<.05*) and attraction went up to the same high level (*F(1,72)=11.4, p<.01*). This result demonstrates that human conversations can repair and improve their relations against the ECA's influence and conversation control contributes to keeping the influence.

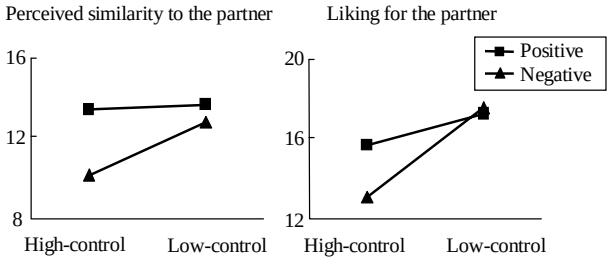


Figure 8. Interaction between *Trend* and *Control* in the feeling toward the partner

Another interaction was found between *Trend* and *Mediate*. In Figure 9, you can see that the ECA had difficulty in presenting itself as a likable third-party when it did not mediate conversation. When the ECA formed a circle with the subjects to have a conversation, the similarity of the ECA to the subjects in the shared-like and unshared-like triads went down (*F(1,23)=4.0, p<.05*) and its attractiveness went down to the same low level as dislikable ECAs (*F(1,23)=7.2, p<.01*). When a subject could see the interaction between the ECA and his/her partner, the ECA seemed to be evaluated badly.

To better understand the mechanisms by which the ECA's influence was lessened, we decided to take a closer look at conversations between participants in those conditions.

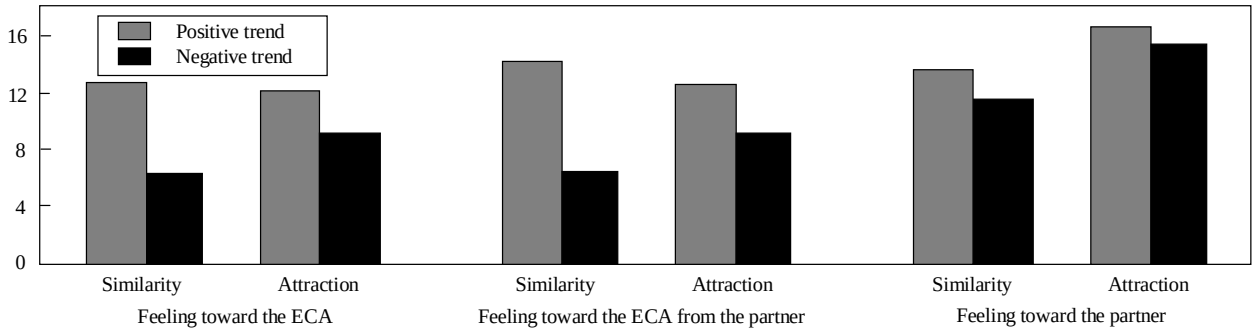


Figure 7. Index means showing balance theory effects

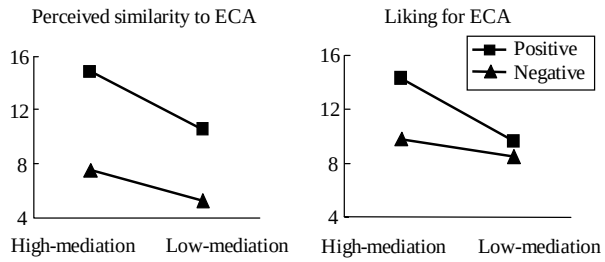


Figure 9. Interaction between *Trend* and *Mediation* in the feeling toward the ECA

4.2 Conversation Data

We analyzed conversations [10], which were recorded in the low-mediation and low-control condition where the ECA took part in a conversation of two subjects. The statistical analysis indicates that this condition makes human relations better and the impression of the ECA worse. You can see the reason of these effects in the two conversation examples, in which italic sentences are menu-based interaction with the ECA.

In Example 1, the subject chose his answer to the question (=>1), while informing this answer to the partner through the vocal-speech channel (=>2). This information is redundant because responses to the ECA through the menu-based text channel can be seen by the partner; therefore, it seems that talking to the partner has priority over answering the ECA. To make matters worse, conversation between subjects often includes remarks about the agent-human exchange to evaluate the ECA.

Example 1. Priority of human conversation

ECA: *This is a little off the subject but, Mr. A, do you prefer Japanese food or Chinese food?*

A: Japanese food…

B: That is really off the subject.

=>2 A: (laugh) Well, I would say Japanese food.

=>1 A: *Japanese food.*

ECA: *I see.*

In Example 2, disagreement expressed by the ECA (=>1) causes the antipathy of the subjects toward it (=>2) and leads to sympathy between them. People in public places generally take care to "save face," and they also take similar measures for the "face" of others [3]. For example, when someone stumbles over a stone on the road, people around him tend to pretend not to notice it. Similarly, in Example 2, subject B willingly tries to recover the partner's face after it is threatened by explicit disagreement of the ECA in the public conversation (=>2), and this motivates the subjects to have sympathy for each other.

Example 2. Antipathy to the ECA and sympathy between subjects

=>1 ECA: *I do not hit it off well with Mr. A, because you want to visit Universal Studio Japan.*

A: …Fine.

=>2 B: Well, I think Mr. X (the ECA's name) is kind of rude.

A: I'm afraid I'll never get along with him.

Both of these examples show that participants in the study used the conversational channel, when it was available to them, to strengthen their own connection, mitigating the ability of the ECA to affect their impressions of one another.

5. DESIGN IMPLICATIONS

The results of our study suggest that, if we want to build influential social ECAs, we should make sure they take the initiative in conversation, and minimize opportunities for human conversationalists to make remarks about themselves and the ECA that will undermine its influence. Based on these findings, we propose some behaviors to create influential social ECAs and feasible implementation of the mechanisms for the behaviors.

1) Create proactive social ECAs that interact with each person frequently by circulating among people.

ECAs that just wait for people to come to them are easily ignored and marginalized. Instead, the ECA should actively walk through the virtual space seeking to encounter people to carry on one-to-one conversations like the ones in our high-mediation condition. The ECA could choose who to approach based on the number of past encounters with each person and the distance between him/her and the ECA. If the number is less and the distance is shorter, the priority of the person becomes high. Since social ECAs are social entities and cannot be duplicated as computational agents can, a large-scale community using this strategy would require the collaboration of multiple ECAs walking around the virtual space. Shared good (or bad) reputation for the group of ECAs could provide a common ground for establishing their credibility and authority with community members.

2) Lead conversation flow by controlling turn-taking.

When an ECA is engaged in conversation, it should not allow people to form side conversations, ignoring or deriding its contributions. In the experiment, agent-human communication took place entirely in text, which allowed people to carry on meta-conversations with one another in the midst of the dialog, through their voice channel. This suggested to us that it would be best if we could equip ECAs with the capability to lead a vocal dialog with people, so it could rein in their side conversations. As current speech recognition technology is not sufficient for supporting informal chats like the ones we want our social ECA to lead, asking questions through synthesized speech and receiving answers through menu-based interaction is a practical alternative. It would also be possible to implement an ECA that could detect high voice volume and extended conversation between human participants, and then try to break in at a certain point to regain control of the conversation. Without comprehension of the contents of the speech, however, this could be perceived as rude and invasive.

3) Present the impression that the social ECA comprehends the conversation.

In our experiment, people talked freely about the ECA, assuming that it could not understand the contents of their conversation at all. This observation shows the potential

effectiveness of giving participants the impression that the ECA understands what is being said. If people believe that the ECA can understand what they are saying, they may stop making remarks about the ECA in order to maintain friendly social relations with it. It would be easier to implement some limited ability—or example listening for keywords—than complete vocal dialog capability, so it might be feasible given current technologies. To avoid erroneous detection, the ECA could wait until the same keyword is detected repeatedly.

These behaviors all focus on the unique problems and issues of handling groups and their interactions with ECAs in virtual spaces—versus designing ECAs for one-on-one interactions in traditional GUI environments. Many people are the potential conversation partners for social ECAs but may ignore them. Multiple human-human conversations and agent-human conversations occur simultaneously. Testing social ECAs equipped with the capability of these behaviors is our future work.

6. CONCLUSION

Our research aimed to investigate whether a social ECA could use human-human balance dynamics to affect group members' perceptions of one another and of the agent, and also to look at how the agent's mediation of conversation turn-taking modulated this effect. Results of our experiment were as follows:

- In situations where the social ECA controlled the conversational floor and turn-taking, it was effective in eliciting balance effects in group situations.
- When the ECA did not maintain control of the conversation, its ability to elicit balance effects was eliminated.

These results demonstrate that social ECAs can be influential using the same tactics as humans do in group situations, shifting peoples' impressions of themselves and their conversation partners. As lifelike qualities and conversational abilities improve in ECAs, these findings suggest that we should be able to construct highly charismatic and persuasive agents for group situations, using the same tactics that persuasive humans do.

However, the results also show that social ECAs are subject to the same limits and dampeners as humans. Given the chance to converse extensively about the ECA, human participants rendered the agent's attempts at influence fruitless. This result suggests that we need not worry about making our agents too persuasive, so long as we build in natural safeguards for users of such systems, by providing the same inoculation techniques that are available in everyday life.

How could we build ECAs to overcome the effects of conversation between the human participants about the agent? If we wish to preserve conversational parity, we could work to build agents that can 'hold their own' better in consensus-building conversations, through comprehension of face-saving and meta-comments like the ones that were observed in our conversation analysis.

However, we need not assume that it is always advantageous or even effective to provide total conversational parity among humans and agents. In virtual environments, agents may have powers that are above and beyond those of the human interaction partners, and we can exploit these dynamics to create desired effects. For example, in a tutoring situation it may be better to give the social ECA the technological ability to 'control the floor' so that students are not distracted. We see the manipulation of conversational control through the agent's mediation as one of many techniques that can be used in such communities to create new interaction paradigms that may be of great interest and benefit.

7. ACKNOWLEDGMENTS

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