# A Model for Social Regulation of User-Agent Relationships

Sandra Gama, Gabriel Barata, Daniel Gonçalves, Rui Prada, and Ana Paiva

INESC-ID and Instituto Superior Técnico,
Univesidade Técnica de Lisboa, Lisbon, Portugal
{sandra.gama,gabriel.barata}@ist.utl.pt
daniel.goncalves,rui.prada,ana.paiva}@inesc-id.pt

**Abstract.** Conversational agents have been subject of extensive research. While relying on other modalities of interaction beyond written verbal communication, like facial expression and voice intonation, an increasingly wider number of such agents simulate affective behavior in order to convey familiarity and increase believability. In fact, affect plays an important role in the creation and establishment of relationships among people. Actually, exploring the implementation of emotion in virtual agents does in fact potentiate user-agent relationship building. Nevertheless, the evolution of social relationships among people occurs gradually and the degree of intimacy associated with such relationships regulates people's behaviors. Similarly, we must take into account the progressive growth of relationships when modeling user-agent interaction. In this paper we present a model that regulates the development of user-agent relationships, articulating the Social Penetration Theory with personality modeling. User tests showed that gradual relationship building achieved through the implementation of our model makes an agent more interesting, while increasing its believability, engagement and fun.

**Keywords:** Conversational agent, socially intelligent agents, user-agent relationships, social regulation

## 1 Introduction

Embodied artificial agents have become quite popular over the last decade [5] [4]. A wide number of such agents rely on user-agent conversation [9] [15] [24], since it plays a major role in these interactions [7]. It has been proven that affect is very important in the creation of relationships among people and even other species [18]. In fact, conversation agents with affective behavior, besides being more believable, are likely to have increased probabilities of building social-emotional relationships with users [5].

The simulation of affective behavior in synthetic agents, however, does not simply rely on written dialogue, but it takes advantage of other interaction modalities as well, such as facial and body expressions. Interaction with agents that provide such features is potentially richer and more satisfactory [3].

However, affect must be simulated with regard to believability so that relationships between the user and the agent are created and maintained. As a result, need to take into account the normal development of social relationships among humans, which not only goes through several stages, but also occurs in a gradual, progressive way. In order to do so, we have combined results derived from the Social Penetration Theory [1] with personality modeling based on the Five Factor model [10] to regulate the development of user-agent relationships. We present a model that allows user-agent relationships to evolve in a natural, progressive way. Agents that implement this model have the potential to engage users in longer interactions, while maintaing believability.

This paper is organized as follows. In the next section we discuss some relevant related work that situates our approach in the context of social affective conversational agents. We then present a model to regulate affective user-agent relationships based on principles of social interaction and briefly describe the interaction between the user and an agent that has been built upon our model. Lastly, we present and discuss the results of user tests on the model for social regulation of user-agent affective relationships.

## 2 Related Work

Given the importance of conversation in building relationships between users and virtual agents [7] and the role that affect plays in creating agents that are both believable and engaging [3], several research studies have been conduced regarding the creation of social affective conversational agents. In fact, the maintenance of relationships is strongly related to the management of attitudes [6]. As a consequence, the expression of emotion must be carefully taken into account when creating a conversational agent. Particularly, an agent that has an associated model of emotions is likely to better understand the user, thus adapting its responses accordingly [13].

A very popular model of emotions for agents is the OCC model [17], according to which emotions are the result of the agent's interpretation of events, other agent's actions and object's features, as well as the agent's reaction to these aspects. Many studies base their work on this model, such as Elliot's research [14], who implements an affective reasoner according to the OCC model. A particularly interesting aspect of this model is its empathetic unit, which simulates empathy in human beings, generating empathic actions derived from the OCC, taking into account another agent's concerns. In order to create a dynamic behavior, the FLAME model [13] is particularly noteworthy. It represents emotions by intensity through fuzzy logic and, regarding emotional states and behaviors, it maps events and expectations accordingly. As a result, the agent dynamically generates adaptive responses, increasing believability. Yet another interesting model to represent agent behavior is PAR [2], which takes into account the agent's own actions, as well as other agents', and allows acting, planning and reasoning on these actions. It combines the OCC model for emotion analysis and generation with The Five Factor Model of personality traits (OCEAN)

[10], which regulates affect display according to personality representation. Even though these models allow the simulation of affective actions and study emotion expression in order to improve relationships, they do not model any form of either social behavior regulation of emotion or gradual relationship development.

Actually, several research studies rely on social regulation mechanisms for relationships using the Social Penetration Theory. One such study is Cassel and Bickmore's research [8], which takes into account several concepts underlying this theory as a strategy to obtain collaboration. They have created an agent that relies on small-talk in order to create conditions for task-talk leading to the achievement of interpersonal goals. The Social Penetration Theory has been further used in the context of synthetic agents. An example is Schulman and Bickmore's [22] conversational agent that persuades users to perform physical exercise. Interaction consists of an introductory dialogue that takes into account Social Penetration Theory's concepts. A strategy is followed in which superficial topics are discussed, followed by slight self-disclosure by the agent and self-disclosure eliciting. Then, only after empathic actions are performed and conversation status is assessed does a persuasive dialogue take place.

All aforementioned models and systems either research the user-agent affective relationship in some way or explore the development of more personal relations with regard to a particular practical goal. However, none of them articulates personality modeling and affect with social regulating mechanisms to create and further develop relationships. We have attempted to bridge these two very important aspects of social behavior with a model that associates the regulation of social relationship gradual building with personality and emotion.

## 3 A Model for Social Regulation of User-Agent Relationships

In order to regulate the development of affective relationships between users and virtual agents, we have created a model that conceptualizes the gradual evolution of an user-agent relationship. A particularly relevant foundation of our work is the Social Penetration Theory [1]. Furthermore, we rely on the Five Factor Model of personality [10] to both create the agent's personality and iteratively build the user's psychological nature through interactions over time. Emotions are determined not only by both user and agent's personality models, but also by relationship development regulation. The following sections go into further detail regarding each aspect of our model.

### 3.1 Social Regulation

In order to endow social user-agent relationships with human-like, gradually developing relationships, our model relies on social regulation of social connections which, consequently, restricts affect expression as well. Our approach thus consists of an articulation between a perception-action paradigm [21] and the Social Penetration Theory [1]. As for the perception-action paradigm, it is inspired in

the studies performed by Rodrigues et al. [21], which is grounded both in the Perception Action Model (PAM) [19] and in Vignemont and Singer's Research [11], stating that the agent has to choose an action regarding the perception it builds upon input stimuli. As a result, that action also causes changes in the agent's surrounding environment. These changes are processed, leading to new actions, making up an interaction cycle. The Social Penetration Theory [1] describes the gradual development of social relationships. Being defined as the process of increasing disclosure and intimacy in a relationship, it consists of four stages [25]: **(i) Orientation**, characterized by small-talk and disclosure of superficial information; **(ii) Exploratory Affective Exchange**, where topics begin to be further explored and some deeper conversations take place, as well as slight disclosure; **(iii) Affective Exchange**, where further intimacy is explored and sensitive topics are discussed, with negligible regard to superficial conversations and **(iv) Stable Exchange**defined by intimate conversation and disclosure of sensitive topics.

We have adopted this theory in order to create a representation for relationship evolution over time. To do so, we took two different definitions into account: *Affinity* and *Intimacy*. The first is related to the establishment of aspects in common while engaging in small talk or superficial interaction. As such, it is more associated with initial stages of a relationship. It is part of deeper relationships as well, although it does not play a relevant role for relationship development after the second stage. As for *Intimacy*, it consists of disclosure and exploration of deeper subjects in conversations. Even though in general it is not present until the second stage of the relationship, it is of uttermost importance to the development of deeper relationships.

These two concepts are used in our model for the simulation of Social Penetration Theory's four stages [25]. The first stage (*Orientation*) may be described as an interaction where only trivial topics are discussed and disclosure remains at a superficial level. Only the increment of *Affinity* as a result of interaction accounts for relationship evolution to the second stage (Exploratory Affective Exchange). Here, despite the importance of minor disclosure that begins to take place, trivial topics still play a relevant role in the establishment of the relationship. Despite the increase of *Affinity* accounting for the greatest part of relationship evolution, it is not until a certain level of *Intimacy* is reached that the relationship evolves to the next level. When the third stage (*Affective Exchange*) is reached through the exploration of further topics and slight personal disclosure (and consequent *Intimacy* increase), it is not until both deeper conversations and greater disclosure take place that the relationship reaches the last stage (*Stable Exchange*). At the third stage, even though *Affinity* is still taken into account, *Intimacy* is more relevant for evolution. When the relationship reaches the last level, only *Intimacy* is taken into account, since superficial conversation now plays a negligible role in the relationship. Depending on interaction, relationships may also regress. When that happens, depenetration [1] takes place.

In order to simulate relationship development, we have defined two variables, $aff$ and $int$, that model each of these concepts. While $aff$ represents *Affinity*,

corresponding to the discussion of superficial topics, *int* stands for *Intimacy*, expressing personal disclosure. Evolution of *Affinity* and *Intimacy* is calculated according to Equations 1 and 2, respectively.

$$\begin{aligned} &aff_{t+1} = aff_{interaction} + aff_t \ , \\ &t \geq 0 \ \wedge \ aff_0 = 0 \ \wedge \ aff_{interaction} \in \mathbb{Z} \end{aligned} \tag{1}$$

$$\begin{aligned} &int_{t+1} = int_{interaction} + int_t \ , \\ &t \geq 0 \ \wedge \ int_0 = 0 \ \wedge \ int_{interaction} \in \mathbb{Z} \end{aligned} \tag{2}$$

To summarize, both *Affinity* and *Intimacy* scores after an interaction ($aff_{t+1}$ and $int_{t+1}$) are the sum of the values for these variables before the interaction ($aff_t$ and $int_t$) and *Affinity* and *Intimacy* values associated with the interaction ($aff_{interaction}$ and $int_{interaction}$). Either of the latter values may be negative, depending on the conversation option that is chosen by the user. As a consequence, despite initial *Affinity* and *Intimacy* values being equal to 0, these may assume negative values as a result of unfavorable interactions.

Regarding relationship evolution, we modeled each stage according to the aforementioned concepts of *Affinity* and *Intimacy*, following the Social Penetration Theory [1] and the underlying stage definition [25]. Each stage of a relationship has an associated numerical threshold value both for *Affinity* and *Intimacy*. The current stage is thus modeled according to Equation 3.

$$stage = i : \begin{cases} affT_i \leq aff < affT_{i+1} \ \wedge \\ \wedge \ intT_i \leq int < intT_{i+1} & \text{if } i \in \{1,2,3\} \\ \\ affT_i \leq aff \wedge intT_i \leq int & \text{if } i = 4 \end{cases} \tag{3}$$

To summarize, if we take into account Social Penetration Theory's four states, the relationship is on a stage $i$ ($i \in \{1,2,3\}$) if the current *Affinity* value ($aff$) is higher than or equal to the threshold associated with the current stage ($affT_i$) and lower than the threshold for the next stage ($affT_{i+1}$). It should also be verified that the present *Intimacy* value ($int$) is higher or equal than the current stage's intimacy threshold ($intT_i$) and lower than the threshold for the next stage ($intT_{i+1}$). Since there are no stages beyond stage 4, we have created a special condition for this level, so that stage computation does only take into account the current stage's thresholds ($affT_i$ and $intT_i$).

Another particularity is that there is no intimacy threshold for stage 2, since at this point only superficial conversation accounts for the evolution of the relationship, being disclosure not normally present before the second stage. Similarly, there are no lower threshold values for *Affinity* or *Intimacy* for the first stage.

Relationship stage modeling is then used for social regulation. It is actually the main basis for action decision. In fact, our computational model for a socially

regulated agent follows Social Penetration Theory's [1] principles associated with each relationship stage when making decisions on which actions to perform. For instance, it is not until the second stage that the model allows the agent to perform slight disclosure. Similarly, the expression of some strong emotions, like disgust or great happiness, only begin to occur at the third stage of the relationship. On the other hand, on the first and second stages, the agent often displays a polite smile. Regarding physical closeness representation, there are three different proximity frames. The agent's visual representation on the first stage consists of its full body, while at the second stage we can see a closer representation, where it is depicted approximately from its waist up. Regarding further stages, the agent's face is zoomed in, representing increased proximity.

### 3.2 Personality Modeling

The ways in which people perceive and react are affected by personality. Even though certain particular behaviors may change over time, personality itself remains almost constant over one's lifetime [2]. The Five Factor Model of personality traits [10] has been generally accepted [26]. This model represents a taxonomy that captures individual psychological traits. It describes the human personality as consisting of five traits (*Big Five*): **(i) Openness to Experience**, curiosity and appreciation for new actions or notions, such as art and adventure; **(ii) Conscientiousness**, a consistently planned behavior instead of a generally spontaneous course of action; **(iii) Extraversion**, or the combination of both an energetic behavior and the inclination to explore social relationships; **(iv) Agreeableness**, consisting of a disposition to cooperate, as well as to be compassionate with other people; and **(v) Neuroticism**, or emotional instability, characterized by the inclination for mood swings. We relied on the Five Factor Model to build both the agent's and the user's personality model. Personality is thus defined as a 5-tuple of traits, as depicted in Equation 4: *openness* ($o$), *conscientiousness* ($c$), *extraversion* ($e$), *agreeableness* ($a$) and *neuroticism* ($n$).

$$\begin{aligned} &personality = (o, c, e, a, n) \ : \\ &\{o, c, e, a, n\} \in \mathbb{N} \wedge \{o, c, e, a, n\} \in [1, 5] \end{aligned} \tag{4}$$

A numerical value is assigned to each trait, following a 5-point scale, ranging from 1 (lowest) to 5 (highest). For instance, a score of 5 points for *openness* corresponds to an extremely creative, curious and complex personality, while on the other extreme a score of 1 point is associated to quite a conventional and uncreative personality. A 3 points' score corresponds to a personality that is virtually neutral concerning openness.

**Agent personality** When creating the personality model for a conversational agent that aims at building an evolving relationship with the user, we have defined high scores for all the traits except *Neuroticism*, following Equation 5.

$$personality_{agent} = \{(o, c, e, a, n)\} : \\ \{o, c, e, a, n\} = \{5, 5, 5, 5, 1\} \tag{5}$$

We have modeled the agent's behavior so that it has a very positive attitude towards the user. Therefore, it is:

- Open to interaction, especially curious;
- Reliable, so that the user may depend upon it, as well as careful when approaching the user;
- Sociable and, most particularly, very friendly;
- Good natured and sympathetic, easily agreeing and empathizing with the user;
- Calm and relaxed, with no insecurities regarding either itself or its relationship with the user.

**User Personality Modeling** User personality is taken into account when performing agent decision making. At the beginning of each interaction, since there is no *a priori* available information on the user's personality, all personality traits are assigned an initial score of 3 points out of the aforementioned 5-point scale, according to Equation 6.

$$personality_{user(t=0)} = \{(o, c, e, a, n)\} : \\ \{o, c, e, a, n\} = \{3, 3, 3, 3, 3\} \tag{6}$$

As conversation takes place, the user's personality model is iteratively updated. Each user interaction option is assigned a tuple of personality traits' values $(o, c, e, a, n)$, ranging from 1 to 5 points, corresponding to the intensity of the traits that are expressed in that interaction. For instance, if the user selected an option where she replied to the user *You are welcome. I'll always be here for you.*, corresponding to a strong agreeableness (while it does not contribute to other factors), the interaction resulting tuple would be $(3, 3, 3, 5, 3)$, with a resulting score of 5 for agreeableness and a 3-point score for all other traits. Personality is updated regarding both these values and the assumptions from the previous model, as depicted in Equations 7 and 8.

$$personality_{user(t+1)} = \{(o, c, e, a, n)\} : \\ \{o, c, e, a, n\} = updateTrait(T) \tag{7}$$

$$updateTrait(T) : T_{t+1} = \frac{S \times T_t + T_{int} + (S - 1) \times T_t}{2S} \tag{8}$$

Here, the previous trait value $T_t$ is weighted with the interaction trait value $T_{int}$, regarding the relationship stage $S$. The deeper the relationship is, the less impact a single interaction has upon it, as stated by Altman and Taylor [1].

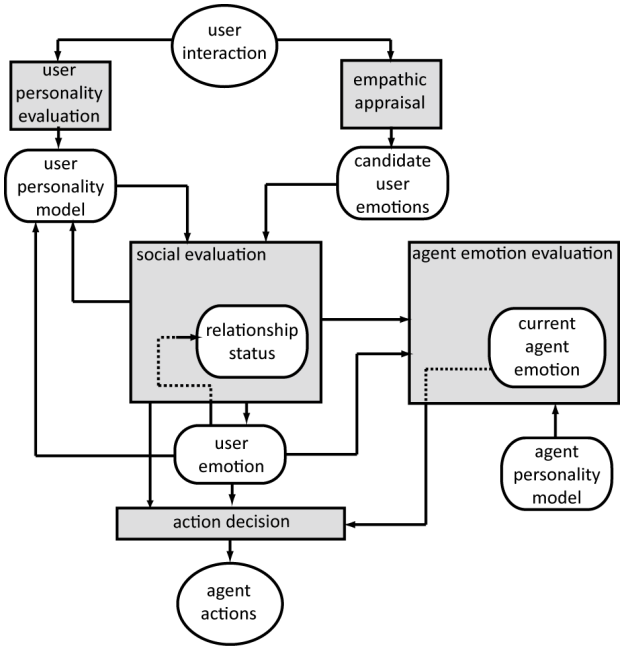


**Fig. 1.** Model Diagram

### 3.3 Model Overview

Our model, as depicted in Figure 1, consists of five main modules:

- *User Personality Evaluation* takes the user's chosen verbal interaction as input and updates the user personality model regarding the current interaction. It takes into account the valence of the answer regarding all personality traits, as well as resulting affinity and intimacy scores.
- *Empathic Appraisal*, while also taking the user written interaction as input, this module creates a set of candidate user emotions that may be associated with the interaction option that has been selected.
- *Social Evaluation* as aforementioned, regulates the development of relationships. This module is central, since it regulated merged information from both the user personality model and the set of candidate user emotions to infer the current user emotion. It does so by assigning probability functions to candidate emotions, regarding numerical values of each personality trait, and then choosing the best candidate.
- *Agent Emotion Evaluation* processes the current agent's emotion regarding the current relationship status and user emotion, taking into account the agent's personality model.
- *Action Decision* makes a decision on which actions to perform, both verbally and visually, taking into account both the current relationship status and both the user's and agent's current state of emotions.

However, actions are not limited to written verbal expression. Actually, regarding the fundamentally social and emotional characteristics of relationships [5] and the fact that people respond to social cues from a computer in a similar way to other people's, even if unconsciously [20], we created a model enables the agent to visually represent affect. Since facial expressions are a powerful way to convey emotion [Ekman77], we modeled the *six basic expressions* [12]: *happiness*, *sadness*, *surprise*, *anger*, *disgust*, *fear*, as well as the neutral expression and an expression of strong happiness. Furthermore, since the representation of proximity increases the closeness felt by the user [16] [3], our model supports the three aforementioned conversational frames, that are directly related to the relationship's current status of intimacy.

## 4 Evaluation

In order to perform evaluation of our model, we have implemented an agent that is built upon it, which interacts through written dialogue and expresses both facial expressions and physical proximity. The agent takes the initiative of interacting by prompting the user with a simple phrase and a polite smile. The user then chooses a verbal response out of a list of verbal interactions. The agent reasons upon this answer by updating both the user's model of personality and the relationship's Social-Penetration-based level and it then infers the user's current emotional state. Finally, it generates a response that is expressed in both a verbal and visual way, to which the user again responds, continuing the interaction cycle until ten minutes of interaction have been reached.

### 4.1 Design and Procedure

So that we could evaluate the model, with especial focus on the role of social regulation of relationship development, we created two different test conditions. The first one consisted of the interaction with an embodied virtual agent that implemented a version of our model without the social regulation component being active, while on the second the user interacted with a visually similar agent where our model was fully integrated.

As stated, the objective of this research was to study the impact of our model in the development and regulation of a relationship between the user and a conversational artificial agent. In particular, we intended to study three particular interaction aspects: believability, engagement and fun. To do so, we designed a questionnaire to be filled in at the end of each user test. Along with a small number of profiling questions, and given that friendship is a particularly relevant type of social relationship, we used some questions from an adapted version of the McGill Friendship Questionnaire [23] to infer engagement and fun. In order to study believability, we also created a set of questions comparing user-agent conversation to interaction with other human beings. The resulting questionnaire was subject to validation with 5 users before performing further tests, in order to first assess its explicitness and validity. At the evaluation stage, we started tests

by briefly presenting the agent to each test subject, while verbally and visually explaining how to interact. Afterwards, we allowed users to freely interact for at least ten minutes. Participants were then asked to fill in the questionnaire. We had a total of 30 participants, 15 for each test condition. All subjects were university students, 11 (36.67%) of whom were female and 19 63.33% male. Furthermore, 24 (80%) subjects were aged between 18 and 25, while the remaining 6 (20%) belonged to the age group between 26 and 35 years old.

### 4.2 Results

Regarding the three aspects we have taken into account, believability, engagement and fun, the general average results are depicted in Figure 2, for both test conditions (either without or with social regulation). It is immediately clear that all measured aspects display general higher values when comparing both test conditions. In particular, average believability increased from 3.04 ($\overline{x} = 3.04$, $\sigma = 0.56$) to 3.82 ($\overline{x} = 3.82$, $\sigma = 0.55$), while engagement from 3.73 ($\overline{x} = 3.73$, $\sigma = 0.47$) to 4.49 ($\overline{x} = 4.49$, $\sigma = 0.53$) and fun from 3.38 ($\overline{x} = 3.38$, $\sigma = 0.47$) to 4.11 ($\overline{x} = 4.11$, $\sigma = 0.50$).

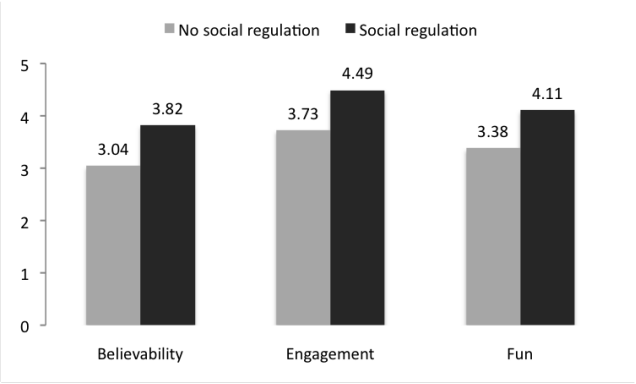


**Fig. 2.** Average Global Results

Looking more closely at the results, a Shapiro-Wilk test showed some evidence against normality ($W_{EngagementSocialRegulation} = 0.87$, $p < 0.05$). The fact that some of the data are non-normal suggested the adequateness of a Kruskall-Wallis test to understand the impact of social regulation. As a result of performing such tests for comparing both test conditions for the three aforementioned aspects, we were able to conclude that social regulation does in fact have a great impact on either believability, engagement or fun. In particular, when concerning believability, the model version with social regulation (Mdn = 3.67) differs significantly from the model without this feature (Mdn = 3.00) ($U = 187.50$,

$p < 0.05$, $z = -3.09$). As for engagement, social regulation also seems to have a great impact, since the version that displays this feature (Mdn = 4.67) is significantly different from the one who does not (Mdn = 3.67) ($U = 189.00$, $p < 0.05$, $z = -3.15$). Regarding fun, social regulation is very relevant as well. In fact, there is a significant difference between the condition where social regulation is taken into account (Mdn = 4.00) and the scenario one where this feature is not active (Mdn = 3.33) ($U = 190.00$, $p < 0.05$, $z = -3.19$).

This corroborates the previous general conclusions derived from Figure 2, confirming that, in fact, the social regulation component of our model has a great impact in all aspects we have taken into account: believability, engagement and fun, validating our hypothesis that social regulation plays an important role concerning user-agent interaction.

## 5 Conclusions and Future Work

The popularity of conversational virtual agents has become increasingly higher over the years. The exploration of emotion is virtual agents, besides improving user-agent relationships, increases believability. However, when regarding the nature of social relationships, we must take into account the associated particularities, such as their gradual development over time. To do so, we have created a model that regulates not only the evolution of relationships but also the actions to perform regarding the current status of the user-agent relationship. We have articulated the Social Penetration Theory [1] with Five Factor personality modeling [10], allowing a user-agent relationship to naturally unfold. We have performed user tests with an agent implementation of our model, which have shown promising results, ascertaining that our model does, in fact, increase believability, while engaging users in a positive, engaging and fun interaction experience. One very interesting aspect to take into account in the future would be to implement memory mechanisms to further enhance interaction over time, since we already provide social mechanisms that will potentially keep users engaged in interaction for a longer period of time. Not only would such a research study be very interesting, but it would also provide us with the means to adapt our model to more human-like, longer-term interactions.

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