

# Simulating Affective Communication with Animated Agents

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**Abstract:** This paper introduces a model of interaction between users and animated agents as well as inter-agent interaction that supports basic features of affective communication. As essential requirements for animated agents' capability to engage in and exhibit affective communication we motivate reasoning about emotions and emotion expression, personality, and social role awareness. Our implemented, entirely web-based system demonstrates animated agents based on our model of affective communication. Agents are able to give natural responses and therefore come across as believable and even interesting conversational partners.

**Keywords:** interaction models, intelligent systems, affective (emotional) aspects of interaction, animated agents

## 1 Introduction

Our concept of affective communication derives from the influential paradigm of *affective computing*, “computing that relates to, arises from, or deliberately influences emotions” (Picard, 1997). In line with this work, we assume that emotions are indispensable for effective communication, and thus promote the view that emotions should be integrated to models of human-computer interaction. In particular, we envision that humans interact with animated agents, i.e., cartoon-style characters that may behave in believable and appropriate ways.

Animated agents with affective behavior are already used in various application domains. They perform as virtual tutors in interactive learning environments (e.g., Johnson et al., 2000), as virtual presenters on the web (e.g., André et al., 2000; Ishizuka et al., 2000), and as virtual actors for entertainment (e.g., Rousseau and Hayes-Roth, 1998) and language conversation training (e.g., Prendinger and Ishizuka, 2001).

Our goal is to develop a general framework for affective communication that covers various forms of user-agent and inter-agent interactions. Specifically, we will propose components of agents' mental models that enable them to process emotions and show affective behavior. As such our approach can be characterized as a theory of ‘cold’ emotions, i.e.,

affective communication is considered as a dispassionate cognitive process, where animated agents in no way ‘have’ emotions. The main contribution of our paper is a computational model of affective communication that allows for natural responses and social behavior.

The programmable interface of the Microsoft Agent package (Microsoft, 1998) will be used to run example conversations. Although these off-the-shelf animated agents (characters) are quite restricted in the number of behaviors, the package comes ready with a speech recognizer and a text-to-speech engine that allow client-side execution in a web browser.

The rest of the paper is organized as follows. In the next section, we describe a framework for modeling and simulating conversations between multiple agents. In Section 3, the core components of the design of animated agents are introduced. Starting with the capability of emotion expression, we develop an affective reasoner for reasoning about emotions, a rudimentary model of personality, and a simple model of social role awareness. Section 4 introduces so-called ‘filter programs’ that function as a ‘filter’ between the agent's affective state and emotion expression. After that, we illustrate our approach by example runs of our web-based system that features animated agents as conversational partners in

role-playing environments. In Section 6, we briefly discuss and conclude the paper.

## 2 Simulating Conversations

A conversation is often seen as an activity where multiple (locutor-)agents participate and communicate through multiple channels, such as verbal utterances, gestures, and facial display. Each agent has its own goals and will try to influence other participants' mental states (e.g., beliefs, goals) and affective states (e.g., emotions). Moulin and Rousseau (2000) distinguish three levels of communication:

- At the *communication level* agents perform activities related to communication maintenance and turn-taking.
- At the *conceptual level* agents transfer concepts.
- At the *social level* agents manage and respect the social relationships that hold between agents.

Our system integrates (limited forms of) all three levels. The first level implements conversational features of human-human communication (Cassell and Thórisson, 1999). At the conceptual level, information is passed from one agent to other agents (including a human agent) as a simplified symbolic representation of the utterance, e.g., if an agent orders tea, this is simply represented as *order\_tea*. According to their role in the social context, the social level puts behavioral constraints on agents' actions and emotion expression (Moulin, 1998). This issue will be discussed in more detail in Sections 3 and 4.

As an example, consider an animated agent playing the role of a customer called 'Al' and an agent character in the role of a waiter called 'James'. Al orders tea from James by saying "May I order tea please?". The corresponding *communicative act* is formalized as

$com\_act(al,james,order\_tea,polite,happiness,s0)$

where the argument 'polite' is a qualitative evaluation of the linguistic style (LS) of the utterance, the argument 'happiness' refers to Al's emotion expression, and *s0* denotes the situation in which the utterance takes place.

Following Moulin and Rousseau (2000), we assume that a conversation is governed by

- a *conversational manager* that maintains a model of the conversation, and
- an *environmental manager* that simulates the environment in which the agents are embedded.

For simplicity, we assume that the conversational manager operates on a shared knowledge base that is visible to all agents participating in the conversation

(except for the user). It stores all concepts transferred during the conversation by updating the knowledge base with

$com\_act(S,H,C,LS,E,Sit)$

facts. Moreover, the conversational manager maintains a simple form of turn-taking management, by assigning agents to take turns based on their personality traits. E.g., if James is an extrovert waiter, he would tend to start a conversation with a customer, which is formalized as

$initiative(james,extrovert,take)$

The environmental manager simulates the world that agents inhabit and updates its (shared) knowledge base with the consequences of their actions. E.g., if the agent character Al got his tea in situation *s5*, this will be stored as

$holds(al,has\_tea,s5)$

The characteristics of the environment are stored by a set of facts and rules. Situation calculus is used to describe and reason about action and change in the environment (Russell and Norvig, 1995).

## 3 Components of Affective Communication

Each agent involved in a conversation is assumed to have its own mental model. A mental model may contain different kinds of entities, including world knowledge (beliefs), affective states (emotions, personality traits, attitudes), goals and plans. In this paper, we will concentrate on those entities that seem most important for affective communication: emotions, personality, and social role. Our model of multi-agent conversation is illustrated in Figure 1.

Simulating Multi-agent Conversation

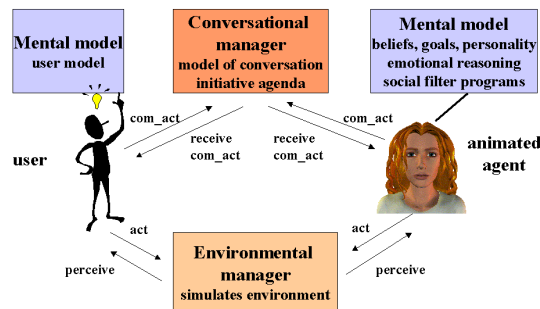


Figure 1: Simulating a conversation between an animated agent and user (agent).

Here, a situation is displayed where a user communicates with an animated agent. Similarly, the

model can be used for the communication between two or more agents, possibly involving a user. Our focus is on mental models of animated agents that support believable affective behavior. The user's mental model might be captured by building up a user model. In the present paper, however, we side-step this problem (despite its importance).

### 3.1 Emotion Expression

It is widely accepted that animated agents capable of emotion expression are crucial to make the interaction with them more enjoyable and compelling for users (e.g., Lester et al., 1999). Emotional behavior can be conveyed through various channels, such as facial display (expression), speech and body movement.

The so-called 'basic emotions' approach (Ekman, 1992) distills those emotions that have distinctive (facial) expressions associated with them and seem to be universal: *fear*, *anger*, *sadness*, *happiness*, *disgust*, and *surprise*. More precisely, Ekman prefers to talk about (basic) emotion *families*. Thus it is consistent to have many expressions for the same basic emotion. Characteristics of basic emotions include, e.g., quick onset (emotions begin quickly) and brief duration, which clearly distinguish them from other affective phenomena such as moods, personality traits, or attitudes. Note that only enjoyment and possibly surprise are 'positive' emotions. The enjoyment family covers amusement, satisfaction, sensory pleasure, pride, thrill of excitement, and contentment. Interestingly, the positive emotions do not have a distinct physiological signal. Ekman explains this by referring to the minor relevance of positive emotions in evolution.

The 'basic emotions' approach provides a useful list of emotions as an emotion family inventory for animated agents *as it explicitly relates emotion to behavior*. Besides facial expressions, Ekman also suggests other signals, such as speech and body movement to express emotions. Most importantly, Murray and Arnott (1995) describe the vocal effects of Ekman's five basic emotions. E.g., if a speaker expresses happiness, then his or her speech is typically faster (or slower) and higher-pitched, whereas a sad speaker's speech is usually slow and lower-pitched. When using those results for speech synthesis, however, we have to be aware that speech contains a variety of information, including cues to speaker identity, affect, and emphasis. Picard (1997) reports on work saying that emotional arousal is communicated by pitch and loudness, whereas the realization of emotional valence needs more sophisticated cues, e.g., rhythm, and also non-acoustic cues such as facial expression.

Although a 'basic emotions' theory allows relating emotion to behavior (emotion expression), it cannot answer the question *why* an agent is in a certain emotional (or affective) state. However, in order to express an emotion, we have to start with processing the agent's emotional (or affective) state.

### 3.2 Reasoning about Emotion

Many systems that reason about emotions, so-called *affective reasoners*, derive from the influential 'cognitive appraisal for emotions' theory of Ortony, Clore and Collins (1988), also known as the OCC model. The OCC model views emotions as valenced (i.e., positive or negative) reactions to events, agent's goals, standards, and preferences. Here, emotions (emotion types) are grouped according to cognitive eliciting conditions and labeled by a word or phrase such as 'joy' or 'angry at'. In total, twenty-two emotion types are motivated. The OCC model can be represented as a set of rules and might thus be seen as a model of (emotion) causation that allows to reason about emotions (O'Rourke and Ortony, 1994).

We defined rules for some of more frequently occurring OCC emotion types: *joy*, *distress*, *hope*, *fear*, *happy for*, *sorry for*, *angry at*, *gloats*, and *resents*. E.g., the emotion types 'happy for' and 'hope' are described as follows:

**Emotion type 'happy for':** an agent *L1* is in the emotional state of 'happy for' an agent *L2* in situation *S* IF *L1* experiences joy over a state-of-affairs *F* presumed to be desirable for *L2* in *S*.

**Emotion type 'hope':** an agent *L* is in the emotional state of 'hope' in situation *S* IF *L* wants that a state-of-affairs *F* holds in *S* AND *L* anticipates *F* in *S*.

A salient feature of our model of affective communication is that basic emotions (used for emotion expression) should not be confused with the emotion types that refer to an agent's cognitively derived emotional states. This is justified by the regulatory function of personality and social role for emotion expression, which will be discussed in the following sections.

### 3.3 Personality

As opposed to emotions, personality traits are typically characterized by patterns of thought, attitudes, and behavior that are permanent or at least change very slowly (e.g., Moffat, 1997). Since personality persists over lengthy periods of time, it is essential that animated agents show *consistent* personalities (Rousseau and Hayes-Roth, 1998).

In order to keep things simple, we consider only two dimensions of personality, which seem crucial for social interaction and affective communication.

- *Extraversion* refers to an agent's tendency to take action (values: 'outgoing', 'neutral', and 'introverted').
- *Agreeableness* refers to an agent's disposition to be sympathetic (values: 'friendly', 'indifferent', and 'unfriendly').

If the animated agent James is outgoing and friendly, it is formalized as

*personality\_type(james,outgoing,friendly)*

As mentioned in Section 2, we consider the first dimension, extraversion, in the conversational manager: outgoing agents try to take turn in a conversation whenever possible, whereas introverted agents only respond when offered to take turn. In our model, the second dimension, agreeableness, is reflected by the linguistic style the agent chooses when responding to other agents as well as vocal parameters set according to the vocal effects of basic emotions.

### 3.4 Adequacy of the Mental Model

At this point it seems reasonable to ask whether the proposed internal states of agents' mental models are adequate with respect to some psychologically corroborated agent architecture.

A generally accepted fact about affective agent architectures is the distinction between 'primary' emotions or (emotional) *reflexes*, and 'secondary' emotions that involve *deliberation* about the agent's beliefs, goals, and attitudes (Picard, 1997). The OCC model certainly encodes the deliberative layer. The reactive layer might be implemented by a set of condition-action rules (Russell and Norvig, 1995). Those rules will fire immediately when the respective conditions are met. In addition, Allen (1999) proposes a *meta-management* layer that is responsible for an agent's adaptability by monitoring and controlling reactive and deliberative management mechanisms. However, at this moment our model does not provide any means for meta-management.

An interesting aspect of Allen's work is that he considers all 'higher-level' mental concepts such as beliefs, intentions, emotions, and personality as (motivational) *control states* that he defines as "information-bearing representations of an information-processing control system". In practice, this means that a mental concept that might function as a predictor of behavior can be considered as a control state. E.g., if we can say "she does this because she has a friendly personality", without

referring to other of the observed agent's mental concepts (e.g., intentions), it is a good indicator that 'personality' is a control state. A control state not considered by Allen (1999) is the social role played by an agent in a certain social context. We will argue that *social role awareness* is equally important to other mental concepts.

### 3.5 Social Context

A significant portion of human communication takes place in a socio-organizational setting where participating agents have clearly defined *social roles*, such as sales person and customer, teacher and student, or software assistant and user (Moulin, 1998). Each role has associated behavioral constraints, i.e., responsibilities, rights, duties, prohibitions, and possibilities. Depending on its role, an agent has to obey communicative conventions. These conventions function as a regulatory for the agent's choice of, e.g., verbal expressions in a given context. *Conventional practices* (i.e., behavioral constraints and communicative conventions) can be conceived as guidelines about socially appropriate behavior in a particular socio-organizational setting. Below, it will be argued that the choice of verbal and non-verbal behavior (emotion expression) crucially depends on the agent's social role and personality.

Formally, roles in social or organizational groups are ordered according to a power scale, which defines the social power of an agent's role over other roles. For simplicity, we consider just two such relations for agents *Li* and *Lj*: *Li*'s role *Ri* is higher ranked on the power scale than that of *Lj*, *Rj*, or *Li*'s role and *Lj*'s role have the same social rank. The power relations are stored as facts of the form

*social\_relation(Rel,Ri,Rj)*

where the relation *Rel* is either ">" or "=". Social roles and associated power relations specify the *social network*. We explicitly condition an agent's response on whether the agent *Li* respects the conventions associated with its social role towards the role of *Lj*, by stating

*respects\_conventional\_practices(Li,Lj)*

If conventional practices are not respected, we write

*violates\_conventional\_practices(Li,Lj)*

This is of course a very simple view of a social network but, as shown below, it already allows us to explain various phenomena in actual conversations.

## 4 From Emotional State to Emotion Expression

As mentioned above, one of our basic assumptions is that the emotional state derived from the affective

reasoner should be clearly distinguished from the agent's actual behavior, e.g., emotion expression. Consider the following example for the emotional state 'angry at': Assume you ask your boss to give you some vacation and your boss turns you down. You are now angry at your boss because you cannot do the trip you were looking for. How will you react to your boss? Presumably you will nod, showing that you understood your boss' answer, and try to convince your boss that you really need some days off in a calm voice. Your behavior – suppressing the expression of your emotional state (angry at your boss) – can be explained in at least two ways.

First, you might have *personality traits* that characterize you as friendly and introverted. Second, and probably more important in this scenario, you might be aware of your *social role* as an employee which puts behavioral restrictions on your answer to your boss. In order to account for the 'mismatch' of the output of emotional reasoning (the emotional state 'angry at'), and emotion expression ('neutral'), we will introduce so-called (*social*) *filter programs*.

#### 4.1 Filter Programs

Basically, a (social) filter program consists of a set of rules that encode qualifying conditions for emotion expression. The program acts as a 'filter' between the agent's affective state and its rendering in a social situation, such as a conversation. We consider the agent's personality and the agent's social role as the most important emotion expression qualifying conditions (see Figure 2).

##### Filter Programs for Affective Communication

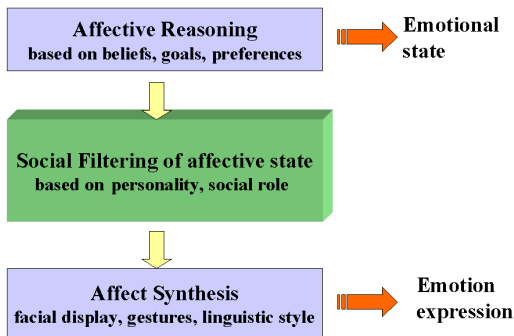


Figure 2: Operation of a filter program.

The definitions of emotion expression are consistent with Brown and Levinson's theory of social interaction, as reported in Walker et al. (1997). The following rules are clearly incomplete in the sense that they only partially describe reasons for expressing a certain emotion.

If the conversational partner has more social power, the expression of 'negative' emotions is typically suppressed, resulting in 'neutral' emotion expression.

**Emotion expression 'neutral':** an agent *L1* displays emotion expression 'neutral' towards agent *L2* IF

- *R2* is higher on the power scale than *R1*
- AND *L1* respects practices towards *L2*
- AND [*L1* is angry at *L2*
  - OR *L1* is in state 'distress'
  - OR *L1* is in state 'fear'].

The first two conditions of the rule concern the social context, the third condition (a disjunction) accounts for the output of the affective reasoner, the emotional state. Here, the agent's emotion expression is assumed to be independent of its personality traits.

If the agent communicates with an agent whose role is equal or lower, personality traits come into effect. Hence, if an agent's personality can be characterized as unfriendly, the agent may will likely show its emotional state. An agent might even express happiness about something, which – the agent believes – distresses another agent.

**Emotion expression 'happiness':** an agent *L1* displays emotion expression 'happiness' towards *L2* IF

- *R1* is equal or higher than *R2*
- AND *L1* respects practices towards *L2*
- AND *L1* has unfriendly personality
- AND *L1* is gloating regarding *L2*.

Since we clearly distinguish between emotional state and emotion expression, we may add another possibility of an agent's misinterpretation of other agents' behavior. *First*, an agent never has direct access to others mental states, it can only have (possibly false) beliefs about their mental (e.g., emotional) states. *Second*, our distinction allows that agents 'cheat' in their behavior by expressing a misleading emotion. E.g., an agent may express a sad emotion, pretending to be in a distressed emotional state, although it is in a happy emotional state.

#### 4.2 Violations of Practices

Although obedience to conventional practices is expected in real-world social settings, violations of practices occur, and we need to account for them in our framework. What happens if your personal interface assistant refuses to follow your order? This situation typically triggers a negotiation process where the agent with higher social rank (e.g., a

software user) makes his or her request more explicit, or even refers to his or her social role and associated rights, e.g., the power to request tasks from subordinates (Moulin, 1998).

## 5 Illustration

We implemented a web-based environment where users can engage in a role-play with animated agents or just experience interactions among animated agents. In the following, we first describe our implementation, and then illustrate affective communications by two example runs of our system.

### 5.1 Implementation

The programmable interface of the Microsoft Agent package (Microsoft, 1998) is used to run our interactive sessions in a web browser (Internet Explorer 5 or higher). This choice put some serious restrictions from the outset: the characters available for this package have only a limited number of behaviors (so-called *animations*) which confines the realization of basic emotions. However, our goal is naturalness on the level of appropriate affective responses rather than life-likeness (in the sense of realistic behavior). The Microsoft Agent package provides controls to embed animated characters into a web page based JavaScript interface, and includes a voice recognizer and a text-to-speech engine. Prolog programs implement all reasoning related to conversation and environmental management, and agents' mental models (affective reasoning and filtering). Jinni 2000 (BinNet Corp.) is used to communicate between Prolog code and the Java objects that control the agents through JavaScript code.

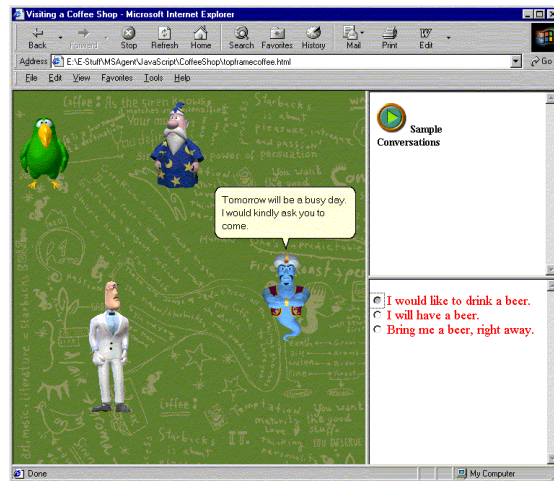
In a role-playing session, the user can promote the conversation by uttering one of a set of predefined sentences that are displayed on the screen. Animated agents will respond by synthetic speech, facial display, and gestures. An agent's verbal and non-verbal responses are synthesized in its mental model and interpreted in the browser through JavaScript functions. The parameters for speech output are set in accordance with the vocal effects associated with the five basic emotions (Ekman, 1992). Facial display of animated agents is limited to the predefined animations from the Agent package (e.g., 'pleased', 'sad'). A limited form of conversational behavior is implemented, e.g., the animations 'confused' (lifting shoulders) and 'don't recognize' (put hand to ear) are used if the user's utterance is not recognized.

Certainly, the mentioned restrictions are just limitations pertaining to the agent system we currently

use, rather than shortcomings of our underlying model of affective communication. In the near future, we plan to substitute the Microsoft characters by more expressive animated agents.

### 5.2 Example Runs

We will illustrate our system by showing two example runs. In the first example, the user takes the role of a (friendly) customer who interacts with an unfriendly, neutral waiter agent James, who himself interacts with a friendly manager agent as an employee. This situation is shown in Figure 3.



**Figure 3:** Sample conversation with James as waiter agent, Genie as manager agent, and two customer agents.

The following is an annotated trace from our affective communication system.

- [s0] Customer: *I would like to drink a beer.* [User may also choose other beverages, and for each, he or she may select the linguistic style (polite, neutral, or rude).]
- [s1] James (to customer): *No way, this is a coffee shop. Get out of here.* [Considers it as blameworthy to be asked for alcohol and shows his anger. We assume equal social rank of waiter and customer.]
- [s2] [The manager of the coffee shop appears.]
- [s3] James (to manager): *Good afternoon, boss. May I take a day off tomorrow?* [Performs welcome gesture. Following conventional practices, the waiter is polite to his manager.]
- [s4] Manager: *Tomorrow will be a busy day. I would kindly ask you to come.* [Uses polite linguistic style in accordance with his personality traits.]
- [s5] Waiter: *Ok, I will be there.* [Considers it as blameworthy to be denied a vacation and is angry.]

However, he is aware of his lower social rank and thus does not show his anger. Instead, he shows neutral emotion expression.]

The communicative act of the customer (user) has the form

*com\_act(user,james,order\_beer,polite,neutral,s0)*

Since the animated agents do not understand English, a library is used to associate the user's utterance with an 'effect', e.g., the regulations of the coffee shop are violated, and an evaluation of its linguistic style, such as polite, rude, or neutral. Moreover, as an emotion (expression) recognition module is not part of our system, we set 'neutral' as the default value for user input (but see the work of Picard (1997) on emotion recognition). The waiter agent's answer is formalized as

*com\_act(james,user,refuse\_beer,rude,anger,s1)*

Similarly, the library is employed to generate the syntactic form of the animated agent's response. As described in Section 2, the environmental manager simulates the environment. In this example, it includes the fact

*act(manager,appears,s2)*

which triggers the waiter agent's reaction in situation s3. In accordance with the contents of James' mental model, our rules for affective reasoning and filter programs, the waiter agent shows his anger towards the customer (user), but suppresses his anger towards the manager agent.

The second example run is a variation of the previous example. Here we assume a friendly, extrovert waiter agent who does not respect conventional practices towards his (indifferent) manager agent.

- [s0] Waiter: *Welcome to our coffee shop! May I take your order?* [Starts the conversation because of his extrovert personality.]
- [s1] Customer: *Bring me a beer, right away.* [User chooses rude linguistic style.]
- [s2] James (to customer): *I would really like to offer you a beer, believe me. Unfortunately, I am not allowed to serve alcoholic beverages by law.* [Concludes that the customer is distressed and feels sorry for the customer.]
- [s3] [The manager of the coffee shop appears.]
- [s4] James (to manager): *Good to see you, boss. Tomorrow I will take a day off.* [Performs welcome gesture.]
- [s5] Manager: *Actually, I need you tomorrow. Thank you.* [Uses neutral linguistic style.]
- [s6] Waiter: *Too bad for you. I will not be here.* [The waiter is angry as the manager refuses to give him a vacation. Since the waiter does not

respect conventional practices towards the manager, he expresses his anger and refuses to obey the manager's order.]

Our system is used for the pedagogical task of language conversation training, in particular, to improve English conversation skills of native speakers of Japanese. We conducted some preliminary experiments indicating that users enjoy interacting with our animated agents, and rate them as consistent in their affective reactions, and even interesting. However, a more severe investigation of the effectiveness of our affective communication model is still missing.

## 6 Discussion and Conclusion

In this paper, we propose a model for affective communication that accounts for important features of human-human communication: reasoning about emotions and emotion expression, personality of conversing agents, and social role awareness. The novel aspect of our work is the introduction of filter programs that mediate between an agent's affective reasoning component and the agent's behavior, especially emotion expression.

Although initial experiments with our animated agents proved their 'social robustness', i.e., adequacy of responses according to social conventions, our approach suffers from several shortcomings that indicate avenues of future research. First, *social agency* is not incorporated to our approach. Besides appropriate emotion expression, other (equally important) behavioral constraints apply to socio-organisational settings. The role of an agent is associated with certain responsibilities, rights, duties, prohibitions, and decision power (Moulin, 1998). E.g., consider an agent that works as a broker agent on your behalf.

Second, an obvious weakness of our approach is that we do not provide an explicit formalization of *speech acts*. Consequently, all of the dialogue contributions have to be carefully hand-crafted. Moulin (1998) introduces a new notation for speech acts, in particular conversational schemas that allow an agent to select speech acts in accordance with communicative conventions. Additionally, we would like to *consider linguistic style (LS) strategies*, as discussed by Walker et al. (1997). Those strategies determine semantic content, syntactic form and acoustical realization of a speech act, qualified by the social situation. Application of LS strategies supports affective and social interactions that allow agents to maintain public face (i.e., autonomy and approval).

In summary, we have described a web-based interactive environment featuring animated agents with the ability to engage in affective communication. By considering the issues described in this section, we hope to obtain a deeper understanding of the affective bases of communication. Ultimately, we hope that our system will be conceived as an enjoyable language conversation training tool.

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