Generic Personality and Emotion Simulation for Conversational Agents

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Abstract

This paper describes a generic model for personality, mood and emotion simulation for conversational virtual humans. We present a generic model for updating the parameters related to emotional behaviour, as well as a linear implementation of the generic update mechanisms. We explore how existing theories for appraisal can be integrated into the framework. Then we describe a prototype system that uses the described models in combination with a dialogue system and a talking head with synchronised speech and facial expressions.

Keywords: personality, emotion simulation, facial animation, artificial intelligence

Introduction

With the emergence of 3D graphics, we are now able to create very believable 3D characters that can move and talk. Multi-modal interaction with such characters is possible as the required technologies are getting mature (speech recognition, natural language dialogues, speech synthesis, animation, and so on). However, an important part often missing in this picture is the definition of the force that drives these techniques: the individuality. In this paper we explore the structure of this entity as well as its link with perception, dialogue and expression. Figure 1 depicts how we view the role of personality and emotion as a glue between perception, dialogue and expression.

In emotion simulation research so far, appraisal (obtaining emotional information from perceptive data) is popularly done by a system based on the OCC model [1]. This model specifies how events, agents and objects from the universe are appraised according to respectively their desirability, praiseworthiness and appealingness. The latter three factors are decided upon by a set of parameters: the goals, standards and attitudes. The model delivers us emotional information (i.e. the influence on the emotional state) with respect to the universe and the things that happen/exist in it. In order to have a working model for simulation, one is of course obliged to define the goals, standards and attitudes of the simulator. These factors can be considered as the ‘personality’ of the simulator. In this case, the personality of a simulator is (partly) domain-dependent. However, more recent research—the OCC model dates from 1988—indicates that personality can be modelled in a more abstract, domain-independent way [2, 3]. In this case, personality is an ensemble of factors/dimensions that each denote an influence on how perception takes place and how behaviour is shown. An interface between multi-dimensional and domain-independent personality models and the OCC model does not yet exist. In order to create an integrated model that can handle both appraisal and emotion-based behaviour, we need to define how we can use a domain-independent personality model and still use the OCC model for appraisal. In this paper we will investigate the nature of this relationship and propose how to parameterize it so that it can be used in concrete applications.

The effect of personality and emotion on agent behaviour has been researched quite a lot [4], whether it concerns a general influence on behaviour [5], or a more traditional planning-based method [6]. Various rule-based models [7], probabilistic models [8] and fuzzy logic systems [9] have been reported in the past. Our model is not targeted for one specific kind of behaviour synthesizer. We try to develop a personality and emotion simulator that can be used as a separate module and that can be easily customized depending on which dialogue system, planning system or reasoning system is used. *How* behaviour should be influenced by personality and emotion is depending on the application and the system type that is used and it is out of the scope of this paper.

Finally, personality and emotion will have an effect on how behaviour is expressed (speech will have different intonations, a face will make expressions reflecting the emotional state, a body will make different gestures according to the personality and the emotions). A first step towards such an approach is described in [10], which describes a system that can simulate personalized facial animation with speech and expressions, modulated through mood. There have been very few researchers who have tried to simulate mood. Velásquez [11] proposed a model of emotions, mood and temperament that provides a flexible way of controlling the behaviour of the autonomous entities. According to Velásquez, moods and emotions are only differentiated in terms of levels of arousal. He proposed simple models for blending, mixing and decaying emotions to subsequently select actions of the agent. Moffat [12] states that personality and emotion are basically the same mechanisms only differentiated by two cognitive variables time and duration, and personality can be seen as consistent expression of emotion.

This paper is organized as follows. In the next section, we introduce the generic emotion and personality model. Subsequently, we discuss how individuality can be captured, what models are available from psychology and how they can be integrated into a coherent framework. Also we present an update mechanism for our model. Then, the relationship between the OCC model of appraisal and personality is explored. And finally, we present an example of how to use the personality and emotion model in an application that enables a user to actually see a virtual character with expressions corresponding to its internal state. For more details about this application, please see Egges *et al.* [13] and Kshirsagar *et al.* [14, 15].

1 A Generic Personality and Emotion Model

The intention of this section is to introduce the concepts that we will use in our model. In the next section we will explain how these concepts interact and how they are maintained. We will start by defining a small scenario.

Julie is standing outside. She is holding a heavy box. She has to bring the box upstairs. A passing man offers to help her carry the box upstairs. The personality of Julie is crucial in how she perceives this act and how she will react to it. Table 1 shows how personality aspects can influence perception and behaviour. As someone is never 100% extravert or 100% neurotic, each personality factor will have a weight in determining how something is perceived and what decisions are being taken.

Of course, this is a simplified representation of reality, since Julie's behaviour will not only be based on emotions, but also on reasoning. A dialogue system or intelligent agent will require concrete representations of concepts such as personality, mood and emotional state so that it can decide what behaviour it will portray [5, 16]. As such, we need to define exactly what we mean by personality, emotion and other related concepts in order to describe how they can be simulated and used by other systems.

1.1 Basic Definitions

An individual is an entity that is constantly changing (having different emotions, moods, etc.). So, when we speak of an *individual*, we always refer to it relative to a time t. The moment that the individual starts existing is defined by $t = 0$. The abstract entity that represents the individual at a time t we will call I_t from now on. In the simple case, an individual has a *personality* and an *emotional state* (we do not yet take mood into consideration). The model based on this assumption is called PE. In our framework, the personality is constant and initialized with a set of values on $t = 0$. The emotional state is dynamic and it is initialized to **0** at $t = 0$ (we will go in more detail about this later on). Thus we define I_t as a tuple (p, e_t), where p represents the personality and e_t represents the emotional state at time t. In our example, Julie will portray emotions (that change over time) based on what happens, but how she obtains these emotions and the behaviour that results from it, depends on a static part of her being, the personality.

From psychology research, there are many personality models that consist of a set of dimensions, where every dimension is a specific property of the personality. Take for example the OCEAN model [3], which has five dimensions (see Table 2) or the PEN model [2] that has three dimensions.

Generalizing from these theories, we assume that a personality has n dimensions, where each dimension is represented by a value in the interval $[0, 1]$. A value of 0 corresponds to an absence of the dimension in the personality; a value of 1 corresponds to a maximum presence of the dimension in the personality. The personality p of an individual can then be represented by the following vector:

Vector representation of personality

$$p = \begin{bmatrix} \alpha_1 \\ \vdots \\ \alpha_n \end{bmatrix}, \forall i \in [1, n] : \alpha_i \in [0, 1] \tag{1}$$

As an example, we can specify an OCEAN personality (thus $n = 5$) that is very open, very extravert but not very conscientious, quite agreeable and not very neurotic:

$$p = \begin{bmatrix} 0.8 \\ 0.1 \\ 0.7 \\ 0.5 \\ 0.05 \end{bmatrix} \tag{2}$$

Emotional state has a similar structure as personality. The emotional state is a set of emotions with a certain intensity. The size of this set depends on the theory that is used. For example, in the OCC model, 22 emotions are defined, while Ekman [17] defines 6 that are used as a basis for facial expression classification. The emotional state is something that can change over time (for example due to a decay factor). Therefore, when we speak about an emotional state, we speak of it relative to a time t. We define the emotional state e_t as an m-dimensional vector, where all m emotion intensities are represented by a value in the interval $[0, 1]$. A value of 0 corresponds to an absence of the emotion; a value of 1 corresponds to a maximum intensity of the emotion. This vector is given as follows:

$$e_t = \begin{cases} \begin{bmatrix} \beta_1 \\ \vdots \\ \beta_m \end{bmatrix}, \forall i \in [1, m] : \beta_i \in [0, 1] & \text{if } t > 0 \\ \mathbf{0} & \text{if } t = 0 \end{cases} \tag{3}$$

Furthermore, we define an emotional state history ω_t that contains all emotional states until e_t, thus:

$$\omega_t = \langle e_0, e_1, \ldots, e_t \rangle \tag{4}$$

An extended version of the PE model can be given by including *mood* (we will call this the PME model). As such, we now define the individual I_t as a triple (p, m_t, e_t), where m_t represents the mood at a time t. Mood has never been as deeply researched and accepted as the notions of personality and emotional state and therefore its definition can be a bit tricky (which is why we omitted it from the basic framework). Mood is less static than personality and less fluent than emotional state [10]. It is an intermediate form that exists between the two and that describes a rather static state of being that lasts longer than the average emotion (see also Figure 2). This state of being can be one-dimensional (being in a good or a bad mood) or perhaps multi-dimensional (feeling in love, feeling depressed).

Whether or not it is justified from a psychological perspective to have a multi-dimensional mood is not in the scope of this paper. However, we will provide for a possibility of having multiple mood dimensions, since it is more general, so one can choose how many dimensions mood actually has. We define a mood dimension as a value that is either negative or positive and that lies in the interval $[-1, 1]$. Supposing that there are k mood dimensions, the mood can be described by a vector:

$$m_t = \begin{cases} \begin{bmatrix} \gamma_1 \\ \vdots \\ \gamma_k \end{bmatrix}, \forall i \in [1, k] : \gamma_i \in [-1, 1] & \text{if } t > 0 \\ \mathbf{0} & \text{if } t = 0 \end{cases} \tag{5}$$

Just like for the emotional state, there is also a history of mood, σ_t, that contains the moods m_0 until m_t:

$$\sigma_t = \langle m_0, m_1, \ldots, m_t \rangle \tag{6}$$

2 Emotional State and Mood Updating

2.1 Updating the Emotional State (PE model)

From a dialogue system, intelligent agent or any other A.I. system, the emotion framework will obtain emotional information. This information can, for example, be constructed based on the event appraisal model as described in OCC. We define the emotional information as a *desired change in emotion intensity* for each emotion. Then, the final emotion intensity can be calculated based on different parameters in the emotion framework. If we represent the desired change of emotion intensity by a value in the interval $[0, 1]$, then the emotion information a (or *emotion influence*) can be described by a vector that contains a desired change of intensity for each of the m emotions:

$$a = \begin{bmatrix} \delta_1 \\ \vdots \\ \delta_m \end{bmatrix}, \forall i \in [1, m] : \delta_i \in [0, 1] \tag{7}$$

The emotional state can then be updated using a function $\Psi_e(p, \omega_t, a)$. This function calculates, based on the personality p, the current emotional state history ω_t and the emotion influence a, the change of the emotional state as a result of the emotion influence. A second part of the emotion update is done by another function, $\Omega_e(p, \omega_t)$ that represents internal change (such as a decay of the emotional state). Given these two components, the new emotional state e_{t+1} can be calculated as follows (see Figure 3 for a graphical overview):

$$e_{t+1} = e_t + \Psi_e(p, \omega_t, a) + \Omega_e(p, \omega_t) \tag{8}$$

Given the basic PE-model, little is said about *how* the emotional state is updated when an emotion influence has to be processed. There are a lot of different implementations possible, and more elaborate research should be performed to determine the ideal update process. This process should both give realistic results and be computationally light. In this section we only give a simple linear implementation of the model that does not take into account the emotion history.

The linear implementation is given by the definition of the function $\Psi_e(p, \omega_t, a)$ and the function $\Omega_e(p, \omega_t)$. First, we will give a possible definition for Ψ_e. As we have a vector p of length n and a vector e_t of length m, we define an $m \times n$ matrix P_0 that we will call the *Personality-Emotion Influence Matrix*. This matrix indicates how each personality factor influences each emotion. P_0 has to be defined once, depending on which personality model and emotion model is used. Then, assuming that the personality p will not change, we can calculate the product of P_0 and p, which will give us a vector u indicating the importance of each emotion depending on the personality dimensions:

$$u = P_0 \cdot p = \begin{bmatrix} \epsilon_1 \\ \vdots \\ \epsilon_m \end{bmatrix} \tag{9}$$

We use this vector to construct the diagonal matrix P:

$$P = \begin{bmatrix} \epsilon_1 & 0 & \cdots & 0 \\ 0 & \epsilon_2 & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \epsilon_m \end{bmatrix} \tag{10}$$

For each emotion, matrix P contains a value that defines how strong an emotion can be given the personality p. For example, a very agreeable and extravert personality will have a highly positive value for the ‘joy’ emotion and a very small value for the ’distress’ emotion. Given the matrix P, $P \cdot a$ calculates the change in the emotional state given the emotion influence a. Thus, the function Ψ_e can be defined as follows:

$$\Psi_e(p, \omega_t, a) = P \cdot a \tag{11}$$

As can be noted, this implementation makes no use of the emotional state history. For the Ω_e function, we will only show the implementation of a simple, personality-independent decay. The Ω_e function is defined as an m-dimensional vector (there are m emotions):

$$\Omega_e(p, \omega_t) = \begin{bmatrix} -C_e \\ \vdots \\ -C_e \end{bmatrix} \tag{12}$$

C_e defines the amount of decay for each emotion. We normally use 0.01 as a value.

2.2 Updating the Emotional State and the Mood (PME model)

When mood is a part of the simulation, the update process slightly changes. When an emotion influence has to be processed, the update now happens in two steps. The first step consists in updating the mood; the second step consists of updating the emotional state. As such, the mood is updated by a function $\Psi_m(p, \omega_t, \sigma_t, a)$ that calculates the mood change, based on the personality, the mood history, the emotional state history and the emotion influence. Secondly, the mood is internally updated using a function $\Omega_m(p, \omega_t, \sigma_t)$ (similar to updating the emotional state internally with factors such as decay). Thus the new mood m_{t+1} can be calculated as follows (for a graphical overview of the first update step, see Figure 4):

$$m_{t+1} = m_t + \Psi_m(p, \omega_t, \sigma_t, a) + \Omega_m(p, \omega_t, \sigma_t) \tag{13}$$

The emotional state can then be updated by an extended function Ψ'_e that also takes into account the mood history and the new mood. Furthermore, we have to take the mood into account in order to internally update the emotional state. This is achieved by the function $\Omega'_e(p, \omega_t, \sigma_{t+1})$. The new update function to calculate e_{t+1} is given as follows (for a graphical overview of the second update step, see Figure 5:

$$e_{t+1} = e_t + \Psi'_e(p, \omega_t, \sigma_{t+1}, a) + \Omega'_e(p, \omega_t, \sigma_{t+1}) \tag{14}$$

We will now give a simple linear implementation of the PME model. This means providing a definition of the mood update function Ψ_m, the internal mood update function Ω_m, and an emotion update function Ψ'_e[1]. First we will take a look at the mood update function Ψ_m.

Given an emotion influence, we have to calculate the new mood vector. In this linear implementation, the new mood is dependent on three factors: the emotion influence, the personality and the current mood. First, we will look at the emotion influence. We need

[1] In this implementation, we define $\Omega'_e = \Omega_e$.

a representation of what the relation is between every emotion and every mood dimension. For each mood dimension, an emotion has either a positive or a negative influence. For example, when we have the mood dimension bad–good, then the *joy* emotion will have a positive effect, while the *angry* emotion will have a negative effect. Of course, there are gradients of positivity and negativity. Therefore, we define an *Emotion-Mood Influence Matrix* Q that defines the relation between the emotions and each mood dimension. The matrix Q is an $k \times m$ matrix since there are m emotions and k mood dimensions. The effect of the emotion influence a on the mood is then calculated by $Q \cdot a$.

Additionally, we need to take into account the personality. The size of the mood change will depend on the personality factors (an emotional stable personality will in general have small mood changes) and—similarly to the emotion update using the personality—we now also define an $n \times k$ *Personality-Mood Influence Matrix* R_0. This matrix indicates how each personality factor influences each mood dimension. We calculate a vector v as follows:

$$v = R_0 \cdot p = \begin{bmatrix} \kappa_1 \\ \vdots \\ \kappa_k \end{bmatrix} \tag{15}$$

This vector now consists of a stability parameter for each mood dimension. When there is only one mood dimension good-bad, and the personality is emotionally stable and agreeable, then this stability parameter will be small, which will result in a small mood change. This relationship can be established as follows. We construct a diagonal matrix R using the vector

v:

$$R = \begin{bmatrix} \kappa_1 & 0 & \cdots & 0 \\ 0 & \kappa_2 & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \kappa_k \end{bmatrix} \tag{16}$$

Then, the function Ψ_m can be given as follows:

$$\Psi_m(p, \omega_t, \sigma_t, a) = R \cdot Q \cdot a \tag{17}$$

The second function, Ψ'_e, consists of two parts. The first part (personality influence on emotion) we take directly from the PE model (see Equation 11). The second part—how mood influences emotion—is calculated by defining an $m \times k$ *Mood-Emotion Influence Matrix* T that is multiplied with the new mood m_{t+1}. The result of the multiplication gives us the influence of the mood on the final emotional state. In order to relate the result with the actual emotion influence, we first construct a diagonal matrix A from the emotion influence vector a as follows:

$$A = \begin{bmatrix} \delta_1 & 0 & \cdots & 0 \\ 0 & \delta_2 & & \vdots \\ \vdots & & \ddots & 0 \\ 0 & \cdots & 0 & \delta_m \end{bmatrix} \tag{18}$$

And so we obtain the following definition for the function Ψ'_e:

$$\Psi'_e(p, \omega_t, \sigma_{t+1}, a) = \Psi_e(p, \omega_t, a) + A \cdot T \cdot m_{t+1} \quad (19)$$

Finally, we will give a function for mood decay, Ω_m:

$$\Omega_m(p, \omega_t, \sigma_t) = -C_m \cdot m_t \quad (20)$$

C_m is a variable that defines the speed of the decay. In our simulations, we normally use a value of 0.01.

Personality, Emotion and the OCC Model of Appraisal

As OCC is the most widely accepted appraisal model, we will present some thoughts about how to integrate our framework with OCC. Since OCC does not use a personality as described in our framework, we need to make a link on this level. OCC uses goals, standards and attitudes. These three notions are for a large part domain dependent. As multidimensional personality models are domain-independent, we need to define the relationship between this kind of personality model and the personality model as it is used in OCC. We will choose an approach where we assume that the goals, standards and attitudes in the OCC model are fully defined depending on the domain. Our personality model will then basically serve as a **selection criterion** that indicates what and how many goals, structures and attitudes fit with the personality. How this criterion is defined, depends of course on the personality model that is used. Because the OCEAN model is widely accepted, we will use this model to illustrate our approach. For an overview of the relationship between OCEAN and the goals, standards, and attitudes, see Table 3. Every personality factor has its influence on the goals, standards and attitudes in the OCC model and their intensity in the personality determines the final effect on the goals, standards and attitudes.

Goals

First, we will take a look at the goals of an appraisal system and how this can be influenced by OCEAN parameters. The **Conscientiousness** parameter influences how soon goals will be abandoned and new goals are adopted. A conscientious personality will try and achieve all goals that he/she has set. **Agreeableness** defines if someone will adopt or abandon goals in favor of others. Finally, neuroticism is more of a natural reaction to pressure and stressful circumstances. Although there is not a direct connection between neuroticism and goals, neurotic people will in general experience negative thoughts, which can lead to less ambition.

Standards

The **Openness** factor will influence how fast standards can change, based on things that happen in the Universe. An open personality will change his/her standards of what ought to be fairly quickly, while a closed personality will not. **Agreeableness** is an indicator of whether or not someone is prepared to *compromise* his/her standards in favor of someone else. Finally, neuroticism will not influence the standards.

Attitudes

The two most important factors that influence the attitudes of a personality in OCC, are **Extraversion** and **Agreeableness**. Both factors will have a positive effect on whether someone likes people in general. An extravert personality will be pleased to communicate and have a positive attitude towards people in general. An agreeable personality will easily adapt to other people and thus also create a positive attitude towards them. Also, **Openness** influences the attitude of someone towards new elements in his/her environment.

3 Application

3.1 Overview

It is very difficult to demonstrate the model as explained in the previous sections, since there are so many different variables involved in the process. It is not possible to show the exact influence of each variable separately, but we will make an attempt to show the validity of the model by showing the result of its application. We have built a conversational agent represented by a talking head. The center of the application is a dialogue system that generates different responses based on the personality, mood and emotional state. The system responses are coded as Finite State Machines. For a simplified example, see Figure 6. In the future, we can use more elaborate methods of dialogue management but for now we chose this approach since it is very easy to implement and it provides for an easy way to construct a system that takes decisions based on the emotional state. The personality and emotion model is implemented using the 5 factors of the OCEAN model of personality, one mood dimension (a good-bad mood axis) and the 22 emotions from OCC plus 2 additional emotions (disgust and surprise) to have maximum flexibility of facial expression. The response that is generated by the dialogue system is augmented with emotional information from the emotional state, which, in turn, is used by the visual front-end to generate speech synchronized with facial expressions. An example of such an annotated response can be (the tags consist of a joy emotion percentage of 58 and a pride emotion percentage of 30):

```
|JO58PR30|Thanks! I like you too!
```

Defining new dialogue systems with different personalities is rather easy once the update functions for the specific models (OCC and OCEAN) are established. A user can simply define a personality by specifying the 5 parameters. Also, the Finite State Machine approach allows us to structure the dialogue in such a way that different components can be programmed (for example, a chatting component, an agent identity component, etc.) and afterwards reused in other dialogue systems. In this way, dialogue system developers can use the generic dialogue components as a basis for a domain-specific dialogue system. For a more detailed overview of this system, see Egges *et al.*.

3.2 Visual Front-end

Our graphical front-end comprises of a 3D talking head capable of rendering speech and facial expressions in synchrony with synthetic speech. The facial animation system interprets the emotional tags in the responses, generates lip movements for the speech and blends the appropriate expressions for rendering in real-time with lip synchronization[2]. Facial dynamics are considered during the expression change, and appropriate temporal transition functions are selected for facial animation. The snapshots of the facial expressions used by our system are shown in the Figure 7.

We use MPEG-4 Facial Animation Parameters as low level facial deformation parameters. The details of the deformation algorithm are explained in [14]. However, for defining the visemes and expressions, we use the Principal Components (PCs) as described by Kshirsagar *et al.* [15]. The PCs are derived from the statistical analysis of the facial motion data and reflect independent facial movements observed during fluent speech. They are used as high level parameters for defining the facial expressions and visemes. The use of PCs facilitates realistic speech animation, especially blended with various facial expressions. The main steps incorporated in the visual front-end are the following:

1. Generation of FAPs from text: For this we use available text-to-speech (TTS) software that provides phonemes with temporal information. The co-articulation rules are applied based on the algorithm of Cohen *et al.* [18] that is adopted for use with

[2] For more details on expressive speech animation, see Kshirsagar *et al.* [15].

the PCs.

2. Expression blending: The dialogue system outputs expression tags with the text response. Each expression is associated with an intensity value. An attack-sustain-decay-release type of envelope is applied for the expressions and it is blended with the previously calculated co-articulated phoneme trajectories. This blending is based on observed facial dynamics, incorporating the constraints on facial movements wherever necessary in order to avoid excessive/unrealistic deformations.

3. Periodic facial movements: Periodic eye-blinks and minor head movements are applied to the face for increased believability. In future, these movements should be extracted also from the dialogue module, considering their relation with the semantics and context.

3.3 Example interaction

As an example, we have developed a small interaction system that simulates Julie's behaviour. We have performed these simulations with different personalities, which gives different results in the interaction and the expressions that the face is showing. The interaction that takes place for an extravert personality (90% extravert) is shown in Figure 8. Figure 9 shows how the personality and emotion based response is generated in this case. However, when we change the personality so that it becomes more neurotic (90% neurotic), the interaction also changes significantly (see Figure 10).

Finally, when the extraversion parameter is set to a lower value, the responses of the dialogue system are also becoming less extravert. When the personality is very introvert, the dialogue system rather replies with ‘Thanks’ and ‘The third floor’ in stead of the responses given in the two figures.

4 Conclusions and Future Work

In this paper we have presented a basic framework for personality, mood and emotion simulation. We have described how different parts of this model interact and how the update process takes place. Subsequently we have shown how this framework can be integrated with an application such as an expressive MPEG-4 talking head with speech synthesis. Although we have tested our system with the OCEAN model of personality and the OCC emotion structure, our model can be easily adapted to work with other kinds of multidimensional personality and emotion models. Once these models have been chosen and the update process has been specified, users can easily manipulate the personality dimensions while the update process changes accordingly. One point of further investigation is how the appraisal data is transferred to the personality and emotion module. Currently, only a desired change in emotion intensity is passed on. However, one can imagine that the appraisal process also gives more information, such as emotion dynamic parameters. Also, the current linear implementation of the update process is limited. Whether or not such an implementation is sufficient for realistic simulation will be partly determined by the user studies we are currently performing to validate the personality and emotion framework. Finally, our current implementation does not yet support the direct control over face movements such as eye blinking and head rotation. Our future work will focus on these limitations of the system. Furthermore we will explore how personality and emotion are linked to body behaviour and what computational methods are required to simulate this link.

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Personality Aspect	**Julie’s Perception**	**Julie’s Behaviour**
Extravert	Julie perceives the proposal of the man as very positive. She feels gratitude.	Based on her emotion she makes a decision to let the man help her. She smiles friendly and she says she is very happy that he proposed to help her.
Introvert	Julie perceives the proposal as invading her privacy. She feels distress and fear.	Julie tells the man she does not require any help. She looks a bit afraid.
Neurotic	Julie fears that the man wants to steal the box from her. She feels afraid.	Julie tells the man she does not require any help. She looks afraid.

Table 1: Aspects of personality and possible effects on perception and behaviour.

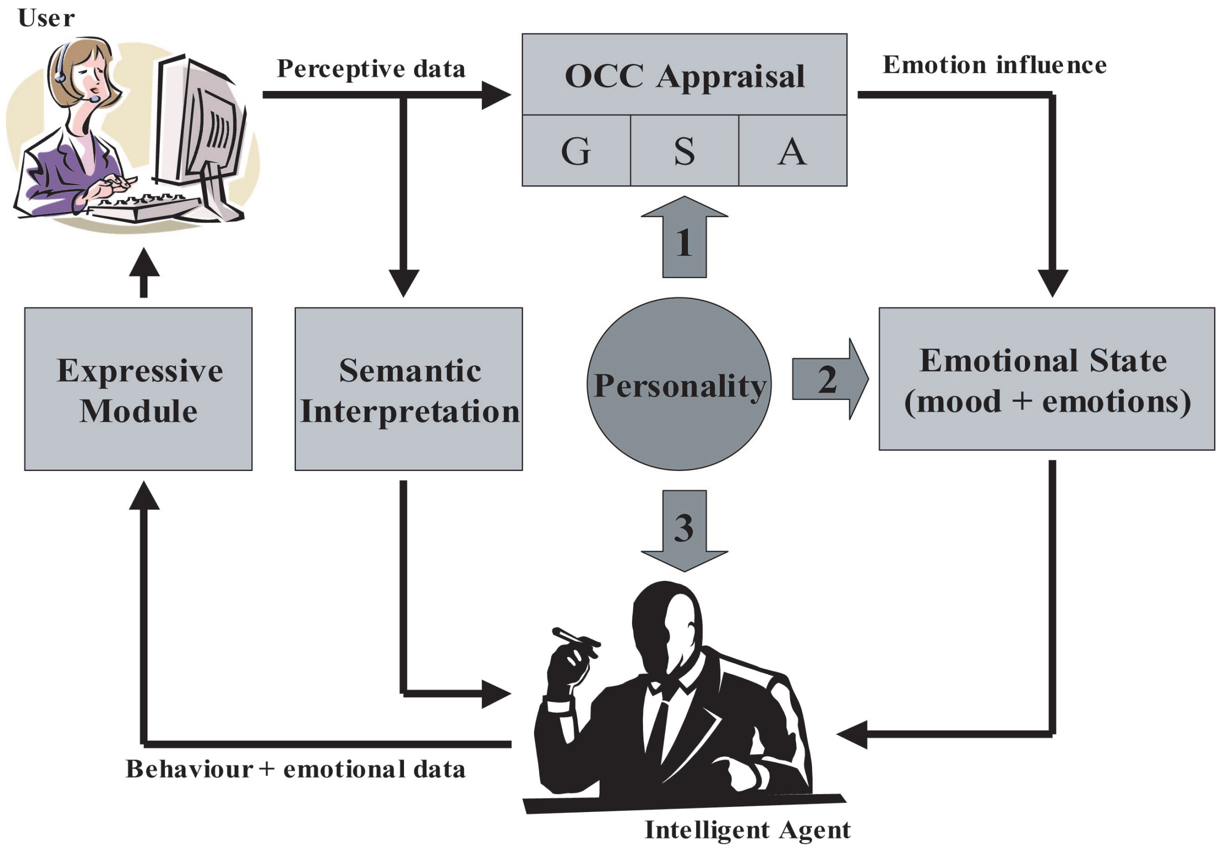

Figure 1: Overview of the emotional state and personality in an intelligent agent framework. Perceptive data (such as speech, text, images, etc.) is interpreted on an emotional level by the OCC appraisal model. The personalized parameters of the model, Goals (G), Standards (S) and Attitudes (A) are defined by a multi-dimensional personality model (1). This results in an *emotion influence* that determines, together with the personality (2) what the new emotional state and mood will be. An intelligent agent uses the emotional state, mood and the personality (3) to create behaviour, which is expressed using emotional data (which can either be obtained directly from the personality and mood/emotion module, or be passed on by the Intelligent Agent).

Factor	**Description**	**Adjectives used to describe**
Openness	Open minded-ness, interest in culture	Imaginative, creative, explorative
Conscientiousness	Organized, persistent in achieving goals	Methodical, well organized, dutiful
Extraversion	Preference for and behaviour in social situations	Talkative, energetic, social
Agreeableness	Interactions with others	Trusting, friendly, cooperative
Neuroticism	Tendency to experience negative thoughts	Insecure, emotionally distressed

Table 2: The OCEAN model of personality.

Figure 2: Personality, mood and emotion on a scale from static to dynamic.

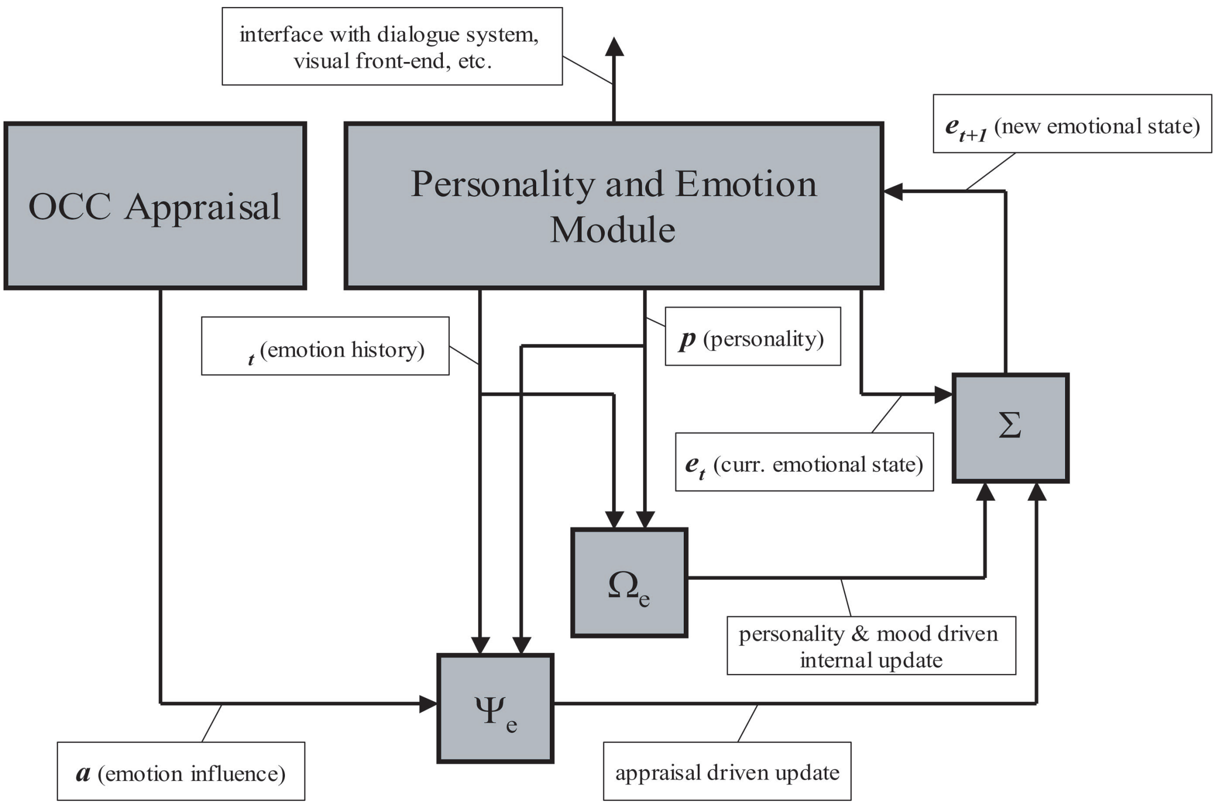

Figure 3: A graphical overview of the emotion update process.

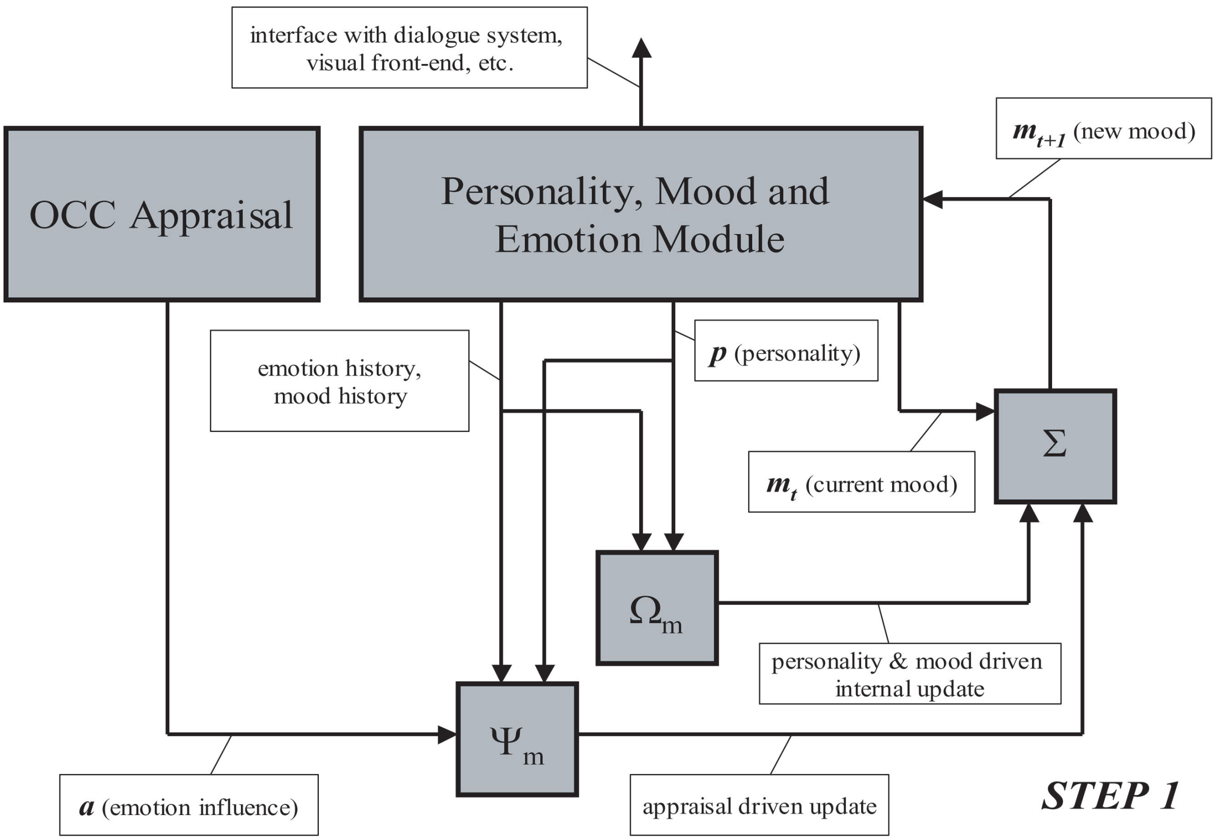

Figure 4: A graphical overview of the mood update process (the first step of the two-step update process).

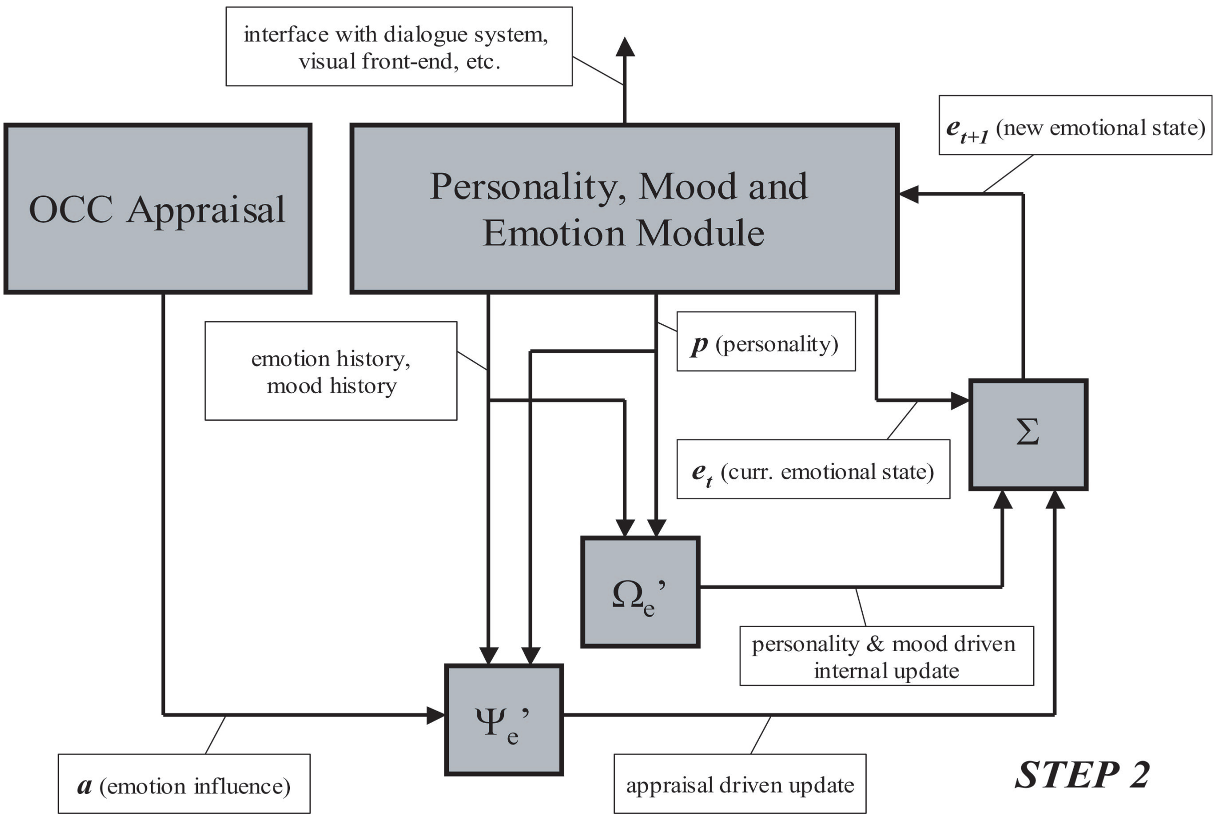

Figure 5: A graphical overview of the emotional state update process (the second step of the two-step update process).

	Goals	**Standards**	**Attitudes**
Openness		making a shift of standards in new situations	attitude towards new elements
Conscientiousness	abandoning and adopting goals, determination		
Extraversion			willingness to communicate
Agreeableness	abandoning and adopting goals in favor of others	compromising standards in favor of others	adaptiveness to other people
Neuroticism	low goals and ambitions		

Table 3: Relationship between OCEAN and OCC parameters.

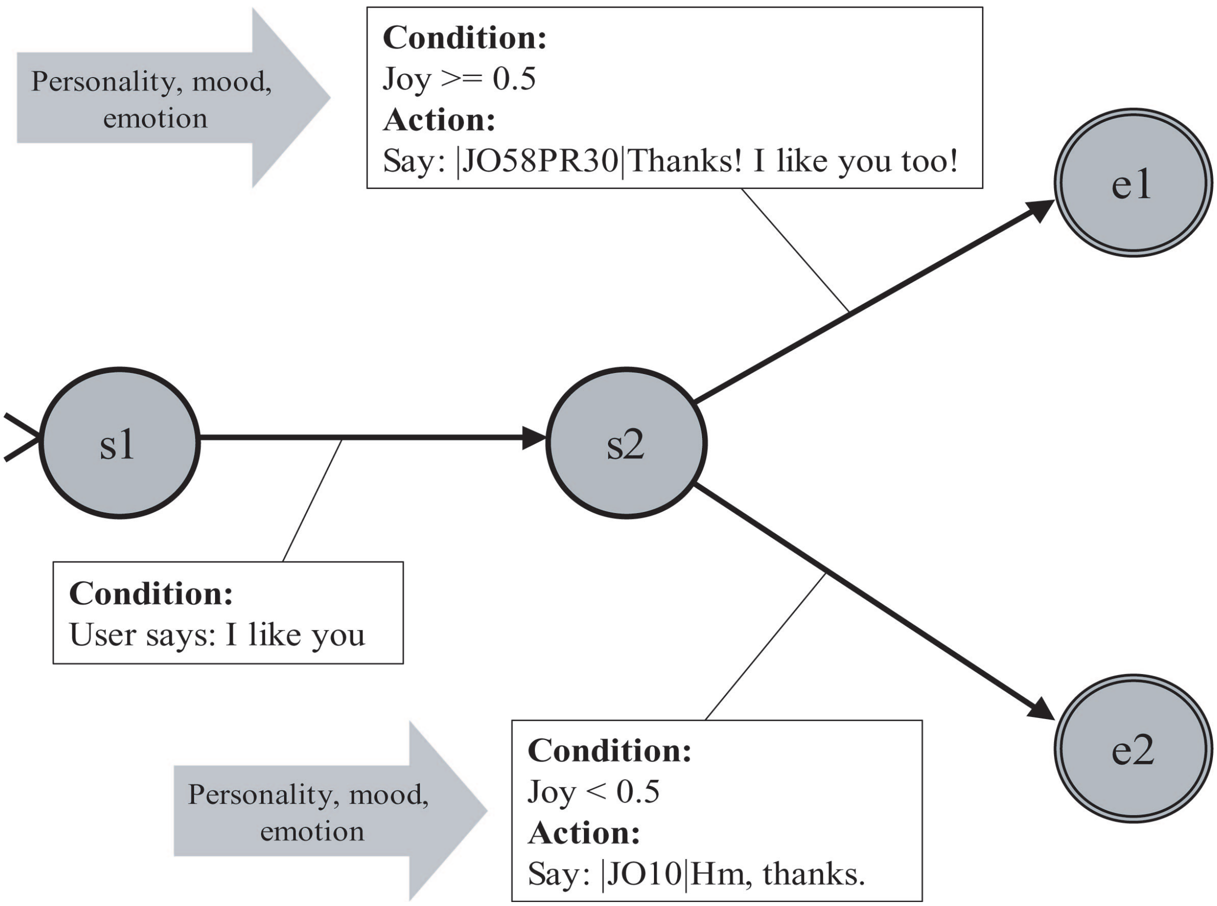

Figure 6: A simplified example of a Finite State Machine that selects different responses based on different emotions.

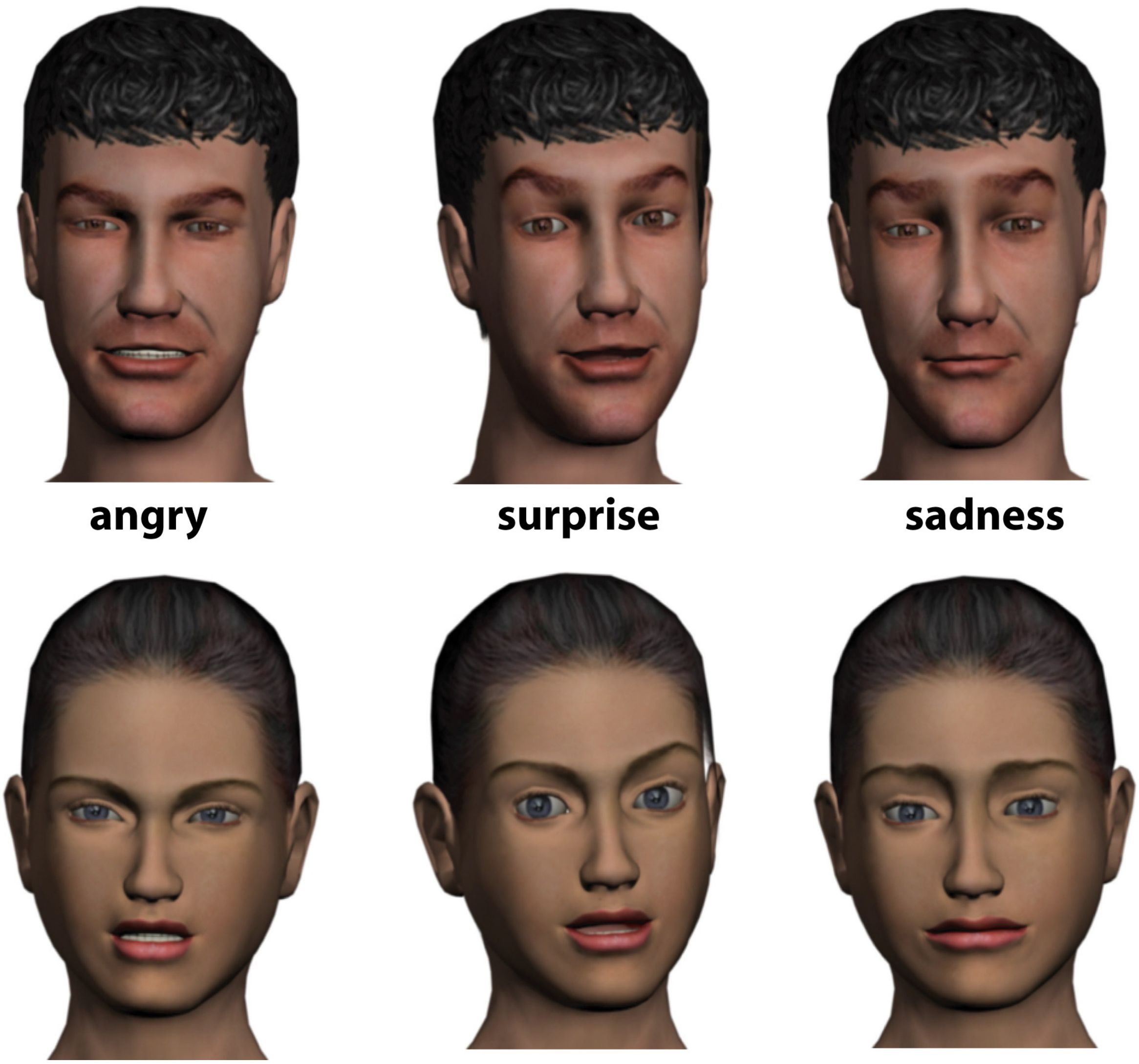

Figure 7: Various Expressions for the Virtual Human

<Man> Can I help you carry this box upstairs?
<Julie> |GR30|Oh thank you! That is so nice of you to ask!

<Man> On what floor are you living?
<Julie> |GR99|The third floor. It's quite high! I am so glad you are helping me out!

Figure 8: Julie’s behaviour as an extravert personality (the extraversion parameter is set to 90%).

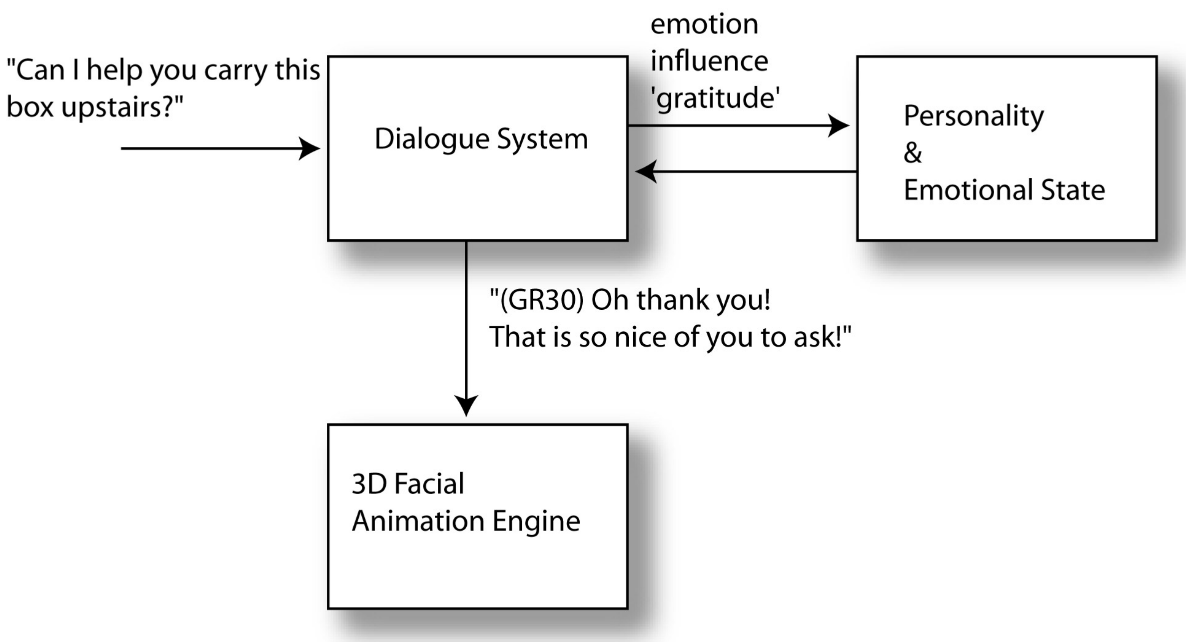

Figure 9: The data flow for an extravert personality. The dialogue system generates an emotion influence according to the input of the user. This emotion influence is processed according to the personality and the mood, which results in an emotional state. The dialogue system then generates a response based on the new emotional state data. Finally, the response is viewed using the 3D Facial Animation Engine.

<Man> Can I help you carry this box upstairs?
<Julie> |FE34|No I don't need your help

<Man> On what floor are you living?
<Julie> |FE99|That is none of your business. Go away!

Figure 10: Julie’s behaviour as a neurotic personality (the neuroticism parameter is set to 90%).