

Simulation of the Dynamics of Non-Player Characters' Emotions and Social Relations in Games

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Abstract

One of the main challenges faced by the video game industry is to give life to *believable* Non-Player Characters (NPCs). Research shows that emotions play a key role in determining the behavior of individuals. In order to improve the believability of NPCs' behavior, we propose in this article a model of the dynamics of emotions taking into account the personality and the social relations of the character. First, we present work from the literature on emotions, personality and social relations in Computer Science and in Human and Social Sciences. We focus on the influence of personality on the triggering of emotions, and the influence of emotions on the dynamics of social relations. Based on this work, we propose a dynamic model of the socio-emotional state and its implementation as part of a tool for game programmers. This tool aims at the simulation of the evolution of emotions and social relations of NPCs based on their personality and roles.

Index Terms

Non-Player Character (NPC), emotions, social relations, personality.

I. INTRODUCTION

The success of a video game, as for other works of art, relies greatly on its ability to give a feeling of immersion to the player. This feeling is related to the notion of *willing suspension of disbelief* [6], *i.e.* to the player's decision to live fully a story despite the lack of realism of some details. In order to create an environment, a world or a story which helps this process, the game designer needs to aim for credibility rather than realism. Credibility in a game is a rather complex notion which implies a degree of consistency between the various elements of the world (events, environments, characters, interactions,...) [37]. In many games, this consistency relies significantly on the behaviors of Non-Player Characters (or NPCs). Key elements of the narrative, their credibility is paramount to the player's perception that he/she observes truly living beings.

However, in modern video games, which may be viewed as interactive media, the player's actions directly impact the progression of the narrative. The designer cannot therefore predict precisely the direction taken by the story as he cannot know beforehand where the player will take it. This is why the NPC's credibility becomes difficult to ensure. A first approach is to consider the tree of possibilities, where each player's choice (action, dialog, etc.) corresponds to the branching out towards two

or more directions. The NPC's behavior in this case is somewhat modeled *a priori*, using for example scripting languages or finite/states automata. This approach, though very much used in industry up to now, quickly meets some serious limitations: either the density of the tree of possibilities is too low and the player quickly realizes that the universe he explores, which was meant to be open, is actually closed, which makes it disappointing; or this density is too high, which leads to programming issues, in terms of complexity, time, cost and also reliability¹.

Another approach consists in giving to the NPCs a degree of autonomy, considering them as intelligent agents making decisions and acting as a function of their own goals. This approach raises questions which are classical for Artificial Intelligence researchers related to the design of intelligent agents in complex environments. Here again the specific nature of video games is that the goal is not to reach some form of optimal behavior as measured by an agent/centered objective performance criterion, but really to produce behaviors which are credible from the player's standpoint. Credibility, as suggested above, relies greatly on the notion of consistency. Let's outline below two dimensions of consistency in NPCs' behavior:

- consistency with past behavior, with the idea that the behavior from an NPC has to be compatible with what we observed from them previously. This translates into the idea that the stable dimensions of a character need to be visible in the long term. Let us mention here two elements which we will tackle later in this article : (1) the personality, *i.e.* the set of psychological traits, suitably parametrized, which impacts the perceptions, motivations and actions of a character; (2) the individual experience, seen as the set of events the character lived previously and memorized. An NPC will therefore have to behave consistently with its past experience (the acquired knowledge, tastes or preferences that its past behavior has indicated, etc.) as well as with the personality traits which have been attributed to it. Any deviation from this principle would lead, for a majority of players, to a feeling of disbelief, and end the feeling of immersion, with a negative impact on the gaming experience.
- consistency with the current environment, with the idea that NPCs must display a good reactivity to events happening in their environment, including the player's actions (or the actions of the player's avatar to be precise). As a simple example, a surprising action from the player (let's say his/her avatar becomes violent with a yet friendly NPC) has to lead to a quick revision of the motivations of his/her interlocutor (in our example, the cooperative NPC will have to become unfriendly, uncooperative, etc.). This fine modeling of the motivational and decisional process can be done in a credible manner by taking into account the dynamics of the emotions and social relations of NPCs. Indeed, emotions are defined as cognitive and physiological mechanisms for the adaptation of behavior to the environment [36], which lets one react in various situations by influencing reasoning and decision making. Social relations between individuals represent attitudes one has toward another. They evolve as a result of interactions and have a direct impact on behavior. A credible simulation of these two dimensions, emotions and social relations of NPCs, therefore appears critical to the design of immersive games [30], [27].

To summarize the above line of reasoning, we went from the notion of immersion to the idea of NPC credibility, supported by two types of behavioral consistency (behavior internal consistency, and consistency with the environment). Based on [30],

¹In many real life cases, the tree is actually both too dense for the developers and not enough for the players so both mentioned issues can be encountered simultaneously

[27], a key hypothesis in the work presented here is that both these types of consistency would be improved by a better emotional model taking into account the character's personality and the dynamics of social relations. In this article, we present a model of personality, emotions and social relations aiming at the improvement of NPC credibility in video games. As we will see in II, these three notions have been the topics of intense research both in the field of Social and Human Sciences and in the field of *Affective Computing* [38]. Results found in the literature form a basis of useful pieces to build a more general model for an NPC architecture. It is therefore a first goal of this article to present and piece together results from various sources in a model that is unique and consistent, detailed in III. Moreover, the model we are interested in focuses on the interactions between its various elements, including especially the influence of personality on emotions and of emotions on social relations. In a second stage, a novel feature of our work is to propose an operational numerical model (whereas research from psychology usually stops at qualitative models) that is capable of computing and updating dynamically the emotional states and social relations of NPCs. The operationalized model is introduced in the first part of Section IV.

A third concern which guides our work is the ambition to propose a model that can be integrated in production tools for programmers of video games. Game developers are usually not specialists of Artificial Intelligence or Cognitive Psychology. This guided us toward models which are relatively simple to use. This leads us to keep our representations parsimonious (as few variables as possible) and also to minimize the number of parameters to be set by the user. We introduce the implementation of our model in a tool that is simple to use in the second part of Section IV. Lastly, we discuss in Section V the perspectives opened by our work, especially concerning its application to the design of NPC behaviors with improved credibility.

II. BACKGROUND

In this section, we present models of emotions, personality, and social relations that have been proposed in the literature and we discuss their applications to model Non-Player Characters' behavior.

A. Emotions models

Research shows that the expression of emotions is useful to create an illusion of life in virtual character and to increase their *believability* [2], [52]. The main challenges to create believable emotional virtual character are to identify in which circumstances which emotions should appear, how to display emotions, and which behavior results from these emotions. In the work presented here, we are more particularly interested in the *triggering conditions of emotion* (i.e. in which circumstances which emotions should appear). Our research is based on the *Cognitive Appraisal Theory of Emotions* [46], [43], [36]. According to this theory, emotions are triggered by the subjective appraisal of an event. The perception and the cognitive appraisal of the event determine the type and the intensity of the felt emotions [46]. The appraisal of an event depends on each individual and more particularly on his/her goals and beliefs. Consequently, a same event may trigger two different emotions for two distinct persons.

To model the emotional process, most computational models are based on the well-known OCC model (Ortony, Clore, and Collins' model) [36]. In this model, the emotions are triggered by the appraisal of three different aspects of the world: the consequences of an event on the agent's goals, the actions performed by the agent, and the objects in the environment. For

instance, an event that enables an agent to achieve one of its goals triggers joy; a blameworthy action done by the agent triggers shame; the perception of an object may trigger disgust according to the agent's preferences. Finally, in the OCC model, a set of simple rules, which can be easily implemented, is proposed to identify which emotions are triggered in which situations (described in terms of goals and beliefs). Based on this approach, in Dyer's computational model [12], the causes of emotions are represented by agent's beliefs on the state of its goals and on the responsible agent. For instance, an agent has a joy emotion when it believes that one of its goals is achieved and an anger emotion when another agent has threatened one of its goals. In [9], an emotion is triggered by an agent's belief that the probability to complete one of its goals has been modified. For instance, a positive emotion is triggered when an agent believes that the probability to achieve one of its goals has increased. In [45], based on the PAD model [31], emotions of characters in video games are represented through three emotional dimensions: pleasure, arousal, dominance. To model the dynamic of emotions, three types of influence are considered: physical (fatigue, illness,...), chemical (alcohol, medicine,...), and psychological (freedom, hostility,...). Each type of influence has a specific effect on the emotional dimensions. For instance, fatigue induces a decrease of pleasure and arousal. However, the main problem of this model is that the game designer has to define the effect of each event of the game on the emotional dimensions. In the ALMA model [18], three kinds of affect are considered: emotions, mood and personality. The mood, in the center of the model, is represented based on the PAD model [31]. It is defined by default depending on the virtual character's personality. The dynamic of the mood is computed based on the intensity of the virtual character's emotions. The current mood of the virtual character is then used to determine its dialog behavior (wording, phrasing, dialog strategy, gesture, and posture). The EMA (EMotion and Adaptation) model proposed by Gratch and Marsella [21] considers both the triggering of virtual humans' emotions and their coping behavior resulting from their triggered emotions. In our model, the NPCs' coping behavior is not modeled. In EMA, the triggered emotions are computed based on the virtual humans' plans. Based on the *Affective Reasoner* [15], a goal-based model of emotions, in the more specific context of tutorial systems, a pedagogical agent expresses various emotions in order to motivate students during their learning experience [24], [16]. In the *FearNot!* computer application developed to help to reduce bullying problems in schools, *FATIMA* (Fearnot AffecTive Mind Architecture) architecture has been proposed to manage the virtual characters' emotions [10]. Inspired by [21], emotions are computed based on the characters' goals and plan. Moreover, emotional reactions of virtual characters depend on their personality. As proposed in Section III.C, the decay function of the emotion intensity and the threshold that defines the minimal value for the emotion to have an impact, is defined according to the virtual characters' personality. In some computational models, a *BDI* (*Belief-Desire-Intention* [41]) representation is used to represent the emotions' triggering conditions [23], [32].

However, this approach used in the computational models presented above, based on the agent's goals, is difficult to apply in game design environment. Indeed, the game designer should determine and explicitly (and formally) represent NPCs' goals. This task is itself a difficult problem, even for experts in knowledge representation and Artificial Intelligence, in particular when it is necessary to take into account unpredictable actions of a player and the large amount of NPCs that may execute various and rich actions. It is the reason why we propose, in this article, an adaptation of the OCC model based on *attitudes* of NPCs towards actions, objects and other characters of the environment. This model, presented in more details in Section III-B, meets our objective to construct a tool which can be used easily by game designers to simulate NPCs' emotions.

B. Personality models

Although personality plays a crucial role in the selection of a character's behavior [35], most interactive games use *ad hoc* personality models, that do not rely on current work in Social Science and Psychology. One can outline two main approaches: category-based models (in which strongly specific behaviors are linked to categories such as “good/bad”; these categories are defined *a priori* in the game scripts) and attribute-based approaches (for instance, in Role Playing Games, the numeric value of “charisma” is used to compute the probability that an NPC transfers confidential informations to the player's character). This lack of theoretical background often leads to unrealistic behaviors in these games.

Most work in Cognitive Psychology focused on personality as a tool to characterize individual behaviors. The resulting models define a set of personality traits, each trait being associated to specific properties in the behavior. For instance, introvert people tend to express fewer emotions [29].

The model proposed by Eysenck [17] defines people's personalities using two traits:

- *Extroversion*, as opposed to *introversion*, describes the tendency to express emotions and to interpret events positively (as a consequence, an extrovert character tends to feel higher positive emotions, such as joy or hope).
- *Neuroticism*, as opposed to *emotional stability*, corresponds to more rapid changes in the emotional state and a tendency to interpret events negatively (as a consequence, a neurotic character tends to feel higher negative emotions).

The OCEAN model [29] distinguishes five traits. In addition to extroversion and emotional stability, the authors outline the importance of the agreeable (*i.e.* the tendency to empathy), the consciousness (as opposed to neglect) and open-mindedness (*i.e.* spirit of adventure). However, other personality traits can be used to characterize someone. For instance, in the MBTI model [4], extroversion, intuition, sensory receptivity and judgment capacity are considered. One strong advantage of the OCEAN model with respect to the MBTI model is that it proposes a detailed enumeration of behavior categories attached to each personality trait. This definition of behavior characteristics attached to each personality trait for each individual allows us to define the attitudes of NPCs in our model. On the contrary, MBTI is more focused on the *detection* of each personality trait to help individuals determine their preferences in terms of leadership and communication, not their behavior. Moreover, several works [54], [28] outline the influence of some personality traits on the intensity of triggered emotions. For instance, an extrovert personality tends to have higher positive emotions, such as joy. Using such models allows us to increase the believability of NPCs by adapting the emotional reaction depending on their triggered emotions and their personality.

The influence of personality on emotions has also been studied by several researchers in the domain of virtual agents. Some approaches [15], [9] model the personality of a virtual agent as a mechanism that evaluates the agent's goals and preferences, so as to determine its emotional reaction to events. However, this model also encounters the limitation of explicit description of all NPCs' goals by the game programmer. For this reason, in our work, we adopt a trait-based approach [44], based on empirical results ([13], [39]) and works in Social Science and Psychology [54], [28], that allows us to define the impact of personality on the trigger of emotions.

C. Social Relations models

Interactions between agents (virtual or human) are not only emotional but also intrinsically social [33]. NPCs perform generally some roles typically portrayed by humans (for example the role of guide). During an interaction, different social relations can then appear between characters (player or non-player). Several researchers have proposed to model the social context of virtual characters to increase their believability. For instance, [44] suggest a social-psychological model including personality, emotions, and attitudes. The character's behavior is computed based on its personality and attitudes. In [53] and [1], the linguistic style of dialog between virtual characters is determined according to social variables (social distance and power) [53] and user's emotions [1]. [20] proposes a social layer that manages communication and biases plan generation and execution in accordance with a social context. In [40], social filter programs are proposed to constrain a character's expression of emotion depending on the social context (represented through social power and social distance), the virtual character's personality, and its emotions. [3] propose to use the character's social relations with the user to identify the appropriate subject to discuss with the user.

In computational models of social characters, social relations are generally represented by a finite set of variables. Each of them characterizes a specific dimension of a social relation between two agents (virtual or human). No consensus exists on the type and number of variables required to model social relations. However, the literature seems to outline four main social variables: the *degree of liking* [22], [44], [40] one has for another²; the *dominance* [22], [44], [40], *i.e.* the power that an agent can exert on another agent; the *solidarity* [3], *a.k.a.* social distance [5], is sometimes used [53], [1], which can be defined as the degree of "like-mindedness" or having similar behavior dispositions (*e.g.* similar political membership, family, religions, profession, gender, etc.) [3]; the *familiarity* may be used to characterize the type (private or public) and amount of information exchanged between two agents [3]³. These variables are those proposed in the dimensional model of interpersonal relations of Svennevig [51]. Based on this literature, in our model, we consider these four social variables to represent a social relation.

As it turns out, the models of social context in existing work are generally *static*. Researchers have mainly focused on the impact of social context on virtual character's behavior. Few researchers propose a model of the dynamics of social context. [39] propose functions to model the dynamics of a character's attitude and familiarity toward another character according to the valence of emotions triggered during the interaction, *i.e.* their positive (*e.g.* joy) or negative (*e.g.* fear) aspect. However, this model does not take into account the distinct impacts of different types of emotions. Research shows that emotions of the same valence but different types (like shame and distress) may have different impacts on social relations [48], [8]. In this paper, we go further by proposing a model of the dynamics of character's social relations based on emotions, in checking those of the character and those expressed by its interlocutor.

III. OUR MODEL

Figure 1 describes the general architecture of our model. Each NPC is characterized by its *personality*, defined by a set of traits, and its *social roles*, which determine its initial social relation with other NPCs (see Section III-D). As the games progresses, the scenario or other characters trigger *events* perceived by the NPC. The formal model of these events is presented

²The term *attitude* is sometimes used to refer to the degree of liking.

³The familiarity may be built by a long-time parallel history (friends, family,...), or through an institution (company, association,...).

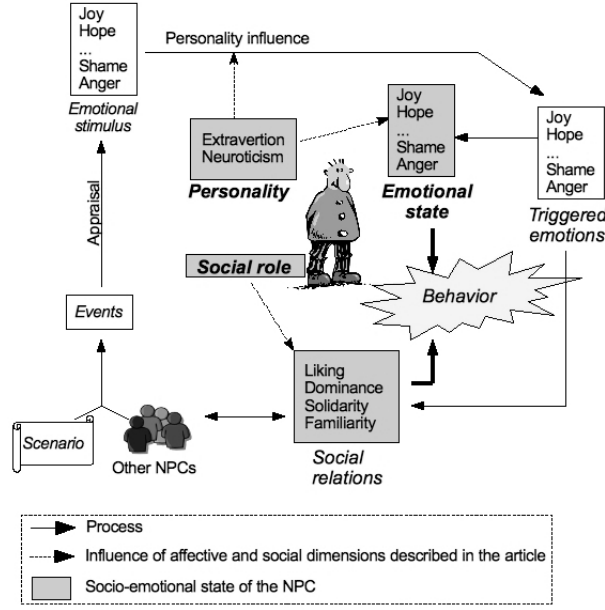


Fig. 1. Overview of our model

in Section III-A. These events are appraised by the agent using an OCC-based algorithm, presented in Section III-B. This computes the emotional stimulus associated with the event. Afterwards, the influence of personality allows us to determine the intensity of emotions triggered in the NPC's mind (Section III-C). These triggered emotions are then used to update the NPC's emotional state and to alter its social relations with other NPCs, according to the cause of the emotional event (Section III-D).

A. Knowledge representation

In order to appraise emotions triggered by events, we have to rely upon a formal representation of the game's world and events. The knowledge representation model we present here is voluntarily simple, so as to be handled by game designers and game programmers who are not AI specialists.

1) *Vocabulary*: The game lexicon is defined *a priori* by the set $\text{Voc} = \mathcal{A} \cup \mathcal{O}$. Objects $o \in \mathcal{O}$ represent the game entities that are not capable of reasoning, as opposed to agents/NPCs. The actions $a \in \mathcal{A}$ are couples $(\text{name}_a, \text{effect}_a)$ where name_a is a unique identifier of the action (generally a verb in the infinitive form) and effect_a describes the effect of the action represented by a value between -1 (which corresponds to actions that have a negative impact on the individual who undergoes this action) and 1 (which corresponds to actions that have a beneficial effect). Note that unlike *attitudes*, which are subjective, the effect of an action is defined independently from any NPC. Thus, it takes the same value for all characters. For instance, all characters consider that the "Kill" action has an extremely negative impact on the casualty ($\text{effect}_{\text{kill}} = -0.9$).

2) *An NPC's attitudes*: Let \mathcal{P} be the set of NPCs, characterized by their socio-emotional state. For each character $x \in \mathcal{P}$, we define its set of attitudes toward each element in the lexicon (*i.e.* its positive or negative state of mind with respect to each element) using two functions:

- *attitude* : $\mathcal{P} \times \mathcal{O} \cup \mathcal{P} \rightarrow [0, 1]$ defines the attitude toward objects and characters in the environment. The value -1 corresponds to the situation in which the NPC strongly hates the object; 1 represents uncontrollable love. We will see

in Section III-D that the attitude toward NPCs is computed automatically in our model: it corresponds to the degree of liking, as defined in the social relation between the NPCs. The attitude toward other objects must however be defined by the game programmer⁴.

- $praise : \mathcal{P} \times \mathcal{A} \rightarrow [0, 1]$ defines the attitudes toward possible actions. $praise(x, a) = -1$ means that x considers the action a as blameworthy (i.e. totally in contradiction with his or her moral principles), whereas $praise(x, a) = 1$ when he or she considers that the action is highly praiseworthy. Note that, unlike the action effect (which is given from an objective point of view), the praiseworthy aspect of an action is defined from a subjective point of view for each character, since it depends on the socio-cultural context⁵

3) *Events*: Our event representation model is inspired by Sowa graphs [50], in which actions are at the core of the world’s description and are linked to other entities (that participate in the action definition) using roles. In order to keep the model at a simple level, usable by game programmers and, more generally, people with no competency in knowledge representation, we reduced our model to two roles: “Agent” (the individuals that participate actively to the action performance) and “Patient” (the individuals that undergo the action).

Each event evt in our model is thus represented by a 4-uplet $\langle agent, action, patient, dc \rangle$ with:

- $agent_{evt}$ is the individual that performs the action. In the general case, the “agent” is an NPC (for instance: in “Bob stole the treasure”, the agent is the NPC *Bob*). We use the agent X to represent the fact that the event’s recipient does not know who is responsible for this action (for instance, “someone stole the treasure”). We use \surd in the agent field for actions that do not require an agent (for instance, “Bob is dead”).
- $action_{evt}$ is the event’s actions, represented by its name $name_a$. In the previous example “Bob is dead”, $action = being_dead$.
- $patient_{evt} \in \mathcal{P} \cup \mathcal{O}$ is the individual that undergoes the action. It can be either an NPC or an object in the game. In the example “Bob is dead”, the NPC Bob is the patient of the action (it has no power on its execution).
- $dc_{evt} \in [0, 1]$ is the degree of certainty of the event, whose meaning varies depending on the situation. We use $dc = 1$ to represent situations in which the NPC that receives the event is certain that the event occurred. For instance, when it witnesses or participates directly in the action. $dc \in]0, 1[$ represents the situation in which the NPC estimates that the event is more or less credible, either because it has been related by an unreliable interlocutor, or because it has been obtained by inference from the NPC knowledge base. Last, we use $dc = 0$ to represent the fact that an event previously considered for “possible” by the NPC did not occur⁶. This mechanism, strongly coupled with the NPC memory and inference engine, is not presented in this paper. It is achieved by the character’s reasoning engine.

Note that the event representation includes only a simple temporal representation with a date defined in the scenario (Section IV). This is sufficient for our purpose since the time has impact not on the triggering of emotions, but only on emotion intensity. Accordingly, a temporal representation is considered for the computation of emotion intensity through the decay

⁴Our implementation allows the game programmer to define NPC classes and to attach default attitudes to these classes.

⁵Note that the proposed formalism does not include the representation of an NPC’s goals, which can be problematic to distinguish action such as “killing for money” from “killing to save people”. This problem can be overcome by associating semantic information to actions (for instance by creating an action `killing_for_money` with a low praise value and `killing_for_save_humanLife` with a high praise value).

⁶We will not represent all events that do not occur in the game, but only those that have been considered by the NPC.

function introduced in Section IV.A.

The main difficulty for game programmers modeling events is that the model does not generally correspond to the direct transcription of the natural language utterance, because it must take into account pragmatics of the situation interpreted by the NPC. For instance, if we consider the situation in which Bob is alone facing a vicious Troll handling a battle-axe, the event is not only $\langle Bob, see, ViciousTroll, 1 \rangle$ (“Bob sees the vicious Troll”) but also and more importantly $\langle ViciousTroll, kill, Bob, 0.7 \rangle$, *i.e.* Bob thinks that he is going to be killed by the vicious Troll (and he is sadly rather certain about this).

B. Emotions representation

In theories of emotion coming from psychology, no consensus exists on the type and number of emotions that one may experience. We choose to base our representation of emotions on the OCC model [36] and more particularly on the recent simplification proposed by one of its authors [35], in which 10 emotions are proposed to represent one’s emotional experience, whereas the OCC model considers 21 emotions. As in the OCC model, in the simplification proposed by Ortony [35], the emotions are considered according to their triggering conditions: *joy* (resp. *distress*) caused by a desirable (resp. undesirable) event; *hope* (resp. *fear*) caused by an expectation of a desirable (resp. undesirable) event; *relief* (resp. *disappointment*) caused by a non-occurrence of of an expected undesirable (resp. desirable) event; *pride* (resp. *shame*) following a praiseworthy (resp. blameworthy) action done by the agent; and *admiration* (resp. *anger*) following a praiseworthy (resp. blameworthy) action done by another agent.

We propose to represent each emotion by a variable with a value varying in $[0, 1]$. The set of emotions of NPC i at a time t is then represented by a vector $e_i(t) \in ([0, 1])^{10}$ in which $e_i^{(j)}$ give the intensity of the emotion j (joy, distress, etc). In our work, based on [11], [47], we define 3 different emotional vectors to represent respectively :

- the *emotions triggered* by an event (noted $e_{-d_i}(evt)$ for NPC i for event evt): these emotions depend both on the emotional stimulus associated with the event and the NPC’s personality;
- the *emotional state* of an NPC (noted $e_{-e_i}(t)$ for NPC i at time t): these emotions represent the set of emotions felt at a given time by an NPC. They are updated according to triggered emotions and decrease naturally through time.
- the *emotions expressed* by character i at time t (noted $e_{-exp_i}(t)$) : a character may decide to express emotions different from its felt emotions [40].

In our research, we focus more particularly on the NPCs’ triggered emotions and emotional state.

In our model, we first compute an *emotional stimulus* associated to an event (Figure 1). The emotional stimulus of an event corresponds to the emotions that an NPC should have following this event if the NPC has a neutral personality (another personalities may modify the impact of an emotional stimulus on the NPC’s emotions, impact of personality on emotions is described in Section III-C). Our approach is based on a simple method using NPC’s attitudes towards the different elements and possible actions of the environment.

Types of emotions. To identify the types of the triggered emotions, we base our work on the conditions described in the OCC model [36] (Section II-A) illustrated Figure 2.

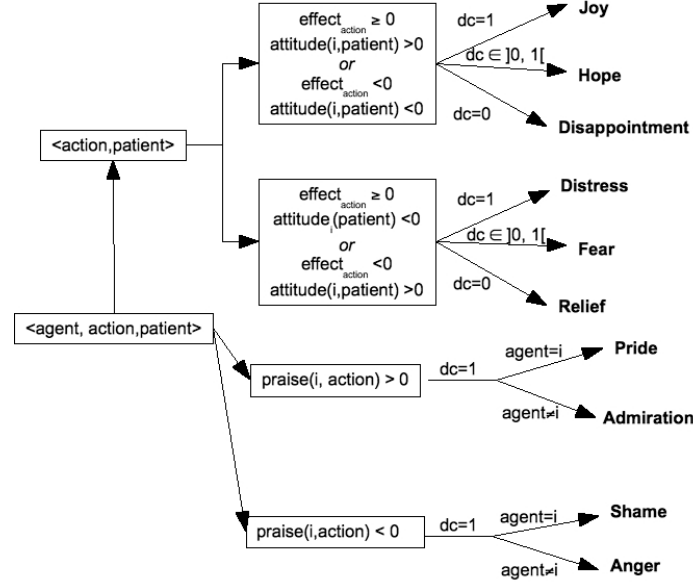


Fig. 2. Rules on triggered emotions for NPC i following event $\langle \text{agent}, \text{action}, \text{patient} \rangle$ or $\langle \text{action}, \text{patient} \rangle$

A desirable event (from the OCC point of view) for NPC i may correspond to two different cases: (1) an event with an action that has a positive or neutral effect ($\text{effect}_{\text{action}} \geq 0$) on a appreciated patient (an object or an NPC) ($\text{attitude}(i, \text{patient}) > 0$), for instance $\langle \text{eat}, \text{cake} \rangle$, or, (2) an event with an action that has negative effect ($\text{effect}_{\text{action}} < 0$) on a patient that is not appreciated ($\text{attitude}(i, \text{patient}) < 0$), for instance $\langle \text{throw}, \text{garbage} \rangle$. According to the OCC model, such events trigger the joy emotion when they occur ($dc = 1$), hope when the events are uncertain ($dc \in]0, 1[$) and disappointment when they do not occur but were expected ($dc = 0$). Reciprocally, an undesirable event corresponds to an event with an action that has a positive or neutral effect on a patient not appreciated (for instance $\langle \text{eat}, \text{garbage} \rangle$) or with an action that has a negative effect on an appreciated patient (for instance $\langle \text{throw}, \text{present} \rangle$). Such events trigger distress, fear or relief. Moreover, depending on the degree of certainty of the event, on the actor of the event and the praiseworthy aspect of the action, based on the OCC model, the event may also trigger an emotion of pride, admiration, shame or anger (Figure 2). The triggering of such emotions may also depend on whether the action has been done intentionally or unintentionally. To avoid a representation of intentions and goals, in our model, we have supposed that all actions are done intentionally.

Intensity of emotions.

According to the OCC model, the intensity of the emotions of joy, distress, relief, disappointment, hope, or fear is positively correlated to the degree of desirability/undesirability of the event and to its probability of occurrence (in the case of hope and fear). In our model, the degree of desirability is computed based on the effect of the action $\text{effect}_{\text{action}}$, the attitude toward the patient ($\text{attitude}(i, \text{patient})$) and the probability of the event occurrence (which corresponds to the degree of certainty dc)⁷.

⁷In the case of disappointment and relief, the OCC model suggests to use the degree of certainty of the event which does not occur and the effort realized to avoid or enable the occurrence of this event. These elements are not taken into account in our model because they depend on the NPCs' behavior model and memory

In the same way, the intensity of pride, shame, admiration, or anger depends on the degree of praiseworthy/blameworthy of the action (that is represented in our model by $praise(i, action)$) (Figure 3).

Note that the proposed model of emotions is voluntarily more simple than goal-based models of emotions such as the EMA model [21] described in Section II.A. Our model has been specifically designed to enable game designers to easily simulate the dynamics of NPCs' emotions, with the objective, not to model humans' emotions, but to simulate believable emotional NPCs.

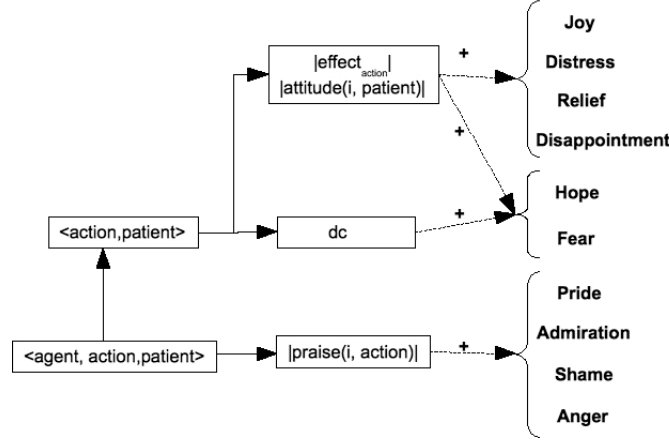


Fig. 3. Impacts of attitudes on intensity of triggered emotions

C. Influence of personality on emotions

Research in social science and human psychology [54] has shown that personality influences not only the behavior of an individual, but also his/her emotions. In this paper, we do not tackle the issues related to the influence of personality on an NPC behavior for action selection or the expression of emotions (these aspects are discussed in Section V). To model the influence of personality on emotions, we propose to consider three elements: the impact of personality on triggered emotions, the impact on the emotions reduction and the emotions' intensity threshold.

Impact on triggered emotions.

Personality traits. Works by [54] and [28] outline the following influences:

- an *extrovert* individual feels positive emotions with a higher intensity than neutral or introvert personalities. However, extroversion has no impact on negative emotions.
- a *neurotic* individual feels negative emotions with a higher intensity, without any impact on positive emotions.
- an *agreeable* individual feels empathy-oriented emotions (e.g. distress for others) with a higher intensity and negative emotions directed toward the interlocutor (e.g. resentment) with a lower intensity.

In our work, we did not represent emotions in relation with the interlocutor. The initial OCC model [36] defines two pairs of emotions in relation with others: *happy-for* (resp. *sorry-for*), which occurs when someone we appreciate undergoes desirable (resp. undesirable) events, and *gloating* (resp. *resentment*), which occurs when someone we do not appreciate undergoes

desirable (resp. undesirable) events. Taking into account these emotions requires us to evaluate the emotional impact of events on others, which raises the problem of modeling the other's preferences. For this reason, in our model, we only considered the *extroversion* and *neuroticism* traits when computing the impact of personality on triggered emotions.

Representation of an NPC's personality. The personality of an NPC is represented in our model by a vector of n value in $[-1, 1]^n$, each value corresponding to a personality trait, 0 standing for neutral personality. In this paper, we only consider the *extroversion* and *neuroticism* traits. The personality of an NPC is thus a pair: $(p^{(extro)}, p^{(neuro)}) \in [-1, 1]^2$.

Impact of personality on the intensity of triggered emotions. The emotion triggered by an event is directly computed in our model from the emotional stimulus, as defined in the previous section, and the personality traits' values. For a given value of an emotional stimulus, the more the NPC is extrovert, the higher the triggered joy, hope, pride and relief emotion values will be. Conversely, the more the NPC is neurotic, the higher the values of distress, fear, shame and deception will be. As will be shown in Section IV-A, this variation in the emotion intensity corresponds to a multiplicative factor on the emotional stimulus.

Impact on the emotion's decrease.

The *decrease function* characterizes the temporal evolution of the intensity of an NPC's emotion when no emotional stimulus occurs. The intensity of emotions in the NPC emotional state naturally decreases when no emotion is triggered [38]. The decrease of each emotion is defined by a monotonous function that depends *a priori* on personality [28] and that tends toward the neutral state. For instance, negative emotions are often considered as more prevailing than positive emotions [14], [42]. In our model, each component of the emotional state's vector will be attached to a specific decrease value, whose expression can depend on the personality.

Intensity threshold.

Several computational models [15], [9], [42] define intensity thresholds, whose value depends on the character's personality. The intensity thresholds define the minimal value for the emotion to have an impact on the NPC's behavior or on the emotions expressions. For instance, with an intensity threshold 0.2 for the emotion of joy, if the NPC has a emotion of joy with an intensity under 0.2, its behavior or expression will not be altered by this emotion.

To represent this aspect, in addition to the numerical computation of emotion intensities, we use an emotion activation threshold. An emotion is made visible by the behavior engine only if its value is higher than this limit. This solution allows us to come back to a discrete (and symbolic) model of emotions, for instance for the behavior selection. In a similar way, we define a saturation threshold above which the emotion is considered as so strong that it suppresses the rational decision making processes of the NPC (this allows us to define non-rational behaviors in extremely stressing situations, for example). The use of these two thresholds in the reasoning engine is out of the scope of this paper and will not be presented here.

D. Dynamics of social relations.

Social relation representation.

In accordance with the previous research (Section II-C), the relation of NPC i with character j , from the point of view of i , at time t is formally represented by a quadruplet $social_relation_{i,j}(t) = \langle liking, dominance, familiarity, solidarity \rangle$ in which the elements represent respectively the *degree of liking* i has for j at time t ($\in [-1, 1]$); the *power* that i thinks it can exert on j at time t ($\in [-1, 1]$); the *degree of familiarity*, i.e. the average degree of confidentiality for i of the information that i has transmitted to j ($\in [0, 1]$); and the degree of *solidarity* that represents the degree of “like-mindedness” or having similar behavioral dispositions that i thinks to have with j ($\in [0, 1]$). As stated above, social relations are not necessarily symmetric: $\exists i, j \text{ } social_relation_{i,j}(t) \neq social_relation_{j,i}(t)$.

Social relations settings.

In most existing models, the settings of an agent’s social relations are made intuitively. However, research shows that social variables depend not only on the individual but also on his social role in relation to the one of his interlocutor [5]. Based on this work, we propose to compute the initial values of social relations based on the NPC’s social roles and those of its interlocutors. To model a character’s social role, we propose to represent it *relatively* to another social role. The roles of two persons interacting correspond to particular pairs of complementary roles: employee/manager, child/father, patient/doctor, woman/man, etc. Given R the sets of roles, and two roles $(r_x, r_y) \in R^2$, we note $social_role_{r_x/r_y}$ the social role r_x in relation to the social role r_y (e.g. $social_role_{employee/manager}$ represents the social role of employee in interaction with his manager). In order to represent a character’s social role in a consistent way with its social relations, a social role r_x/r_y is formally defined by a quadruplet in which elements represent respectively the degree of liking, dominance, familiarity, and solidarity *a priori* of an NPC with role r_x with another character with role r_y . For instance, the value $role_liking_{r_x/r_y}$ will be close to -1 for a gangster (r_x) in relation to a policeman (r_y) (i.e. gangsters generally do not like policemen). By default, When the roles r_x and r_y do not correspond to a pair of complementary roles (for instance woman/employee, father/doctor), $social_role_{r_x/r_y}$ and $social_role_{r_y/r_x}$ equal to the null vector (noted $social_role_{r_x/r_y} = 0$). Since a character i may endow several roles at the same time during an interaction with a character j (for instance a police-woman facing a gangster man in context of game), we have to combine these roles for the settings of the social relation. To compute the resulting values of a combination of several roles, we propose to use by default an average of the complementary roles⁸. Moreover, according to [5], the *solidarity* between two persons (called social distance in [5]) depends on the solidarity of each of them with others in the local social universe. For instance, two French individuals in a foreign country might be more in solidarity than in France. This phenomenon is explained by the fact that “wherever one is, all members of the social local universe must be assigned a place across the entire scale of social distance” [5]. Then, in our model, the value of role solidarity equals the value of solidarity of the role r_i in relation to the role r_j divided by the maximum value of solidarity that the character with role r_i has with the others characters of its environment. Consequently, as suggested in [5], all agents of the social local universe are

⁸The average is a first approximation. In some cases, certain roles may have a higher impact depending on characteristics of virtual characters (for instance a misogynist character). A weight may then be associated to the roles to compute combination of several roles. Note that character’s social role representation corresponds to *stereotypes*. The initial value of social relations may be manually modified when the settings of social relations are made.

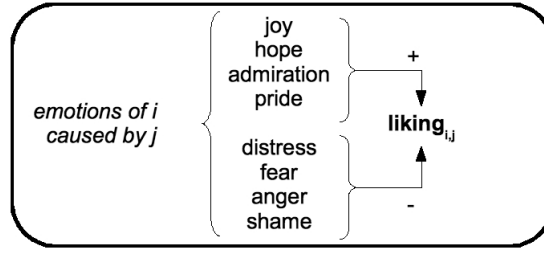


Fig. 4. Impacts of emotions on liking

assigned across the *entire* scale of solidarity⁹.

Emotions-based dynamics of social relations.

Research shows that, during an interaction, a person's emotions and those of his interlocutor may lead to a change in their social relations [34], [8], [48]. In the following, we analyze separately the dynamics of each variable of a social relation of NPC i during an interaction with another character j according to their emotions. If no event occurred, we suppose that the social relation does not evolve. In the contrary case, the intensities of the emotions triggered by the event are used to update the social variables:

1. Liking. [34] shows that the degree of liking one has for another depends on the valence (positive versus negative) of the emotions induced by the latter. Thus, we model that a *positive (resp. negative) emotion* of i caused by j induces an increase (resp. a decrease) in the degree of liking i has for j as illustrated Figure 4.

2. Dominance. [48], [25] show that pride and anger reflect a domination whereas shame, distress, and admiration correspond to an inferior status. Consequently, we can model that emotion of *pride* or *anger* of i caused by j induces an increase in the dominance value that i thought to have on j . Conversely, an emotion of *fear*, *distress*, *admiration*, or *shame* of i caused by j infers a decrease in the dominance i thought to have on j . Moreover, in [26], expression of distress or fear reflects a low value of dominance. Finally, some types of emotions expressed by someone affect the dominance value of the person who perceives it. We can model that the expression by j of an emotion of *fear* or *distress* induces an increase in the dominance of i (Figure 5). Consequently, if the event triggers fear or distress for i and j with the same intensity the dominance of i on j will not change.

3. Solidarity. According to [8], negative emotions caused by another person leads to a decrease in the solidarity value whereas the triggering of positive emotions does not modify this value. We model that a *negative emotion* of i caused by j induces a decrease in the value of solidarity that i thought to have with j (Figure 6). Moreover, [25] shows that the expressed emotions reflect a person's mental states and then indirectly his goals, beliefs, expectations, plans, etc. Consequently two individuals expressing similar emotions in reaction to a same situation should feel more in solidarity. Inversely, expression of opposite emotions may lead to a decrease of solidarity. Then, in our model, an incongruence (*resp.* congruence) may lead to a decrease

⁹Others variables may influence the initial values of social relations, as for instance the non-verbal behavior or the physical attraction [22]. In our model, we do not take into account such non-verbal aspects.

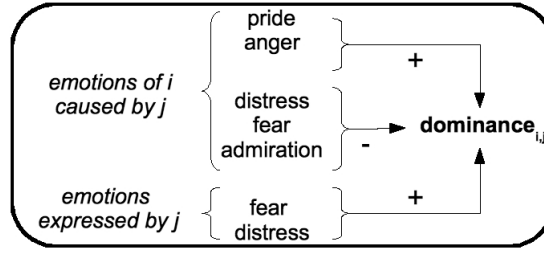


Fig. 5. Impacts of emotions on dominance

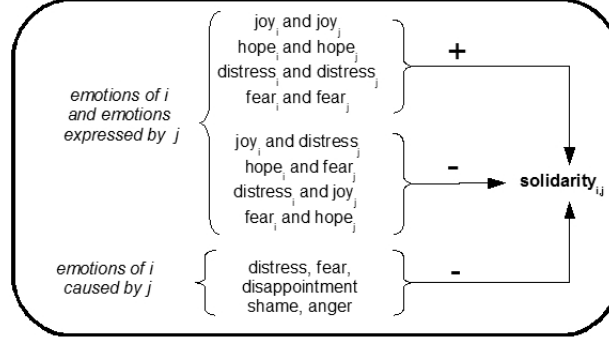


Fig. 6. Impacts of emotions on solidarity degree

(resp. increase) in solidarity. If the triggered emotion of i is *joy* or *hope* (and is not caused by j) and j expressed emotion of the same type, the solidarity increases (Figure 6).

Moreover, research shows that solidarity influences liking. Indeed, it appears that one likes more similar persons [49]. Then, we can suppose an increase in solidarity of i with j induces an increase in the degree of liking i has for j .

4. Familiarity. In the literature, emotions seem to not have a direct impact on the familiarity (*i.e.* on the degree of confidentiality of the information transmitted by a person). However, research shows that one confides more in another when the former likes the latter [7]. Therefore, we model that the more the character likes another one the more it will transfer a confidential information to it. In other words, the familiarity is indirectly connected to the liking variable. Indeed, an increase in the confidentiality of the information transferred leads to an increase in the familiarity value. This mechanism depending on the implementation of the NPC's behavior is not presented in this paper.

IV. IMPLEMENTATION AND ILLUSTRATIVE EXAMPLE

In this section, we present the implementation of our model and the evaluation of simple scenarios.

A. Implementation

Our model (presented in Section III) is semi-quantitative: the numerical functions corresponding to the influence of personality on emotions and of emotions on social relations are not described. We briefly present in the following the functions used for the implementation.

The formulas are based on previous work in emotional computing or in psychology, adapted to our model. For the computation of the emotion intensity, we use the average function as proposed by [19], [42] in their own models. These models have been

evaluated and show convincing results. For the computation of the influence of personality on emotions, we based our work on [18]. The personality has a multiplicative influence on emotions such that a neutral personality would not alter emotions and an excessive personality trait will increase the intensity of impacted emotions. Note that [18] was proposed in the frame of moods, using the PAD model [31]. However, the same psychological background applies, which is the reason why we could adapt this computation to our emotion model. For the decay function for emotion intensity, we based our work on [38] and [18]. Again, the evaluation in both publications showed good results and, although the models slightly differ, the work on moods can be transposed to our emotions model.

Computation of the intensity of emotional stimulus. In our model, the type of the emotion triggered by a given event is described in Figure 2. The intensity of the emotional stimulus $e_d'_i(e)$ associated to event e for NPC i is computed based on the absolute value of the attitude of i toward the patient of the action ($attitude(i, patient)$), the absolute value of the attitude of i toward the action ($praise(i, action)$), the absolute value of the effect of the action ($effect_{action}$), and the degree of certainty of the event (dc). Let k be the type of the emotion triggered by the event e . Based on [19], [42], the intensity $e_d^{(k)}_i(e)$ is computed as follows (av is average function):

- For $k \in \{\text{joy, distress, relief, disappointment}\}$,

$$e_d^{(k)}_i(e) = av(|attitude(i, patient)|, |effect_{action}|)$$

- For $k \in \{\text{hope, fear}\}$,

$$e_d^{(k)}_i(e) = av(|attitude(i, patient)|, |effect_{action}|) * dc$$

- For $k \in \{\text{pride, admiration, shame, anger}\}$,

$$e_d^{(k)}_i(e) = |praise(i, action)|$$

Computation of the intensity of triggered emotions. The intensity of triggered emotions is computed based on the intensity of the emotional stimulus and on the personality. For each personality factor j and each type of emotion k , we define a function $f(p^{(j)}, e^{(k)})$ that returns a value in $[0, 1]$. This value represents the influence of personality factor j on emotion i (0 means that j has no influence on k)¹⁰. Inspired by [18], the influence of personality p on the intensity of emotion k (noted i_k) is then computed according to the impact of all personality factors $p^{(j)}$ on $e^{(k)}$ ($card$ represents the size of the set):

$$i^{(k)}(p) = \frac{\sum_{j=1}^n f(p^{(j)}, e^{(k)})}{card(f(p^{(j)}, e^{(k)}) \neq 0)_{j=1, \dots, n}}$$

The intensities of emotions triggered by event e for NPC i with personality p are computed based on the stimulus $e_d'_i(t)$ and

¹⁰In our implementation, we use the same function for all the pair (j, k) identified in psychological models of personality. This function is linear on $p^{(j)}$ in $[0, 1]$. Consequently, the intensity of the triggered emotion equals to the one of the stimulus for a neutral personality ($p^{(j)} = 0$) and increase of 50% when $p^{(j)} = 1$.

the factor $i^{(k)}(p)$ for each emotion k :

$$e_d_i(e) = \begin{pmatrix} e_d_i^{(1)}(e) * (1 + i^{(1)}(p)) \\ \vdots \\ e_d_i^{(m)}(e) * (1 + i^{(m)}(p)) \end{pmatrix}$$

Update of emotional state. Without event, the intensity of NPC's emotions decreases. Inspired by [38], [18], our decay function is defined as follows:

$$\forall k, e_e_i^{(k)}(t) = e_e_i^{(k)}(t-1) * e^{-decreaseRate}$$

The decrease rate is defined for each emotion according to the personality¹¹. If an event e occurs at time t , the emotional state of the NPC is computed based on the previous emotional state and on the emotions triggered by the event:

$$\forall k, e_e_i^{(k)}(t) = \max(e_d_i^{(k)}(e), e_e_i^{(k)}(t-1) * e^{-decreaseRate})$$

Update of social relations. Let f_{sr} be the function as follows:

$$f_{sr} : (e_d_i(e), e_exp_j(t)) \rightarrow \Delta SocialRelation_{i,j}(t)$$

The inputs of this function are the emotions of i triggered by e ($e_d_i(e)$) at time t and those expressed by its interlocutor j at the same time ($e_exp_j(t)$). The output of this function is a vector representing the variation of the social relation given these emotions ($\Delta SocialRelation_{i,j}(t)$). f increases for each dimension of $\Delta SocialRelation_{i,j}(t)$ in relation to each dimension of the emotional vectors $e_d_i(e)$ and $e_exp_j(t)$ (apart from the solidarity which increases when the emotions are similar). The function f_{sr} returns a null vector when the emotional vectors are null.

We introduce the function g_{sr} :

$$\begin{aligned} g_{sr} : & \quad (social_relation_{i,j}(t), \Delta SocialRelation_{i,j}(t)) \\ & \rightarrow social_relation_{i,j}(t+1) \end{aligned}$$

This function takes as input the current social relation $social_relation_{i,j}(t)$ of the NPC with its interlocutor and the vector of the social relation's variation returned by the previous function f ($\Delta SocialRelation_{i,j}(t)$). g returns the updated social relation. g is increasing and has a low slope on 1 and -1 to represent the fact that the social relation is hard to alter when on the extremes. For instance, a sine function can be used. Finally, function φ_{sr} is defined as follows:

$$\begin{aligned} \varphi_{sr}(social_relation_{i,j}(t), e_d_i(e), e_exp_j(t)) \\ = g_{sr}(social_relation_{i,j}(t), f_{sr}(e_d_i(e), e_exp_j(t))) \end{aligned}$$

This function takes as input three vectors representing respectively the current social relation of the NPC with its interlocutor,

¹¹In our implementation, we use the same rate 0.1 for all emotions.

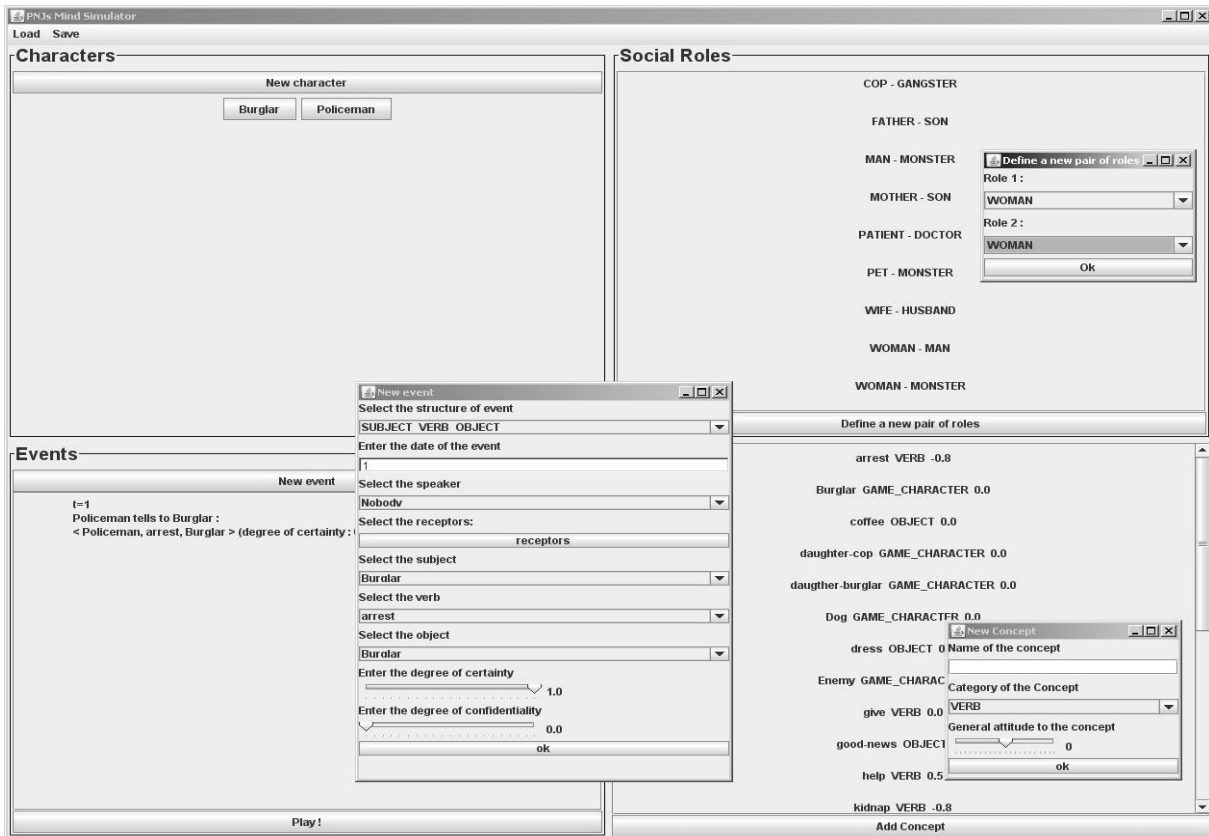


Fig. 7. Interface of the tool

its triggered emotions, and those expressed by its interlocutor. It returns the updated social relation.

Our model has been implemented in Java as a tool that enables game designers to simulate the impact of a scenario on NPCs after defining the vocabulary of the game, the NPCs and their personality and social roles, and the events of the scenario. The general interface (Figure 7) is divided in 4 parts:

- the *interface of complementary pairs of social roles* (at the top right) to define, visualize, and modify the pairs of social roles associated to the scenario. Their values can be modified manually through this interface;
- the *interface of NPCs* (at the top left) to visualize the set of defined NPCs. For each NPC, a personality, social roles, initial values of social relations and attitudes can be defined. A frame, associated to each NPC, enables one to visualize the dynamics of its emotional state and of its social relations with other NPCs of the scenario, and the history of its triggered emotions (Figure 8);
- the *interface of the vocabulary* (at the bottom right) to visualize and modify the lists of objects and actions defined in the game, the attitudes of NPCs towards the objects, the effects and the praiseworthy aspect of the actions by default;
- the *interface of the events* (at the bottom left) to visualize and modify the events defined in the scenario by a quadruplet $\langle Agent, Action, Patient, dc \rangle$, and characterized by a date, an optional speaker and receptors (NPCs that receive the information or perceive the event).

At the bottom of the interface of the events, a button is used to start the simulation of the scenario. The emotional state and

Fig. 8. Frame of an NPC

social relations of each NPC are then updated according to this scenario (Figure 8).

B. Illustrative example

In order to illustrate our model and our tool, we have tested it with two simple scenarios that we have imagined, inspired by adventure games such as *Fahrenheit*. The context of the first scenario is a police interrogation (a burglar facing a policeman) at the police station. After a break-in at a jewelry store, the police arrested the burglar but the loot is missing. The policeman wants the burglar to confess where the money and the jewels are hidden.

1. *Policeman* : The facts are not in your favor, you know. Ten people saw you threaten the manager with a weapon
2. *Burglar* : So, what do you want?
3. *Policeman* : You know, I'm not a bad guy...(the policeman is preparing a cup of coffee)
4. *Policeman* : Do you want some coffee? (the policeman offers a cup of coffee to the Burglar)
5. *Policeman* : ...I know that your child has been kidnapped. Same thing happened to me last year, I had to negotiate with those b*** I know what it is (expression of distress)
6. *Policeman* : I want to help you. Just tell me where you hid the money
7. *Burglar*: I need this money to save my child!
8. *Policeman* : We have received new information about the kidnappers. We know where your kid is being kept
9. *Policeman* : Tell me everything and I'm sure I can find a solution to avoid you going to jail

We have tested this scenario on the NPC burglar with different personality (neutral and neurotic). At the beginning of the interaction, given the social roles of the characters, we suppose that the burglar is submissive related to the policeman (the initial value of dominance is -0.3) and dislikes him (the initial value of liking is -0.5)¹². The dynamics of the burglar's emotional state and social relation, given its personality, are illustrated in Figure 9 and 10.

The first utterance, encoded in the scenario as event $\langle policeman, arrest, burglar, 0.8 \rangle$, triggers an emotion of fear for the burglar because the effect of the action *arrest* is negative (-0.8) and because the burglar has a positive attitude toward himself (0.3). This emotion of fear induces a decrease of the degree of liking the burglar has for the policeman. The preparation of the coffee (third utterance), which corresponds to the expectation of a desirable event for the burglar who has a positive attitude toward the coffee (0.4), triggers hope emotion. This emotion induces an increase of the degree of liking. The intensity of the

¹²The initial values may be manually modified if the characters have a specific relationship; for instance if they are friends.

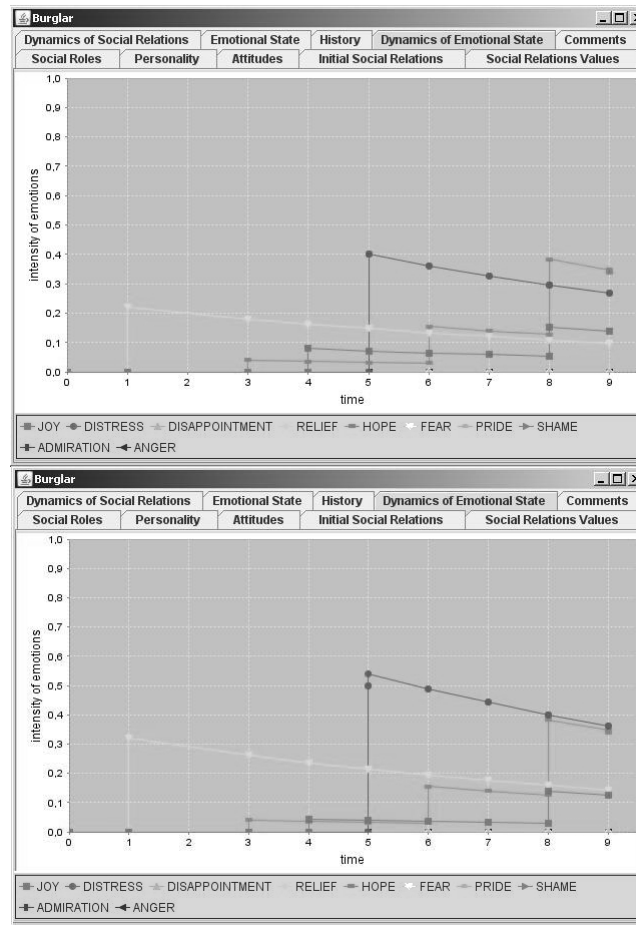


Fig. 9. Dynamics of the burglar's emotional state with a neutral personality (top) and with a neurotic personality (bottom).

emotion depends on the value of the attitude and the degree of certainty of the event (0.4). Consequently, the joy emotion triggered by the fourth utterance is lower than the one triggered by eighth utterance. An emotion may also be triggered by the retrieval of a desirable or undesirable event, as illustrated utterance 5: this utterance triggers distress with a high intensity for the burglar. But, since the policeman is not responsible for this negative emotion (he is not the kidnapper), the event has no impact on the degree of liking. On the contrary, the congruence of the triggered emotion of the burglar and the emotion expressed by the policeman (expressing distress) induces an increase of the solidarity and, by side effect, of the degree of liking. Moreover, because of the burglar's emotion of distress, its dominance decreases (Figure 10).

By comparing the dynamics of the burglar's emotional state depending on its personality, we can observe that the intensity of negative emotions is higher when the NPC is neurotic. Consequently, the impact on social relation is different: the burglar feels, in this case, more submissive but its degree of liking remains low. Then, the behavior of the NPC may be different depending on its personality. For instance, in our example, the values of social relation will be used to determine which information the character transfers to its interlocutor. If the degree of liking, dominance and familiarity reach a given threshold, the burglar will confess where the money and the jewel are.

The context of the second scenario is a job interview. The PC (Player Character) has to be recruited in a company as a seller to infiltrate the company. During the job interview, the PC faces the director of the company in her office. The director is a

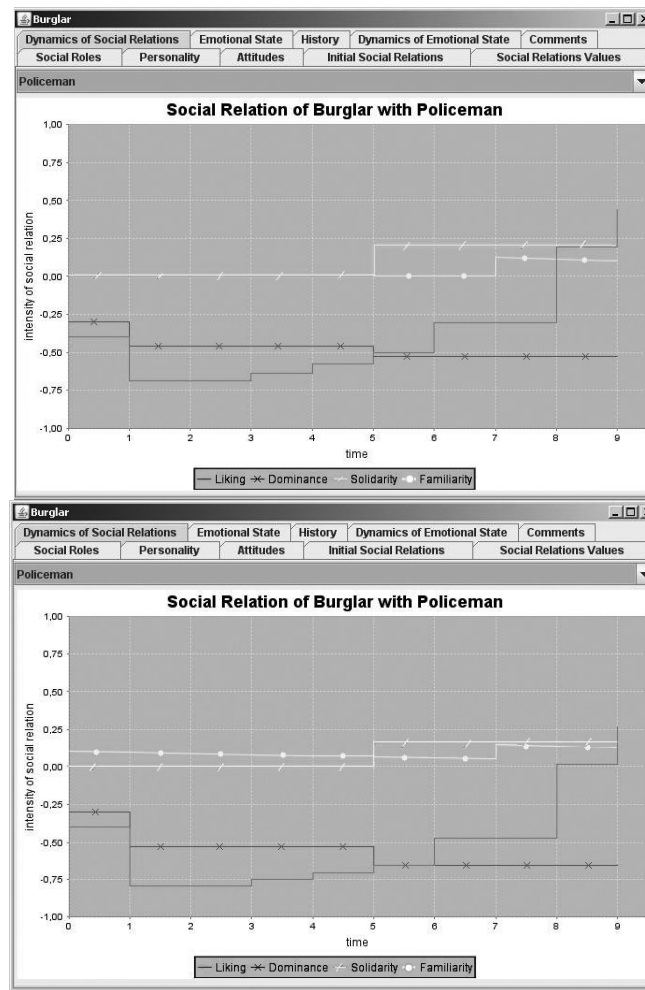


Fig. 10. Dynamics of the Burglar social relation with the Policeman for a neutral personality (top) and for a neurotic personality (bottom).

woman whereas the PC is a man. Consequently, as a beginning of the job interview, given the genders and the social roles of the characters, the initial value of the director's dominance is low (the initial value of dominance is 0,05) and the initial value of solidarity is null. The PC may obtain the job if the degree of liking, solidarity, and dominance of the director toward the PC reach certain thresholds. Let's imagine that the following dialog between the director and the PC takes place:

1. *Director* : So, why do you think this job is for you?
2. *PC* : I have a lot of experience and I'm very motivated!
3. *Director* : You know I despair because the company is losing money (expression of sadness). I really need a good seller
4. *PC* : Yes, I know that the financial situation is not easy currently, for me too it's difficult to find a job (expression of sadness).
5. *PC* : I'm afraid to not have this job and then I will not be able to keep my apartment (expression of fear)
6. *PC* : You know I agree to not be paid in the first month.
7. *Director* : Ok, this job is for you !

We have tested this scenario on the NPC director (with a neutral personality). The dynamics of the director’s emotional state and social relation with the PC is illustrated in Figure 11.

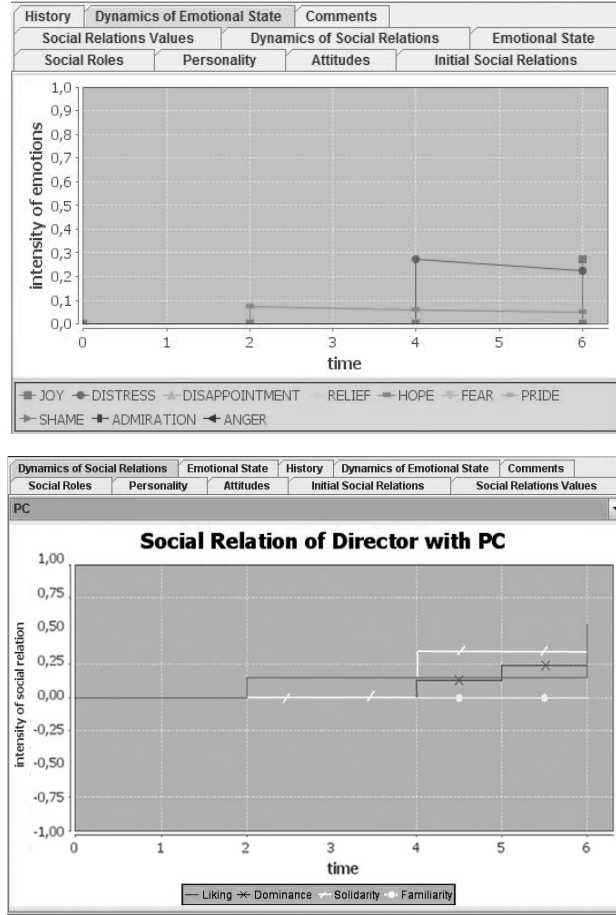


Fig. 11. Dynamics of the director’s emotional state (top) and social relation with the PC (bottom).

The second utterance, encoded in the scenario as event $\langle \text{director}, \text{have}, \text{good} - \text{seller}, 0.6 \rangle$, triggers an emotion of hope for the director because the attitude of the director toward the concept of *good seller* is positive (-0.5). This emotion, caused by the PC, induces an increase of the degree of liking the director has for the PC. As illustrated utterances 4 and 5, the PC’s expressions of emotion induce an increase of the Director’s solidarity when they express the same emotion, and an increase of the director’s dominance in the case of PC’s expressions of distress or fear. The utterance 6, encoded as the event $\langle \text{PC}, \text{offer}, \text{money}, 1 \rangle$ in the scenario, triggers an emotion of joy for the director since the director has a positive attitude toward the concept of *money*, and the effect of the action *offer* is also positive. Finally, the PC obtains the job because the degree of liking, solidarity, and dominance of the director toward the PC have reached certain thresholds.

V. CONCLUSION AND FUTURE WORK

In this article, we have motivated the use of enriched models for Non-Player Characters in video games to improve the feeling of immersion and ultimately the player’s enjoyment. More specifically, we focused on a model of the dynamics of emotions taking into account the personality and the social relations. Though the relevant literature on these topics is rich and varied with contributions from social and human sciences as well as affective computing, the models they propose usually

consider the various aspects we are interested in but in an isolated and sometimes partial manner. After a presentation of the relevant works from this literature, we have proposed a model which is global and original, focusing both on the interactions between its various components, and on the dynamic nature of emotions and social relations. Moreover, this high level model which is consistent with results from psychology has been in a second stage made operational so as to allow the prediction of updated emotional states and social relations useful in real applications such as a video game. Indeed, the developed tool allows game designers, with very little authoring effort, to show evidence of the impacts of behaviors on virtual characters' emotions and social relations.

Though these results constitute significant advances, various perspectives are open to improve and extend them. In a first stage, our model needs a more complete experimental evaluation, and this is especially true of its operational version. Indeed, though it claims to be consistent with results from psychology, it actually goes further by making precise predictions on internal states. Numerical functions and parameters were chosen with care, but in a heuristic manner, so they can only be validated with a deeper experimental analysis with human subjects. More precisely, our model is based on the following assumptions: (1) a fictional narration in which characters' behaviors are not consistent with the emotional and social context loses significantly in credibility; (2) our model enables one to simulate the dynamics of virtual characters' emotions and social relations in a believable way; and (3) our model and the proposed tool are simply enough to be handled by non specialists. To validate the first assumption, a test with users watching different versions of a fictional narration could be performed. For the second assumption, given a known story as input, we could verify if our model predicts the emotions and social relations of virtual characters in a believable way. Lastly, for the third assumption, game designers could be requested to perform specific modeling tasks to evaluate the usability of the developed tool.

Though this paper focuses on the emotional level, this is not the final objective of our work. The benefits of our enriched modeling will indeed appear more clearly when its integration in a full model with action selection and behavior control will be completed and tested. We have not addressed this important dimension here as it is ongoing work taking place in our research group and with academic and industry partners. In this context, we focus so far on the question of dialogs in adventure games, with the intention of offering an alternative to scripted dialogs, well known for the feeling of repetition they leave in most players. An architecture based on autonomous agents integrating the emotional model presented here should lead to dialogs which are more natural, more consistent with the story and the context and more reactive to events in the scenario and the player's actions. However this ambition finds practical limitations since most current video games have their dialogs prerecorded by professional actors for the sake of voice realism. To extend our non-scripted approach fully, one would need to control the entire chain of dialog production, including stages such as language generation, vocal synthesis and interpretation with emotional rendering. In the short term, we are working on the issue of utterance selection (in a list of pre-recorded utterances) using our model. Besides this, we can control fully the dialog production chain of a few key NPCs for who the vocal realism is not considered too important. In the mean time, our model and its extensions for action selection will be applicable to dialog management in adventure games and more generally to action selection taking into account an emotional dimension. However, currently in our model, emotions are directly connected to behavior. A dimensional emotion representation, such as the PAD representation [31] using pleasure, arousal, and dominance dimensions, should be added to

facilitate the connection between emotions and behavior. In the longer term, we can envisage that our NPCs will be able to take into account the emotional and social impact of their actions so as to guide their strategy for dialog, and more generally, for behavior.

Lastly, in conclusion, though we have kept in mind throughout this article the idea that our work is applied to video games, let us note that the heart of the model we presented is generic and could be applied potentially to any domain using synthetic actors, or more generally intelligent agents, with an emotional level. The two characteristics of video game applications which are particularly helpful here are the availability of experimental environments (games) to evaluate our work, and a framework where the final goal is not psychological realism (copying human cognition) but the production of credible characters, where small deviations from realism are not necessarily catastrophic as long as global consistency is maintained.

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REFERENCES

- [1] E. André, M. Rehm, W. Minker, and D. Bühler, "Endowing spoken language dialogue systems with emotional intelligence," in *Affective Dialogue Systems*, 2004, pp. 178–187.
- [2] J. Bates, "The role of emotion in believable agents," *Communications of the ACM (CACM)*, vol. 37, no. 7, pp. 122–125, 1994.
- [3] T. W. Bickmore and J. Cassell, "Relational agents: a model and implementation of building user trust," in *CHI*, 2001, pp. 396–403.
- [4] I. Briggs Myers, *Understanding Personality Type*. Davies-Black Publishing, 1980.
- [5] P. Brown and S. Levinson, *Politeness: Some Universals in Language Usage*. Cambridge University Press, 1987.
- [6] S. T. Coleridge, *Biographia literaria*, 1817.
- [7] N. Collins and L. Miller, "Self-disclosure and liking: A meta-analytic review," *Psychological Bulletin*, vol. 116, pp. 457–475, 1994.
- [8] J. de Rivera and C. Grinkis, "Emotion as relationships," *Motivation and Emotion*, vol. 10, pp. 351–369, 1986.
- [9] F. deRosis, C. Pelachaud, I. Poggi, V. Carofiglio, and B. D. Carolis, "From Greta's mind to her face: Modelling the dynamics of affective states in a conversational embodied agent," *International Journal of Human-Computer Studies*, vol. 59, no. 1-2, pp. 81–118, 2003.
- [10] J. Dias and A. Paiva, "Feeling and reasoning: a computational model for emotional agents," in *EPIA Affective Computing Workshop*, 2005.
- [11] T. DuyBui, "Creating emotions and facial expressions for embodied agents," Ph.D. dissertation, University of Twente, 2004.
- [12] M. G. Dyer, "Emotions and their computations: Three computer models," *Cognition and Emotion*, vol. 1, no. 3, pp. 323–347, 1987.
- [13] A. Egges, X. Zhang, S. Kshirsagar, and N. Magnenat-Thalmann, "Emotional communication with virtual humans," in *The 9th International Conference on Multi-Media Modeling*, 2003, pp. 243–263.
- [14] M. S. El-Nasr, J. Yen, and T. R. Ioerger, "Flame: Fuzzy logic adaptive model of emotions," in *Proceedings of International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2000, pp. 219–223.
- [15] C. Elliot, "The affective reasoner: A process model of emotions in a multi-agent system," Ph.D. dissertation, Northwestern University, 1992.
- [16] C. Elliot, J. Rickel, and J. Lester, "Integrating affective computing into animated tutoring agents," in *Proceedings of the IJCAI (International Joint Conference on Artificial Intelligence) Workshop on Animated Interface Agents: Making Them Intelligent*, 1997, pp. 113–121.
- [17] H. J. Eysenck, *The biological basis of personality*, C. C. Thomas, Ed. Springfield, 1986.
- [18] P. Gebhard, "Alma - a layered model of affect," in *Proceedings of International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, 2005.
- [19] J. Gratch, "Emile: Marshalling passions in training and education," in *Proceedings of International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2000.
- [20] —, "Socially situated planning," in *AAAI Fall Symposium on Socially Intelligent Agents, The Human in the Loop*, North Falmouth, 2000.

- [21] J. Gratch and S. Marsella, "A domain-independent framework for modeling emotion," *Journal of Cognitive Systems Research*, vol. 5, no. 4, pp. 269–306, 2004.
- [22] K. Isbister, *Better Game Characters by Design: A Psychological Approach (The Morgan Kaufmann Series in Interactive 3D Technology)*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc., 2006.
- [23] P. Jaques and R.-M. Vicari, "A BDI approach to infer student's emotions," in *Proceedings of the Ibero-American Conference on Artificial Intelligence (IBERAMIA)*, 2004, pp. 901–911.
- [24] W. Johnson, J. Rickel, and J. Lester, "Animated pedagogical agents: Face-to-face interaction in interactive learning environments," *International Journal of Artificial Intelligence in Education*, vol. 11, pp. 47–78, 2000.
- [25] D. Keltner and J. Haidt, "Social functions of emotions," in *Emotions: Current issues and Future Directions*, T. J. Mayne and G. A. Bonanno, Eds. The Guilford Press, 2001, pp. 192–213.
- [26] B. Knutson, "Facial expressions of emotion influence interpersonal trait inferences," *Journal of Nonverbal Behavior*, vol. 20, pp. 165–182, 1996.
- [27] M. Lombard and T. Ditton, "At the heart of it all: The concept of presence," *Journal of Computer Mediated-Communication*, vol. 3, no. 2, 1997.
- [28] O. Luminet and N. Vermeulen, *The Handbook of cognitive psychopathology*, 2004, ch. Personality and cognitive psychopathology.
- [29] R. McCrae and P.T.Costa, "Validation of the five-factor model of personality across instruments and observes," *Journal of Personality and Social Psychology*, vol. 52, pp. 81–90, 1987.
- [30] A. McMahan, *The Video Game Theory Reader*. Wolf, M. and Perron, B., 2003, ch. Immersion, Engagement and Presence: A Method for Analyzing 3-D Video Games, pp. 67–86.
- [31] A. Mehrabian, "Pleasure-arousal-dominance: A general framework for describing and measuring individual differences in temperament," *Current Psychology*, vol. 14, no. 4, pp. 261–292, 1996.
- [32] J. Meyer, "Reasoning about emotional agents: Research articles," *International Journal of Intelligent Systems*, vol. 21, no. 6, pp. 601–619, 2006.
- [33] C. Nass, J. Steuer, and E. Tauber, "Computers are social actors," in *CHI*. Boston, USA: ACM press, 1994, pp. 72–77.
- [34] A. Ortony, *Memories, thoughts, and emotions: Essays in honor of George Mandler*. Hillsdale, NJ : Erlbaum., 1991, ch. Value and emotion.
- [35] —, "On making believable emotional agents believable," in *Emotions in Humans and Artifacts*. MIT Press, 2002, pp. 189–211.
- [36] A. Ortony, G. Clore, and A. Collins, *The cognitive structure of emotions*. Cambridge University Press, United Kingdom, 1988.
- [37] K. Perlin, "Toward interactive narrative," in *Virtual storytelling*, 2005.
- [38] R. Picard, *Affective Computing*. MIT Press, 1997.
- [39] H. Prendinger, S. Descamps, and M. Ishizuka, "Scripting affective communication with life-like characters in web-based interaction systems," *Applied Artificial Intelligence Journal*, vol. 16, no. 7-8, pp. 519–553, 2002.
- [40] H. Prendinger and M. Ishizuka, "Social role awareness in animated agents," in *Proceedings of International joint Conference on Autonomous Agents and Multi-Agent Systems (AAMAS)*, 2001, pp. 270–277.
- [41] A. S. Rao and M. Georgeff, "Modeling rational agents within a BDI-architecture," in *Proceedings of the International Conference on Principles of Knowledge Representation and Reasoning (KR)*, 1991.
- [42] S. Reilly, "Believable social and emotional agents," Ph.D. dissertation, Carnegie Mellon University, 1996.
- [43] I. J. Roseman, "A model of appraisal in the emotion system," in *Appraisal Processes in Emotion: Theory, Methods, Research*, K. Scherer, A. Schorr, and J. T., Eds. Oxford University Press, 2001, pp. 68–91.
- [44] D. Rousseau and B. Hayes-Roth, "A social-psychological model for synthetic actors," in *International Conference on Autonomous Agents*, 1998.
- [45] R. Schaap and R. Bidarra, "Towards emotional characters in computer games," in *The 7th International Conference on Entertainment Computing*, 2008.
- [46] K. Scherer, "Emotion," in *Introduction to Social Psychology: A European perspective*, M. Hewstone and W. Stroebe, Eds. Oxford Blackwell Publishers, 2000, pp. 151–191.
- [47] K. Sehaba, N. Sabouret, and C. Corruble, "An emotional model for synthetic characters with personality," in *ACII Conference*, 2007.
- [48] M. Shiota, B. Campos, D. Keltner, and M. Hertenstein, *The Regulation of Emotion*. Lawrence Erlbaum Associates, 2004, ch. Positive Emotion and the Regulation of Interpersonal Relationships, pp. 127–155.
- [49] E. Smith and D. Mackie, *Social Psychology*. Psychology Press, 2007, ch. Liking and Loving, pp. 393–436.
- [50] J. Sowa, *Encyclopedia of Artificial Intelligence*, 1992, ch. Semantic networks.
- [51] J. Svennevig, *Getting Acquainted in Conversation*. Philadelphia: John Benjamins, 1999.
- [52] F. Thomas and O. Johnston, *The Illusion of Life: Disney Animation*. Disney Editions, 1981.

- [53] M. A. Walker, J. E. Cahn, and S. J. Whittaker, "Improvising linguistic style: Social and affective bases for agent personality," in *First international conference on Autonomous Agents*, 1997, pp. 96–105.
- [54] D. Watson and L. A. Clark, "On traits and temperaments: General and specific factors of emotional experience and their relation to the five-factor model," *Journal of Personality*, vol. 60, pp. 441–476, 1992.

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