



**NECA**

NET ENVIRONMENT FOR EMBODIED EMOTIONAL  
CONVERSATIONAL AGENTS

**D9b**  
**Report on affective reasoning  
and cultural diversity**

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## **Executive Summary**

The NECA project will develop a new generation of mixed multi-user / multi-agent virtual spaces populated by affective conversational agents. A particular focus in the project lies therefore on the communication between animated characters that exhibit credible personality traits and affective behaviour. Dealing with synthetic emotions requires (a) the identification of emotional states, (b) their digital representation, and (c) the provision of a machinery that is able to determine and adjust emotional states for an agent taking into account factors such as the agent's personality profile, its current context and history of interactions with other emotional entities. The affective state of an agent will be used within NECA for affective multi-modal generation, which includes the generation of facial expressions, body postures and gestures, and affective language and speech production.

In this document we will focus on the modelling of emotions and personality and not how they are conveyed by the system in terms of multi-modal generation. We will also investigate models of cultural diversity, i.e. how the cultural background influences the experience and expression of emotions.

## Purpose

The aim of this document is to give an overview of existing models of emotions and personality for embodied conversational agents. Existing approaches for affective reasoning will be evaluated in terms of their usefulness and applicability for the NECA project.

The document forms the basis for the decisions to be made within the consortium on how emotions and personality will be represented and processed within the different modules.

## Introduction

There is now a consensus between researchers working in this area, that emotions and personality are essential ingredients when building embodied animated agents [Bat94, CSPC00, Pai00, TP97]. A majority of the work done in this field addresses the problem of representing and reasoning with affective states and how to exhibit credible personality traits and affective behaviour with animated agents. Another large group is concerned with computational simulations of the (theorized) human process that produce emotion and with methods for detecting the emotional state of humans.

Here, we will focus on the modelling of emotions and personality and not how they are conveyed by the system in terms of multi-modal generation. More precisely, we will focus on those models that can be used to enhance the illusion of believability in our characters, i.e. we do not claim that our models capture the affective phenomena of the human emotion process in its entirety.

## Models of Emotion

In this section we will try to give an overview of the most prominent psychological theories of emotion which often serve as a basis for computational models of emotion. Rather than discussing each theory in detail and making a critical assessment of it, we will try to highlight the core elements and how the main concepts can be formalized.

We would like to stress the fact that possibly many computational models can be consistent with the appearance of emotional states, i.e. the same theory can lead to a number of implementations that differ widely in their modelling approach (e.g. using Bayesian networks, neural networks, rule-based systems, etc.).

### The Theory of Ortony, Clore, and Collins

The theory of Ortony, Clore and Collins [OCC88] is one of the “appraisal theories” of emotion in which the individual is said to make a cognitive appraisal of their current state relative to a desired state. Emotions are defined as *valenced reactions* to events of concern to us, actions of those we consider responsible for such actions, and objects. These three classes of reactions lead to three classes of emotions, each based on evaluations in terms of different kinds of knowledge representations.

The OCC-Model works at the level of emotional clusters (emotional types), where the emotions in each cluster share a similar cause, e.g. the “distress type” describes all emotions caused by displeasing events (sad, distraught, lovesick, etc.). Emotions are defined as the result of three types of subjective appraisal:

1. desirability of events with respect to the agent’s goals (event-based emotions)
2. praiseworthiness of actions with respect to a set of standards (agent-based emotions)
3. appealingness of objects with respect to a set of attitudes (object-based emotions)

Depending on which of these is the focus of attention, the primary affective reactions include being pleased or displeased, approving or disapproving, and liking or disliking. For example, the reaction of being pleased or displeased reflects one's perception of the consequences of events as being desirable or undesirable. Desirability is computed on the basis of the implications an event appears to have on one's goals.

The authors state in the introduction: "..., we would like to lay the foundation for a computationally tractable model of emotion. In other words, we would like an account of emotion that could in principle be used in an Artificial Intelligence (AI) system that would, for example, be able to reason about emotion.". They present a system of rules and representations about the elicitation of emotions, e.g. thresholds and decay properties for each emotional type.

The OCC-Model has served as the basis for several computational models of emotions. Some of the earliest ones are the Em Emotion Model [RB92] developed within the Oz project and Elliot's Affective Reasoner [Ell92].

## The Émile and IPD System

The Émile system developed by Jonothan Gratch [Gra00] focuses on the problem of emotional appraisal and modeling of "task-oriented" emotions (emotions arising from performing a concrete task). In [GM01] on page 279 Gratch provides a concise description of the Émile system.

"Building on Elliot's [Ell92] construal theory, Émile characterizes the emotional impact of external events through a set of knowledge structures called *construal frames*. [...] Each frame describes the appraised situation in terms of a number of specific features, including the point of view from which the appraisal is formed, the desirability of the situation, whether the situation has come to pass or is only a possibility and whether the situation merits praise or blame. These features are derived from domain independent rules that examine the state of plan memory, an advance over prior approaches that utilize large numbers of domain specific rules to form the same assessment. Some examples of these domain independent rules (there are about thirty) include:

- If an agent has a goal and no known action achieves this effect, this is undesirable
- If an agent intends to use an action to achieve a goal and a subsequent action defeats the effect of this action, this is undesirable
- If an agent intends to perform an action that achieves a goal for another agent, this is praiseworthy

Émile also draws heavily on the explicit plan representation to derive the intensity of emotional response, incorporating the view of Oatley and Johnson-Laird [OJL87] and Neal Reilly [Rei96] that emotion are related to the probability of the event in question (e.g. the probability of goal achievement or the probability of a threat) and the utility of the impacted goals, both of which are derived from the current plan structure. The importance of subgoals is related to how they further intrinsic goals. As intensity is based on the current plans, the assessment is a reflection of their current state and changes with further planning.

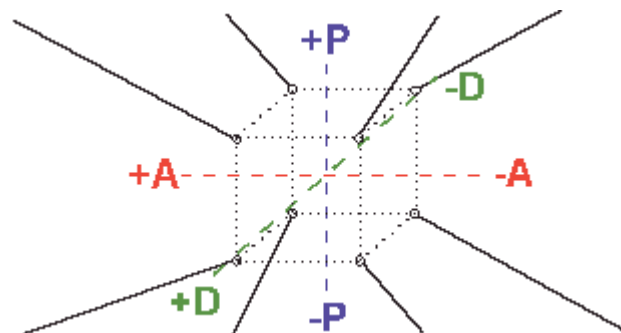
Each appraisal frame corresponds to an emotion instance. These instances are aggregated into "buckets" corresponding to emotions of the same type, and instances decay over time. Thus, threats to multiple goals will be aggregated into an overall level of fear. The aggregated buckets roughly correspond to the overall assessment of the agent's emotional state and are used to drive emotional expression.

Émile provides a rich plan-based model of emotional appraisal, the task of assessing the relationship between external events and an agent's internal beliefs, plans, desires, social norms, and so forth. Émile does not explicitly address the problem of how this assessed emotional state impacts behaviour, or how to effectively convey this state to a human participant."

To address this problem, Gratch and his colleagues have started to integrate the Émile system with Marsella et al.'s IPD system [MJL00] into a single unified system [GM01]. IPD models the impact of emotions on behaviour, in particular the impact on the physical expressions of emotional state through suitable choice of gestures and body language. IPD relies on the Physical Focus model and attempts to mediate competing communicative and non-communicative demands on an agent's physical resources, esp. gesturing and gaze, in a fashion consistent with the current emotional state by grouping behaviours into modes. There are five distinct focus modes (e.g. body focus, transitional, communicative) and each one is associated with distinct emotions and physical expressions. Rules map the current aggregated emotional state into a specific mode.

## The PAD Emotional State Model

The PAD Emotional State Model developed by Mehrabian [Meh96], consists of three nearly independent dimensions that are used to describe and measure emotional states (or feelings, affective conditions): *pleasure vs. displeasure*, *arousal vs. nonarousal*, and *dominance vs. submissiveness*. Pleasure-displeasure distinguishes the positive-negative affective quality of emotional states, arousal-nonarousal refers to a combination of physical activity and mental alertness, and dominance-submissiveness is defined in terms of control versus lack of control. Specific terms describing emotions can be visualized as points in a three-dimensional PAD emotion space (see Figure). Alternatively, when the PAD scale scores are standardized, each emotion term can be described succinctly in terms of its values on the pleasure-displeasure, arousal-nonarousal, and dominance-submissiveness axes.



The following sample ratings illustrate definitions of various emotion terms when the scores on each PAD scale range from -1 to +1: angry (-.51, .59, .25), sleepy (.20, -.70, -.44), and bored (-.65, -.62, -.33). Thus, according to the ratings given for "angry," it is a highly unpleasant, highly aroused, and moderately dominant emotional state. "Sleepy" consists of a moderately pleasant, extremely unaroused, and moderately submissive state, whereas "bored" is composed of highly unpleasant, highly unaroused, and moderately submissive components.

Within the PAD Model, there are eight basic and common varieties of emotion, as defined by all possible combinations of high versus low pleasure (+P and -P), high versus low arousal (+A and -A) and high versus low dominance (+D and -D). Thus, for instance, *anxious* (-P+A-D) states include feeling aghast, bewildered, distressed, in pain, insecure, or upset; *hostile* (-P+A+D) states include feeling angry, catty, defiant, insolent, and nasty; and *exuberant* (+P+A+D) states include feeling admired, bold, carefree, excited, mighty, and triumphant.

The PAD Model is part of a more general social/personality theory where emotions, temperament, and situations are described using three analogous sets of factors. In the theory, situations are described in terms of their emotional effects (i.e., pleasant vs. unpleasant, arousing vs. unarousing, inducing dominance vs. inducing submissiveness). Furthermore, situations and temperament are treated as independent variables that influence behaviour

through their combined impact on emotions (i.e., emotions serve as mediating variables that intervene between situations and temperament, on the one hand, and behaviour, on the other).

## Models of Personality

Psychologists assume that individuals have long-term traits that guide their attitude and responses to events. In the following section we use the term *personality* to describe permanent (or very slowly changing) patterns of thought, emotion, and behaviour, associated with an individual. The personality profile of an agent determines how he experiences and expresses its emotions. In the psychological literature various models of personality exist. Here we will focus on those that have been used for embodied conversational characters.

### The Five Factor Model

In psychological research, a predominant model of personality is the Five Factor Model [MJ92]. The FFM is a purely descriptive model, with the five dimensions (*Extraversion*, *Agreeableness*, *Conscientiousness*, *Neuroticism*, and *Openness*) being derived from a factor analysis of a large number of self- and peer reports on personality-relevant adjectives. The descriptive nature of the FFM provides an explicit model of the character's personality and has been used to integrate models of personality into lifelike characters.

- **Neuroticism** refers to the number and strength of stimuli required to elicit negative emotions in a person. More resilient persons are bothered by fewer stimuli in their environment, and the stimuli must be strong in order to bother them.
- **Extraversion** refers to the number of relationships with which one is comfortable. Extraverts tend to be more physically and verbally active, and to be more friendly and outgoing around others. Introverts tend to be more independent, reserved, steady, and more comfortable with being alone. In between these two extremes are the ambiverts, who are able to move comfortably from outgoing social situations to the isolation of working alone.
- **Agreeableness** refers to the number of sources from which one takes one's norms for right behaviour. High agreeableness describes a person who obeys to many norms. Low agreeableness describes one who, in the extreme, only follows one's inner voice.
- **Openness** refers to the number of interests to which one is attracted and the depth to which those interests are pursued. High openness refers to a person with many interests and consequently, less depth within each interest.
- **Conscientiousness** refers to the number of goals on which one is focused. High conscientiousness refers to a person who focuses on fewer goals and exhibits the self-discipline associated with such focus.

Sometimes only a subset of these five dimensions is used when modelling the personality of an agent. For example, in [ARvM+00] the authors focus on social interactions thereby concentrating on extraversion (with the possible values *extrovert*, *neutral*, or *introvert*) and agreeableness (with the possible values *agreeable*, *neutral*, or *disagreeable*), since these two traits seem to be most important for social interactions [IN98].

### The Theory of Personality Types

There are many modern theories of the personality based on the idea of four personality factors. Perhaps the most influential of these is to be found in the work of the Swiss psychologist, Carl Gustav Jung. He defined personalities as belonging to one of four different types; Sensing, Intuitive, Feeling and Thinking. It was Jung's opinion that people instinctively understand the personality in terms of a set of four elements (his four types being one example of such a set, and the four humours blood, yellow bile, phlegm, and black bile of the Greeks

being another). These groups of four (technically called “tetralogies”) underlie a very large number of personality assessment techniques.

The theory of Personality Types as it stand today, contends that:

- An individual is either primarily **E**xtraverted or **I**ntroverted
- An individual is either primarily **S**ensing or **i**Ntuitive
- An individual is either primarily **T**hinking or **F**eeling
- An individual is either primarily **J**udging or **P**erceiving

The possible combinations of the basic preferences form 16 different personality types. Each of us has a natural preference which falls into one category or the other in each of these four areas, and our native personality type indicates how we are likely to deal with different situations that life presents, and in which environments we are most comfortable.

Some of the most important recent work done in the field on personality typing has been done by David Keirsey, who has created the theory of temperament associated with type [KB84]. In his research, he has made observations that have allowed him to combine two of the four sets of preferences, into four distinct temperament categories. Each of the sixteen personality types fits into one of these temperament categories. Keirsey uses his own description for the temperament types, and the individual personality types listed within each temperament. He describes, for example, the **NT** – *the Rationals* primary objective as "Knowledge Seeking". The NT group includes the types:

- **ENTJ** - "The Fieldmarshals"
- **INTJ** - "The Masterminds"
- **ENTP** - "The Inventors"
- **INTP** - "The Architects"

The model makes detailed assumptions about the strengths and weaknesses, as well as the preferences of each individual type. Additionally, it makes very precise assumptions about what kind of personal relationships each type may have with any of the others and how they develop over time.

## Correlation between Emotions and Personality

Moffat [Mof97] differentiates between personality and emotion by using the two dimensions *duration* and *focus*. Whereas personality remains stable over a long period of time, emotions are more short-lived. Moreover, while emotions are focused on particular events or objects, factors determining personality are more diffuse and indirect.

Personality and emotions can be conveyed in various ways. According to empirical studies, extravert characters use more direct and powerful phrases than introvert characters [Fur93], speak louder and faster [Sch79] and use more expansive gestures [Gal92].

Different personality traits have different influences on emotions. Extraversion tends to be related to positive affect, and neuroticism with negative affect. A happy agent, for example, tends to be more happy if the agent’s personality is extravert and agreeable. Personality traits affect the decay process as well. If an agent’s personality is extravert and agreeable, the baseline of the agent’s intensity value for happiness will not decline to zero in the decay function but to a positive value above zero.

G. Ball and J. Breese use a Bayesian network to model the relationships between emotion and personality and their behavioural expression [BB00]. Bayesian networks [Jen96] are a formalism for representing networks of probabilistic causal interactions that have a number of properties that make them an attractive mechanism for modelling emotion and personality,

e.g. they deal explicitly with uncertainty at every stage, which is extremely useful for modelling the non-deterministic dependencies between emotion/personality and behaviour.

The Bayesian model they have built contains internal states for emotional *valence* and *arousal* and for the *dominance* and *friendliness* aspect of personality. Valence represents overall happiness encoded as *positive* (happy), *neutral*, or *negative* (sad). Arousal represents the intensity level of emotion, encoded as *excited*, *neutral*, or *calm*. Dominance indicates a disposition towards controlling or being controlled by others, encoded as *dominant*, *neutral*, or *submissive*. Friendliness measures the tendency to be warm and sympathetic, and is encoded as *friendly*, *neutral*, or *unfriendly*. These dimensions are treated as unobservable variables in the Bayesian formalism, with links connecting them to nodes representing aspects of behaviour that are judged to be influenced by that hidden state. The behaviour nodes include linguistic behaviour (paraphrase selection), vocal expression (base pitch and pitch variability, speech speed and energy, posture, and facial expression).

## Emotion and Cultural Diversity

The expression of emotional states (e.g. facial expression) is governed by social and cultural norms, so called display rules, that have a significant impact on the intensity of emotion expression [Ek72]. Display rules are cultural conventions about withholding, disguising, or exaggerating expressions. According to several theorists, spontaneous emotional expressions do not convey accurate emotional information because people have been socialized to cover up their natural expressiveness in many circumstances. The kind and extent of this socialization is thought to vary from culture to culture. There is, some empirical evidence that different types of events make different groups of people happy, sad, joyful, etc. The American culture, for example, attaches great importance to the notion of independence (satisfying ones own needs creates positive feelings) whereas in the Asian culture interdependency seems to be more important (group conformity feels good). The cultural background should therefore not be neglected, when modelling our emotional conversational agents.

The cultural background is also an important determinant of how people work, see for instance a comparative study of computer-supported cooperative work (CSCW) in Japan and Scandinavia [Hea97]. From studies on CSCW we do not only learn that the use of technology is strongly influenced by culture, but also recognize the “importance of culture as a variable in the technology design process” [Hea01].

Katherine Isbister has worked on cross-cultural differences in nonverbal communication. In [Isb01] she claims that “culture shapes not only the words we use, but also many other qualities of our communication. One vastly important area is the nonverbal communication that accompanies speech-gestures, the distance between us when we speak, the length of pauses and the cadence of turn-taking in speech, and so forth. [...] Although researchers agree that there are some primary emotions that are universally recognized (Ekman's work is the classic line of research), they also agree that cultures widely vary in the display rules about when one should display an emotion, and how strongly. And, there are expressions that seem to exist only in certain cultures. When it comes to speech pauses, gestures, eye contact, proximity to one another, and many other factors, researchers have demonstrated that cultures have widely divergent norms.”

One way to account for cultural diversity obviously is cultural localization of software and technology, especially when a culturally homogeneous user group is envisaged. The internet on the other hand has a strong potential for work and communication across cultures. For intercultural communication to be successful, the design of supportive environments is of great importance, i.e., an ultimate goal is to design environments that “help users to come to an understanding of each other, and each other's culture, via the online environment” [Ray01]. In [KGG01] an example is given how user data and user feedback collected from a

net environment populated with embodied characters can be used to learn about cultural similarities and differences.

Within the NECA project we plan to integrate models of cultural diversity into our platform. Since to our knowledge no computational models of personality and emotions exist that address this problem, i.e. that take the cultural background into account when generating and expressing emotional states, the emerging NECA platform will enable the development of conversational characters for cross-cultural WWW applications.

## Conclusion

In this document we have presented some approaches on how to model emotion and personality in embodied conversational agents, we have discussed the correlation between these two concepts, and we have addressed some issues that are important for designing virtual characters for a multi-cultural world.

The approaches presented differ with respect to of their usefulness and applicability in the NECA project. NECA focuses on credible agent-agent interaction patterns to be observed by a human user. In NECA scenarios such as the eShowRoom and Socialite demonstrators, these interaction patterns will take the form of believable dialogues between multiple agents generated by the system. The idea is that the system takes the role of a producer that generates a “script” for the agents. The script specifies the verbal and non-verbal behaviours to be carried out by each agent, i.e. the agents become the actors of this “play”. The generation of these dialogues will rely on an explicit representation of an agent’s goals, standards, and preferences. This implies that “appraisal theories” of emotion like the OCC-Model are more suitable to accomplish this task than the PAD Emotion Model since the appraisal process which assesses the relationship between external events and an agent’s internal beliefs, plans, desires, social norms, and so forth, relies on exactly these knowledge representations. A similar argument holds for descriptive models of personality like the Five-Factor-Model and models built on personality types because they make precise assumptions about the preferences of each individual type.

In addition to the *structure* of the dialogues, the emotional representations generated by the affective reasoning component will also influence expression, both verbal and non-verbal. This involves an additional level of complexity, because in particular, the expression of emotions in the face [Ekm72] and in the voice [SCDC01] are based on different research traditions. While in the field of facial expression, emotions are generally described in terms of six basic emotions, it has been argued [SCDC01] that in view of speech synthesis, emotions may better be described with three emotion dimensions similar to those used in the PAD model. Therefore, individual components of the NECA system will have to map the output of the affective reasoning module onto appropriate representations. This can be achieved, for facial expressions, by grouping emotion categories, and for speech synthesis, by locating emotion categories in the three-dimensional emotion space [CDCT01].

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