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# Experimentation with GRACE, the Generic Model of Emotions For Computational Applications\*

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**Abstract:** In this paper, we present a model of emotions that we proposed in EmotiRob project. First of all, we make a comparison of recent models of emotions and show that our model is generic in basing on the theories of Ortony et al., of Lazarus, of Scherer and then the personality theory of Meyers-Brigg and Meyers. Then, we present our experimentation with the first instance of the model and its result to validate our work.

**Keywords:** Emotions modeling, Emotion definition, Human-Machine interaction.

## 1. INTRODUCTION

Nowadays, an increasingly number of scientists conduct their research to the design of emotions in computational agents (including “softbots” as well as embodied robots) that must perform unanticipated tasks in unpredictable environments. This tendency comes from the rapid development of human-machine applications in our everyday life. Conversational agents, embodied agents, and then robot assistants, robot servants or companion robot become more and more popular. A main demand for this kind of things is having human-characteristics like personality traits and/or emotional behaviour.

In the same tendency, our project EmotiRob [1][2] aims at designing a robot companion for impaired children or for children having to undergo lengthy hospital stays. In fact, the experiments previously conducted on elderly people staying in pensioners' homes with the Paro [3] seal designed by T. Shibata (AIST, Japan) have clearly shown that robot companions can bring some moral and psychological comfort to fragile people. We used Paro to carry out two experiments with disabled children. The experiments showed that the kind of psychological comfort provided by the robots depends on the quality of the affective bridge built between them and the children. It seems obvious that the link could be significantly enhanced if robots were able to understand human speech and to react emotionally in return.

So, beside the actual design and making of a robot, our project involves also the construction of a corpus of child speech within the particular context ; a linguistic study of the corpus with a view to applying the results to natural language processing techniques (particularly in natural language understanding); and studies on perception and emotions modelling. In this paper, we would like to focus on our works

on emotions modelling. We report on the results of our first experiment on the emotional model GRACE.

Section 2 of this paper gives an overview on some psychological theories on which we base our model. Recent works on computational modelling of emotions are presented in section 3. We describe, in section 4, GRACE – our generic model of emotions with its justification. The section 5 presents the goal of the experiment, the way it has been performed and the results obtained. Finally we present our future work and give some conclusions.

## 2. BASED THEORIES

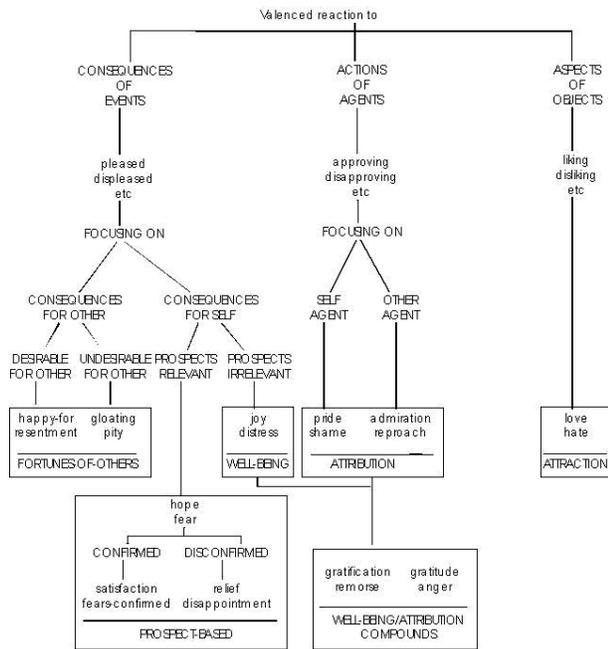
In this section, we will mention some psychological theories that influences the construction of our model of emotions: the theory of Ortony & al on **event appraisal**, the theory of Lazarus about **appraisal** and **coping**, and thirdly the theory of Scherer about **emotional processes**. The section then ends with the theory of Meyers-Brigg and Meyers on **personality** which is important for us to conceive the model.

### 2.1 Theory of Ortony & al. (1988)

For Ortony, Clore and Collins [4], emotions are valenced reactions to events, agents or objects. These events, agents or objects are **appraised** according to an individual's goals, standards and attitudes.

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**Figure 1: OCC's typology**

The positive aspect of this theory is that it is very close to a computational approach. This theory is basic for most of models of emotions thanks to its generic evaluation criterions on emotions.

### 2.2 Theory of Lazarus (1991)

According to Lazarus [5], there are two processes that allow individual to stabilize his relation with environment: cognitive evaluation (appraisal) and adaptation (coping).

Lazarus defined cognitive evaluation as an adaptive process serving to conserve or to modify the relation between agent (its beliefs, its goals) and the world (its constraints, its modifications) in the way to maintain balances. For him, when a situation is evaluated as stressful, individual has to adapt: that is the role of the two **copings**:

- **Problem-focused coping** will try to solve the problem (classical approach), but can also avoid it by denying the problem to minimize the effect.
- **Emotion-focused coping** differs from avoidant strategies as it refers to efforts aimed at regulating the emotional response to the problem. The strategy is no longer to solve the problem, but its consequence in the body.

### 2.3 Theory of Scherer

For Scherer [6] five subsystems functionally defined are involved with emotional processes:

- An **information-processing subsystem** evaluates the stimulus through perception, memory, forecast and evaluation of available information.

- A **supporting subsystem** adjusts the internal condition through control of neuroendocrine, somatic and autonomous states.
- A **leading subsystem** plans, prepares actions and selects between competitive motives.
- An **acting subsystem** controls motor expression and visible behavior.
- A **monitor subsystem** finally controls the attention which is assigned to the present states and passes the resulting feedback on to the other subsystems.

Scherer is especially interested in the information-processing subsystem. According to his theory this subsystem is based on appraisals which Scherer calls **stimulus evaluation checks (SEC)**. The result of these SECs causes again changes in the other subsystems.

Scherer sees five substantial SECs, four of which possess further subchecks.

- The **novelty check** decides whether external or internal stimuli have changed; its subchecks are suddenness, confidence and predictability.
- The **intrinsic pleasantness check** specifies whether the attraction is pleasant or unpleasant and causes appropriate approximation or avoidance tendencies.
- The **goal significance check** decides whether the event supports or prevents the goals of the person; its subchecks are goal relevance, probability of result, expectation, support character and urgency.
- The **coping potential check** determines to what extent the person believes to have events under control; its subchecks are agent, motive, control, power and adaptability.
- The **compatibility check** finally compares the event with internal and external standards; its subchecks are externality and internality.

Each emotion can, according to Scherer, thus be clearly determined by a combination of the SECs and subchecks.

### 2.4 MBTI of Meyers-Brigg and Meyers

Another study that affects our work is The Myers-Briggs Type Indicator [7] - a self-report instrument that helps to identify an individual's strengths and personality preferences. According to the authors, the **Personality type** is evaluated in responding four questions: where you focus your attention, the way you take in information, the way you make decisions and how you deal with the outer world. These four questions permit to characterize a personality trait on four categories: Energy (**Extraversion (E)** or **Introversion (I)**), Information (**Sensing (S)** or **Intuition (N)**), Decisions (**Thinking (T)** or **Feeling (F)**) and Lifestyle (**Judging (J)** or **Perceiving (P)**).

We would like to integrate personality in our model of emotions because personality is incontestable, it characterizes

an individual, it influences the way one perceives, thinks, acts and even the way one changes in his everyday life.

### 3. RELATED WORKS

We have made a comparison of recent computational models of emotions to find out if there exists a generic model that we could customize for our project.<sup>2</sup> From 2000 up to now, many researchers interested in modeling emotions like El-Nasr et al with their *FLAME* (2000) [8], Bui et al with *ParleE* (2002) [9], robot *Kismet* of C. Breazeal (2002) [11], model *Greta* of Pelachaud et al (2003) [12], Gratch and Marsela with their model *EMA* (2004) [13], Carole Adam with the model *GALAAD* (2005) [14] and *PLEIAD* (2007) [15], etc. In fact, these models have all implemented **event appraisal** following the theories of Ortony et al and Lazarus. But the strategy of **coping** is applied only in *FLAME*, *EMA*, *GALAAD* and *PLEIAD*. Generally, **personality** has not much attention. Only *Greta* and *ParleE* implemented personality traits in their models to take into account the relationship between personality and emotions.

**Table 1: Synthesis of comparison of different models of emotions**

No	Name of model	appraisal	coping	personality
1	FLAME[8]	Yes	Yes	No
2	ParleE [9]	Yes	Not mentioned	Rousseau's model[10]
3	Robot <i>Kismet</i> [11]	Yes	Not mentioned	No
4	<i>Greta</i> [12]	Yes	Not mentioned	Personality trait
5	<i>EMA</i> [13]	Yes	Yes	No
6	GALAAD[14]	Yes	Yes	no
7	PLEIAD[15]	Yes	Yes	No

In conclusion, we find that there is no consensus on computational model of emotions. There is no model of emotions that not only has characteristics of **event appraisal**, **coping** but also contains a complete **personality** influence. That is the reason why we propose here a generic model of emotions which gives a global view on emotional processes so that one could customize to adapt to any particular computational approach.

### 4. GRACE – GENERIC COMPUTATIONAL MODEL OF EMOTIONS

#### 4.1 GRACE – Generic Robotic Architecture to Create Emotions

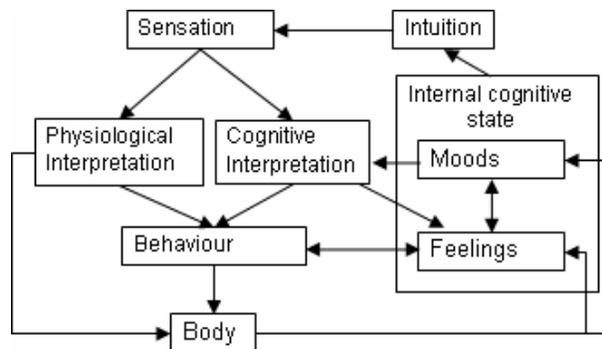
<sup>2</sup> A complete comparison can be found in [17]

*Definition of emotion:* an emotion is the process that characterises the human body's response to an event.

An **event** is a perception of human body about a change (or an absence of change) in environment or about an internal change (or an absence of change) inside the body.

**Human body's response** is one or several internal changes (undetectable by external observer) inside the body, or an expression/posture on the body (detectable by external observer) or an absence of change.

Based on this definition we propose the following model in Fig.2:



**Figure 2: GRACE - Generic Robotic Architecture to Create Emotions**

In this model *Sensation* is the basic starting point. The sensation is generated by an event, something which really exists or not, but which generates a physiological change in the body and/or by sending subjective information (from *Intuition*) to the sense-organs: touch, hear, see ... This sensation will be processed in two ways. First, the *Physiological Interpretation* will directly interpret this initial signal into a body reaction (the heart races ...) and will also alert the module *Behaviour*. On the other hand, the *Cognitive Interpretation* will interpret the signals received from *Sensation* into cognitive information about the environment situation.

The *Behaviour* will then calculate the response from the information coming for the perceptions based on the *Internal Cognitive State*. This response is sent to the *Body* where the physical reaction will take place.

#### 4.2 Integration of characteristics of emotions processes in GRACE

So, how are integrated the theories on **event appraisal**, **coping**, **personality** or the **theory of Scherer** that we presented above?

#### 4.3 Event appraisal

In fact, the theory of Ortony et al gives us the idea of when a sensation can take place and then how this sensation can be treated in interior. When an event takes place (an external change or internal change), this event will be captured by

*Sensation* module and then given to *Interpretation* level for further processing. The interior analysis of this event takes into account the relation of the current goals and interests which is coming from the theory of Ortony et al about **event appraisal**.

#### 4.4 Coping

In our model, we tend to resolve the strategy of **coping** in the internal analysis. Generally speaking, the strategy of **coping** influences the information processing rules from *Interpretation* level and *Internal Cognitive States* up to *Behaviour* decision-making. The result of this influence is the behaviour (or action) that will be expressed by the *Body*.

#### 4.5 Five subsystems of emotions

Secondly, to compare our model with the **theory of Scherer** above, we have:

- The first subsystem (**information-processing subsystem**) is the process evaluating information from module *Sensation* to *Interpretation* level then finally to module *Behaviour*.
- The **supporting subsystem** will be implemented in the modules *Psychological Interpretation* and *Body* to adjust the internal condition.
- **Leading subsystem** will be implemented in module *Behaviour*.
- The **acting subsystem** is integrated in module *Body*.
- **Monitor subsystem** will be developed in module *Internal Cognitive States*.

#### 4.6 MBTI for personality

The MBTI proposes four categories to build personality. Our model completely covers these four categories:

The first one is the *Energy* splitted in **Extraversion** (E) or **Introversion** (I). In the generic model this particular feature is integrated in the *Mood* and *Behaviour* modules. Secondly, *Information* category of the MBTI is completely covered by the generic architecture. The **Sensing** is constructed with the two *Interpretation* modules and the **Intuition** by the *Intuition* module. Then, the third category is *Decisions*: **Thinking** (T) or **Feeling** (F). We cover these two approaches by the way that the *Behaviour* module of the generic model is coded. Last category of MBTI - **Judging** (J) or **Perceiving** (P) can be coded at the *Interpretation* level. In fact, it is a level of interest for the sensation that will be used.

## 5. EXPERIMENTATION

The goal of the phase Experimentation is to validate the pertinence of the proposed model.

We decided to begin with simplified version of GRACE to see if its implementation could be recognized as having emotion by an observer. In this first instance we only use *cognitive*

*interpretation*, *behaviour*, *body* and a very simplified *internal state*. For personality type, we test our instance with the category Energy (**Extraversion/Introversion**) of MBTI. Details on implementation are described below.

#### 5.1 Implementation of components

*Cognitive Interpretation* makes an interpretation of the story. The story will be cut into a suit of events (An event is a moment of story that can make a big change in emotional state of listener/audience). Each event will be estimated based on 3 characteristics: urgency  $Urg_e$ , danger  $Dag_e$ , affection  $Aff_e$ . Urgency  $Urg_e$  corresponds to urgency level of event which implies a demand of a quick reaction; danger  $Dag_e$  here represents danger level of the detected event; and affection  $Aff_e$  indicates the favorable level of detected event. For this first instance, the events suit and the values of three characteristics are manually measured according to the intention of the story. The choice of three characteristics urgency  $Urg_e$ , danger  $Dag_e$ , affection  $Aff_e$  is inspired from **stimulus evaluation checks (SECs)** of Scherer. Note that the SECs of Scherer possess many subchecks while we propose here only three. This is because our first instance is a very simple version of completed GRACE one. A completed version of GRACE will be developed in our future works.

Additionally, *Cognitive Interpretation* modifies the information based on the personality; it changes the previous values following the calculus:

- $Aff_{per} = Aff_e +/- (Aff_e/2.8)$
- $Dag_{per} = Dag_e +/- (Dag_e/2.8)$

We use + for **extraversion** and – for **introversion**. The value 2.8 is chosen among several values manually adjusted during implementation phase.

At *Internal Cognitive State* level we implement some decay functions for the change of emotions over time. These are the normal law functions which permit each emotion to change according to its proper characteristics (for example: fear increases/decreases very fast; happiness change speed is more interior than fear, sadness is even slower than happiness, etc.). Parameters of normal law applied for the decay functions of each emotion are:

- For happiness, mean  $\mu = 1$ , variance  $\sigma = 1.85$ ;
- For sadness: mean  $\mu = 1$ , variance  $\sigma = 5$ ;
- For fear: mean  $\mu = 1$ , variance  $\sigma = 0.5$ .

Moreover, *Internal Cognitive State* gives prediction on how the emotions will change in the next event according to the evolution of current situation. For example, if good thing is predicted to happen then happiness will increase. On the contrary, if things seem to go worse, happiness will decrease while sadness and fear will become stronger. Since this prediction involves implementation of complicated elements like personal history, belief, mental state, personal knowledge, etc., we decide to measure this prediction by hand in our first instance of GRACE.

*Behavior* component: This component in fact calculates the intensity of emotions associated to the detected event. Result of this calculation is passed to *Body* to be expressed. We

implement in *Behavior* some mathematic formulas to calculate the intensity of basic emotions:

- $Happy_{current} = Happy_{precedant} + (Aff_e * Happy_{predicted})$
- $Sad_{current} = Sad_{precedant} - (Aff_e * Sad_{predicted})$
- $Fear_{current} = Fear_{precedant} + (Aff_e * Fear_{predict}) + (0.1 * Dag_e * Urg_e)$

*Body* component: There will be a graphical presentation of emotions expressed.

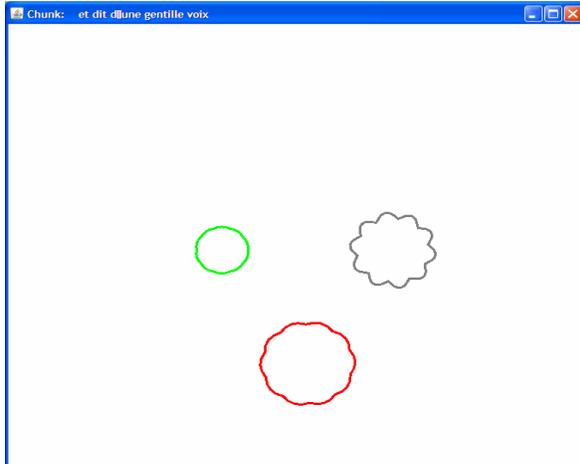


Figure 3: Graphical presentation 1 of Body component

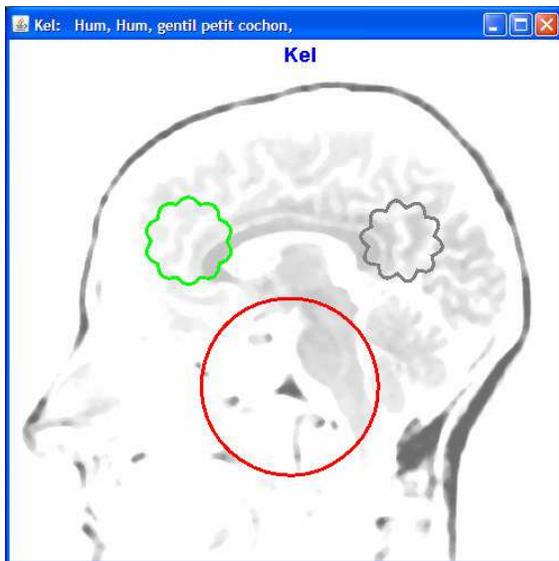


Figure 4: Graphical presentation 2 of Body component

Note that there are only three basic emotions we focus on this first test. This is because the events suit we used for the phase experimentation can create principally significant changes for these three emotions. The events suit is generated from an extract of the history “three small pigs” and the chapter “Looking for mother” in the film “Bambi” of Walt Disney. In fact, we analyzed these two extract in following the intention of the author, which means that we cut these extracts into

small pieces. Each piece is tended to cause a big change in the emotional state of listener/audience. These two suits are then used as input for our instance to calculate the change of three basic emotions. The result obtained at *Body* component is used for the phase Experimentation. For experimentation, we made two instances of GRACE which simulate two different personality types Extraversion and Introversion situated in the Energy dimension of MBTI standard. We named Kel for extroversion version and Ly for introversion version.

## 5.2 Experiment and results

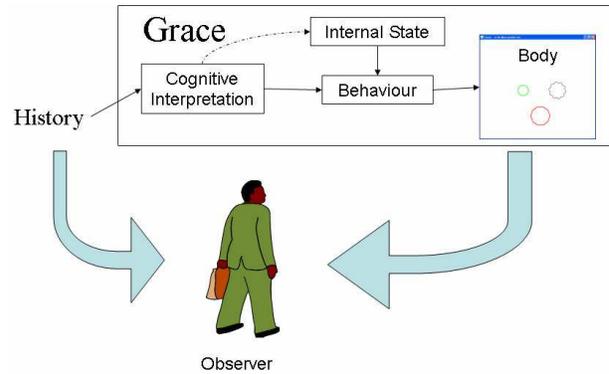


Figure 5: Experimentation scenario for GRACE

In experimentation, we have people (age 10 - 45) silently sitting in front of computer screen where the graphical presentations of GRACE are played. Before showing the presentations, we explain them that they will see a simulation of the brains of two robots who react to the extract of history/film. After having shown the reaction of GRACE instances with the two extracts, we examine these people about what they saw on the screen. They will be demanded to explain us what the graphical presentation is associated and what the difference between Kel and Ly is. Then we have them watch GRACE instance reaction the second time. We ask them after this time the same question to see if they perceived something different to what they saw at the first time. Our goal is to find out if the three circles are considered as emotions and if the personality of the two version of GRACE instance is detectable. Here is the result of experimentation:

- The test is not compatible for children of 10 years old or less because of its abstraction level.
- For the others (about 15 persons):
  - 1 person can see nothing representative in the first time and in the second time he assumed that he can see the circles have something in common with the sadness and the fear.
  - 4 persons saw that the circles correspond to the intonation and the image during the lecture/evolution of scene in the film. This assumes that they saw nothing in common between the three circles and emotions.

- 10 persons assured that they could feel something emotive that is presented on the screen. Some said they saw the tress, the attention of robots to the change in the history/film. Others said they could see the fear and the sadness during watching the two instances. This assumed that these three circles were recognizable as emotions representation.
- For the personality, five persons said that there is no difference between Kel and Ly; one said that Ly is more active than Ly; there are 9 persons assumed that Kel is more active, more sensible, and more expressive than Ly.

Generally speaking, we can see that 50% of people can find out that the three circles correspond to emotions and the difference between the personality type of Kel and Ly is their exteriority. This permits us to believe that our component seems validated. This result is not good enough to validate the approach but we can consider that it is in a good way and we can now discuss some points.

### 5.3 Discussion

After the experiments with others, we found out some interesting points in our works:

- The quality of test result depends on the presentation form of the two instances. For example, we have used some times the version where there is a background image (see fig. 4). This version with background image troubled the audience: they sometimes assured that the three circles correspond to the human senses (see, hear and smell) due to the position of the circles. So we can notice that the way we build a “body” to show the emotional activity of GRACE is very important: it must not contain a semantic giving the answer (if we show a face smiling then the relative behavior would be easy to recognize), it must not to be so abstract that people could not make a link between what they see and what is happening.
- The choice of the story is very important. The two events suits used have very few moments where can give rise to happiness. So, there is almost nobody can anticipate the happiness circle. This makes us thinks about a more precise/fine choice of examples used for next time experimentations.

## 6. CONCLUSION

In this paper, we have presented our proposed definition of emotions where we claimed that an emotion is a process in the human body started from the *Sensation* of a event though *interpretation* level which takes into account the *internal cognitive state*. The process continues down to the *Behavior* part where the intensity of current emotions will be calculated. The *Body* is responsible to express the calculated intensities to outer world according to the personality type of individual. We have made a comparison between our model

with some others recent models to prove that our model is quite general. We presented into detail our simplified instance and the result of our first experiments with this instance. The result of experimentation is quite positive which encourages us to continue our development of GRACE. Although there remain some problems in the experimentation, the result we obtained is a good signal for the development of GRACE. Since our GRACE is still in its early life, every comment on its composition and also all others concerned aspects is always welcome.

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