

humaine

D7d

**Proposal for exemplars and work towards them:
Emotion in Cognition and Action**

Workpackage 7 Deliverable



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| Author(s) | Lola Cañamero, Arjan Egges, Fiorella de Rosis, Sabine Payr, Paolo Petta and WP7 members (see below) |
| EC Project Officer | Philippe Gelin |

Address of lead author: Lola Cañamero

School of Computer Science
University of Hertfordshire
College Lane
Hatfield, Herts AL10 9AB
United Kingdom

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1 The place of this report within HUMAINE

The HUMAINE Technical Annex identifies a common pattern that is followed by most of the project's workpackages

“The measure of success will be the ability to generate a piece of work in each of the areas which exemplifies how a key problem in the area can be solved in a principled way; and which also demonstrates how work focused on that area can integrate with work focused on the other areas. We call these pieces of work *exemplars*. The exact form of an exemplar is not pre-specified: it may be a working system, but it might also be a well-developed design, or a representational system, or a method for user-centered design.” (p. 4)

“To that end, each thematic group will work out a proposal for common action, embodied in one or more exemplars to be built during the second half of the funding period.” (p.16)

“The process will begin with production by each thematic group of a review of key concepts achievements and problems in its thematic area; and drawn from the review, an assessment of the key development goals in the area. This review and assessment will be circulated to the whole network for discussion and comment, aimed both at building understanding of basic issues across areas, and at identifying the choices of goal that would be most likely let the different groups achieve complementary developments. That consultation phase will provide the basis for deliverables in month 11, which describe in some detail a few alternatives that might realistically be chosen as exemplars in each area, and their linkages to issues in other thematic areas. A decision and planning period will follow, involving consultation within and between thematic areas, leading to presentations at the second plenary conference, which will describe a single exemplar that has been chosen for development in each area, and the way work on the exemplar will be divided across institutions. The remainder of the project will be absorbed in developing the chosen exemplar.” (p. 21)

The consultation phase has now ended. Near-final plans were presented to the whole network at the Plenary in May 2005, and adjustments have been made accordingly.

This deliverable reports the plans that have now been set out for the remaining 25 months of the project. They are necessarily provisional, because they will be subject to two reviews (in 2006 and 2007) before they are completed.

Work has begun on several aspects of the planned program. It is also reported.

Ethical issues affect the whole of HUMAINE, but rather than repeating essentially similar points in multiple deliverables, they will be handled coherently in a single document, D0o (Science and Society).

The following institutions and persons have contributed in various forms to the elaboration of this deliverable:

ICCS-NTUA: Kostas Karpouzis

UNIGE-GERG: Didier Grandjean, David Sanders, Etienne Roesch

UNIGE-MIRALAB: Arjan Egges

UH: Lola Cañamero, René te Boekhorst, Orlando Avila-García, Arnaud Blanchard, Robert Marsh

Paris 8: Christopher Peters

OFAI: Sabine Payr, Paolo Petta, Stefan Rank

DI-BARI: Fiorella de Rosis, Valeria Carofiglio, Nicole Novielli

EPFL: Alejandra García-Rojas, Etienne de Sevin, Daniel Thalmann

DIST: Ginevra Castellano, Antonio Camurri, Gualterio Volpe

INESC ID: Ana Paiva, João Dias

KCL: John G. Taylor, Nienke Korsten

CNRS – EPML38: Philippe Gaussier, Jacqueline Nadel

FT-RD: Magalie Ochs, Franck Panaget

IST: Ana Paiva

HWU: Ruth Aylett, Pablo Lucas dos Anjos, Mei Yii Lim

CNR: Cristiano Castelfranchi, Maria Miceli

USC: Jonathan Gratch, Stacy Marsella

2 Brief overview of Workpackage 7 and its exemplar

This section presents a brief summary of our proposed exemplar, stressing key aspects and refinements made over previous versions. We refer the reader to deliverables D7b and D7c for the evolution of the exemplar and for lengthier descriptions of the aspects highlighted here.

2.1 The field covered by Workpackage 7

The focus of WP7 was identified in the TA to be a principled effort to achieve a better understanding of basic issues and open research topics regarding the involvement of emotions in cognition and action, with a view to grounding and promoting sound research into artificial emotional systems for artifacts that must interact with humans. The main task of WP 7 was further specified in D7b (page 5) as “the investigation of (computational) ‘internal’ mechanisms (emotion architectures) that allow to synthesize or generate emotions and to model their involvement in various aspects of cognition and action in emotion-oriented systems.”

2.2 Research objectives

This task clearly necessitates an integrated effort spanning different disciplines, rather than the development of isolated engineering projects. In the TA, the need for a shared critical reflection in this area was identified regarding different aspects: key conceptual issues, assumptions and dependencies; open research problems; key research and application scenarios; analysis of needs and directions for future research and applications based on a critical analysis of existing approaches, systems and tools; evaluation methods, scenarios and tools; analysis of needs for recommendations of good practice; requirements for usability; and potential for cross-fertilization among disciplines. Such are our “horizontal” research objectives. The exemplar has been conceived to address these aspects in a principled and tractable way.

2.3 The proposed exemplar

The exemplar proposed for WP 7 is titled *Comparative Approaches to Emotion-Oriented Architectures: Assumptions, Integration Challenges and Guidelines for Future Research*. This title has been chosen to stress various ideas:

- “Comparative approaches” wants to emphasize the fact that this WP acknowledges and welcomes the diversity of conceptual and computational models and frameworks that are and can be used to model emotional systems. These different approaches are not necessarily equivalent or redundant, and the task of this exemplar is to understand (in a deep sense) their scope, limits, incompatibilities and complementary aspects.
- “Comparative approaches” also wants to de-emphasize the idea of a “unified” design or model for an emotion-based architecture.

- The subtitle “Assumptions, integration challenges and guidelines for future research” stresses the nature of our common, principled integration effort in setting sound grounds that can guide future research in the area.

The main output of this exemplar will be an edited book that ensures principled integration. Working groups and institutions are and will continue developing different types of outputs (designs, implementations, experimental and theoretical analysis, etc) as part of / as a basis for their contribution to this exemplar.

2.3.1 Main elements of the exemplar

Our exemplar has four main elements within and across which our integrative effort takes place. These elements correspond to major approaches in the conceptualization and modeling of emotions and their influence in cognition and action in emotion-oriented architectures. Each element will be addressed by a working group. In previous deliverables (in particular D7b and D7c), these elements were termed (1) emotion in “lower-level” cognition and action; (2) emotion in “higher-level” cognition and action; (3) bridging the gap between “lower-level” and “higher-level” cognition and action; and (4) emotion in social cognition and interaction. Such labels, in particular “lower-level” and “higher-level” cognition and action were chosen for several reasons: (a) they reflect a traditional distinction in Artificial Intelligence and Cognitive Science that is also present in current emotion-oriented architectures; (b) although – sadly – it is sometimes forgotten by those different traditions, the use of the comparative forms “-er” emphasize the fact that “lower” and “higher” are relative terms that cannot be properly understood in isolation; (c) those labels are general enough to encompass a number of distinctions found in the different disciplines and traditions regarding the study of emotion and cognition-action, such as bottom-up/top-down, reactive/deliberative, sub-symbolic/symbolic, embodied/reasoning-based, etc. Those labels thus seemed very appropriate tools to organize work within the exemplar, always keeping in mind the largely arbitrary nature of such distinctions. However, interaction with other workpackages, with other communities, and feedback from the reviewers have stressed the fact that the terms “lower-level” and “higher-level” cognition and action are still too semantically loaded in Artificial Intelligence and Cognitive Science and can sometimes lead to misinterpretations of our approach and objectives. This and the fact that each element has by now narrowed down its scope to focus on specific aspects of those “umbrella terms” has made us rename the elements of the exemplar as follows, to reflect their main focus:

- Element 1: Emotion in embodied cognition and action
- Element 2: Emotion in reflective cognition and action
- Element 3: Bridging the gap between embodied and reflective cognition and action
- Element 4: Emotion in social cognition and interaction

We are aware that these labels can also be controversial (as in fact any label), but we hope that their more intuitive meaning will avoid misinterpretations and keep the focus of our work away from old debates and ill-posed problems that we would not like to reproduce in our emotion-oriented systems. We refer the reader to Section 3 for brief characterizations of the scope of each element. Integration efforts in the investigation of assumptions, integration challenges, and guidelines for future research take place at three levels: within elements, across elements within the workpackage, and with a selection of other workpackages.

2.3.2 How the elements link to each other

As stated above, the division of the exemplar into elements responds to a large extent to reasons of analysis and work organization, namely the need to divide a very complex problem into more manageable sub-problems. The elements proposed constitute partial and complementary views on the same common problem from different perspectives – modeling the relations and (mutual) influences between emotion and cognition-action in emotion-oriented architectures. Our approach aims at critically understanding the applicability, contributions and limitations of these perspectives, and this requires close interaction among them. Deliverable D7c (in particular Section 2.4) and the next sections outline some of the measures taken to achieve such interaction, such as participation of the same people in several elements, panel discussions and publications explicitly addressing this issue, and the inclusion of all the elements in various events.

2.3.3 How the elements link to other aspects of HUMAINE

Deliverable D7c (Sections 1.2.3 and 2.5) develops on the links with other workpackages. The main links that we would like to highlight here are:

With WP3: dialogue between their “blueprint for an affectively competent agent” (WG2) and computational models. Thread A of Element 3 (cf. D7c) is carried out in close collaboration with WP3, and Thread B has already provided valuable feedback for WP3, as discussed in mutual visits of GERG and OFAI. In addition to cross-links at the WP3 and WP7 workshops, such dialogue has already been taking place in two jointly co-organized symposia (at the 2nd Plenary and ISRE’2005), and the special issue of the journal *Neural Networks* edited by John G. Taylor, Klaus Scherer and Roddy Cowie. The upcoming international workshop “Agent Construction and Emotions: Modeling the Cognitive Antecedents and Consequences of Emotion” (ACE 2006), organized by members of this WP, will deepen even further the intersection of emotion theories and computational modeling.

With WP4-WP6: integration of architectures for emotion, the generation of socially meaningful expressive emotional behaviour, and its recognition. An element of the exemplar explicitly addresses this. Other links more focused on WP6 include: (a) theoretical input and feedback to the “creating affective bonds” and “imitation” aspects of their exemplar; (b) current work on back-channeling in WP6 is framed with an architectural decomposition of system components that has been subjected to the evaluative criteria of Element 3, in particular regarding its interactive qualities and the use of layering; and (c) three editorial projects – the book *Animating Expressive Characters for Social Interaction*, edited by Lola Cañamero and Ruth Aylett (John Benjamins, to appear 2006), a special issue of the *International Journal on User-Modeling and User-Adapted Interaction* edited by Sandra Carberry and Fiorella de Rosis (to appear June 2006), and a special issue of the *International Journal of Humanoid Robotics* edited by Catherine Pelachaud and Lola Cañamero (to appear September 2006).

With WP8: Elements 2 and 4.2 of our exemplar is tightly connected to projects aimed at simulating affective dialogs which are performed in the scope of WP8 and WP6, by various partners (e.g. QUB, DI-Bari, FT-RD). They play, in that scope, the role of integrating models of agent’s and users’ minds with various types of affect – from ‘light’ emotions (irritation, frustration, satisfaction...) to interpersonal stance. Also, HW Affective Guide work in WP8 will be covered in the first Subtask of Element 3, and insights gathered in this Subtask will in turn be provided to all WP8 application-oriented efforts.

With WP9: close connection especially between Element 4 of WP 7 and Elements 1 and 2 (“Criteria for usable affective interaction systems” and “Evaluation metrics for criteria”) of WP9 with regard to conceptual dimensions of and methods for evaluations of ECAs. Close co-operation is ensured informally by strong institutional and personal overlap of contributors to both WPs (DI-Bari, OFAI).

With WP10: In multiple past and future exchanges (including two two-day visits to WP7 labs by S.Döring and P.Goldie: to OFAI in November 2005, and to UH in Spring 2006), critique of utility-based approaches and issues with objective frames of evaluative reference are under analysis from both, the synthetic point of view of WP7 and the perspective of Applied Ethics of WP10. The Subtask on grounding of the normative social infrastructure is of particular relevance in this linkage.

2.3.4 Output of this exemplar

In addition to the contributions to the project Handbook, the proposed main common output arising from this exemplar is an edited book, with contributions reflecting our critical and integration efforts. The contents would include:

- Theoretical chapters:
 - One introductory chapter on the aims, program and achievements of the exemplar
 - One chapter addressing integration challenges among the elements of the exemplar (normally co-authored by the WP leader and the coordinators of the different working groups or the persons more actively involved in this reflection)
 - One chapter per working group addressing challenges / results of their particular element of the exemplar from a theoretical or conceptual point of view (co-authored e.g. by the people more actively involved in each working group)
- “Technical” contributions: Various chapters on systems, designs, experimental studies, scenarios, etc, developed within the exemplar (co-authored by relevant contributors)
- Chapters stressing links with other workpackages, in particular WP3, WP4, WP6, WP8.

3 The program of research: description and plans

This section summarizes our program of research and plans for the remainder of the project, paying particular attention to aspects that were less developed or did not appear in deliverables D7b and D7c, due in most cases to the integration of new HUMAINE partners in 2005.

3.1 Element 1: Emotion in embodied cognition and action

3.1.1 Coordinator

Lola Cañamero (UH)

3.1.2 Main participants

UH: Lola Cañamero, René te Boekhorst, Arnaud Blanchard, Robert Marsh (new PhD students also likely to join from January 2006). Former participants: Orlando Avila-García, Ignasi Cos-Aguilera, Richard French.

GERG: David Sander, Didier Grandjean

Paris8: Christopher Peters

KCL: John Taylor, Nienke Korsten

CNRS STIC-SDV EPML 38: Philippe Gaussier, Ken Prepin, Jacqueline Nadel

3.1.3 Rationale and scope of element 1

This element investigates aspects of emotions related to their embodiment, and in particular interactions between emotions and cognition-action as occurring through the body. Autonomous robots and ECAs are the platforms used as a basis for the work developed in this element of the exemplar. The focus of this approach is on the dynamics of interactions between agents and their environment and on emotion (and intelligence) seen in terms of processes. Emotions are thus conceptualized as dynamical processes strongly rooted in the embodiment of agents and highly dependent on the dynamics of the interactions with the physical and social environment. Element 1 focuses on the following main aspects:

E1.1 – Emotional modulation of perception-action in embodied agents

This subtask takes an embodied AI perspective, which regards cognition-action as tightly coupled perception-action loops mediated by a dynamically fluctuating internal environment. We model emotions in those perception-action loops in an incremental way, in terms of (patterns of) “neuro-hormonal modulation” (that we will refer to as “emotional modulation” for short) acting on the same underlying “neural substrate” – the nervous system in the case of humans, robotic architectures in our models – rather than modeling them in terms of basic categories or of points in a dimensional space. Compared to other emotion models such as “circuit models” or “adaptational models” (see Section 4 of deliverable D3c for a characterization of these models), and as discussed more extensively in D7b, this approach to emotion modeling permits a more seamless integration of emotion and cognition-action since emotions correspond to different “functioning modes” of the same underlying “neural

substrate” and associated cognitive and behavioural “functions” such as perception, attention, prioritization of motivations, behaviour selection, and behaviour execution.

Under this theme, we take an incremental perspective to investigate how “emotional modulation” of different aspects of (motivation-based) robotic architectures alters their “functioning mode” (functionality and performance) in different ways, making the resulting behaviour better (or worse) adapted to different types of (action selection) environments and the problems they pose. Our research goal and approach is to understand key properties of emotional systems by “generating” them (in autonomous robots) as a function of properties of their underlying mechanisms, rather than trying to “mimic” current models and findings about human emotions from neuroscience or psychology. However, biological and psychological plausibility of this investigation is of paramount importance in order to make a contribution towards understanding emotions in humans and other animals (and to provide feedback to WP3); this will be achieved by multi-disciplinary collaboration between roboticists, neuroscientists and psychologists to design relevant scenarios and uncover and test properties of mechanisms and interactions relevant to emotional systems. We focus in particular in emotional modulation of perception (see e.g. Adolphs, 2004; Vuilleumier, in press) in scenarios involving “flee/fight” emotional mechanisms and behaviours.

Sound development of these architectures also involves assessing the advantages (and disadvantages) that the addition of “emotional modulation” to a motivated architecture brings to autonomous agents from a functional point of view, i.e., the effects of such modulation on their performance and their capability to adapt to different environments. We will thus evaluate all our experimental studies from this perspective, using mainly the performance indicators developed by Avila-García and Cañamero (2002, 2003) in the context of action selection and that we have already started applying to simple emotionally modulated architectures as part of the HUMAINE exemplar (Avila-García and Cañamero, 2004, 2005).

E1.2 – Analysis of embodied emotion-oriented architectures and behaviour

In addition to the assessment of the effects of “emotional modulation” from a functional point of view (i.e. on the agent’s performance and adaptation) carried out in subtask E1.1, proper understanding of those emotion-oriented architectures and their behaviour requires systematic (formal) analysis from the perspective of their emergent and dynamical properties. We have identified two main aspects where analysis is needed, and could also provide novel contributions to operationalize some models investigated under WP3:

On the one hand, the behavioural “side effects” (emergent functionality) resulting from modulating the architecture of an autonomous agent in interaction with the real world need to be understood: (a) as part of the overall behavioural dynamics, and (b) as a result of the interactions between the internal dynamics of the architecture and the environment. Ethological methods pick up the manifestations of these side effects in a systematic way, as already outlined in deliverable D7c, thus covering (a). Comparison of the results of ethological analysis with the results of “functional” evaluation will contribute to (b). Such comparison must go beyond selected relevant examples and into formalization of underlying mechanisms in order to draw up a framework that facilitates the union of ethological concepts and the notions of physiological regulatory systems and physiological measurements. Its structure should allow for a meaningful inclusion of the notion of emotion. “Meaningful inclusion” implies that while developing the model it becomes more and more clear how the insertion of the initially vague concept of emotion makes ever more sense. Starting with a very coarse model of motivational dynamics, the notion of emotion will be increasingly sharpened by identifying it with the added refining structures needed to bring the model closer to its aim. In other words, we will not begin with a definition of emotion in order to model it,

but rather to start modeling in order to arrive at a definition. The model formalism used is known as the mathematical theory of dynamical systems – a collection of mathematical tools for the analysis of differential- and difference equations. With such formalization we would also like to contribute to operationalize the view of emotions as dynamical systems postulated by some psychological models (see e.g. Lewis and Granic, 2002).

On the other hand, we should be able to understand the “scope” of different architectures (the types of problems they can solve) and how different architectures relate, e.g. whether two architectures belong to the same “family” and can be reduced to a single architecture. This analysis should go beyond experimental comparisons on benchmarks, where results focus on optimality with respect to the benchmark, e.g., how unknown or unpredictable events are dealt with. If we want to become a mature scientific discipline, we should try to analyze, compare and predict the behaviours of different architectures and understand their design principles mathematically. We thus need tools to analyze both natural and artificial emotional systems. Previous related work has focused on mathematical tools to formalize pure behaviourist or reactive systems (e.g., Steels, 1994), measuring the complexity (in terms of fractal dimension, for instance) of very simple behaviours like obstacle avoidance (Smithers, 1995), or some partial aspects of complex systems such as learning (see extensive literature on neural networks). Yet, it remains difficult to overstep the old frame of cybernetics. Finding the fundamental variables and parameters regarding some particular cognitive capabilities will be a long and difficult work well beyond the scope of this project, but we hope to contribute some initial ground to build upon. Our formalism will build upon a previous one developed to define perception as a potential function built from the integration of sensory-motor signals (Gaussier, 2001), and later applied to a very simple robotic architecture to learn to recognize and reproduce facial expressions without having to program the innate capability to recognize the facial expressions of others (Gaussier *et al.*, 2004a, 2004b). Within HUMAINE, we would like to extend this work to allow the analysis/synthesis of more realistic and complex emotional systems and also to study formally the dynamics of human machine/interactions in the case of systems able to learn online.

E1.3 – Novelty detection and emotion-attention interactions

This subtask explores interactions between emotion and more complex forms of cognition-action, namely novelty detection and attention in the context of perception and production of facial emotional expressions, and uses ECAs as main platform for this work. It thus establishes close links with Element 4 of the exemplar and with WPs 4 and 6. Novelty detection (suddenness, familiarity, predictability) is a first step towards endowing agents with the ability to appraise their (virtual) environment. Based on the functions of novelty detection and appraisal in humans (see e.g., Grandjean and Scherer, 2003; Pourtois *et al.*, 2004a, 2004b, 2005), computational appraisal for virtual agents is important for, among other things: (1) helping to determine objects of interest in the environment as part of an agent’s attention system, (2) orienting attention through eye and head movements, (3) modulating the agent’s representation of the object in memory and (4) generating appropriate sequences of facial expressions for the upper region of the agents face.

We will carry out an investigation of computational approaches to novelty detection for emotional processing in computer agents with synthetic vision, memory and attention capabilities. This work will be developed in the theoretical framework of appraisal processes in emotion. The adopted methodology involves three tiers, the first of which is to categorize and describe the processing and timing of novelty in the human brain based on psychological and cognitive neuroscience perspectives. The second tier involves the collection or definition of computational approaches, new and existing, that parallel (in a much simpler way) their

human counterparts and which could be used to create a synthetic novelty detection system for an artificial agent. The third tier involves the selection and implementation of a subset of computational novelty approaches we have described from the second tier, for the purposes of processing and generating certain agent behaviours, such as gaze and change in upper facial area.

3.1.4 Main steps planned towards producing this element

3.1.4.1 Subtask E1.1 – Emotional modulation of perception-action in embodied agents

Main contributors and their contributed expertise:

- UH: Lola Cañamero, Robert Marsh, motivation- and emotion-based embodied robotic architectures and their assessment in terms of viability-based performance indicators.
- GERG: David Sander, emotional modulation of perception-action from the perspectives of cognitive neuroscience and psychology (appraisal theory); amygdala.
- KCL: John Taylor and Nienke Koersten, neural network models of emotional processing and their neural correlates.

Summary of key steps:

1. Final (re-)implementation of robotic architecture in the robotic platform chosen to conduct the investigation (previously LEGO robots, currently the more powerful Sony AIBOs) is being undertaken and should be completed by January 2006.
2. Design, implementation and testing of robotic scenario building on and extending mechanisms and problems previously investigated (Avila-García and Cañamero, 2004, 2005); critical commentary from neuroscience / psychology perspectives by June 2006.
3. Based on results and feedback from previous step and related theory (e.g., Adolphs, 2004; Sander *et al.* 2003, 2005; Vincent, 1990; Vuilleumier, in press), discussion and selection of subset of significant properties of emotional systems (e.g., temporal dynamics of hormonal modulation, temporal unfolding of emotional-perceptual processing) to be investigated further in subsequent experiments.
4. Design, implementation and testing of one / two robotic scenarios based on hypotheses and predictions from previous step.

Summary of planned publications:

- Submission to Intl. Conference of Simulation of Adaptive Behaviour (SAB'06) on first new set of experiments (step 2 above)
- Submission to relevant journal (e.g. *Cognitive Systems Research*) on relations between robotic experiments and models from neuroscience and psychology.
- Submission to technical conference (e.g. Intl. Conf. on Artificial Life 2007) or journal on second set of experiments, including relation to neuroscience

- Chapter submission to WP7 book summarizing experiments and their relation to theory
- Chapter submission to project Handbook on incremental design of emotional systems

3.1.4.2 Subtask E1.2 – Analysis of embodied emotion-oriented architectures and behaviour

Main contributors and their contributed expertise:

- UH: René te Boekhorst, ethological and non-linear analysis of behaviour; Lola Cañamero, motivation- and emotion-based embodied robotic architectures and their assessment in terms of viability indicators; Arnaud Blanchard, affect-oriented perception-action robotic architectures for adaptation and imitation.
- CNRS-EPML 38: Philippe Gaussier, Pierre Andry, Ken Prepin, robotic perception-action control architectures and their mathematical formalization; Jacqueline Nadel, developmental psychology of emotion and imitation, use of robots in the study of human emotion and social interaction.
- Commentary related to the conceptualization of emotions as dynamical systems and processes in psychology will be solicited from Klaus Scherer (GERG) and/or possibly other psychologists adopting this model but external to the network.

Summary of key steps:

1. Ethological analysis of observed motivational and emotional behaviour of selected robotic scenarios developed under subtask E.1.1. The aim of the ethological analysis in this case is to uncover the factors affecting “emotions” by modeling Markov chains after systematically varying experimental conditions (spatial distribution of the resources, initial starting position of the robots, presence or absence of a competitor, inactivation of the “emotional” modulation, etc.).
2. Non-linear dynamical systems study of motivations and emotions: Formalization of mechanisms underlying motivations and emotional modulation in order to draw a framework that facilitates the union of ethological concepts and observations and the notions of physiological regulatory systems and physiological measurements.
3. Cognitive system formalism to study motivations and emotions: Development of an algebra useful to describe (in terms of analysis and synthesis) realistic emotional systems and their interaction dynamics, including (a) motivation- and emotion-based control architectures for autonomous robots, and (b) the dynamics of human-machine interactions in the case of systems able to learn online, such as the system developed by Blanchard and Cañamero (2005b), thus also integrating systems investigated under Element 4 of the exemplar.
4. Comparison of the above analysis methods and their contributions.

Summary of planned publications:

- Technical paper on ethological analysis of emotionally-modulated behaviour of robots to be submitted (Spring 2006) to relevant technical international conference (e.g. From Animals to Animats – SAB’06) or journal (e.g. *Adaptive Behaviour* or *Artificial Life*).

- Draft paper on non-linear dynamical systems study of motivations and emotions available for commentary from other HUMAINE members by Spring 2007. This might eventually result in a formal publication.
- Technical paper on cognitive system algebra to study motivations and emotions to be submitted to relevant international conference (e.g. IJCAI'07 or ECAL'07) or journal (e.g. *IEEE Trans. on Systems, Man and Cybernetics*) by Spring 2007.
- Chapter submission for WP7 book summarizing and comparing the different aspects of analysis of emotional systems investigated in this subtask.

3.1.4.3 Subtask E1.3 – Novelty detection and emotion-attention interactions

Main contributors and their contributed expertise:

- GERG: Didier Grandjean, Novelty processes at psychology and cognitive neuroscience levels
- Paris8: Christopher Peters, Visual attention for embodied agents
- KCL: John Taylor, Nienke Korsten, Neural network based attention model

Summary of key steps:

1. Theoretical categorization and description of different types of novelty in the human brain, their relation to emotional processes and their timing at the behavioural and cerebral level.
2. Enumeration of a number of (simplified) key computational modules necessary for modeling novelty calculation for artificial agents in virtual environments with synthetic vision capabilities.
3. Implementation of a subset of the theoretical framework from (2) for the purposes of calculating novelty in a virtual scene from the perspective of an ECA, animating simple orienting reflexes towards items of novelty and generating responsive facial behaviours from the first stages of the component-process model (i.e. suddenness, familiarity, predictability).

Summary of planned publications:

- Submission to 2006 Artificial Intelligence and the Simulation of Behaviour (AISB'06) Convention. Potential content: Work-in-progress regarding computational novelty and attention modeling based on theory
- Submission to Cognitive Systems Research journal. Potential content: Theoretical integration of psychology and cognitive neuroscience of novelty processing and future possibilities of implementation for ECAs.
- Submission to Intelligent Virtual Agents (IVA) 2007. Potential content: Description of computational novelty and attention modules and potential applications to embodied agents in virtual environments.

- Computer Animation and Social Agents Conference (CASA) 2007. Potential content: Description of integrated computational novelty and attention model with capabilities applicable to embodied agents in virtual environments.
- Chapter for WP7 book. Provisional working title: “Computational novelty and attention approaches for emotion-related processing in embodied agents”.

3.2 Element 2: Emotion in reflective cognition and action

3.2.1 Coordinator

Fiorella de Rosis (DI-Bari)

3.2.2 Main participants

DI-Bari: Fiorella de Rosis, Valeria Carofiglio, Nicole Novielli

FT-RD: Magalie Ochs, Franck Panaget

CNR: Cristiano Castelfranchi, Maria Miceli

USC: Jonathan Gratch, Stacy Marsella

3.2.3 Rationale and scope of element 2

This element investigates the influence of emotions in cognition and action from the perspective of subjective perception (as rendered by introspection and mediated by linguistic accounts) and reasoning. It largely follows the approach of symbolic AI according to which intelligence and emotion are studied independently of their embodiment and are modeled by symbolic representations and symbol processing rules. It thus focuses on cognitive-emotional phenomena as accessible to conscious awareness and describable by natural languages, i.e. in terms of discrete mental states. In AI and cognitive science this approach has been captured in so-called “cognitive models” applied to both, reasoning processes and emotions.

The main theme investigated by this element is thus the development of cognitive Belief-Desire-Intention-and-Emotion (BDI&E) models and critical reflection on their possible role in human-technology interaction and communication. It is thus closely related to the “persuasion” elements of the exemplar of WP8, in particular regarding the mutual relations between the “external” manifestations of persuasion and their use and recognition in dialogues, and the mental states underlying persuasion.

Research on cognitive models of emotions in HUMAINE is focused on integrating BDI models of agents with affective aspects of various kinds: personality, mood or individual emotions. The chosen application domain for this kind of models is dialog simulation. At the same time, these models are seen as a method to integrate results of recognition algorithms with knowledge about the context in which data employed in these algorithms have been collected. Two main formalisms are employed by the groups involved in this sub-group, either individually or in combination: modal logic (by France Telecom R&D) and probability theory (by the University of Bari). This gives to HUMAINE the opportunity to test the two methods through several scenarios extracted from real dialog corpus of France Telecom and to discuss advantages and disadvantages of the two approaches. Regarding the degree to which a model of emotion captures real-world processes, the relevant question is “What type

of modeling method best fits?” Researchers agree that rational agents with an explicit representation of the notion of mental state allow to directly identify the emotion-elicitation process. However, due to the complexity of this process, many aspects are unpredictable, and hence uncertain. As a consequence, all proposed models attach some notion of uncertainty to the primitives *belief* and *goal*. In the scope of the Humaine’s network of excellence, to capture the notions expressed by these primitives two approaches prevail:

- In (Carofiglio *et al.*, 2002, 2005, and forthcoming 2006), the authors use probability theory (Belief networks – BN) to manage uncertainty by explicitly representing the conditional dependencies between the variables included in the model: first and second-order beliefs, goals and emotions. They therefore use dynamic belief networks DBNs as a monitoring system that employs the observation data in the time interval $(T_i, T_i + 1)$ to generate a probabilistic model of the agent’s mind at time T_{i+1} , from the model built at time T_i . They employ this model to reason under uncertainty about the consequences of an observed event on the monitored goals.
- In (Ochs *et al.*, 2005), a model of rational agent based on a formal theory of interaction called the Rational Interaction Theory (Sadek, 1991) is used. The implementation of this theory has given rise to Artemis (Sadek *et al.*, 1997), a rational dialog agent technology that provides a generic framework to instantiate intelligent agents able to engage with both human interlocutors and artificial agents in a rich interaction. In the Rational Interaction Theory, the model of the agent’s mental state is based on the three primitives above. In order to provide emotions eliciting-events representation to a rational agent, they have described emotions as particular configurations of mental attitudes through the formalization of appraisal variables.

Both methods seem to be suited for representing long and short-term affective components and simulate how emotions are triggered and how several emotions may mix over time. Each of them presents pro and cons which should be discussed more in depth.

Another aspect merits to be examined, considering the application domain of these models (dialog simulation). We refer to the possibility of employing the same model in a ‘prognostic’ and in a ‘diagnostic’ mode: that is, to envisage the possible emotional impact on the user of a given ‘communicative act’ of the agent and to interpret a particular emotion (or blending of emotions) displayed by the user.

3.2.4 Main steps planned towards producing this element

Summary of key steps:

1. Clarification of psychological theories behind these models: in particular, relationship between anticipation and emotion; theory of cognitive dissonance and their variants (ongoing).
2. Analysis of aspects that cognitive models should represent, to be of use in human-technology communication research: personality factors, emotion mixing, time decay, role of the social context and others (ongoing).
3. Investigation of the role of uncertainty in the representation of this knowledge and how it may be treated (probability theory vs. fuzzy sets or other, *ad hoc* methods).

4. Application and comparison of models for emotion activation and recognition purposes to dialogs (several scenarios extracted from real dialog corpus of France Telecom).
5. Development and application of validation methods for these models.

Summary of planned publications:

- Submission to the workshop *Agent construction and emotions: modeling the cognitive antecedents and consequences of emotions* (ACE2006), Vienna, April 2006.
- Submission to an international journal (e.g. *Interaction Studies*) on a model of interpersonal stance with ECAs.
- Chapter for the WP7 book on the comparison of both BDI&E models based on their application to the scenarios derived from the real dialog corpus.
- Chapter for the Handbook or the WP7 book with the results of our analysis of BDI&E methods available in this domain (in particular, of those developed by the groups involved in WP7), with some suggestions of when it is or it is not worth using them.

3.3 Element 3: Emotion in bridging the gap between embodied and reflective cognition and action

3.3.1 Coordinator

Paolo Petta (OFAI)

3.3.2 Main participants

OFAI: Paolo Petta, Stefan Rank

HW: Ruth Aylett, Pablo Lucas dos Anjos, Mei Yii Lim

USC: Jonathan Gratch, Stacy Marsella

INESC-ID & IST: Ana Paiva, João Dias

KCL: John Taylor, Nienke Korsten

GERG: Klaus Scherer, Etienne Roesch, David Sander

UOXF: Brian Parkinson

Univ. of Manchester: Sabine Döring

Former participants: Daniel Thalmann, Etienne de Sevin (EPFL)

3.3.3 Rationale and scope of element 3

This element investigates the role of emotions in relating behavioural meaning and symbolic representations: how do the processes that depend directly on embodiment through sensing,

motor action, and homeostatic internal processes, shape and constrain symbolically-based activities, and vice-versa? (It thus also reflects in engineering terms the challenge to relate the 'reflective/symbolic' language of Psychology to the 'embodied' view of Neuroscience). To this end, a subtask (described in deliverable D7c) contributes a scenario-based survey aimed at characterizing the overall range of bridging functions of emotions in cognition and action. This activity is complemented by a pair of subtasks proceeding in a focused way, researching and proposing extensions over specific models of embodied and reflective cognition and action; a fourth subtask tackles the gap between micro- (individual-based) and macro- (social) views on social functions of emotion, thereby providing a bridge to Element 4. The main subtasks of this element 3 are:

E3.1 – A scenario-based survey of bridging functions of emotions

This subtask is aimed at providing a survey of state-of-the-art emotion architectures and the scenarios they have been applied to, documenting success stories and important failures in a coherent, principled vocabulary and against authoritative competence in emotion theory provided by partners from WP3. Given the early status of the field, this survey will mainly cover a selection of characteristic emotion-oriented systems, chosen according to criteria laid out in more detail in D7c.

E3.2 – Improving upon symbolic models of reflective cognition and action

Due to the level of abstraction adopted, various important aspects of emotions remain outside the scope of symbolic models of reflective cognition and action. Reified modal emotions, static appraisal frames, clear-cut framing of discrete events, and use of inter-subjective vocabulary to model private (subjective) states and processes are some examples reflecting the distance maintained from current sensing. Emotions in contrast also serve functions in the very construal of situational meaning and in biasing the conceptualization of the environment; further, the importance of the distinction of emotionally experienced situations as object of emotion and the cause of emotion, which may or not be a datum of experience has been emphasized – see e.g. Frijda (1986, p.188ss) and Reisenzein (in press). This subtask will research directions and means to improve upon symbolic reflective architectures using the EMA architecture (Gratch & Marsella, 2004) as first reference system to bridge from.

E3.3 – Improving upon embodied models of cognition and action

This subtask will research directions and means to improve upon embodied architectures by extending towards reflection providing e.g. stock-taking or categorizing functionalities, thereby mirroring the direction taken in subtask E3.2. Here, an instance of an embodied emotional architecture under development at UH will be taken as the 'from' starting point, and reflective architectures as covered in WP6 will be considered as first (although not necessarily the ideal) candidates for the 'to' system. In analogy to E3.2, particular attention will be paid to the critical literature addressing fundamental limitations of today's approaches to embodiment, while particular attention will be paid to relevant WP3 Theory (such as evidence for discrepancies between the results of reflective assessments and actual inputs, or degrees of influence of interpretative or inferential processes correlating inversely to coherence and richness of stimulation).

E3.4 – Bridging the gap between micro- (individual-based) and macro- (social) views on social functions of emotion

Emotions play an important functional role within both individuals and societies, thereby forming an important bond between these two levels of analysis. In particular, there is a bi-directional interrelationship between social norms and emotions, with emotions playing an instrumental role for the sustenance of social norms and social norms being an essential element of regulation in the individual emotional system. Research in this Element will address the interplay between cognition and action, at both micro and macro levels, with the aim to improve the understanding of the relation of internal affective architecture and social interaction. Ethical issues may arise in diversified societies in the context of the tension between enforced norms and encultured suggestive interaction procedures. Here, this Element could contribute to WP10 (Ethics) with models of the development of commonly agreed standards within originally disparate groups of individuals. In close co-operation with Element 4, this subtask will carry out critical evaluations commonly employed for the explanation and simulation of human social behaviour – cf. Staller *et al.*, (2000), Staller & Petta, (2001), in particular, logic-based models.

3.3.4 Main steps planned towards producing this element

3.3.4.1 Subtask E3.1 – A scenario-based survey of bridging functions of emotions

Main contributors and their contributed expertise:

- All WG partners (Subtask leader: Stefan Rank, OFAI)

Summary of key steps:

- This subtask is organized in five Threads, cf. deliverable D7c

Summary of planned publications:

- Submission to ACE2006: Agent Construction and Emotions: Modeling the Cognitive Antecedents and Consequences of Emotion, April 18-20, 2006, Vienna, Austria, EU
- Submission to Narrative AI and Games, AISB 2006 convention, April 5-6, 2006, University of Bristol, Bristol, England, UK, EU.
- Submission to IVA2006: The 6th International Conference on Intelligent Virtual Agents, 21st-23rd August 2006, Marina del Rey, LA, CA, USA.
- Chapter submissions for WP7 book summarizing key findings of this subtask.
- Contribution to the HUMAINE handbook

3.3.4.2 Subtask E3.2 – Improving upon symbolic models of reflective cognition and action

Main contributors and their contributed expertise:

- OFAI: Paolo Petta, Stefan Rank (Situating emotion architectures)

- USC: Jonathan Gratch, Stacy Marsella (EMA, a reference symbolic emotion architecture)
- KCL: John Taylor, Nienke Korsten (Computational cognitive neuroscience)
- GERG: Etienne Roesch and Klaus Scherer (WP3 Theory)
- UOXF: Brian Parkison (WP3 Theory)

Summary of key steps:

1. In-depth analysis and discussion of the scope of the EMA architecture (ongoing, but carried out largely during the month-long visit paid by Jonathan Gratch to OFAI in July 2005).
2. Analysis of the applicability of elements from critiques of introspectionist analysis (derived from e.g., Brentano 1874; Gibson 1966, Frijda 1986 section 4.3, pp.186ss.) to identify theoretically important directions of research.
3. Identification of an example embodied AI system to bridge to, along with example interactions between these systems (informed by results of key step 2), e.g. constraints on what behaviours are primed; emotion regulation and coping styles; or stereotyped social behaviours and rituals on the one side, and e.g., internal attentional focus; constraints on cognitive appraisal and reasoning; bias on theory of mind applied to actions of others; emotional flooding.
4. Identification of mechanisms supporting such interactions (informed by WP3 Theory) and (possibly) limited empirical validation.
5. Jointly with E3.3, evaluation of progress achieved towards understanding (bridging) the gap

Summary of planned publications:

- Paper submission to a specialized conference in late 2006 (e.g., International Conference on Cognitive Modeling 2007)
- Journal article on the EMA emotion model (to be submitted to either *Emotion and Cognition* or *Emotion*)
- Conference submission on an evaluation study of EMA to IVA2007
- Chapter submission for WP7 book summarizing key findings of this subtask.

3.3.4.3 Subtask E3.3 – Improving upon embodied models of cognition and action

Main contributors and their contributed expertise:

- HWU: Ruth Aylett (embodied and reflective architectures)
- INESC-ID: João Dias (reflective symbolic architectures)
- IST: Ana Paiva (reflective symbolic architectures)

- KCL: John Taylor, Nienke Korsten
- GERG: David Sander
- UH: Lola Cañamero and Robert Marsh will provide information regarding their motivation- and emotion-based embodied robotic architectures and critical commentary on results from this subtask, ensuring the link with Element 1.

Summary of key steps:

1. Selection and in-depth analysis of the scope of the chosen ‘from’ system
2. Analysis of the applicability of elements from critiques of embodied systems to identify theoretically important directions of research.
3. Identification of an example reflective system to bridge to, along with example interactions between these systems (cf., E3.2 step 3)
4. Identification of mechanisms supporting such interactions (informed by WP3 Theory) and (possibly) limited empirical validation
5. Jointly with E3.2, evaluation of progress achieved towards understanding (bridging) the gap

Summary of planned publications:

- Submission to *Psychonomic Bulletin & Review* commenting on “Six Views of Embodied Cognition”

3.3.4.4 Subtask E3.4 – Bridging the gap between micro- (individual-based) and macro- (social) views on social functions of emotion

Main contributors and their contributed expertise:

- HW: Pablo Lucas dos Anjos, Ruth Aylett (embodied and reflective architectures)
- Univ. of Manchester: Sabine Döring (ethical theory of norms)
- UOXF: Brian Parkinson (social psychological perspective on emotions)
- OFAI: Paolo Petta (computational study of social norms)

Summary of key steps:

1. Critical review of theories of emotionally empowered social models
2. Derivation of a principled design for socially situated agents, avoiding gratuitous reification of normative and emotional elements
3. Empirical validation in an agent-based social simulation scenario
4. (Alongside) Cooperation with Element 4 (Emotion in social cognition and interaction), and with WP10 relevant topics

Summary of planned publications:

- Submission to IVA 2006, The 6th International Conference on Intelligent Virtual Agents, 21st -23rd August 2006, Marina del Rey, LA, CA, USA.
- Submission to JASSS (The Journal of Artificial Societies and Social Simulation)
- A chapter submission for the WP7 book on the modeling of the interplay of social normativity and emotions

3.4 Element 4: Emotion in social cognition and interaction

3.4.1 Coordinator

Arjan Egges (UNIGE-MIRALab) and Lola Cañamero (UH): coordinators of subtask “Closing the emotion recognition-generation-expression loop”

Sabine Payr (OFAI): coordinator of subtask “Socially situated affective dialogue”

3.4.2 Main participants

UNIGE: Arjan Egges (MIRALab), Didier Grandjean (GERG)

EPFL: Alejandra García-Rojas

ICCS-NTUA: Kostas Karpouzis

DIST: Ginevra Castellano, Antonio Camurri, Gualtiero Volpe

UH: Arnaud Blanchard, Lola Cañamero

CNRS-EPML38: Jacqueline Nadel, Philippe Gaussier, Pierre Andry, Arnaud Revel

OFAI: Sabine Payr

U. Sheffield: Peter Wallis

DI-Bari: Fiorella de Rosis

CNR: Maria Miceli, Isabella Poggio

3.4.3 Rationale and scope of element 4

This element of the exemplar investigates the roles of emotions in social cognition and interaction. Contrary to the previous elements, emotions, cognition and action are not modeled from the perspective of the individual agent but from the point of view of the interaction itself. Therefore, the unit of analysis is not the individual (its embodiment or its mental states) but the *relations* in groups of two or more agents. These relations might appear as a result of a wide range of “internal” and “external” factors, and can be investigated from a micro- or a macro-level perspective. This element thus covers a very wide range of topics. Its goal is to work towards an understanding of key representative problems in the thematic area,

especially of the interrelations with other elements and workpackages. It focuses on two main subtasks:

E4.1 – Towards socially meaningful emotional agents: Closing the emotion recognition-generation-expression loop

To be emotionally competent in the context of social interaction in a way that is meaningful to humans, an agent must integrate the capabilities to express and recognize/respond to emotions with an emotion-oriented architecture that grounds and coordinates such capabilities in a socially meaningful way. This theme seeks to make a contribution towards establishing principled and well-founded links between the production of socially meaningful expressive behaviour, emotion-oriented architectures that can ground the generation of this behaviour, and analysis/recognition of such expressive behaviour in social settings. It thus explicitly establishes links with WPs 4 and 6. Due to the complexity of each of these aspects, they are usually developed independently, and this is the case in works with robots, ECAs, virtual humans, and other software simulations. Even within HUMAINE, these aspects have been allocated to different Workpackages (4, 6 and 7), due to the need to divide problems so that they can be addressed in a tractable way. We are aware of the artificial nature of this division, but also of the difficulty of trying to overcome it; therefore, we cannot aim at proposing full-blown solutions but rather guidelines and proofs-of-concept of some of the key aspects relevant to such integration. To ensure the feasibility of this task, we will focus particularly on a type of (non-verbal) interactions that involves the “sharing” of affective state by two or more agents as mediated through the body (including the face), so that (shared) affective state can be appropriately recognized from its behavioural manifestations. Our primary context will thus be that of affective imitation-related interactions, focusing on parameters related to the dynamics of emotional expression and interpretation. We will use different platforms / types of “embodiments” (humans, robots, virtual humans and ECAs) and social / interactive situations (performing arts, developmental psychology, human-robot and human-machine interaction) in order to avoid producing too narrow an outcome that would be biased towards one of them.

E4.2 – Socially situated nature of emotions: Socially situated affective dialogue

Since the Media Equation (Reeves and Nass, 1996), the HCI community has more or less implicitly assumed that interactive machines are viewed as social partners by their users. This seems to apply to ECAs even more, since their whole design aims at offering the user a social counterpart to interact with. Work in HUMAINE is based, among others, on the insight that recognition, interpretation and generation of emotions is a keystone to sustainable social relationships between humans and humans, and hence, between humans and “social machines”. The focus of affective human-ECA interaction has been, so far, on individual emotions (e.g., fear, anger, joy) rather than on social emotions (e.g., irritation, attraction). Researchers in different domains have come to the conclusion that there is more to such a relationship than mastering emotional (verbal and non-verbal) expression during the interaction. For example, results from emotion recognition in “natural” conversation remain unsatisfying and call for a shift in perspective from the subject alone to the interaction as a whole (Batliner *et al.*, 2004). Humans and interactive artifacts are cast in roles that are socially (globally) constructed outside the situation and locally “managed” by interactants, but not freely neglected or cast aside (Guilfoyle, 2003). We call this fact the “social situatedness of interaction”, factored, among others, by power and trust relations among agents. The need for an emotional model to represent and reason about social power has been recognized but not implemented, e.g. in EMA, probably the most complex and advanced architecture currently around (Gratch and Marsella, 2004). The issue of power relations and

social identity has also been addressed in the context of verbal abuse in chatterbot interactions (De Angeli and Carpenter, 2005). However, what is most missing in this area is a *common conceptual framework* for the interpretation of social relationships between humans and artifacts, e.g. persuasion, advice-giving, inquiry, abuse, conversational implicature, etc. We wish to extend to social relationship the range of affective factors which are considered in interaction. The main questions we have to address are: (a) What kind(s) of “social knowledge” is/are necessary to correctly recognize and interpret user emotion and build sustainable social relationships?; (b) How can “social knowledge” be incorporated into appraisal-based theories of emotion?; (c) In what social role the artifact with which the user is interacting is cast and which roles does it assume by design?; and (d) What does this imply for (the design of) human-machine interaction? The output produced will be a design-oriented theoretical reflection.

3.4.4 Main steps planned towards producing this element

3.4.4.1 Subtask E4.1 – Closing the emotion recognition-generation-expression loop

Main contributors:

- UNIGE: Arjan Egges (MIRALab), Didier Grandjean (GERG)
- EPFL: Alejandra García-Rojas
- ICCS-NTUA: Kostas Karpouzis
- DIST: Ginevra Castellano, Antonio Camurri, Gualtiero Volpe
- UH: Arnaud Blanchard, Lola Cañamero
- CNRS-EPML38: Jacqueline Nadel, Robert Soussignan, Arnaud Revel, Philippe Gaussier, Pierre Andry

Summary of key steps:

1. Elaboration of feature-based appraisal checks for facial expressions, based on MPEG-4-related concepts and building on experience from earlier projects regarding dimensional models for facial expressions and hand gestures. These checks will be tested on a common synthesis virtual environment (Greta) to ensure interoperability with other exemplars. They will also be compared with tests on human recognition of / response to emotional expression in robotic faces.
2. Investigation and guidelines to translate information described using high-level parameters such as emotion and personality into direct control of expressive (bodily and facial) behaviour. No clear and generic system/methodology exists that instructs us on how to achieve expressive behaviour mediated through emotions and personality. In the case of virtual humans, a means to create realistic body (and face) motions is to use motion capture techniques. However, there is very little control over how the virtual human is actually moving. Clearly, systems that generate expressive behaviour using emotion and personality information will need a great level of control over the body of the virtual human. However, only detailed control of expressive behaviour is not enough: a structure is required that describes (and allows to reconstruct, stock, retrieve and reuse) possible relationships between emotions, personality and motions semantically, such as an ontology.

3. Investigation of (some of) the roles of rhythm, synchronization, movement and posture / gestures as components of emotional processes and conveyors of emotional content across various types of interactive scenarios and platforms, involving different combinations of human, robotic, and virtual social partners. This investigation will be based on available literature and comparison of empirical studies in different areas and settings (performing arts, developmental psychology, human-robot and human-ECA/virtual human interactions) and mainly focused on affect- and imitation-related activities (e.g. contagion, empathy).
4. Analysis and evaluation (from embodied robotics and developmental psychology views) of robot-human interactive systems that close the emotion recognition-generation-expression loop.
5. Early specification towards the elaboration of a dynamic model for emotion recognition / interpretation that takes into account the dynamics of an emotional process in terms of the dynamics of its motor behaviour. This would combine expertise and insight gained from performing arts (dance), embodied robotics and (developmental) psychology.

Summary of planned publications:

- Submission to relevant conference (e.g. IFIP Conference on AI Applications) or journal (e.g. *Humanoid Robotics*), of paper on feature-based appraisal checks for facial expressions, in particular on requirements in the form of a table of applications vs. features, and a facial expression recognizer based on dimensional and appraisal models. Possibly also organization of a related special session during the ICANN 06 conference next year in Athens.
- Submission(s) on guidelines and evaluation criteria for systems that generate expressive behaviour mediated through personality and emotions, supported by several evaluation studies performed by the partners involved in the working group. These evaluations will identify needs and problems in the different systems and they will establish a “common ground” for constructing expressive behaviour synthesizers. Potential targets are the CASA’06 conference, the *Intl. Journal of Human-Computer Studies*, or the WP7 book.
- Submission on investigation of the roles of rhythm, synchronization, movement and posture/gestures as components of emotional processes and conveyors of emotional content across various types of interactive scenarios and platforms. Potential targets are the journal *Interaction Studies* and the WP7 book.
- Submission on robot-human interactive systems that close the emotion recognition-generation-expression loop. Potential targets: *Intl. J. Humanoid Robotics*, WP7 book.
- Draft document on early specification towards the elaboration of a dynamic model for emotion recognition / interpretation based on the dynamics of motor behaviour. Possibly submission for WP7 book, perhaps as part of the previous point.

3.4.4.2 Subtask E4.2 – Socially situated affective dialogue

Main contributors:

- OFAI: Sabine Payr
- DI-Bari: Fiorella de Rosis
- U. Sheffield: Peter Wallis
- CNR: Maria Miceli and Isabella Poggi

Summary of key steps:

1. Elaboration of a “map of the territory” to identify existing “resources” and needs towards the elaboration of a common conceptual framework for the interpretation of social relationships between humans and artifacts (ongoing)
2. Investigation of sociological, sociolinguistic and related research work to come up with methods and models that relate discourse behaviour to social roles, e.g. power relationships, cf. the “Power-Related Talk” approach, Thimm *et al.* (2001); Thimm and Kruse (1993). This step involves cooperation with WP 9, Elements 1 and 2, insofar as it touches on the issue of what aspects or conceptual dimensions of ECAs are evaluated; and consequently on the evaluation methods.
3. Analysis of affective dialogue and persuasion systems elaborated under Element 2 of this exemplar and WP8 from the perspective of this conceptual framework.
4. Critical evaluation of logical models that are commonly employed for the explanation and simulation of human social behaviour, with a focus on the interrelationship between emotions and social norms. This step will be carried out in close cooperation with Element 3, subtask E3.4.

Summary of planned publications:

- Submission to an appropriate conference/symposium (e.g. CASA 2006) outlining approaches and initial work on the “map”.
- Submission to *Applied AI Journal* elaborating the aforementioned submission and integrating some elements of analysis of affective dialogue systems (step 3)
- Chapter submission for WP7 book, provisionally “Socially situated affective dialogue”

3.5 Steps to ensure co-ordination

Coordination of joint activities has been (and will be) ensured through various means, such as email and telephone exchanges, telephone / skype conferences, uploading working papers on the portal and use of the portal collaboration facilities, visit to partners (both using the interchanges program and self-funded from the partners’ travel budget, see a selection of visits in Section 4.5.1), and working meetings arranged taking advantage of HUMAINE and other conferences and events. We will continue to use similar instruments during the rest of the project. In addition, we plan to organize small thematic workshops (involving thematic groups within one element or across elements), using the interchanges program whenever possible.

The different elements of the exemplar are highly related among them and with other workpackages, as we have been indicating at relevant points, and good amount of interaction will be needed. Coordination among ‘subtasks’ of the elements can be summarized as:

- Element 1: The various subtasks are very interrelated, e.g., the analysis carried in subtask E1.2 is primarily based on the work carried out in E1.1, and subtask E1.3 increases the level of complexity of the “perceptual” aspect (and its interactions with emotion) of the emotionally modulated perception-action loop considered in E1.1. Coordination of subtasks is concerned with the identification of key properties underlying “embodied” interactions between emotion and cognition-action. Main coordination instruments planned: exchanges of papers, workshops of the entire E1 in 2006 (target: Spring) and in 2007 (target: Summer/Autumn).
- Element 2: Coordination activities will be targeted at achieving a deeper critical understanding of the potential and roles of cognitive Belief-Desire-Intention-and-Emotion (BDI&E) models in human-technology interaction and communication. Main coordination instruments planned: several meetings between DI-Bari and CNR-Rome; visit from France Telecom to DI-Bari; meeting in Vienna (april 2006) of partners involved in WP7, in the scope of the ACE’06 Symposium.
- Element 3: Coordination activities are targeted at ensuring complementarity of the different aspects in ‘bridging the gap’ and input/feedback from the other elements and related workpackages (particularly 2 and 10). Coordination instruments have already been detailed through the description of the element; other instruments include a meeting of Elements 3 and 4 (2nd quarter 2006), and a visit of Brian Parkinson (UOXF) to OFAI, within the interchanges program (end of 1st quarter of 2006).
- Element 4: Co-ordination of subtasks is concerned with identification of links between requirements for socially situated affective systems (focus of subtask E4.2) and their consequences for generation and recognition of socially meaningful expressive behaviour (focus of subtask E4.1). Main coordination instruments: exchange of papers, meeting at CASA 2006.

3.6 Steps to ensure dissemination

This workpackage has been very active in dissemination activities, both within HUMAINE (cf. the numerous presentations of this WP at all the network events held so far; also links with other workpackages) and outside the project, as evidenced for example by the editorial projects, conferences, and invited talks listed in Section 5.2.

Future dissemination outside the network will continue along the same lines; as an example, members of this WP (R. Aylett, L. Cañamero, F. de Rosis, A. Paiva and P. Petta) are actively involved in the preparation of a HUMAINE-associated bid to organize the 2nd edition of the *International Conference on Affective Computing and Intelligent Interaction (ACII 2007)*. As part of this bid, the scope of the conference would be extended to include topics related to “emotion in cognition and action” and to “theories and models of emotions”, absent from the first edition.

Future dissemination activities within HUMAINE will also include strong presence of this WP in activities organized by other WPs. In addition, interaction with other WPs will be ensured through contributions (as chapter (co-)authors, discussants, or commentators) to the

project Handbook, and through contributions solicited from members of other WPs (as chapter (co-)authors, discussants, or commentators) the WP7 book.

4 Summary of work done to date

4.1 Element 1: Emotion in embodied cognition and action

Tasks

Subtask E1.1 (emotional modulation of embodied perception-action):

- Design, implementation and evaluation of various types of robotic architectures from the perspective of their potential for emotional modulation (draft documents, presentations and publications produced).
- Initial experiments on modulation of exteroception and interoception in LEGO robots. Papers circulated on these experiments and related theory from neuroscience and psychology. Meetings and discussions held at various HUMAINE events.
- Draft document on the neural correlates of stimulus evaluation checks (SEC's) from appraisal theory (developed for use within E.1.3 as well).
- Presentations at HUMAINE WP3 workshop (Cañamero and Avila-García), Computational modeling” symposium within Plenary 2 (Frangopoulos-Taylor, Cañamero), WP7 workshop (Taylor, Grandjean, Marsh), and “Computational modeling” symposium at ISRE’05 (Cañamero).

Subtask E1.2 (analysis):

- Design, implementation and recording of systematic robotic experiments for ethological analysis. Detailed analysis of videos is currently ongoing, and preliminary draft documents have been produced
- Presentations at HUMAINE events by te Boekhorst (workshops of WP3, WP4 and WP7) and Gaussier (WP7 workshop).
- Application of algebra formalism to a very simple architecture that learns to recognize and reproduce facial expressions without having the innate capability to recognize the facial expressions of others.
- Initial meetings on joint work on formalizations (dynamical systems and algebra) at and after the HUMAINE WP7 workshop in London (July 4-6, 2005) and Epigenetic Robotics Workshop in Nara, Japan (July 22-24, 2005).

Subtask E1.3 (novelty detection and emotion-attention interactions):

- Literature review, background study and presentation of novelty and processing of faces based on gaze configurations and facial expression.
- Study of and presentation on relationship between novelty and emotional processes and temporal sequence of appraisal processing at different levels in the brain.
- Implementation of direction of attention perception module for driving the behaviour of embodied agents.

- Presentations by Grandjean and Peters at HUMAINE WP7 workshop.

Publications

Subtask E1.1, see references: Avila-García and Cañamero (2004, 2005), Cañamero (2005), French and Cañamero (2005).

Subtask E1.2, see references: Cañamero and Gaussier (2005), Prepin *et al.* (submitted 2005)

Subtask E1.3, see references: Peters (submitted 2005); Sander *et al.* (in press);

4.2 Element 2: Emotion in reflective cognition and action

Tasks

- Email discussions and meetings at the HUMAINE Plenaries and WP7 workshop regarding comparison of BDI&E models and application to dialogue corpus. Preparatory work on the dialog corpus of several applications of France Telecom to extract emotional dialog situations from vocal and written corpus (ongoing until February 2006).
- Draft document on “anticipation and emotion”.
- Discussions on BDI&E models at several meetings (Vienna 2004, AISB’05, WP7 workshop) and paper on cognitive emotion models sent to AISB’05 symposium.
- Several meetings between CNR-Rome and DI-Bari on validation of cognitive models of emotion and ‘cognitive dissonance’ (past and planned).

Publications

See references: Carofiglio and de Rosis (2005); Carofiglio *et al.* (forthcoming 2006); Miceli *et al.* (in press); Ochs *et al.* (2005).

4.3 Element 3: Emotion in bridging the gap between embodied and reflective cognition and action

Tasks

Subtask E3.1:

- Resources and bibliographic records have been added on the Humaine portal.
- Seed version of the survey paper and of the evolving documents being worked on in this Subtask are accessible on the portal
- Presentations at the WP7 Workshop

Subtask E3.2:

- Definition of workplan and first in-depth critique of EMA during exchange visit of Jon Gratch (USC) to OFAI; arrangements for research license of EMA for OFAI.
- Discussion of presentations of EMA and TABASCO at the ISRE 2005 symposium.
- Coverage in the WP7 presentation by Paolo Petta and Ruth Aylett

Subtask E3.3:

- Specification of workplan
- Notes by Nienke Korsten and John Taylor (KCL) on appraisal from a neurobiology perspective (Neural correlates of Stimulus Evaluation Checks)

Subtask E3.4:

- First outline of scope of work during exchange visit by Pablo Lucas dos Anjos (HWU) at OFAI;
- Initial specification of workplan

Publications

See references: Gratch & Marsella (in press); Lim *et al.* (2005, 2005a); Rank (2005), Rank & Petta (2005, 2005a), Rank *et al.* (2005, in press); Sevin, de & Thalmann (2005), Sevin, de (2006).

4.4 Element 4: Emotion in social cognition and interaction

Tasks

Subtask E4.1 (closing the emotion recognition-generation-expression loop):

- For step 1: work on visual emotion recognition from low-level features and currently considering a multi-modal/continuous approach. Annotated dataset containing facial expressions and another with hand gestures, used to train neural networks, HMMs and neurofuzzy algorithms. Presentation by Malatesta at WP7 workshop and paper submitted to IJHR 2006 special issue.
- For step 2: several meetings, presentation by Egges and Garcia-Rojas at WP7 workshop and papers submitted to IJHR 2006 special issue.
- For step 3: discussions and posters presented by Castellano and Blanchard at several HUMAINE meetings, presentation by Nadel at AISB'05 symposium, and exchange of papers written on different aspects of this topic.
- For step 4: elaboration of affect-oriented perception-action architectures for synchronization, imprinting and adaptation in the context of imitation; exchange of papers; presentations by Nadel and by Blanchard at workshops of WP6 and WP7, and by Gaussier at WP7 workshop.

- For step 5: initial (formal) analysis of robotic architectures of the above type using the algebra proposed under Element 1 of the exemplar.

Subtask E4.2 (socially situated affective dialogue):

- Organization of workshop “Sociality with Machines” by OFAI (November 2004), starting point for cooperation on this subject
- Exchange of papers, preparatory work by partners (see publications) and discussions by email, telephone and at different HUMAINE events and other conferences
- Presentations at WP7 workshop by Payr and de Rosis

Publications

Subtask E4.1, see references: Blanchard and Cañamero (2005a, 2005b); Cañamero and Gaussier (2005); Egges *et al.* (submitted 2005); García-Rojas *et al.* (submitted 2005); Prepin *et al.* (submitted 2005); Raouzaïou *et al.* (submitted 2005).

Subtask E4.2, see references: Cavalluzzi *et al.* (2004); de Rosis *et al.* (2005); Miceli *et al.* (in press); Wallis (2005).

4.5 Coordination activities

4.5.1 Examples of visits

Funded by the Interchanges Program:

- May 2005: Visits of Pablo Lucas dos Anjos (14 days) and Ruth Aylett (3 days) from HWU to OFAI as part of Element 3. Main topics: furthering of research agenda in Element 3, work on the survey in Subtask 1 (Threads A-C according to Deliverable D7c). Preparation of two joint presentations (Paolo Petta + Ruth Aylett, Stefan Rank + Pablo Lucas dos Anjos) for the WP7 workshop, joint survey paper seed (Rank *et al.*, 2005; also part of D11a); Paolo Petta (OF AI) to serve as external Ph.D. advisor (clearance by HWU pending).
- November 2005: 1-month visit of João Dias (INESC-ID) to USC as part of Element 3. Main topic: improving validation of emotion models against human data by automatizing the generation of textual descriptions from emotion evoking scenarios with a model-to-text conversion program.

Funded by partners:

- December 2004: 2-day visit of Arnaud Blanchard (UH) to GERG. Main topic: design and discussion of robotic scenarios to act as platforms for subtask E.1 of Element 1.
- January 2005: 2-day visit of Paolo Petta (OF AI) to GERG. Main topic: collaboration of WP3 and WP7.
- July 2005: 1-month visit of Jon Gratch (USC) to OFAI. Main topics: in-depth critical discussion of the EMA and TABASCO architectures; development of further workplan on Subtask 2; organisation of the international ACE 2006 symposium.

- July 2005: 1-day visit of Philippe Gaussier (CNRS-EPML38) to UH. Main topic: discussion on formalization of emotionally modulated robotic architectures
- November 2005: 2-day visits of Peter Goldie and Sabine Döring (Univ. Manchester) to OFAI. Main topics: critiques of utility-based and objective frame-of-reference oriented evaluative models from WP7 and WP10 points of view.
- Spring 2006: 2-day visit of Peter Goldie and Sabine Döring (Univ. Manchester) to UH.

4.5.2 Work involving all the elements

The main pieces of work involving all the elements and their relations consist of (a) distribution of a questionnaire prior to the WP7 workshop and discussions around it regarding the (theoretical and computational) assumptions underlying the different models and approaches involved in the exemplar; and (b) several meetings explicitly organized for the purpose of fostering the understanding and dialogue among the different elements, namely:

- Symposium *Agents that Want and Like: Motivational and Emotional Roots of Cognition and Action* (http://homepages.feis.herts.ac.uk/~comqlc/emotivation_aisb05) organized within the 2005 AISB Convention at the University of Hertfordshire, UK, on April 14-15, 2005. The program is enclosed below.
- Workshop of WP7, held King's College London on July 4-5, 2005. The program is enclosed below, and the presentations are available on the HUMAINE portal.
- Symposium on “computational modeling of emotions” held at the Second Plenary meeting of HUMAINE, addressing also the relationships between theories (WP3) and implemented models (WP7). The program and the presentations are available on the HUMAINE portal.
- Symposium on “computational modeling of emotions” organized at the 13th *Conference of the Intl. Society for Research on Emotion* in Bari, Italy, July 14, 2005, addressing also the relationships between theories (WP3) and implemented models (WP7); see Section 5.2.2.

4.5.2.1 Program of the AISB'05 Symposium ‘Agents that Want and Like: Motivational and Emotional Roots of Cognition and Action’

Held at the University of Hertfordshire, College Lane Campus, Hatfield, Herts AL10 9AB

Thursday April 14, 2005

8:30 – 9:00 Coffee

9:00 – 10:00 *AISB'05 Plenary talk III*

Hiroshi Ishiguro: From inter-personal to social relationships with robots – studies on interactive humanoids and androids

10:00 – 10:30 Coffee

- 10:30 – 12:20 *Session 1: Characterizing motivation and emotion*
- Keynote 1: Emotion as motivated behaviour – George Ainslei (50 min)*
- Keynote 2: Emotions as evaluations – Peter Goldie and Sabine Döring (50 min)*
- 12:20 – 12:30 *Poster spotlights (see list of posters at the end of the timetable)*
- 12:30 – 13:45 Lunch and Poster session
- 13:45 – 14:45 *AISB'05 Plenary talk IV*
- Alison Jolly: Social intelligence in primates and primatologists
- 15:00 – 16:30 *Session 2: Modeling and analyzing emotion in social contexts*
- Motivating dramatic interactions – Stefan Rank and Paolo Petta (30 min)
 - Emotion and motivation in embodied conversational agents – Nicole C. Krämer, Ido A. Iurgel and Gary Bente (30 min)
 - Synthetic emotivators – Carlos Martinho and Ana Paiva (15 min)
 - Experimental study of emotional manifestations during a problem-solving activity – Delphine Duvallet and Evelyne Clément (15 min)
- 16:30 – 17:00 Coffee
- 17:00 – 18:30 *Session 3: The many faces of motivation and emotion: Bringing together modeling frameworks – Panel discussion. Participants: Rene te Boekhorst (University of Hertfordshire), Joanna Bryson (University of Bath), Ron Chrisley (University of Sussex), Stacy Marsella (ISI), Murray Shanahan (Imperial College), Steve Torrance (University of Sussex)*
- 19:30 – 22:00 Excursion with dinner

Friday April 15, 2005

- 8:30 – 9:00 Coffee
- 9:00 – 10:00 *AISB'05 Plenary talk V*
- Luc Steels: Stages and challenges in evolving language-like communication for robotic agents
- 10:00 – 10:30 Coffee
- 10:30 – 12:30 *Session 4: Links between motivation and emotion*
- Keynote 3: The missing link between emotion and motivation: Insights from developmental research – Jacqueline Nadel (1 hour)*
- General discussion (1 hour)*
- 12:30 – 13:45 Lunch and Poster sessions
- 13:45 – 15:45 *Session 5: Emotion-cognition links in adaptation and learning*
- Hormonal modulation of perception in a motivation-based action selection architectures – Orlando Avila-García and Lola Cañamero (30 min)

- The emotive episode is a composition of anticipatory and reactive evaluations – Mercedes Lahnstein (30 min)
- Cost minimisation and Reward maximisation. A neuromodulating minimal disturbance system using anti-hebbian spike timing-dependent plasticity – Karla Parussel and Leslie S. Smith (15 min)
- Personality and learning in robots: The role of individual motivations / expectations / emotions in robot adaptive behaviours – Barbara Caci, Maurizio Cardaci, Antonio Chella, Antonella D’Amico, Ignazio Infantino and Irene Macaluso (15 min)
- A consideration of decision-making, motivation and emotions within Dual Process theory: supporting evidence from Somatic-Marker theory and simulations of the Iowa Gambling task – Kiran Kalidindi, Howard Bowman and Brad Wyble (15 min)
- A model of emotional influence on memory processing – Philippe Chassy and Fernand Gobet (15 min)

15:45 – 16:15 Coffee

16:15 – 17:45 Session 6: *Emotions, beliefs and misbeliefs*

- Models of misbelief: Integrating motivational and deficit theories of delusions – Ryan McKay, Robyn Langdon and Max Coltheart (30 min)
- See what you want, believe what you like: Relevance and likeability in belief formation – Fabio Paglieri (30 min)
- Cogito ergo ago: Foundation for a computational model of behaviour change – Cosimo Nobile and Floriana Grasso (15 min)
- Integrating domain-independent strategies into an emotionally sound affective framework for an intelligent learning environment – Mohd Zaliman Yusoff and Benedict du Boulay (15 min)

17:45 Closing

List of posters (displayed for the entire duration of the symposium):

- Analysis of the human physiological responses and multimodal emotional signals to an interactive computer – M. R. Ciceri, S. Balzarotti and P. Colombo
- Motivation-driven learning of action affordances – Ignasi Cos-Aguilera, Lola Cañamero and Gillian Hayes
- Figurative language expressing emotion and motivation in a web-based learning environment – Manuela Delfino and Stefania Manca
- Motives inside out – Kamalini Martin
- Emotions as reasons for action: a two-dimensional model of meta-telic orientations and some empirical findings – Ulrich Mees and Annette Schmitt
- Symbolic objects and symbolic behaviours: cognitive support for emotion and motivation in rational agents – Antônio Carlos da Rocha Costa and Paulo Luis Rosa Sousa
- An affective model of action selection for virtual humans – Etienne de Sevin and Daniel Thalmann

4.5.2.2 Program of WP7 Workshop ‘Emotion in Cognition and Action’

Monday July 4, 2005

8:45 – 9:00 Arrival and registration

9:00 – 9:15 Introduction to the Workshop – Lola Cañamero

Session 1: Brains and Bodies in Emotion Modeling

- 9:15 – 10:00 Emotion-Attention Interactions – John Taylor
- 10:00 – 10:15 Steps Towards Modelling Attention to Expressive Faces for Agent Interaction – Christopher Peters
- 10:15 – 10:30 The emotive episode is a composition of anticipatory and reactive evaluations – Mercedes Lahnstein
- 10:30 – 11:00 Coffee break and Poster session
- 11:00 – 11:30 Novelty and Emotional Processes: Reciprocal Benefits of Psychological and Cognitive Neuroscience Approaches – Didier Grandjean
- 11:30 – 11:45 Critically Evaluating the Design of Emotional Agents – Robert Marsh and Lola Cañamero
- 11:45 – 12:45 Discussion on Element 1 of the Exemplar: Assumptions, Research Challenges and Guidelines for Future Research
- 12:45 – 14:15 Lunch

Session 2: Emotion in Social Cognition and Interaction

- 14:15 – 15:00 Emotional Development and Social Interaction – Jacqueline Nadel
- 15:00 – 15:15 From Imprinting to Adaptation: Building a History of Affective Interaction – Arnaud Blanchard and Lola Cañamero
- 15:15 – 15:30 Detection of emotional state grounded by Interaction – Ken Prepin, Philippe Gaussier and Jacqueline Nadel
- 15:30 – 16:00 Emotion in social interaction: A view from outside – Sabine Payr
- 16:00 – 16:30 Coffee break and Poster session
- 16:30 – 17:00 Animals, Robots, Methods and Models: Contributions from Ethology to Emotion Research – Rene te Boekhorst
- 17:00 – 17:30 Affective Virtual Human Animation - Arjan Egges, Alejandra García-Rojas and Nadia Magnenat-Thalmann
- 17:30 – 18:30 Discussion on Element 4 of the Exemplar: Assumptions, Research Challenges and Guidelines for Future Research
- 20:15 Workshop Dinner

Tuesday July 5, 2005*Session 3: Beliefs, Desires, Intentions and Emotions*

- 9:00 – 9:45 Emotions as a Mental Mode – Aaron Ben-Ze'ev
- 9:45 – 10:30 Cognitive Emotion Models: some thoughts on their tuning and their possible use in communication processes – Fiorella de Rosis and Valeria Carofiglio
- 10:30 – 11:00 Coffee break and Poster session

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|---------------|--|
| 11:00 – 11:15 | Agents that Reason, Plan and have Emotions – Maria R. Cravo |
| 11:15 – 11:30 | Is there an emotional component to giftedness? The effect of cognitive manipulation on the emotional experience of gifted and ordinary children – Netta Revhon-Damti |
| 11:30 – 12:00 | Emotions and Values – Peter Goldie |
| 12:00 – 13:00 | Discussion on Element 2 of the Exemplar: Assumptions, Research Challenges and Guidelines for Future Research |
| 13:00 – 14:30 | Lunch |
| | <i>Session 4: Emotion in Bridging the Gap between Lower- and Higher-Level Cognition and Action</i> |
| 14:30 – 15:00 | What is In an Affective Architecture for Situated Agents? Towards Theoretical and Conceptual Clarifications – Paolo Petta and Ruth Aylett |
| 15:00 – 15:15 | What is In an Affective Architecture for Situated Agents? Examples from Existing Systems – Stefan Rank and Pablo Lucas dos Anjos |
| 15:15 – 15:30 | Feeling and Reasoning: A Computational Model for Emotional Agents – João Miguel Dias and Ana Paiva |
| 15:30 – 15:45 | Multimodal emotion recognition: Implementation, results and challenges – Lori Malatesta |
| 15:45 – 16:15 | Coffee break and Poster session |
| 16:15 – 17:15 | Discussion on Element 3 of the Exemplar: Assumptions, Research Challenges and Guidelines for Future Research |
| 17:15 – 18:00 | Consolidating the Exemplar: Final Plans and General Discussion |

5 Conclusion

5.1 Obstacles encountered or foreseen

The main difficulties to implement the program of activities encountered so far, in addition to those stemming from the challenging nature of the task, are related to the lack of human and economic resources allocated to the implementation of joint activities, in particular if they involve adapting or developing (new) tools. This has forced most partners to concentrate most of their efforts in one main workpackage, contrary to their initial plans, to redefine initial plans towards joint work of a more theoretical nature, and in some cases to devote many more hours to this project than the time officially committed.

Another problem has been the difficulty to organize small thematic working meetings. This was due to the fact that, in the initial stages of the project, most of the travel funding was spent to attend the numerous WP workshops and other more “dissemination-oriented” meetings, leaving little room to organize additional smaller working meetings. The interchanges program provided a partial but not completely satisfactory solution, since it seems to be more oriented towards one-to-one exchanges among institutions. In the new period, we hope to be able to organize such small thematic workshops by using a combination of funding from partners, and the interchanges program (the WP leader has already brought this need to the attention of the project coordinator).

Finally, a non-trivial problem this year has been the delay in releasing the funding for new period, which has forced some partners to borrow resources from other sources and / or to cut down some of the activities of the WP and network (e.g., diminish presence of groups at some events). This has been a major problem for new members, who started their involvement (in all cases with a high level of enthusiasm and commitment) and participation in our activities in early 2005, but had to wait over 10 months to see their budget allocated, thus having to fund their activities from other sources.

5.2 Relation to state of the art and evidence of esteem

The research program of this workpackage has a pioneering nature in many ways, and is targeted towards setting solid grounds to advance the state-of-the-art in the field. Many of the members of this WP also play leading roles in the international scene, both in terms of the quality and international esteem of their work, and of their involvement in community building. This section provides a selection of examples that illustrate these points.

5.2.1 Editorial projects:

Cañamero, L. and R. Aylett (Eds.), *Animating Expressive Characters for Social Interaction*. John Benjamins Publishing Co. (to appear 2006).

Carberry, S. and de Rosis, F. (Eds.), special issue of the *International Journal on User-Modeling and User-Adapted Interaction* (June 2006 issue, ongoing project)

Nadel, J. and D. Muir (Eds.), 2005, *Emotional Development: Recent Research Advances*. Oxford University Press.

Pelachaud, C. and L. Cañamero, (Eds.), “Achieving Human-Like Qualities in Interactive Virtual and Physical Humanoids”. Special issue of the *International Journal of Humanoid Robotics* (September 2006 issue, ongoing project).

5.2.2 Organization of events

L. Cañamero, organizer of the AISB’05 Symposium *Agents that Want and Like: Motivational and Emotional Roots of Cognition and Action*. University of Hertfordshire, UK, April 14-15, 2005. http://homepages.feis.herts.ac.uk/~comqlc/emotivation_aisb05.

F. de Rosis and S. Carberry, organizers of the Workshop *Adapting the Interaction Style to Affective Factors*, in the scope of the *Intl. Conference on User Modeling 2005*.

J. Gratch, S. Marsella and P. Petta, organizers of *Agent Construction and Emotions: Modeling the Cognitive Antecedents and Consequences of Emotion (ACE2006)*, Intl. Symposium of the *18th European Meeting on Cybernetics and Systems Research*, April 18-20, 2006, Vienna, Austria. <http://www.ofai.at/~paolo.petta/conf/ace2006>.

E. Hudlicka and L. Cañamero, organizers of the symposium *Architectures for Modeling Emotion: Cross-Disciplinary Foundations*, of the *2004 Spring Symposium Series of the American Association for Artificial Intelligence*, Stanford University, Palo Alto, CA, USA, March 22–24, 2004. <http://homepages.feis.herts.ac.uk/~comqlc/ame04>.

A. Paiva, E. de Oliveira and C. Martinho, organizers of *Towards Affective Intelligent Systems (AC 2005)*, workshop of the *12th Portuguese Conference on Artificial Intelligence (EPIA’05)*, Covilhã, Portugal, December 5-8, 2005. <http://epia05.di.ubi.pt/index2.html>.

K. Scherer, L. Cañamero and J. Gratch, organizers of the symposium *Computational Modeling of the Emotion Architecture* within the *XIII Conference of the International Society for Research on Emotion (ISRE 2005)*, Bari, Italy, July 11-15, 2005 (symposium held on July 14). Presenters: L. Cañamero, J. Gratch, S. Marsella, P. Petta, K. Scherer. Discussant: P. Goldie. <http://www.isre2005.net>.

R. Ventura, C. Pinto-Ferreira and P. Petta, organizers of *Affective Computational Entities*, symposium of the *17th European Meeting on Cybernetics and Systems Research*, April 13th, 2004, Vienna, Austria. <http://ace2004.isr.ist.utl.pt>.

5.2.3 Invited conference talks

R. Aylett (prepared with M. Schröder and R. Cowie), “Developing a Coherent Approach to Emotion-sensitive Multimodal Interfaces: the European Community’s HUMAINE Project”, keynote speech at the *First Intl. Conference Affective Computing and Intelligent Interaction*, (ACII’05), Beijing, China, October 22-24, 2005. <http://affectivecomputing.org/2005>.

L. Cañamero, “Robots as Tools and Models for Emotion Research”, invited talk at the *ESF Workshop on Social Communication and the Face*, MRC Cognition and Brain Science Unit, University of Cambridge, UK, September 20-22, 2004.

Invited talks at the workshop *Dimensions of Sociality: Shaping Relationships with Machines* hosted by OFAI on November 19 & 20, 2004, by L. Cañamero (“Dimensions of Sociality: what can we learn from “emotional” robots?”), C. Castelfranchi (“An Agent named ToM: Towards 'intentional-stance'-based Agents and Interactions”), F. de Rosis (“Which Affective

Interaction (if any) with an Embodied Conversational Agent?”), S. Marsella (“Emotion in a Manufactured World”).

J. Gratch, invited talk at *Workshop on Integrated Models of Cognitive Systems*, Saratoga Springs, NY, March 2005.

J. Nadel, “Looking at the many faces of human socio-cognitive development: can it help designing ‘social’ robots?”, Plenary talk of the AISB’05 Convention, University of Hertfordshire, Hatfield, UK, April 13, 2005.

J. Nadel, “The missing link between emotion and motivation: Insights from developmental research”, keynote talk at AISB’05 symposium Agents that Want and Like: Motivational and Emotional Roots of Cognition and Action, University of Hertfordshire, Hatfield, UK, April 15, 2005.

P. Petta, “Contributions of emotion research to the design of situated social cognisers”, invited talk at the *Second International Workshop on Ubiquitous Robots*, KAIST, Daejeong, Korea; November 3-5, 2004.

P. Petta, invited talk at *PixelSpaces 2005* (including Humaine project presentation), Ars Electronica 2005, Linz, Austria, September 3, 2005.

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