HUMAINE

D3c

Preliminary plans for exemplars:

Theory

Klaus Scherer and WP3 members

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1. The status of this report

Joint research in HUMAINE aims to produce 'exemplars'. We chose the term exemplars to convey that above all, the systems that we develop should embody sound principles. The systems may be working models or 'in principle' specifications. Embodying sound principles means not only that they should exemplify good ways of addressing individual problems, but also that the set of exemplars taken as a whole defines a rational ways of partitioning the overall problem of developing emotion-sensitive systems. Arriving at a satisfying partition is a major part of the challenge that HUMAINE faces, requiring iteration and consultation between groups dealing with different thematic areas.

The Technical Annex sets process that is designed to meet that challenge. It 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 to let the different groups achieve complementary developments. That consultation phase will provide the basis for deliverables in month 11, which will specify a range of exemplars that deserve serious consideration. A further round of consultation will follow before concrete plans for each workpackage are drawn up and shared at the 18 month plenary meeting.

This report is the review that defines the starting point of the process for workpackage WP3, whose brief title is 'Theory and Models'.

2. Thematic definition of this workpackage

General Description

- Lead person in the group: Prof. Klaus R. Scherer (UNIGE-GERG)
- 96 person/month
- start at month 1

WP3 has a role of consultancy on theories of emotion. Its goal is to **gather, describe, inform and advise** other Work Packages of relevant emotion theories and models.

Its input in HUMAINE is mainly theoretical and will ensure the biological and functional plausibility of implementation attempts of other WP by setting a framework from which could arise both a better understanding of emotions processes (theoretical outcomes) and better emotion-oriented systems (applied outcomes).

Emotion-oriented systems are systems which "relate to, arise from, or deliberately influences emotions" (Picard, 1997). It is commonly addressed by multi-modal platforms which express, perceive, feel and respond to emotional compounds of their environment. The exponentially blooming technological landscape will leave us with no choice but to create a productive link between the man and the machine. With this in mind, it is important to take into account what defines emotions in ourselves to create the perfect interface with the machine: the Psychology meets the Engineering sciences.

How can such input help?

However, even though there is an increasing interest for Affective Science (Davidson, Scherer & Goldsmith, 2003), the field is still divided into numerous theories, concepts and models. There is still a huge work to do before getting a comprehensive and widely accepted theory of emotion.

Therefore, it is the role of the WP3 to compile current emotion theories and introduce them to the HUMAINE community. Our goal is to establish a set of shared definitions, concepts, and a limited number of models for concrete applications. This input will, in turn, allow the engineer-oriented groups to perfect their systems by integrating human-like emotional processes.

Specific areas of work that are already identified:

- WP3 will focus on **consensual operational definitions**, more generally it will attempt to establish a common framework to allow the comparison of theories and models.

- It will also attempt to list **specifications of working models**. This input should allow the identification/selection of specific models for specific purposes/applications.

- WP3 will also propose **concrete ideas for implementations**. These suggestions will integrate fundamental knowledge about emotional processes in human into working simulations. This input will profit to both the Engineer and Psychology community, being applied and implementation-oriented and allowing the study of the intrinsic features of emotion theories.

- Finally, WP3 will contribute to the research community by bringing up **means and tools to assess** the different theories and working models of emotions.

By what means should this goal be reached?

The WP3 has a **communicative role** and will take an active part in the different projects organized by other WP. It will bring psychologically-driven inputs to more engineering oriented sciences groups.

This role will be declined into two parts. On one side, by bringing together the research community and emulate a cross-disciplinary dialog on a common base, and, on the other side by bringing the tools which will allow such mutual understanding.

3. Review of key concepts in the thematic area

The following section is tentatively structured around "central" terms/concepts (in ***bold italics***) and introduces a number of "secondary" terms/concepts (in *italics*).

Appraisal

In emotion psychology the term *appraisal* specifically refers to the cognitive evaluation antecedent to an emotional episode. Central in this concept is the notion that different individuals (with different motives, goals, norms…) will *appraise* the same event/situation in a different way and, consequently, present different emotional reactions. *Appraisal models* are characterized by the *appraisal dimensions* they include – i.e. the aspects of the event/situation that have to be *appraised* by an organism in order to elicit an emotional reaction. Scherer has labeled the *appraisal dimensions* included in his model: *stimulus evaluation checks (SEC)*. In Scherer's model the outcome of the *SECs* is *sequential*. In his view, the *relevance* of the situation/event is appraised first, followed by the *implications* of the situation/event for the goals and needs of the individual. The outcome of the assessment of the individual's *coping potential* (evaluated control over and personal power in the situation) takes place subsequently and, finally, the *compatibility* of the event/situation *with the norms and standards* of the individual will be assessed.

Motivation

Motivation is closely related to emotional reactions, both as an *antecedent* factor and as an *outcome* (consequence).

As antecedents, *motives* contribute to the differentiation of emotional reactions. Individuals will differ in the emotional reaction they will show in a similar situation relatively to their variable motivations in this situation (see the notion of appraisal above; in this sense motives include: *needs, interests, desires*, …).

In turn, motives are affected by emotional reactions. For example, 'fear' would entail a motivation to *flight* and 'anger' a motivation to *fight*.

Some authors consider motivation to be a central component of emotional reactions (see next section: *motivational models*). In their view, the *action tendency* (also called: *action readiness* or *motor preparation*) component of emotional reactions is the essence of the emotional reaction. (see Frijda, 1986).

Approach and *avoidance* are two fundamental *motives* (or *action tendencies*). They are sometimes considered as the two ends of a single dimension. But this view is largely questionable (as indicated by the existence of possible ambivalences, when one aspect of a situation triggers avoidance, whereas another aspect of the same situation triggers approach).

Feeling

The term *emotion* is sometimes used in reference to the *emotional feeling*. The famous controversy between William James and his opponents relied largely on this confusion. When William James stated:

"My thesis is that […] the bodily changes follow directly the PERCEPTION of the exciting fact, and that our feeling of the same changes as they occur IS the *emotion*" (James, 1884, p. 190), he was referring to what we would call today the *emotional feeling*. With this statement, James was stressing the importance of the *peripheral / physiological reactions* for the *subjective experience* of the emotional reaction, as one of his later statements indicates: "Common sense says, we lose our fortune, are sorry and weep; we meet a bear, are frightened and run; we are insulted by a rival, are angry and strike. The hypothesis here to be defended says that this order of sequence is incorrect, that the one mental state is not immediately induced by the other, that the bodily manifestations must first be interposed between, and that the more rational statement is that we *feel* sorry because we cry, angry because we strike, afraid because we tremble, and not that we cry, strike, or tremble, because we are sorry, angry, or fearful, as the case may be. Without the bodily states following on the perception, the latter would be purely cognitive in form, pale, colourless, destitute of emotional warmth. We might then see the bear, and judge it best to run, receive the insult and deem it right to strike, but we could not actually *feel* afraid or angry." (James, 1884, p. 190).

This view – of the *embodiment* of emotional feelings – is today largely accepted by most researchers in emotion psychology and has been recently especially supported by Damasio (1994).

Scherer has proposed that the *emotional feeling* could be considered to function as a *monitoring* system, integrating all information about the continuous patterns of change in the autonomous and motor/expressive systems, as well as, in the appraisal and motivational systems. In this view, the *feeling* corresponds to the *reflection* and *integration* of all the other emotional components.

Following Wundt's early proposal (*introspection* as the method of choice for the study of mental states, 1897), emotional feelings have often been considered in a phenomenological perspective. Different *subjective dimensions* have been put forward by various authors (see next section: *dimensional models*) to account for the *subjective experience* of emotion. The most common dimensions used to describe this *subjective feeling* are: (a) *Valence* – the degree of pleasantness/unpleasantness of the emotional state – (b) *Arousal* – which corresponds to perception of the bodily activation associated to the emotional reaction. Other subjective dimensions used to describe the *emotional feeling* also include: *control*, *power*, *tension*, *intensity*, etc…

Basic emotions

Although *basic emotions* (also called: *fundamental* or *discrete emotions*) can be considered *basic* (or *fundamental*) in a variety of different ways, this concept habitually refers to a research tradition that emphasizes the role *evolution* has played in shaping emotional reactions and displays (see next section: *discrete emotion models*). *Basic emotions* are defined as corresponding to inborn, phylogenetically selected, *neuro-motor programs.* They are in limited number and are *universal* reactions (*universality* operates across ages, across cultures and across species). The reliance on *basic emotions* gave rise to secondary notions such as: *emotion blends* (*mixed emotions*) – to account for the large variety of observed emotional reactions and *display rules* – to account for individual and cultural variations in emotional expressions.

Primary/secondary emotions

This distinction is especially problematic. It refers to several definitions and should therefore be used only with caution.

In his emotion wheel, Plutchik (1962) classified emotion categories along four dimensions (positive/negative, *primary/mixed*, polar opposites, varying intensity). In this system, he distinguishes, eight *primary emotions* (fear, surprise, sadness, disgust, anger, anticipation, joy acceptance). In this view, *secondary emotions* are produced by combinations of *primary emotions*. Hence this definition of *secondary emotions* is close to the concept of *emotion blends* (see above).

Another definition of *primary/secondary emotions* is used in the field of neuropsychology. In this field, *primary emotions* are innate, triggered by sensory input, and processed through the limbic system. Whereas *secondary emotions* (also called *social emotions*) are acquired through learning/experience, generated through higher cortical processing (frontal cortices send signals to limbic structures to generate an emotional response) and are not necessarily "embodied".

Emotional intelligence

The concept of *emotional intelligence* (*EI*) was first introduced by Salovey & Mayer (1990) and relatively quickly popularized by Goleman's (1995) best-selling book. A central notion in this concept is that a variety of *emotional skills/competences* are related and reflect a – more general – underlying *emotional competence*. The *emotional skills/competences* included vary according to the multiple models of EI that have been proposed during the past decade. Skills/competences generally included are related to several aspects, for instance:

- *regulation/coping* – the ability to "manage" ones emotional responses, reduce/suppress them or activate them
- *emotional resilience* – the ability to recover from "traumatic" experiences
- *expressivity* and *regulation of expressivity* – the ability to control – suppress, substitute or simulate emotional expressions
- *emotional sensitivity* – the ability to recognize emotions expressed by others
- abstract understanding of emotional reactions and strategical use of this knowledge – the ability understand and manipulate emotions in others, *machiavelism* or *empathy*

Current studies of EI are frequently relying on *verbal reports* (questionnaire studies). Past results in the fields of *nonverbal skills*, *emotional sensitivity*, *regulation* or *coping* research suggest that some of the emotional competences included in the broad concept of EI might actually be relatively independent.

Emotion

Scherer's definition of emotion *is the following: "*Emotions *are – "*episodes *of massive,* synchronized *recruitment of mental and somatic resources allowing to adapt to or cope with a stimulus event subjectively appraised as being highly pertinent to the needs, goals, and values of the individuals".*

In this definition the notion of *synchronization* is a central feature. Emotions are seen as occurring when the cognitive, physiological and motor/expressive components – which are usually more or less dissociated in serving separate functions – synchronize, as a consequence of a situation/event appraised as highly relevant for an individual.

For the more general definition of *emotions*, one crucial aspect is the distinctive features of *emotions* as compared with other psychological states – that may have an affective element to them but that can hardly be considered to be full-fledged emotions. Scherer has proposed a design feature approach to distinguish the following classes of *affective states*:

- *Emotions* (e.g., angry, sad, joyful, fearful, ashamed, proud, elated, desperate)
- *Moods* (e.g., cheerful, gloomy, irritable, listless, depressed, buoyant)
- *Interpersonal stances* (e.g., distant, cold, warm, supportive, contemptuous)
- *Preferences/Attitudes* (e.g., liking, loving, hating, valuing, desiring)
- *Affect dispositions* (e.g., nervous, anxious, reckless, morose, hostile)

The design features proposed for the differential definition of these states are partly based on a) response characteristics, such as intensity and duration or the degree of synchronization of different reaction modalities (e.g., physiological responses, motor expression, and action tendencies); b) antecedents (e.g., whether they are elicited by a particular event on the basis of cognitive appraisal); and c) consequences in terms of stability and impact on behavior choices. Table 1 shows a proposal for the specific feature profiles of each state. The more important the feature to the definition of the affect, the bolder the dot will be.

Design Features / ***Types of Affect***	Intensity	Duration	Synchro-nization	Event focus	Appraisal elicitation	Rapidity of change	Behavior impact
Emotions: *angry, sad, joyful, fearful, ashamed, proud, elated, desperate*	●	•	●	●	●	●	●
Moods: *cheerful, gloomy, irritable, listless, depressed, buoyant*	●	●	•	•	•	●	•
Interpersonal stances: *distant, cold, warm, supportive, contemptuous*	●	●	•	●	•	●	●
Preferences/Attitudes: *liking, loving, hating, valuing, desiring*	●	●	•	•	•	•	●
Affect dispositions: *nervous, anxious, reckless, morose, hostile*	•	●	•	•	•	•	●

Table 1 – Defining different types of affect: A design feature approach

All of these states have relevance for HMI. However, one can expect that the underlying mechanisms are variable and may interact in complex ways for the different states. For example, each of these states is characterized by a specific pattern of interaction between "*push effects*" (the biologically determined externalization of naturally occurring internal processes of the organism, particularly information processing and behavioral preparation) and "*pull effects*" (socioculturally determined norms or moulds concerning the signal characteristics required by the socially shared codes for the communication of internal states and behavioral intentions). Given that the underlying biological processes are likely to be

dependent on both the idiosyncratic nature of the individual and the specific nature of the situation, relatively strong interindividual differences in the expressive patterns will result from push effects. Conversely, for pull effects, a very high degree of symbolization and conventionalization, and thus comparatively few and small individual differences, are expected. With respect to cross-cultural comparison, one would expect the opposite: very few differences between cultures for push effects and large differences for pull effects. In consequence, computational models of affect that are to serve useful functions in an HMI context need to make clear choices as to which kind of state is to be modeled.

Model (in Cognitive Neurosciences)

The goal of Cognitive Neurosciences is to build a model of cognition. A model is a representation that describes and explains the different components, or sub-processes, involved in a cognitive process, as well as the interactions between them. Building such model consists of identifying the sub-processes and the organization that structures them. Considering the fact that several models can be used to describe the same cognitive activity, it is very important to settle rules and laws in regard to the purpose of the model. For example, such a model must respect two principles: biological plausibility and computational coherence and adequacy.

Computational modeling

Computational modeling has been inspired by Computer Science approaches. It is meant to separate the information, made of the data manipulated by the system, and the treatments, or actions described in terms of rules. Representations, flow charts, are then built, giving a reflection of what occurs in reality.

In order to do so, one has to:

- identify the data (the signifier and the signified) ;
- identify the correlations between them ;
- define the actions (treatments) applied on the data ;
- take into account the influences between the processes described.

One of the first computational model in Psychology has been proposed by Atkinson and Shiffrin (1968, 1979). It describes memory in terms of components through which the information transits. Each component is identified by the quantity of information it will stock and the amount of time it will be stored. The authors distinguish 3 memories (buffers): sensorial memory, short-term memory, and long-term memory.

Although this model is not any more accepted by the research community, it has helped to create this new approach.

4. Review of key achievements in the thematic area

This section first presents a brief description of some emotion models, followed by two illustrations of the predictions made by Scherer's appraisal model with respect to facial and vocal expressions.

A. Models

In Emotion Psychology different research traditions have put their focus on different aspects of emotional reactions and processes. A central goal of WP3 is to present an overview of various research traditions and corresponding models of emotions.

Current emotion models include:

- *Adaptational models* – Highlighting the adaptational function of emotion, primed by evolution to detect stimuli that are vitally significant for the organism's well-being (Öhman, 1986, 1988 "preparedness"; LeDoux (1989, 1996; direct projections from the sensorium and thalamus to the amygdala)

- *Dimensional models* – Differentiate emotions by their position on a pleasantness-unpleasantness (or valence), an arousal or activation dimension, and a tension, power, or control dimension (Wundt, 1905; Schlosberg, 1954; Osgood, Suci, and Tannenbaum, 1957; Davitz, 1969; Russell, 1980; Watson, Clark, & Tellegen, 1988; Lang, et al., 1993)

- *Appraisal models* – Maintain that emotions are elicited by a cognitive evaluation of antecedent situations and events on a number of dimensions, criteria, or checks (Arnold, 1960; Lazarus, 1968; Scherer, 1981; Roseman, 1982, Smith & Ellsworth, 1985; Frijda, 1986

- *Motivational models* – Emotions seen as manifestations of motivation and action tendencies, based on evolutionary primitives (Plutchik, 1962, Frijda, 1986, Buck, 1985).

- *Circuit models* – Based on the assumption that the differentiation and the number of fundamental emotions is determined by genetically coded neural circuits (Cannon 1927, Papez, 1937, Arnold, 1960, Gray, 1973, Panksepp, 1989; Rolls, 1992).

- *Peripheral feedback models* – Pioneered by James/Lange, these models suggest that the peripheral reactions occuring in the process of an emotion episode have a strong determinant influence on the subjective feeling of the individual, to the point where artificially induced motor expression or physiological arousal is expected to actually generate emotional feeling (James, 1884; Lange, 1885; Schachter & Singer, 1962; Laird, 1984; Damasio, 1994)

- *Discrete emotion models* – Based on Darwin's (1872/1998) proposal of limited number of basic or fundamental emotions such as anger, fear, joy, sadness, and disgust (Tomkins, 1962; Ekman, 1972; Izard, 1971).

- *Lexical models* – Theoretical analysis of the semantic implicational structure (especially in relation to goals) underlying major emotion words (Oatley & Johnson-Laird, 1987; Shaver et al., 1987; Ortony, Clore & Collins, 1988)

- *Social constructivist models* – Suggesting that the meaning of emotion is mostly constituted or constructed by socio-culturally determined behavior and value patterns (Averill, 1980; Harré, 1986; Lutz & White, 1986; Shweder, 1993).

A major task of WP3 will consist of providing a critical review of currently held models of emotion, as well as a synthesis of the most pertinent research evidence from the natural and neurosciences and the behavioural and social sciences. Such a review and synthesis will be the basis of recommendations as to the strategic choices to be recommended to other work packages.

B. Examples of predictions on facial and vocal expressions

Different models entail different conceptions and predictions regarding emotional reactions. Figure 1 shows an illustration of the kind of comparison that one can draw to assess different emotion theories. Scherer's Appraisal theory maintains that emotion emerges following a sequence of "checks" that the stimulus perception has to go through ; namely: novelty, intrinsic pleasantness, goal/need conduciveness, coping potential and norm/self compatibility. Each check produces a different part of the expression of the emotion, and the conjunction of them all produces the final emotion. Ekman's discrete emotions model states that built-in emotions (and expressions) appear following a cause-consequence link.

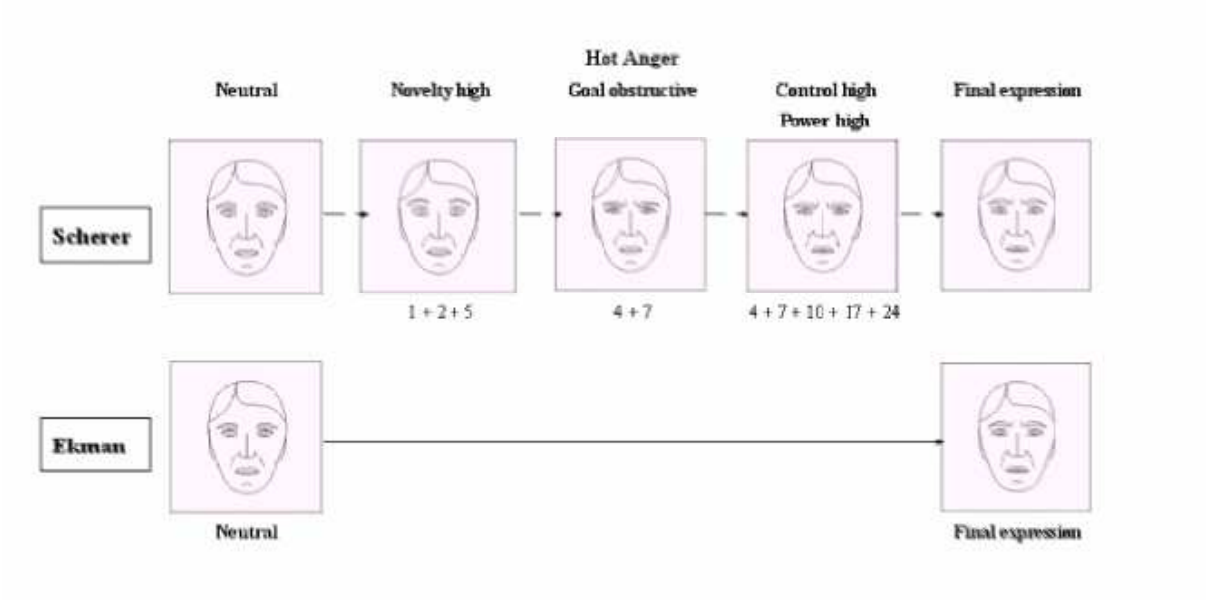

Fig 1. Comparison of Scherer's Appraisal theory and Ekman's discrete emotions model

Scherer also proposed a set of predictions regarding the effect of appraisal outcomes on vocal expressions. Table 2 provides an example for the hypotheses on the effect of appraisal results on the vocal mechanisms and the ensuing changes in vocal expression (predictions from other models regarding vocal expressions are not at hand).

Component patterning theory predictions for voice changes (adapted from Scherer, 1986)

Novelty check	
Novel	Not novel
Interruption of phonation, sudden inhalation, ingressive (fricative) sound with glottal stop (noise-like spectrum)	No change
Intrinsic pleasantness check	
Pleasant	Unpleasant
Faucal and pharyngeal expansion, relaxation of tract walls, vocal tract shortened by mouth corners retracted upward (increase in low frequency energy, F1 falling, slightly broader F1 bandwidth, velopharyngeal nasality, resonances raised) "*Wide voice*"	Faucal and pharyngeal constriction, tensing of tract walls, vocal tract shortened by mouth corners retracted downward (more high frequency energy, F1 rising, F2 and F3 falling, narrow F1 bandwidth, laryngopharyngeal nasality, resonances raised) "*Narrow voice*"
Goal/need significance check	
Relevant and consistent	Relevant and discrepant
Overall relaxation of vocal apparatus, increased salivation (F0 at lower end of range, low-to-moderate amplitude, balanced resonance with slight decrease in high-frequency energy) "*Relaxed voice*" If event conducive to goal: *relaxed voice + wide voice* If event obstructive to goal: *relaxed voice + narrow voice*	Overall tensing of vocal apparatus, decreased salivation (F0 and amplitude increase, jitter and shimmer, increase in high frequency energy, narrow F1 bandwidth, pronounced formant frequency differences) "*Tense voice*" If event conducive to goal: *tense voice + wide voice* If event obstructive to goal: *tense voice + narrow voice*
Coping potential check	
Control	No control
(As for relevant and discrepant) "*Tense voice*"	Hypotonus of vocal apparatus (low F0 and restricted F0 range, low amplitude, weak pulses, very low high-frequency energy, spectral noise, format frequencies tending toward neutral setting, broad F1 bandwidth) "*Lax voice*"
High power	Low power
Deep, forceful respiration, chest register phonation (low F0, high amplitude, strong energy in entire frequency range) "*Full voice*"	Head register phonation (raised F0, widely spaced harmonics with relatively low energy) "*Thin voice*"
Norm/self-compatibility check	
Standards surpassed	Standards violated
Wide voice + full voice (+ relaxed voice if expected or + tense voice if unexpected)	Narrow voice + thin voice (+ lax voice if no control or + tense voice if control)

Table 2 – Component patterning theory predictions for voice changes from Scherer (2003)

Since there are detailed hypotheses as to which profiles of appraisal outcomes produce which modal emotions (see Scherer, 1994, for a definition of "modal emotion"), this set of predictions also allows to generate predictions for complete patterns of modal emotions. For example, a modal emotion that is part of the fear-family is predicted to be produced by the appraisal of an event or situation as obstructive to one's central needs and goals, requiring urgent action, being difficult to control through human agency, and lack of sufficient power or coping potential to deal with the situation. The major difference to anger-producing appraisal is that the latter entails a much higher evaluation of controllability and available coping potential.

Based on these kinds of hypotheses the predictions in Table 2 can be synthesized to predicted patterns of acoustic changes that can be expected to characteristically occur during specific modal emotions. These predicted patterns are shown in Table 3. This table also provides information on which predictions have been supported (predicted change occurring in the same direction) and which have been directly contradicted (actual change going into the opposite direction from prediction) in the study by Banse and Scherer (1996).

Predictions for emotion effects on selected acoustic parameters (based on Table 4 and appraisal profiles; adapted from Scherer, 1986)

	ENJ/ HAP	ELA/ JOY	DISP/ DISG	CON/ SCO	SAD/ DEJ	GRI/ DES	ANX/ WOR	FEAR/ TER	IRR/ COA	RAG/ HOA	BOR/ IND	SHA/ GUI
F0												
Perturbation	<=	>			>	>		>		>		
Mean	< ✓	> ✓	>	<>	<> ✓	> ✓	> ?	>> ✓	<> ✓	<>	< ✓	> ?
Range	<=	>			<	>		>>	<	>>		
Variability	<	>			<	> ?		>> ?	<	>> ✓		
Contour	<	>			<	>	>	>>	<	=		>
Shift regularity	=	<						<		<	>	
Formants												
F1 Mean	<	<	>	>	>	>	>	>	>	>	>	>
F2 Mean			<	<	<	<	<	<	<	<	<	<
F1 Bandwidth	>	<>	<<	<	<>	<<	<	<<	<<	<<	<	<
Formant precision		>	>	>	<	>	>	>	>	>		>
Intensity												
Mean	< ✓	> ✓	> ?	>> ?	<< ✓	> ✓		> ✓	> ✓	>> ✓	<>	
Range	<=	>			<			>	>	>		
Variability	<	>			<			>		>		
Spectral parameters												
Frequency range	>	>	>	>>	>	>>		>>	>	>	>	
High-frequency energy	<	<> ✓	>	>	<>	>> ✓	> ?	>>	>>	>> ✓	<>	>
Spectral noise					>							
Duration												
Speech rate	< ?	> ✓			< ✓	>		>> ✓		> ✓		
Transition time	>	<			>	<		<		<		

Note: ANX/WOR: anxiety/worry; BOR/IND: boredom/indifference; CON/SCO: contempt/scorn; DISP/DISG: displeasure/disgust; ELA/JOY: elation/joy; ENJ/HAP: enjoyment/happiness; FEAR/TER: fear/terror; GRI/DES: grief/desperation; IRR/COA: irritation/cold anger; RAGE/HOA: rage/hot anger; SAD/DEJ: sadness/dejection; SHA/GUI: shame/guilt; F0: fundamental frequency; F1: first formant; F2: second formant; >: increase; <: decrease. Double symbols indicate increased predicted strength of the change. Two symbols pointing in opposite directions refer to cases in which antecedent voice types exert opposing influence. (✓) prediction supported, (?) prediction contradicted by results in (Banse and Scherer, 1996).

Table 3 – Predictions for emotion effects on selected acoustic parameters from Scherer (2003)

5. Review of key problems in the thematic area

The first key problems encountered when working on the theories of emotions could be classified as epistemological, dealing with the nature of the research and its object and the relations between the disciplines involved in the research.

The first major issue, which slows down the research community working on emotion theories, is the lack of **a common language**. Currently, terms such as emotions, moods, sentiments, passions, impulses, drives, well being, attitudes, and trait emotionality are used interchangeably. In the same respect, there is a lack of clarity when it comes to distinguish the different components, or concepts, of affective phenomena: eliciting factors, physiology and motor responses, action tendencies and feeling. Scherer has suggested a design feature analysis allowing a criteria-based differential definition (Scherer, 2000).

This approach is based on an effort of clarification and compiles:

- different measures of emotion: response characteristics, such as intensity and duration or the degree of synchronisation of different reaction modalities (physiological responses, motor expression, and action tendencies)
- antecedents (historical context during which emerges the emotion)
- consequences in terms of stability and impact on behavior choices (goal-dependent).

Since most work in this area has targeted emotions, it seems reasonable to start with this central type of affect and provide a concise working definition. However, this work has to be carried on and extended to common theories of emotion.

Such input would be the blocks used to create the tools that the research community would use. Those tools would take the form of **a common theoretical framework,** which is also lacking, and without which a unified emotion theory will not emerge. This common theoretical framework would be composed of research paradigms, general rules and laws. The research community would use those tools as a means to compare theories and models on a same level.

On the same schema, since emotional processes are studied by many different disciplines (Psychology, Social Psychology, Cognitive Psychology, Cognitive Neuroscience, Neurosciences, Artificial Intelligence, just to name a few), it is very clear that the next issue that needs to be addressed is **a cross-disciplinary dialog** between each of the disciplines involved. Indeed, each discipline uses specific techniques and methods and is impermeable to the knowledge gathered by other disciplines. It is now widely acknowledged that a unique emotion theory will imply gathering knowledge from all disciplines. However, this issue urges the effort of acceptance and use of the techniques and methods proposed by all disciplines. This step forward could bring the researchers to a unique discipline – an "Affective Science" – which will allow the gathering of multiple levels of analysis (Kuhn, 1962 ; Davidson, Scherer & Goldsmith, 2003).

Other key problems involve more applied compounds.

First, the degree of achievement of some of the widely accepted theories of emotions implies **a very high level of complexity** which is sometimes difficult to overcome in-vivo, given actual material resources limitations.

Most theorists now agree that emotions are elicited and differentiated on the basis of appraisal processes (Ekman, 1992 ; Frijda, 1986 ; Ellsworth, 2003 ; Lazarus, 1991 ; Scherer, 1999), although there is disagreement on the extent of appraisal needed (Zajonc, 1984 ; Berkowitz, 2004) and the exact nature of the dimensions used. There are varieties of appraisal theories (Roseman and Smith, 2001) and interesting differences among those theories, although complementary, arise hypothesis which would necessitate resources that are not always available. For example, testing the sequential aspects of appraisals, or the synchrony between components, are very precise statements which are still difficult to address.

In the same respect, the research community (on a wide range, not only Psychologists) lacks **means or tools to assess and compare theories and models**. Indeed, once operationalized, theories of emotion should be tested “in the real world” and tools to do so should be available to the widest research community. Each of the disciplines involved should be able to use and apply the theories and models proposed by others.

6. Assessment of the key development goals in the thematic area

WP3 will divide its effort regarding **conceptual and terminological clarification** around three axis:

- The elaboration of operational definitions for various emotion-related categories – affect, emotion, attitudes, moods, affective personality, and affective stances, provide a basis for recommendations as to the specific attention to be given to each class within the network and the most appropriate contexts to study the forms of affective phenomena that are most relevant to HUMAINE's concerns.

- The valuation of the observed empirical frequency of different kinds of affective phenomena and the odds that they will occurs in different contexts, determining the pertinence for the realization of multimodal interfaces in the real world ; along with the synthesis of empirical evidence to date and check of the feasibility of a join questionnaire study in the HUMAINE countries.

- The linking the operational definitions for different kinds of affective phenomena agreed upon by the HUMAINE partners to lay concepts and verbal labels for different affects to allow ready transfer in both directions and determine areas of overlap and differences ; along with the evaluation of the feasibility of an empirical study for popular terms in the HUMAINE languages based on a systematic grid for comparison (facilitating the transfer of verbal emotion interfaces to different languages).

A common framework will be achieved by building **emotion models (i.e., computational modeling of emotion)**. In this matter, WP3 will focus on:

- establishing a complete inventory of currently used emotion models and the literature pertinent to the respective approach ;

- developing a set of standard criteria to compare the theories and models with respect to their postulates concerning emotion components and processes ;

- examining the possibility of operationalizing the models in the form of computational models that can be realistically implemented and tested in an open system ;

- determining the appropriateness of different models to real world applications and technological products ;

- investigating the utility of different models to generate empirical questions that can be experimentally tested ;

- choosing a theoretical working model that is suited to the development aimes of the network ;

- operationalize the model with respect to system characteristics (basic motivation, current plans, norms), appraisal of induction conditions, and the processing (transfer functions) required for differential response patterning ;
- synthezise material in the literature pertinent to the question of the integration and synchronization of subsystems and subprocesses (e.g., work on sensory and inferential integration, dynamic systems theory, etc.) ;
- specify potential algorithms for the integration and synchronization of subsystems and subprocesses for both measurement and animation purposes ;
- identify the requirements for the implementation of the model.

Also, the following **methods and instruments** are likely to play a major role in the activites of the network by allowing partners to test and address available theories:

- different types of standardized measures for subjective experience ;
- standardized tests of affect-related personality traits ;
- objective assessment of appraisal dimensions ;
- test material for emotional sensitivity and emotional intelligence ;
- computerized content analysis of verbal emotion expressions ;
- nonreactive and implicit measures of affect (e.g., reaction time, implicit association test) ;
- robust measures for the assessment of peripheral physiological response (including ambulatory measurement) ;
- neuropsychological measures of emotion processes (e.g., EEG) ;
- computer simulations and neural networks of emotion processing ;
- state of the art profile similarity and classifications analyses.

7. Relation to other workpackages

WP3 ➔ other WP

- WP7 “Emotion in cognition and action”: theoretical models and empirical data on cognitive appraisal processes, including different levels of neural processing (expert system on appraisal processes)
- WP5 “Data and databases”: gathering corpus of data
- WP4 “Signals to signs”: rule-based emotion model and prediction of emotion expression
- WP6 “Emotion in interaction”: studying individual differences in “emotional sensitivity” (identification/discrimination of emotional expressions in others)
- WP9 “Usability”: Classification of different affective states depending on frequency in applied contexts

Other WP ➔ WP3

- WP4 “Signals to signs”: Methods to measure objective parameters of voice, speech, gesture and posture ; methods for statistical analysis of those measures
- WP7 “Emotion in cognition and action”: Methods for in-vivo testing of physiological, motor and vocal parameters ; collaboration on development of computational model of emotion
- WP6 “Emotion in interaction”: Methods for in-vivo testing of physiological, motor and vocal parameters ; collaboration on development of computational model of emotion

8. Preliminary ideas about possible exemplars

A. First Possible Exemplar

Glossary/thesaurus with conceptual and operational definitions agreed upon in the consortium: this document could gather operational definitions for various emotion-related categories – affect, emotion, attitudes, moods, affective personality, and affective stances.

It will provide a basis for recommendations as to the specific attention to be given to each theories and concepts used within the network, along with the most appropriate contexts to study the forms of affective phenomena that are most relevant to HUMAINE's concerns.

B. Second Possible Exemplar

The second exemplar will be joint projects with WP7 "Emotion and Action" (see Deliverable of WP7, points 8.1 and 8.2, for technical descriptions).

Our participation to these projects will be to ensure the biological plausibility and the computational adequacy and coherence of the models developed.

The projects differentiate different levels of analysis, namely low and high levels of cognition, and therefore a special attention should be given to the functional division of the processes modeled.

As developed in Wehrle and Scherer (2001): in the interest of assuring internal consistency, it is desirable to formalize theories by clearly specifying the underlying constructs and their interrelationships. On the basis of such a formal definition, and appropriate operationalizations, a detailed set of concrete hypotheses, amenable to empirical testing, needs to be elaborated. The results of such hypothesis-testing studies can give rise to further theoretical refinement and, in particular, regular revision of the predictions (see, e.g., Roseman, Spindel & Jose, 1990 ; Scherer, 1993b). Without proceeding in such a strict, theory-guided way, it will be impossible to fruitfully compare the virtues of different theories or to obtain further convergence beyond the present level of generality. Appraisal theories have now reached a stage where such comparison becomes possible and desirable. […] Algorithm-based models require clear specifications of concepts and variables, as well as of presumed relationships. Furthermore, discrepancies and inconsistencies will be readily apparent in attempting to apply stringent modeling. Of course particular importance for the further development of appraisal theories are the issues of parsimony and of the relative importance of different appraisal dimensions (see Scherer, 1997, for a detailed discussion).

9. Conclusions and Way Forward

WP3 is organizing the first HUMAINE workshop. Entitled "**Theories and Models of Emotion**". It will be held in Geneva, from June 17 to June 19, 2004.

Workshops aim at gathering Humaine members around thematic areas and are devoted to a cross-disciplinary dialog on application boundaries.

This workshop is meant to develop connections between the *Psychology* research community and the research community concerned with emotion-oriented systems. Its function is partly didactic, in that researchers with a mainly technological background need to know about the theory and evidence assembled by other disciplines.
In order to achieve this goal, the format of the workshop is largely based on interactions between people, introducing a question/answer process to emulate cognitive appetites.

Further work will be oriented accordingly to expectations and needs raised during this initial workshop.

The workshop will include "hands-on demonstrations of artificial emotion systems", presentations and discussions. The detailed program is described below.

WHEN:

From Thursday, June 17, 2004 — 6pm
To Saturday, June 19, 2004 — around 6pm

WHERE:

University of Geneva - Uni-Mail
40 Boulevard du Pont d'Arve
1205 Geneva
SWITZERLAND

WHAT:

Thursday, June 17		
6pm - 8pm	Welcome & reception, Poster session	
Friday, June 18	"Problems and directions for possible solutions"	
Morning session: "Identifying theoritical problems"		
9am - 9:30am	Welcome address and objectives of the workshop	Klaus R. Scherer
9:30am - 10:30am	Hands-on demonstrations of artificial emotion systems (session 1)	Chair: Paolo Petta
10:30am - 11:00am	Coffee break	
11am - 12am	Hands-on demonstrations of artificial emotion systems (session 2)	Chair: Paolo Petta
12am - 12:30pm	Podium discussion: Operationalizing models for implementation	
12:30pm - 2pm	Lunch break	
Afternoon session: "Identifying theoritical directions to resolve problems"		
2pm - 2:45pm	Possible solutions from Psychological models of emotion	Klaus R. Scherer
2:45pm - 3:15pm	Possible solutions from Cognitive Neurosciences models of emotion	David Sander
3:15pm - 3:45pm	Possible solutions from models of emotional expression	Suzanne Kaiser
3:45pm - 4pm	Coffee break	
4pm - 4:30pm	Possible solutions from Robotic models of emotion	Lola Cañamero
4:30pm - 5pm	Possible solutions from Neural Networks simulations of emotion	John G. Taylor
5pm - 6pm	Plenary discussion and organization of Saturday Working groups	
7pm	Banquet	

Saturday, June 19	"Designing an emotional architecture (a working day for the working groups)"	
Morning session		
9am - 12pm	Parallel meetings of the four working groups	
12pm - 1:30pm	Lunch break	
Afternoon session: Plenary meeting		
1:30pm - 2:30pm	Synthesis of advances during the morning sessions	Work groups leaders
2:30pm - 3pm	Emotion and relation alignment	Brian Parkinson
3pm - 3:30pm	Categories of emotion: everyday psychology and scientific psychology	Peter Goldie
3:30pm - 4pm	Coffee break	
4pm - 4:30pm	Synthesis of advances during the Workshop	Roddy Cowie
4:30pm - 5:30pm	Round table and Closing address	

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Davidson, R. J., Scherer, K. R., & Goldsmith (2003). *Handbook of Affectives Sciences*. Oxford: Oxford University Press.

This handbook is published in the Oxford University Press: "Series in Affective Science" which comprises many other useful books, e.g.:
- *The Neuropsychology of emotion* (Borod)
- *The nature of emotion* (Ekman)
- *Music and emotion* (Juslin & Sloboda)
- *Cognitive neuroscience of emotion* (Lane)
- *Affective neuroscience* (Panksepp)
- *Appraisal processes in emotion* (Scherer)

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