Non-verbal behaviour and attribution of mental states

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ABSTRACT

The project has two aims: the study of mental state attributions to previously perceived non-verbal behaviours and the contribution to the non-verbal communication skills of embodied agents.
For the first task, short audio-visual clips presenting a person in a face-to-face context with another human have been evaluated, through a forced-choice questionnaire. The questionnaire was based on the appraisal theory's items and on the attribution of emotional labels. The appraisal theory enables the understanding of mental states in terms of successive evaluations and enables to predict the link between facial expressions and mental state attributions. In our case it will be used to predict the intuitive answers of participants to the observed expressions.
The second task is to improve the existing communicational capacities of 'embodied conversational agents'. Facial muscle movements will be transposed to a virtual agent, Greta. The interface of this agent will be used as a tool to validate the observations established in the first task. This application of the theory will enable us to run perceptive studies to verify and detail some aspects of the results. What is more, the behaviours verified by perceptive tests as expressing some particular mental states will be added to the agent's repertory, increasing the number of varied facial behaviours.

Keywords: Non-verbal communication, Facial expression, Appraisal theory, Embodied conversational agents.

1 AIMS OF THE RESEARCH

The first objective of the research is to explore the mental states attributions in relation with observed facial expressions. This study has two parts.
First, an observational study is lead on the perception of non-verbal communication cues. In a judgement task, participants observed a human in interaction with another one. They had to answer a questionnaire and evaluate the mental states of observed people. Questions related to cognitive evaluations of a situation as defined by the componential appraisal theory [1] and to the attribution of emotional labels enabled to judge the intuitive interpretation of observed expressions. Videos were coded with the FACS technique [2] by a certified coder. This coding based on the analysis of facial muscle movements and completed by an analysis of torso movements, enables to associate attributions of mental states to the perceived behaviour.
The second objective is to transpose the action units described in the FACS system unto a virtual agent and to create a facial expression repertoire for the agent. These complex expressions, elaborated and defined in the first part of the research from human interactions will be described in a way to be usable by the agent. Precisions will be given concerning the evaluations and situations in which these expressions could be selected.
Expressions synthesised on the agent will be judged by participants. The attributions of mental states to expressions will be evaluated through the same paradigm as in the first study with humans. The duration, intensity and sequencing of facial action units will be manipulated and the impact of these manipulations on mental state attributions will be evaluated. This will enable to clarify the impact of the different elements contributing to the perception of internal states by others.
A particularity of this work lies in the evaluation of behaviour occurring in natural settings. Unlike the majority of studies which rely on videos of actors or other "acted" or stereotypical behaviour, the video corpus used for the study comes from a hidden camera. What is more, the situation is an emotional one, as it shows passengers declaring their

loss of luggage at an airport [3][4]. The use of such a corpus enables the synthesis of natural and non-stereotypic facial movements for virtual agents.

2 State of the art

2.1 Facial expressions

Although emotion has been investigated in relation to the voice, e.g. [10][11][12][13], body movements [29][30], posture [32] as well as more generally in multimodal expressions [28], the major weight of research focuses on the perception of emotion from the face. Facial expressions are a key element in the human communication, contributing to its efficiency by transmitting a large quantity of information [33]. According to some researchers [6][15] expressions can be seen as « rudiments of adaptive behaviour, which have acquired important signaling characteristics » [6]. Thus the expressive behaviour is a socially influenced message, prone to be regulated, as well as a true externalisation of internal states.
Since Charles Bell wrote about the intimate relation between the states of the mind and the body expressions (1844, cited by [34]), and Duchenne [31] has investigated ways in which individual muscles contribute to the perceived facial changes, a great deal of attention has focused on how emotions are communicated through facial expression.
Emotion theories
According to Scherer, emotional states are « almost always accompanied by a motor expression component »[28]. The readability of the body actions and poses enables to infere the internal states and attitudes of the person [28]. Among different emotion theories, two important approaches have been proposed, that diverge in their understanding of the emotions triggering and expression. Both propose explicit predictions for emotion-specific facial expressions, while one conceives emotions as categorical, the other as componential entities.

- discrete emotion theories [8][20][24][25] focus on a small number of so called basic emotions, in particular, anger, fear, joy, disgust, sadness, happiness, shame, and guilt. These are considered to result from innate neuromotor programs and to produce a fixed behavioural response. This expressive response is unitary in nature, emotion-specific and universally recognised
- componential appraisal theories to emotion [1][18][22][23][28] on the other hand stipulate that the individual elements of facial expressions (the micro-expressions) are determined by the appraisals of a given situation.

2.1.1 Discrete emotion theories

According to the discrete emotion theoreticians emotions are triggered by automatic mechanisms, such as neuromotor affect programs. These programs are believed to act independently from cognitive evaluations (e.g. [25]).
Studies following this approach focus on a few prototypical patterns. Tomkins [24], for instance, described these affect programs as leading to some expressive patterns specific to particular emotions. The number of these “basic emotions” is limited. As regards facial expressions, discrete (basic) emotion theory states that they are direct displays of internal states and that the ability to decode them in term of basic emotions is innate [21] and quick, thus considered unconscious [25].

2.1.2. Componential emotion theories

Cognitivist theoreticians following the componential approach to emotion counter the concept of discrete emotions resulting from automatic and biologically fixed programms [6][15][26]. They advance that the variability and complexity of emotions can be understood without any reference to basic emotions. According to those theoreticians, there is a great number of very differentiated emotional states that are captured by the labels only through a process of grouping of different states, through some kind of averaging and central tendencies. Scherer names these “averaged” states “modal emotions” (see for example [1]). The appraisal's theory's predictions for these modal emotions are the same as the ones suggested for basic emotions.
What is specific to the componential appraisal approach is to prone that emotions are the of cognitive evaluations (appraisals). An emotional state would result from the significance given to different elements of an event. An emotion is not defined and triggered directly by a situation or a stimulus, but depends from the relation established between a person and the surrounding environment. This relation is created through appraisal (for a review see [6]).

Although this process relies on a succession of evaluations, it is important to note that some authors emphasise that this cognitive evaluation can happen in an automatic, fast and non conscious manner (see [18]).

2.2 Facial expression predictions

Scherer's model states a direct link between expressions and the underpinning appraisals (eg. [1]). According to Scherer, an emotion is composed of successive evaluations of a stimulus and of different, interconnected and synchronised (motor and physiological) changes that are linked to the sequence. This sequence is defined by a series of checks enabling the evaluation of a stimulus, whether it is internal or external. Micro facial expressions are associated to each appraisal check. These micro-expressions are described in terms of minimal facial muscle movements, that is facial Action Units (AU) as described by Ekman and colleagues in the Facial Action Coding System (FACS ; [2]). The direct link between facial expressions and evaluation checks is described through AUs, each AU being attributed to a specific outcome of an evaluation check.
Thus a facial emotional expression is a superposition of particular micro-expressions resulting from all the successive evaluation checks (novelty, intrinsic pleasantness, goal conduciveness, coping potential, norm compatibility, etc.)
It is interesting to note that applying these appraisal checks predictions to conceive internal states enables to generate a multitude of different response combinations, leading to a great number of possible expressions. What is more, given that some evaluation combinations would be more frequent than others it would lead to the so called “modal emotions” enabling to predict prototypical facial expressions.

2.3 Embodied conversational agents

The constant development of communication technologies leads to an increasing need for virtual intelligence agents able to cope with affective aspects of interactions. Such affective abilities could facilitate the interaction with the user, but also enable contextually more adpted responses [7] and be perceived as more trustworthy [5].
Studies have shown that human interactions with virtual characters are similar to those developped with real humans [14][19][20]. This enables to hypothesise that a human emotion model can be used to modelise artificial emotions.
In order to be valid, such a model needs to include the external state of the agent, that is their expression of emotions, as much as their internal state [16][17]. Such an internal state could be defined for example by an input file defining “the general tendency of an agent” at a give time (communicativity, speed of responding, mood, etc.) or be deduced by a “dialogue system”.
Today, several research teams work on the elaboration of embodied conversational agents with interaction capacities. Embodied conversational agents are software entities with a virtual humanoid appearance. Some agents can express emotions or other internal states' characteristics.
A large number of teams uses the « OCC » model [27], which became a reference for emotion synthesis. Some agents internal states models rely on this computational model and others are inspired by it. According to this model, there are three types of emotions, triggered by the evaluation of three aspects: consequences of events, actions of agents and aspects of objects. Thus, an event enabling the realisation of a goal leads to joy, an agent's action not corresponding to the agent's convictions leads to shame and the perception of an aversive object leads to disgust. The “Virtual Hulman” agent developed by the Geneva MiraLab uses a model inspired by the OCC for the determination of the facial expressions of the agent. This embodied agent can interact with a user and have a basic conversation while expressing emotional states [9]. Although it has a complex internal state model with 24 emotions defined, its expressivity is restricted to the six basic emotion expressions.
Another approach, based on the discrete emotions theory, has been used by Bui [36] who uses a set of fuzzy rules to determine the blending expressions of the six basic emotions [8]. In Bui's work the fuzzy inference determines the degree of muscle contractions of the final expression, as defined by an input emotion intensity.
Some researchers, such as Paleari and Lisetti [16] or Malatesta et al. [35], on the other hand, have focused their work on the temporal relation between different facial actions predicted by the appraisal theory (e.g. see [1]). In [16] the different facial parameters are activated at different moments and the final animation is a sequence of several micro-expressions linked to cognitive evaluations. Malatesta and colleagues [35] have also used sequences predicted by Scherer's componential theory to create manually emotional expressions [16]. Differently from Paleari and Lisetti's work [16], in [35] each expression is derived from the addition of a new AU to the former ones. What is more, the authors [35] compare the additive approach with the sequential one, and find a greater recognition rate for the animations realised with the first approach [17].

It is in continuation of such appraisal componential approaches that the present studies are situated.

3 Problem definition

According to the appraisal theory, the emotional state of an individual is the result of successive appraisals, such as the novelty detection or the coping potential. According to Scherer [1] the same emotional label could be attributed to internal states characterised by slight variations in the outcome of appraisal checks. Thus, the facial expression could not always be linked directly to the emotional label, given that one label can be attributed to differentiated states/appraisal outcomes. It is the result of each appraisal check that is hypothesised to be directly related to particular facial movements, while expressions of one emotion would be more diversified.

We want to verify this hypothesis, by observing the link between seven appraisal attributions, action units (AU) and seven emotional labels. We have chosen the appraisal checks for which concrete facial action predictions have been formulated in the theory: 1) suddenness, 2) goal obstruction, 3) relevance (this is novel and important), 4) coping (mastery over situation) , 5) no coping, (no mastery over situation) 6) violation of internal standards and 7) violation of external standards (this is unfair and immoral).

For example, suddenness is linked to raised eyebrows and goal obstruction is linked to pressed lips. A more limited number of expressive patterns associated with appraisal checks is expected than with emotional labels.

We expect to confirm Scherer and Ellgring's predictions [1] for the five first appraisals. For the internal standards violation, no hypothesis is formulated because of a lack of unanimity in between researchers which all observe different facial changes [6].

The link between appraisal and emotions is also explored. We chose emotions directly associated to some studied appraisals [1]: control over the situation linked to anger, the lack of control to joy, and so on. Relief has been added to counter the bias of a unique positive emotion. Although there are no predictions for this emotion, it has been chosen as it is of particular interest for the virtual agent used.

In each clip, we expect that great attributions of some emotional labels will be linked to significative attributions of the corresponding appraisals, as predicted by theory. However we expect to observe some emotional label attributions without the presence of all contributing appraisals, keeping in mind that by definition emotional terms describe a group of similar but not identical states.

The intensity of emotional labels is expected to be higher for the more prototypical expressions, called modal emotions expressions by Scherer and having the same definition/characterisitcs as Ekman and Friesen's observations for basic emotions [8].

4 First study: preliminaries

In the first study, the facial expressions perceived in the videos by the participants have been evaluated through a questionnaire based on sequential evaluation checks [1] and completed with an attribution of emotional labels. For 24 video clips facial movements are being coded with the FACS system [2]. The facial action units are to be associated with the particular attributions, in order to show the link between AUs, appraisals and emotional labels. The study will be completed with a coding of body movement and postures, as well as with a basic acoustic analysis of the extracts where vocal and/or body activity is observed.

4.1 Material

Extracts from a video corpus [3][4] presenting images from a hidden camera have been selected. They present a face-to-face interaction, where passengers report they have lost their luggage to a hostess. The behaviour of the passenger is evaluated. The original clips from the corpus were one minute long, however as mental state changes appeared during that interval the clips had to be cut into segments presenting one state only per extract. Three experts were asked to evaluate each extract and annotate in time all the perceived internal states, whether these be appraisals, emotions, action tendencies or any other internal changes.

In the case of ambiguity, e.g. when one out of the three evaluators considered less changes in a clip than the other two and suggested a longer extract of a unified state, the clip was cut in a restrictive manner and the ambiguous segment was left out. The final extracts shown to the participants were from 5 to 50 seconds, with a majority falling in the 20-28 seconds.

4.2 PROCEDURE

The study was realised individually on computers, guidelines being clearly provided on screen. The
The participants watched and evaluated from 6 to 42 short video clips, depending on their concentration level and their willingness to participate. After each video participants had to answer the same set of questions.

4.3 HYPOTHESES

An effect of observed/coded facial action units is expected on the attributions. Predictions are formulated for the facial expressions of appraisals (see Table 1) based on the appraisal theory [1]. We expect to observe patterns between attributed emotions and the attributed appraisal checks, as predicted in [1] (see table 2).

Characteristics of the event faced in the clip (evaluated by labelers)	**Facial Action Units expected to be observed in accordance**
Sudden	1+2
Goal attainment obstructive	17+23; 17+24
Relevant and discrepant	4, 7, 23, 17, gaze directed
Control and high power	4, 5 or 17, 23, 25 or 23, 24
Control but no power	1, 2, 5, 26, 20, 38, gaze directed+averted+directed
« Unfair »/external standards violated	10
Internal standards violated	14

Table 1. Expected association between AU[1] and cognitive evaluations. Predictions based on Scherer & Ellgring [1].

	Suddenness	Mastery	Goal obstruction	Relevance	Internal standard violation	External standard violation
Fear	YES	NO	YES	YES		
Joy		YES	NO			
Anger		YES	YES			YES
Sadness		NO	YES	YES		
Shame					YES	
Contempt						YES
Relief						

Table 2. Expected association between emotions and appraisal checks. Predictions based on Scherer (1999).

The appraisal attributions being given on a 7 point scale (from 0=totally disagree to 6=totally agree), an average significantly above 4 confirmed the presence of an appraisal and an average significantly below confirmed the absence of an appraisal in a given clip.
The participants had also to judge if the observed person was showing anger, fear, joy, sadness, shame, contempt and relief. Each emotion being evaluated on a scale from 0 (no emotion) to 6 (strong emotion), an appraisal is considered strongly attributed when the average >2.5 and significantly >1 (as the lower bound of the significance interval .95).

[1]Action Unit explanation:
1 + 2: brows raise 4: brows lower 5: upper lid raise 7: lids tighten 10: upper lip raise 14: dimpler 17: chin raise 20: lips stretch 23: lips tighten 24: lips press 25: lips part 26: jaw drop 38: nostril dilate

4.4 Partial Results

82 male computer science students evaluated 6-42 videos (mode= 13). Each extract was evaluated at least by 20 participants.
Each clip has its own pattern of attributions, which enables us to associate these to different AU patterns.
Given the fact that the number of clips coded until now is limited, the analysis of only one clip will be described here: clip 103b, the number being taken from the original corpus (103) and the letter added after splitting the clip into extracts containing only one internal state (b).

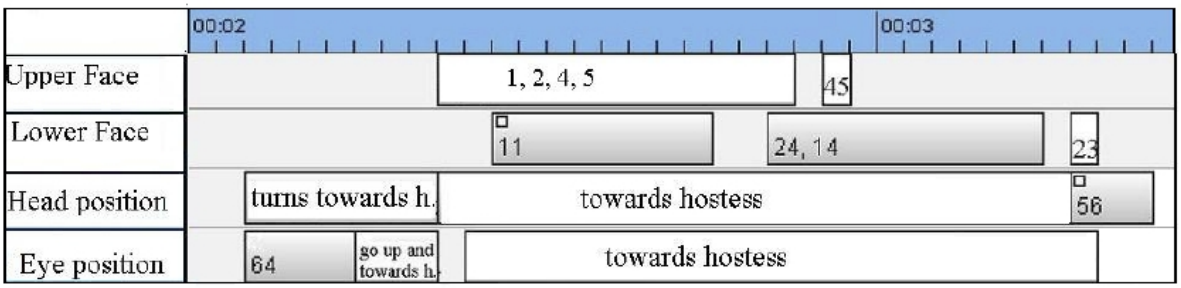

Figure 1. Summarised FACS[2] coding of clip 103b.

After having watched clip 103b, participants attributed mastery/power (average= 6.133 ; conf. interval 5.585-6.682), contempt (2.27 ; 1.61-3.73) and anger (1.6 ; .579- 2.621). No external standards violation has been attributed.

4.5 Result Interpretation for one clip

As expected, one observes an attribution of 'power' associated to the presence of lowered eyebrows and raised upper lids (AU 4+5).
The presence of dimples (AU 14) is observed but it does not lead to an attribution of internal standards violations that was predicted by Scherer [1]. Here it could be associated more with some kind of external standard violations, as contempt has been attributed. These results show an analogy to Kaiser's study, which shows that dimples appear in situations of "injustice" [6].
IN 103b dimples are linked to a pressure of the lips (AU 14+24) and are preceded by the deepening of the nasolabial furrow (AU 11). Such a pattern (AU 14+24) was observed by Michel and Unz (2008) to be associated with contempt, as in our case. The authors deal with spectators' facial expressions during violent TV shows and observe frequent AUs 14+24, AU 14 and AUs 14+17 (dimples with a raised chin).
To summarise, the 103b expression is introduced by upper face AU (brows raised and pulled a little together, with upper lid raised) that are maintained for a second, followed by a marked blink (AU 45). The lower face expressions start a little bit later, however still during the activation of the first upper face units. AUs 14+24 are preceded by a deepening of the nasolabial furrow (AU 11) and followed by tensed lips (AU 23).
It is surprising to find a strong attribution of contempt but no significant attribution of external standard violation, although in theory this appraisal is one of those constituting the emotion of contempt in its modal expression. What is more, contempt being strongly attributed (average sign. >1.6) one could expect an association with a prototypical expression, with the predicted AUs and appraisals, which is not the case.

5 Continuation of the study

The majority of the clips still needs to be coded and the AUs patterns associated with the appraisal and emotional labels attributions.
To go further in the study of the link between behaviour and mental state attributions, different evaluations will be performed. First, some basic vocal analysis will be performed (MFCC, fundamental frequency, energy). In the

[2] Action Unit explanation:
1: inner eyebrow raise 2: outer eyebrows raise 4: brows lower 5: upper lid raise 11: nasolabial furrow deepener 14: dimpler 23: lips tighten 24: lips press 45: blink 56: head tilt right

extracts only few vocalisations occur and we want to control that these have no impact on the emotion and appraisal perception. Moreover, AU patterns determined in the first study will be synthesised with the Greta agent and evaluated using the same questions set as in the human video study. Then some modifications will be applied to the expressions and evaluated consequently. For example, the duration and the co-articulation of different AUs may be modulated and some AUs removed from the observed sequences to check if these are relevant for users' understanding of agents' states. This should clarify which aspects of agents' facial and body movements are essential for behaviour synthesis.

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