The Role of Facial Expression in Intra-individual and Inter-individual Emotion Regulation

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Abstract

This article describes the role and functions of facial expressions in human-human and human-computer interactions from a psychological point of view. We introduce our theoretical framework, which is based on componential appraisal theory and describe the methodological and theoretical challenges to studying the role of facial expression in intra-individual and inter-individual emotion regulation. This is illustrated by some results of empirical studies. Finally we discuss the potential significance of componential appraisal theory for diagnosing and treating affect disturbances and sketch possible implications for emotion synthesis and affective user modeling.

Introduction

The function of emotions can be described with respect to two interrelated regulatory processes in which emotions are involved: the *intra-individual regulation* of thoughts and behavior and the *inter-individual regulation* in social interactions. Major issues concerning the intra-individual process are the relation between emotion and cognition, particularly emotion-antecedent appraisal, and the interactions between different emotion components, in particular the role of subjective experience or feeling state. The inter-individual process can be described in terms of how emotions and emotion expression regulate interpersonal interaction and - vice versa - how emotions are regulated during interactions. Facial expressions can be seen as an interface between these two regulatory processes or systems. They are observable reflections of the internal regulation process and - simultaneously - vehicles for the regulation of the interaction.

Emotion and Facial Expression

There is a long tradition in emotion psychology of examining facial expressions as an observable indicator of unobservable emotional processes. *Discrete emotion theorists* have studied facial expression as the 'via regia' to emotions for many years. Most of their research concerning the universality of *basic emotions* is based on studies about facial expressions (e.g. Ekman, 1994; Izard, 1991). As Ellsworth (1991) has argued, facial expressions have been discrete emotion theorists' major 'evidence' for holistic emotion programs that could not be broken down into smaller units. However, even though universal prototypical patterns have been found for the emotions of happiness, sadness, surprise, disgust, anger, and fear, these findings have not enabled researchers to interpret facial expressions as unambiguous indicators of emotions in spontaneous interactions.

There are a variety of problems. First, the mechanisms linking facial expressions to emotions are not known. Second, the task of analyzing the ongoing facial behavior in dynamically changing emotional episodes is obviously more complex than linking a static emotional expression to a verbal label. Third, the powerful role of regulation and expression control through explicit and implicit social norms and expectations renders the study of expressive behavior particularly difficult. Finally, facial expressions can serve multiple functions - they are not necessarily indicators of emotional involvement.

Facial expressions in social interactions

In spontaneous interactions, facial behavior accompanies emotional episodes as they unfold. Changes in facial configurations can occur very rapidly. Many of the facial patterns that occur during an interaction are not 'true', spontaneous expressions of internal emotional processes. Individuals often use expressive behaviors more or less consciously in order to achieve a social goal, for example to obtain attention or support. Here, the subjective feeling of the person and his or her facial expression may not necessarily correspond. A lack of correspondence between feeling and expression can also be the result of *expression-management* processes serving self-presentation (Goffman, 1959) and *expression-control* processes demanded by sociocultural norms, such as *display rules* (Ekman & Friesen, 1969).

Furthermore, facial expressions also have non-emotional, communicative functions (Wehrle & Kaiser, 2000). A smile or a frown, for instance, can have different meanings. It can be a *speech-regulation signal* (e.g., a back-channel signal), a *speech-related signal* (illustrator), a *means for* *signaling relationship* (e.g., when a couple is discussing a controversial topic, a smile can indicate that although they disagree on the topic there is no "danger" for the relationship), an *indicator for cognitive processes* (e.g., frowning while concentratedly attending to a problem, or when a difficulty is encountered in a task), or an *indicator for an emotion* (affect display). Affect displays that occur during an interaction can refer to the interaction partner (e.g., becoming angry with the other) but it can also refer to other persons or themes the interaction partners are talking about (e.g., sharing the anger about something).

Given and the multi-functionality of facial behavior and the swiftness of expression changes, research paradigms for studying emotions and facial expressions should fulfill the following requirements:

- Approaches to measure facial expressions objectively and on a micro-analytic level are indispensable. Anatomically based coding systems like the *Facial Action Coding System* (FACS; Ekman & Friesen, 1978) lend themselves to this purpose. Only if coding is independent of prior assumptions about prototypical emotion expressions we can test and compare different hypotheses about linking facial expression to emotions.
- The concrete meaning of a facial expression can only be determined within the whole temporal and situational context. In everyday interactions, we know the context and we can use all information that is available to interpret the facial expression of another person. Therefore, facial expressions and emotions should be studied in an interactive context.

Appraisal and Facial Expression

Most studies on facial expression of emotions have been conducted by researchers within the tradition of discrete emotion theories (e.g., Ekman, 1994; Izard, 1991). These theories claim that there is only a limited number of so-called fundamental or "*basic emotions*" and that for each of them there exists a prototypical, innate, and universal expression pattern. In this tradition, a process of mixing or blending of the basic expression patterns explains the variability of the observable emotion expression patterns. Compared to this rather molar approach, componential appraisal theory (for details see Wehrle, Kaiser, Schmidt, & Scherer, 2000) is more molecular, focusing on individual muscles and their functions. Componential appraisal theory assumes that the specific pattern of facial muscle movements, which characterizes the expression of a particular emotional state, is the result of emotion-antecedent cognitive appraisal and associated action tendencies (Frijda & Tcherkassof, 1997; Kaiser & Wehrle, 2001; Smith & Scott, 1997). In line with this reasoning, facial expressions are analyzed as indicators of appraisal processes in addition to or as an alternative to verbal reports and other measures. Facial expressions are not seen as the "readout" of motor programs but as indicators of mental states and evaluation processes.

This interest in facial expressions is linked to the idea that emotion-antecedent information processing can occur at different levels, as suggested by Leventhal and Scherer (1987). The hope is that appraisal processes occurring on the sensory-motor or schematic level that are not or only with great difficulty accessible through verbalization might be accessible via facial expressions. Another reason for analyzing facial expressions in experimental emotion research is that they are naturally accompanying an emotional episode, whereas asking subjects about their feelings interrupts and changes the process.

For instance, there is a general consensus that raising the eyebrows and raising the upper eyelids are associated with appraisal dimensions related to *attentional activity*, *novelty*, and *unexpectedness*. The strongest consensus concerns the postulate that corrugator activity (frown) not only encodes *unpleasantness* but more specifically perceived *goal obstacles* and the presence of *goal discrepancies* (Smith & Scott, 1997).

In our view, the attempts of linking facial actions to appraisal dimensions are not only of theoretical interest; they become crucial as soon as we go beyond the question of the universality of emotional expressions and aiming at studying spontaneous facial expressions in social interactions. We do not deny the existence of distinct facial signals that can be reliably recognized across cultures as expressing the emotions of happiness, sadness, surprise, disgust, anger, and fear. However, the evidence for this has relied almost exclusively on judgment studies using slides of carefully selected expressions. Since such prototypical full-face expression patterns occur rather rarely in daily interactions, the question of whether and how single facial actions and partial combinations can be interpreted becomes crucial.

In the preceding sections, we have illustrated some of the methodological and theoretical problems we are confronted with if we want to study the process of emotional interactions and its reflection in facial activity in interactive settings. To tackle some of these problems we are using a theoretical and experimental framework including computerized data collection and data analysis instruments on the one hand, and computer simulation and theory based synthetic stimuli on the other hand.

Testing Theoretical Predictions with Synthesized Facial Expressions

The *Facial Animation Composing Environment* (FACE; Wehrle, 1995/1999) is an animation instrument that allows researchers to systematically vary different aspects of the dynamics of facial expressions and to control or manipulate other perceptual cues, such as accompanying head movements, head position, gaze direction, or even the physiognomy of a person, all of which might affect emotion inferences. With FACE we can create three-dimensional animated facial expressions in real time. The contours of the face are represented with *splines*, as are the prominent features of the face such as eyebrows and lips. The repertoire of facial expressions for the animation was defined on the basis of FACS. The FACS coding manual gives a detailed description of all the appearance changes occurring with a given Action Unit. This description lists the parts of the face that have moved and the direction of their movements, the wrinkles that have appeared or have deepened, and the alterations in the shape of the facial parts. Action Units can be produced asymmetrically and at different levels of intensity (following the five intensity levels of FACS). In addition, FACE allows the user to vary the intensity and time profiles of facial movements in terms of attack (onset), sustain (apex), and release (offset) duration.

Using FACE in a judgment study, Wehrle et al. (2000) have extended and refined Scherer's original predictions linking facial actions to the postulated appraisal checks (Scherer, 1992). Scherer posits relatively few basic criteria and assumes sequential processing of these criteria in the appraisal process. The major "stimulus evaluation checks" (SECs) can be categorized into five major classes: 1) the novelty or familiarity of an event, 2) the intrinsic pleasantness of objects or events, 3) the significance of the event for the individual's needs or goals, 4) the individual's ability to influence or cope with the consequences of the event, including the evaluation of who caused the event (agency), and 5) the compatibility of the event with social or personal standards, norms, or values (for details see Wehrle et al., 2000; Kaiser & Wehrle, 2001).

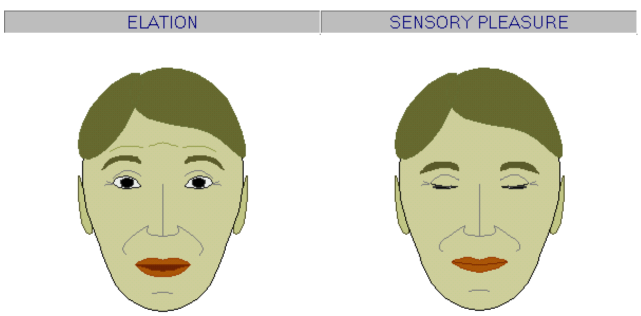

Figure 1. Predictions for the appraisal patterns and the related facial actions for elation and sensory pleasure as published in Wehrle et al. (2000).

Interesting results have been found concerning the differentiation of positive emotions for which discrete emotion theorists and appraisal theorists make different predictions. Proponents of discrete emotion theory argue that positive emotions such as amusement, contentment, excitement, pride in achievement, satisfaction, sensory pleasure, and relief, all share a particular type of smile (i.e., a Duchenne smile, which is defined as the Action Unit combination of AU12 (lip raiser) and AU6 (orbicularis occuli) producing crows-feet wrinkles at the eye corners) and that no further facial signal will be found that differentiates among these positive emotions (Ekman, 1994). Following an appraisal-based approach, Wehrle et al. postulate that these different positive emotions do produce different facial patterns, since the respective underlying appraisal profiles are not identical. The results show that judges differentiated well between sensory pleasure, happiness, elation, and - to a lesser degree - pride (the predicted facial expressions for elation and sensory pleasure are shown in Figure 1).

Appraisal and Facial Expressions in Human-Computer Interactions

In the following, we present some results from our experimental research, using human-computer interactions for studying the dynamics and the interactive nature of emotional episodes. For this purpose, we developed the *Geneva Appraisal Manipulation Environment* (GAME; Wehrle 1996), a tool for generating experimental computer games that translate psychological theories into specific micro-world scenarios (labyrinths with objects and enemies; more details are published in Kaiser & Wehrle, 1996, 2001; Kaiser, Wehrle, & Schmidt, 1998; Wehrle & Kaiser, 2000). GAME allows automatic data recording and automatic questionnaires. While playing the experimental game, subjects are videotaped and these tape recordings allow an automatic analysis of the subject's facial behavior with the *Facial Expression Analysis Tool* (FEAT; Kaiser & Wehrle, 1992; Wehrle, 1992/1996). With FEAT, facial actions are categorized in terms of FACS. These facial data can be automatically matched to the corresponding game data (using the vertical time code as a reference for both kinds of data). In this way, the computer game provides a relatively small but complete context for the interpretation of the internal emotional and cognitive regulatory processes. This is an important point, because what is felt by the subject and what a certain facial expression means is often very context specific.

The behavior of the "virtual" interaction partners in the game is to a large degree determined by the experimenter when defining the experimental game parameters. This approach allows the researcher to create theory based scenarios for specific emotions and to confront all subjects with the same events. However, those events are embedded within a larger context of not completely determined individual paths, since the subjects' behavior and their decisions do influence and change the constellation of the ongoing game to a certain degree. Since all the information necessary to reconstruct the complete situational context is registered, we can follow each individual path. Thus, we can analyze more systematically the sources for differences in individual reactions to a specific event in terms of behavior (attack versus avoidance), appraisal (pleasant versus unpleasant, conducive versus obstruct), and reported feeling (joy, worry, etc).

The results show that the theoretically designed emotion eliciting situations actually led to different empirical appraisal profiles. Also, the participants' subjective appraisals matched closely the objective characteristics of the game situations. Detailed analyses of the subjective appraisal profiles allow us to systematically determine why some subjects report other emotions than the theoretically predicted target emotion, which has been reported by the majority of the participants. For example, when analyzing an *increased-speed* game episode, we found that 73% of the subjects reported relief or happiness when AMIGO (an animated agent in the game, which is generally supporting and helping the player) reduced speed again. However, 27% of the subjects reported anger or disappointment. The analysis of the appraisal profiles showed that those subjects who reacted with a negative emotion to the reduction had evaluated the increased speed as being pleasant (versus unpleasant) and as being less relevant for their goals than subjects that reacted with relief. Furthermore, the automatic data protocol allowed us to predict subjects' emotional reaction on the basis of how successfully they coped with the high-speed episode.

Other interesting results concern role of *expression control* and the role of smiles in this context. Although the interaction is only indirectly social, we find many smiles and *smile controls* (e.g., asymmetric smiles or smiles that occur with signs of negative emotions; see Keltner, 1995), similar to those found in human-human interactions.

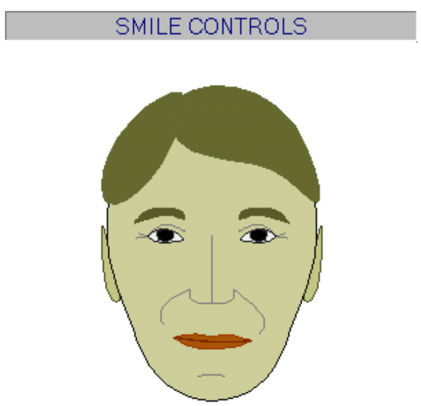

Figure 2. An example of a controlled or masking smile as found in the experimental study (see Kaiser & Wehrle, 2001) and synthesized with FACE.

We are convinced that the regulative function of smiles is not limited to the interactive regulation level but also concerns the intra-psychic regulation (as an intra-psychic coping strategy for handling negative affects). In the experimental game we can differentiate between negative situations that subjects hold themselves responsible for (self-caused) and negative situations that subjects perceive as caused by an agent in the game (other-caused). In line with our hypothesis we find significantly more controlled smiles in self-caused negative situations as compared to other-caused negative situations. Figure 2 shows an example of such a controlled smile in reaction to a player's own mistake. Furthermore, the results indicate that generally interpreting the occurrence of a smile as an indicator of happiness might be misleading.

Individual differences and affect disturbances

An important advantage of an appraisal-based approach is that it allows studying individual appraisal tendencies and action preferences (coping styles) that become evident over different situations and which can be seen as indicators of a more or less stable personal style. For example, some subjects tend to make internal causal attributions (*agency self*) even in situations that are objectively not controllable. Furthermore, we can differentiate the participants' coping strategies according to their rigidity versus flexibility, their impulsivity versus reflexivity, their complexity, and their situational adaptivness. Therefore, one might envisage using the experimental environment for diagnostic purposes.

Kaiser and Scherer (1998) have argued the utility of applying models of normal emotions to a variety of affect disturbances and maladaptive stress responses. Affective disorders can be conceptualized as malfunctions of intra-individual and inter-individual regulation. The former involves inadequate appraisal of situations and events as well as dissociation of the relationships between the different emotion components; the latter comprises inappropriate expression of affect and major deficiencies in the interpersonal adjustment of affect in social interaction. Kaiser and Scherer have formulated concrete predictions concerning disorder specific appraisal biases and deviations from normal emotions including specific facial expression deviations, which can be used to study the underlying – mostly unconscious – processes. Generally, this approach allows us to generate a large number of theoretical predictions that are concrete and testable and that can solidly be based on empirical work. With FACE, we can animate the postulated expression patterns and test their validity in judgment studies asking therapists to decode the expressions in terms of clinical syndromes and appraisal biases (see Figure 2 for some examples of the postulated expressions, synthesized with FACE).

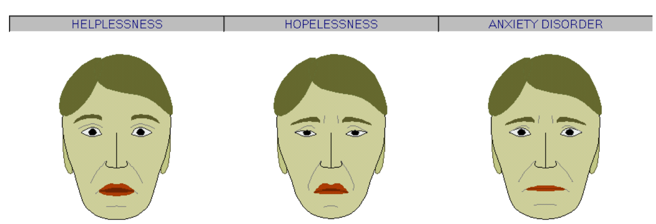

Figure 3. Predictions for the appraisal biases and the related facial actions for helplessness, hopelessness and anxiety disorder as published in Kaiser & Scherer (1998).

Potential implications for clinical research and treatment

Roseman and Kaiser (2001) have pointed to another potential advantage of componential appraisal theory in diagnostic and therapeutic work. The multi-level approach of componential appraisal theories can help to describe the cognitions underlying both the source and surface affects in dynamically interrelated emotion states, and precisely describe the cognitive reinterpretations involved in alternative emotion-regulation strategies or defense mechanisms. Multi-level stimulus processing is increasingly used in discussions of cognition and emotion interaction, especially in the context of memory and affect disturbance (e.g. Johnson, 1994; Power & Dalgleish, 1997; Teasdale & Barnard, 1993). Multi-level approaches may provide an explanation for how simultaneous or conflicting emotions (with different degrees of awareness) could occur. They may also explain why knowledge and feeling can sometimes be dissociated or discrepant. Facial expressions might be indicative for the existence of low-level appraisals that contradict high-level conscious appraisal outcomes. The theoretical predictions resulting from the componential appraisal approach as suggested in Kaiser and Scherer (1998) might guide clinicians who aim at looking beyond the verbally reported emotions.

A common result from clinical studies using micro-analytic techniques is that micromomentary expressions and subtle control indicators (like asymmetric, tense, or masking smiles) occur rather often (e.g., Bänninger-Huber, 1997; Krause, Steimer-Krause, Merten, & Ullrich, 1998). In general, untrained observers are rather bad in detecting micromomentary expressions and control indicators. Being able to correctly decode facial expressions is important for clinical work and treatment. Since FACE allows the dynamic animation of low intense, fast, and rapidly changing facial expressions, including asymmetries (using the same coding extension as FEAT), it is possible to create stimuli sets that could be used as a diagnostic tool for *testing* decoding capacities in clinical populations and as a training tool for *improving* decoding skills in therapists.

Potential implications for emotion synthesis and affective user modeling

This article tried to show how an appraisal-based approach might help us to better understand how emotions are *expressed* and *perceived* in social interactions. With respect to human-computer interactions, these two processes can be related to the *synthesis* of "emotional agents" and the *analysis* of a user's facial expression. In our view, componential appraisal theory has some important theoretical, methodological, and ecological advantages over an emotion-based approach (see also Wehrle, 2001). The appraisal-based approach accounts for the subjective evaluation of a situation that gives rise to an emotional experience and more over it directly links the outcome of this appraisal process to the other components of emotions. This allows us to analyze and to synthesize emotional processes on a level of differentiation that goes beyond basic emotions. For synthetic facial expressions for instance, a dynamic application context could directly be linked to expression changes of an animated agent. Since the process of appraisal and reappraisal is not only determined and changed by external situational cues but also by internal cues that reflect the person's motives, personality, experience etc., those variables should also be considered explicitly.

From the beginning of the early eighties appraisal theories have given important inputs to emotion synthesis and affective user modeling (e.g., Elliot, 1997) However, most of these applications only use appraisal theory to implement the "cognitive" component of an emotional interface (for reviews see Pfeifer, 1988; Picard, 1997). The outcome of the appraisal process is then mapped into an emotion category, which determines the synthesis of the respective facial expression pattern. This might be an unnecessary and complicated procedure that also reduces the available information and might bias the analyses. Furthermore, linking facial expression and other components of emotion directly to appraisal dimensions can take advantage of the computational representations that are commonly already defined in the respective applications (see also Wehrle & Kaiser, 2000).

Acknowledgments. This research was supported by grants from the Swiss National Science Foundation (FNRS 11-39551.93/049629.96 "Dynamic man-computer interactions as a paradigm in emotion research") granted to S. Kaiser and T. Wehrle.

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