

Facial expressions of emotions: A methodological contribution to the study of spontaneous and dynamic emotional faces[†]

ANNA TCHERKASSOF^{1*}, THIERRY BOLLON²,
MICHEL DUBOIS¹, PASCAL PANSU¹
AND JEAN-MICHEL ADAM³

¹University of Grenoble 2, France

²University of Savoie, France

³University of Grenoble 1, France

Abstract

This paper addresses methodological considerations relevant to nonverbal communication of emotion research. In order to gather more information about the interpretations given to spontaneous and dynamic facial expressions, two main objectives guide the present exploratory research. The first one is to obtain naturalistic recordings of emotional expressions in realistic settings that are 'emotional enough'. The second one is to address the issue of dynamic judgments of facial expressions of emotion, that is real-time emotional recognition. An innovative device has been created for this specific purpose. Results show that, although the social nature of the eliciting situation is minimal, the experience of some emotions is reflected on the encoders' faces while being covertly videotaped in natural conditions. Moreover, results show the utility to investigate dynamic emotional judgments of spontaneous and dynamic expressions since observers seem to be sensitive to the slightest facial expression change in making their emotional judgments. A promising paradigm is thus proposed for the study of the dynamics of real-time nonverbal emotional interaction. Copyright © 2007 John Wiley & Sons, Ltd.

The issue of facial expressions' recognition is one of the most debated in the field of emotion. Even though various positions have been taken on this question (Russell, Bachorowski & Fernández-Dols, 2003; Tcherkassof, 1997), it appears that evidence is based for the most part on methods using a static and unnatural material, namely, still photographs of posed facial expressions of emotion (e.g. intentionally encoded by the sender). This kind of methodology raises questions about its ecological validity (Russell, 1994; Wallbott & Scherer, 1986) and the generalisability of the results to real interpersonal emotional communication (Motley & Camden, 1988). Indeed, a number of pieces of evidence indicate that research cannot content itself with data collected with static and posed material.

*Correspondence to: Dr Anna Tcherkassof, Department of Psychology, University Pierre Mendès France, F-38040 Grenoble Cedex 9, France. E-mail: Anna.Tcherkassof@upmf-grenoble.fr

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These evidences, overviewed below, come from researches studying the case of dynamic and/or spontaneous facial expressions of emotion.

THE ISSUE OF STATIC VS DYNAMIC EXPRESSIONS

A large body of research shows that emotion is readily recognised in still photographs of facial expressions (Elfelbein & Ambady, 2002). Nevertheless, in natural settings, emotional messages are conveyed in complex action patterns implying not only facial expression, but also eye gaze direction, head, shoulders and body movement. Regarding facial expressions, individuals typically decode these social signals during dynamic interactions such as conversations (Ekman, 1979). In such natural settings, the face moves and shifts, sometimes even quickly, from one expression to another. In other words, observers in natural environments observe social signals conveyed by the face not as static stimuli but as complex action patterns. Thus, the motion of facial expressions provides observers with other information than the one provided by static expressions since still expressions do not present subtle changes. It may be that differences in the social information displayed by static and dynamic expressions lead to facial recognition differential effects.

Indeed, preliminary investigations suggest that the dynamic aspects of facial movement are likely to be of importance (Bassili, 1978, 1979; Buck, Miller, & Caul, 1974; Hess & Kleck, 1990; Kamachi et al., 2001). Today, for example, the importance of relative timing and temporal evolution of facial signals is commonly acknowledged. The relevance of the relative timing stands out from studies showing that humans are sensitive to the 'correct' timing of the facial display when considering the sincerity or deceptiveness of an emotional expression (Ekman, Friesen, & O'Sullivan, 1988). Yet, studies having systematically investigated this 'correct timing' aspect are scarce (for an exception for smiles¹, see Frank, Ekman, & Friesen, 1993; Hess, Kappas, McHugo, Kleck, & Lanzetta, 1989; Messinger, Fogel, & Dickson, 1999). Regarding the temporal evolution, its pertinence has been mentioned by Ekman and Friesen (1982) for smiles. According to them, false smiles are sometimes obvious because of their short onset and irregular offset times which make them 'socially inappropriate'. Recently, Cohn and Schmidt (2004) have shown that spontaneous smiles are of smaller amplitude and have a more consistent relation between amplitude and duration than deliberate smiles. Hess & Kleck (1990) have also pointed out the importance of the dynamics of facial movements, and particularly the irregularity, or phasic changes, of the expression's unfolding. Thus, pauses and stepwise intensity changes, for example, the number of onset, offset and apex phases that the expression contains, are significant parameters. The relevance of temporal aspects is also stressed in a research conducted by Wehrle, Kaiser, Schmidt & Scherer (2000) on emotion perception for schematic facial expressions. The results support the claim that dynamic displays improve the recognition and differentiation of the facial patterns of emotions as compared to static displays (see also Lemay, Kirouac, & Lacouture, 1995). Moreover, Edwards (1998) has shown that observers are sensitive to subtle changes in a person's facial expression. When asked to assess the temporal progression of emotional facial displays, the participants were able to detect extremely fine dynamic cues. It led the author to assert that facial expressions of emotion are temporally structured in a way that is both perceptible and meaningful to an observer. Thus, static facial expressions of emotion could represent a category of stimuli the emotional contents of which could be processed by distinct mental strategies processes.

¹For example, smiles shorter than 2/3 second or longer than 4 seconds are considered as false smiles.

THE ISSUE OF SPONTANEOUS VS POSED EXPRESSIONS

Spontaneous facial expressions of emotion are generally considered as reflecting the real emotional state experienced whereas posed expressions are considered as non congruent with the experienced emotional state and as intentionally displayed. When comparing judgments of spontaneous and posed expressions, recognition accuracy is much higher in the case of posed expressions (Motley & Camden, 1988). These findings are not surprising since in daily life spontaneous expressions are mild, not very clear-cut (Russell, 1997). Indeed, everyday emotion-eliciting situations are typically less intense and less clear-cut than those used in laboratory experiments (Manstead, Fisher, & Jakobs, 1999). Besides, the link between the underlying emotional state and the related facial display seems to be a weak one (Bonanno & Keltner, 2004; Frijda & Tcherkassof, 1997; Kappas, 2003). For instance, Fernández-Dols, Sánchez, Carrera and Ruiz-Belda (1997) have found no coherence between the subjective reports of the participants watching emotion-eliciting movies and their facial expressions. As an example, two participants have displayed a prototypical expression of surprise while reporting feeling disgust. In other words, the extreme facial configurations such as those used in laboratory experiments as standardised stimuli (most often of Matsumoto & Ekman's, 1988, JACFEE set or Ekman & Friesen's, 1976, pictures of facial affect) are rarely encountered in real life. These extreme configurations, moreover, are 'pure' expressions of the corresponding basic emotion, whereas spontaneous expressions are presumably more often blended expressions than pure ones (Nummenmaa, 1992). Thus, posed expressions are more easily recognised than spontaneous ones probably because they are more prototypical, they are better exemplars of the emotion they depict. As Fernández-Dols and Ruiz-Belda (1997) stress it, they possess an 'artistic truth' that facilitates their recognition. They are also expressed with an exaggerated intensity as compared to spontaneous facial expressions, which makes their identification easier (Hess & Kleck, 1994).

From an encoding point of view, spontaneous expressions and posed expressions differ in terms of morphological and temporal aspects (Ekman & Friesen, 1982). Kanade, Cohn and Tian (2000) provide some examples of such differences. For instance, even if it seems rather easy for anyone to raise the outer corner of eyebrows spontaneously while keeping the inner brows at rest, few can perform this facial action voluntarily. Another example is the spontaneous facial expression of sadness usually characterised by a depression of the lip corners and a raising and narrowing of the inner corners of the brows. Yet, few people can perform these actions deliberately without training. The asymmetry of facial expression is also known to be related to spontaneity and deliberateness of expression (Borod, Koff, Yecker, Santschi, & Schmidt, 1998). Thus, different studies have found that false (deliberate) smiles are more asymmetrical than genuine (experienced) ones (Frank et al., 1993; Hager & Ekman, 1985). Likewise, expressions are generally more intense on the left side of the face, especially for spontaneous ones compared to posed ones (Dopson, Beckwith, Tucker, & Bullard-Gates, 1984; Skinner & Mullen, 1991). Finally, when considering the literature on dynamic expressions, for example, on temporal aspects, individuals seem sensitive to qualitative differences differentiating spontaneous from volitional expressions (Hess & Kleck, 1994). Spontaneous expressions are generally considered to be smoother for example. Spontaneous and deliberate facial expressions differ regarding phasic changes. Hess & Kleck (1990) found that, compared to posed expressions, spontaneous ones have slower onsets and offsets and are less irregular. According to them, the degree of irregularity of the expression is an important feature distinguishing between candid and deliberate expressions. These differences in terms of irregularities could be due to the fact that they are mediated by different neurological pathways (pyramidal and extra-pyramidal motor tracks for volitional and spontaneous facial behaviour, respectively, cf. Rinn, 1984). Thus, differences regarding morphological and temporal features between spontaneous and posed facial expressions of emotion suggest that when considering

the issue of facial expression of emotion, one 'should not regard a few particular prototypical expressions as the most robust source of evidence' (Fernández-Dols et al., 1997, p. 175).

GATHERING NATURAL EXPRESSIONS: METHODOLOGICAL CONSIDERATIONS

Facial expressions of emotion are highly dynamic social signals. The emotion message they display is reflected in facial action patterns. Yet, they have been typically studied as static displays. This is why, even though the central role of the dynamics of facial expressions is endorsed, little is known about the temporal course of facial expressions. Furthermore, most researchers have used emotional expressions simulated or posed by actors. Yet, the lack of spontaneity and naturalness of this material constitutes a serious objection raised against such studies. Thus, as it is claimed by many researchers, there is a strong need for systematic research on spontaneous and dynamic facial expressions of emotion. This need is even more tenacious that research on this issue is likely to provide new and important evidence which will improve our knowledge on emotions.

Why is the use of both spontaneous and dynamic stimuli so rare? One of the major problems is gathering natural facial expressions displaying various emotions, that is, gathering realistic material to be judged by observers. Recording naturally occurring emotional experiences is empirically not easy. Moreover, inducing strong emotional states for experimental purposes gives rise to ethical questions (see Philippot, 1993, for induction considerations). This is why the scientific study of emotion mainly rests on facial expressions posed or simulated by actors, despite the lack of spontaneity and naturalness of this material. Wallbott and Scherer's (1986) statement well embodies the problems researchers in this field are confronted with: 'Simulated emotional expressions are clearly not *natural* enough, the natural expressions of emotion obtained in most studies to date have not been *emotional* enough' (p. 690).

Research attempting to obtain naturalistic recordings of emotional expressions in realistic settings must face, besides the challenge of collecting 'natural and emotional enough' stimuli, the one of the experimenter's demand or experimental context effect. The experimental demand difficulty is a crucial issue when one intends to obtain facial stimuli that represent valid indicators of the underlying emotional state (Wallbott & Scherer, 1986). To make sure that the emotional facial expressions are really natural and spontaneous, it is necessary to induce emotional states without encoders being aware of the emotional nature of the situation, in order to avoid any encoders' expectation. As a matter of fact, such awareness could influence them to express explicitly on their faces the emotional induction to which they are subjected to. The most often used paradigm for inducing emotional states to be displayed on the encoder's face is the one in which the latter looks at emotional excerpts or slides while being himself covertly videotaped (Buck, Savin, Miller, & Caul, 1972; Hess & Kleck, 1990; Wagner, MacDonald, & Manstead, 1986; Zuckerman, Hall, DeFrank, & Rosenthal, 1976). In such a paradigm, one cannot exclude the hypothesis that the obvious emotional nature of the experimental situation somewhat modifies the facial displays of the encoder. Research on spontaneous emotional facial expressions needs to collect facial stimuli provided that the experimental context does not explicitly evoke the issue of emotion.

Finally, tackling the issue of spontaneous and dynamic emotional facial expressions confronts one to another stake: the one of the real-time emotional recognition. Indeed, the counterpart of the temporal unfolding of an emotional facial expression is the temporal progress of emotional recognition. Until now, to our knowledge, no research has studied this issue. Scientific work on recognition of dynamic expressions gathers *a-posteriori* punctual judgments. A film displaying a facial expression is shown to the observer who gives his judgment once the clip is over (Lemay et al., 1995; Matsumoto & Kupperbusch, 2001; Wagner et al., 1986; Wehrle et al., 2000). Another method consists in having

judges scoring the stimuli (most often using the FACS, Ekman & Friesen, 1978; Fernández-Dols et al., 1997; Littell, 1999). Participants can also be asked to arrange emotional expressions in their proper temporal sequence from a set of frames (Edwards, 1998). To our knowledge, the only research having studied the real-time evaluation of dynamic facial information is the one conducted by Buck, Baron and Barrette (1982). In this study, participants had to press a button each time they thought they had perceived a 'meaningful event' when viewing films of spontaneous and dynamic faces of persons reacting to emotionally loaded slides. It should be noted that the accuracy of emotional recognition was not assessed in this study. Therefore, no research on real-time recognition of emotion in facial expressions has been conducted until now even though the pieces of evidence reviewed above show how important temporal cues are (relative timing, duration, etc.).

To summarise, too little data gathered with spontaneous and vivid expressions of emotion is available to date. Likewise, no systematic research has been conducted on the dynamic of the facial recognition of emotions. In order to understand the facial expression process and improve our knowledge of the emotional process, the objective of obtaining natural recordings of emotional expressions in realistic settings remains essential. The goal of the present research is thus to obtain naturalistic recordings of emotional expressions in realistic settings that are 'natural and emotional enough'. The second one is to address the issue of dynamic judgments of facial expressions of emotion, that is of real-time emotional recognition.

In doing so, Ekman's recommendations (1982) have been followed. According to him, an adequate methodology for a relevant emotional induction consists in collecting several corroborating measures, such as *a-priori* assessments of the kind of emotion a given eliciting circumstance should induce (Pilot 1) and simultaneous and/or retrospective self-reports gathered about the affective state experienced by the participant during the spontaneous situation (Pilot 2). A complementary measure is added (Pilot 3): it consists in judgment tasks in which observers assess the emotional 'quality' of the facial expressions in terms of valence and activation dimensions, and of the general affective tone of each recording (external measure).

OVERVIEW

A pilot work (made up of three pilot studies) and one main study were conducted to achieve the above outlined goal. Pilot 1 intends to work out different tasks that elicit various affective states facially displayed, provided that the experimental context does not explicitly evoke the issue of emotion.

Pilot 2 and Pilot 3 aim at obtaining natural emotional expressions video-recorded in realistic conditions. They address the issue of the 'emotional enough' nature of the videotaped facial displays that can be collected when having senders carrying out the computer tasks conceived in Pilot 1. They also deal with the selection of a sample of representative spontaneous and dynamic facial displays.

Finally, the main study deals with the question of collecting dynamic ratings of facial displays, that is of real-time emotional recognition.

PILOT 1: EMOTIONAL INDUCTION TASKS

In order to record naturally occurring facial behaviours, man-computer interactions have been chosen as eliciting circumstances. As a matter of fact, this setting conceived to elicit natural emotional states simulates a real life situation: the one of computer practicing (see also Kaiser, 2003, and Kappas, 2003,

for similar procedures). Since emotion-eliciting situations of daily life are less strong and less unambiguous than those classically used in scientific studies, mild affective states were preferred to prototypical emotions, more rare.

Method

Emotional Elicitation Tasks

Realistic tasks were conceived so as to induce amusement, interest (e.g. positive affective states), irritation and worry (e.g. negative affective states), plus a neutral task. The amusement task consists in choosing the 5 most amusing jokes among 15; the interest task in surfing a Web site plotting the geographic spreading in France (decade by decade) for a given family name; the irritation task in achieving a precision task with a defective computer mouse; the worry task in failing an 'I.Q. Test'². A neutral task consisting in reading a game's directions for use was also thought up.

According to Ekman's (1982) recommendations, the following procedure was undertaken in order to ascertain the appropriateness of the conceived eliciting computer tasks.

Participants

Forty-six ordinary participants (23 females and 23 males) answered two questionnaires.

Procedure

The emotion-inducing tasks were judged by participants in terms of whether they would expect a particular affective state in that situation. In the first questionnaire, they were asked to indicate with their own words the affective state that best corresponded with each of the eight sentences presented. Among these sentences, five depicted the realistic computer tasks conceived for the encoding phase, the three others were distracters. They were next presented with the same sentences again (Questionnaire 2). This time, they were asked to match each of the eight sentences with eight emotion labels (cf. Appendix).

Results

The conceived tasks, as depicted by eight sentences, appear to suitably refer to the corresponding eliciting affective state. Regarding Questionnaire 1, even though the participants have provided several affective states for each task-describing-sentence, a sampling of the emotional verbal descriptions shows that the correct category is assigned to each sentence (Table 1). The study of Questionnaire 2 indicates that participants accurately link the sentences and the target affective state together (Table 2).

²The simulation of a defective mouse is done by having an experimenter, in another room, controlling the mouse without the participant knowing it, thanks to Virtual Network Computer software. The faked 'I.Q. Test' is concocted so that the participant always feels as failing the test: when he/she answers correctly an item, a feedback message indicates on the screen that he/she, as compared to a supposedly control group of social sciences students, has answered too slowly, whereas when he/she gives a wrong answer, the feedback message announces that the answer has probably been given too fast since the 'control group' takes more time to give the correct answer.

Table 1. Questionnaire 1: percentages of answers (free responses) by categories (Pilot 1)

Task-describing sentence no.	No. 1 Amusement	No. 2 Interest	No. 3 No emotion	No. 4 Irritation	No. 5 Worry	No. 6 Pride	No. 7 Perplexity	No. 8 Boredom
Free responses collected	Happiness Joy	Interest Curiosity	Attention Concentration Curiosity Reflexion Interest	Irritation Anger	Worry Anxiety Disappointment Trouble Frustration	Pride Satisfaction Relief	Perplexity Astonishment Lack of understanding Confusion	Boredom Tiresome Despair Annoyance Fatigue
Total of all responses %	100	80	70.2 (no particular emotion : 4.3)	97.9	93.6	76.1	50	56.6

Note: In each column, responses are presented according to their frequency, by decreasing order.

Table 2. Questionnaire 2: percentages of correct task-describing sentences—emotion labels matches (Pilot 1)

Emotional nature of the task	Amusement	Interest	No part. emotion	Irritation	Worry	Pride	Perplexity	Boredom
Emotion label match								
%	97.8	76.1	51.1	93.5	84.8	95.6	69.6	63

PILOT 2: FACIAL DISPLAYS RECORDING

Method

Participants

Forty-three participants (19 females and 24 males, undergraduate French students in computer science) were covertly videotaped while achieving computer tasks. They were told that they were assessing socioeducational software diversissements.

Recording Procedure

The affective eliciting tasks conceived and pre-tested in Pilot 1 were computerised. The participants carried out three of these tasks: a positive one (the amusement or interest task) followed by the neutral one, ending by a negative one (the irritation or worry task). The order of the three emotion elicitation tasks was not counterbalanced, despite a possible contrast effect, in accordance with the 'law of hedonic asymmetry' (Frijda, 1988) which makes it easy to shift from a positive emotion to a negative one, but not the reverse. Their faces were videotaped by a hidden camera located in a cupboard in front of them. The emotional induction of each task was assessed by self-reports once the tasks were carried out³. The emotional induction was assessed by 4-point scales for each task (how much they felt amused, interested, irritated and worried, from 1 'not at all' to 4 'a lot')⁴.

Results

Self-reports' data show that the emotional induction was globally effective for each task (Table 3). For example, when carrying out the amusement task encoders have reported good scores of amusement (2.71) together with low scores for all other affective states. A restriction is observed for the interest scale. For all tasks, encoders have always reported feeling pretty much interested. This is probably due to an accommodating attitude towards the experimenter. Scores on interest scale apart, the affective state target is always the highest and systematically above 2 for all tasks.

Debriefing confirmed that participants have neither been aware of being filmed nor that were they being subjected to an emotional eliciting experiment. Finally, we have obtained all the participants' permission to make use of their face's films for scientific purposes.

³The *in vivo* participants' self-reports were impossible to record since we were looking for conditions that minimise the effect of experimental demand characteristics. Thus, only retrospective self-reports were gathered.

⁴Since there is no necessary correlation between the feeling's intensity and the facial expression displayed (Kappas, 2003), the intensity of the emotional induction as such was not assessed.

Table 3. Emotional induction assessments (Pilot 2)

Task induction emotion	Felt emotion	Amusement	No particular emotion	Irritation	Interest	Worry
Amusement	Group means <i>n</i> = 21	2.71 (0.78)	1.38 (0.67)	1.05 (0.22)	2.71 (0.56)	1.38 (0.50)
No particular emotion	Group means <i>n</i> = 43	1.22 (0.52)	1.73 (0.9)	1.15 (0.36)	2.05 (0.8)	1.39 (0.59)
Irritation	Group means <i>n</i> = 22	2.00 (1.02)	1.18 (0.39)	2.36 (0.79)	2.86 (0.77)	1.73 (0.70)
Interest	Group means <i>n</i> = 22	1.48 (0.75)	1.57 (0.93)	1.10 (0.31)	2.38 (0.86)	1.19 (0.51)
Worry	Group means <i>n</i> = 21	1.71 (1.10)	1.19 (0.51)	2.00 (0.84)	2.95 (1.02)	2.65 (1.04)

Note: SD between brackets.

One hundred twenty nine films (43 participants \times 3 tasks) have been collected. The length of the collected excerpts corresponds to the length of the task. It must be noticed that up to now, there is no consensual criterion for defining dynamic sequences. Researchers using video clips do not always specify the length of their films, and when they do so, do not justify it (clips' length vary from 2 seconds to at least 24 seconds). For the present research, we decided to keep the length corresponding to the natural setting.

First Production of Stimuli Material and Selection of 10 Facial Recordings.

The second step of the study was to select the 'best' material, that is 'natural though emotional enough' stimuli, in order to end up with a good quality sample of spontaneous and dynamic facial displays. Out of the initial 129 films, 49 have been removed for technical reasons (such as bad centering of image) or for feature ones (hand in front of the mouth during all task long, full beard. . .). The 80 remaining films (16 of the amusement task: 6 females, 10 males; 14 of the interest task: 6 females, 8 males; 16 of the irritation task: 10 females, 6 males; 12 of the worry task: 3 females, 9 males; and 22 of the neutral task: 7 females, 15 males) have been reprocessed using Virtual dub software in order to keep 1 minute long excerpts.

PILOT 3: EXTERNAL JUDGMENTS STUDY

A judgment study was then conducted to collect different emotional ratings on each film. The purpose was to assess the emotional 'quality' of the facial displays, in terms of valence and activation dimensions and of the general affective tone of each excerpt, in order to end with a sample of representative facial displays. Indeed, during such a length, the target affective state cannot be expressed continuously and several facial displays are exhibited, among which the target emotion. Thus, one objective was to select the excerpts in which the target affective state is the most displayed. Our second aim was to dispose of a sample of 10 clips showing a sender of each gender for each emotional task—amusement, interest, irritation, worry and neutral—with all different expressive

senders (i.e. 10 different encoders, 5 females and 5 males) each involved in a different emotional task chosen among the above 80 films.

Method

Participants

Seventy-five judges (66 females, 9 males), undergraduate French students in psychology, were recruited.

Stimuli

The 80 remaining excerpts were presented by series of 10 films. The order of the series was counterbalanced over participants. Within each series, an encoder never appeared twice, two encoders carrying out a similar induction-task never followed one another, and the induction tasks were always presented out of order.

Procedure

Participants were presented with one series of 10 films. Following the presentation of each film, participants were asked to assess the general valence and degree of activation of the facial displays of the encoder on two different 7-point scales (from -3 : unpleasant to $+3$: pleasant and from -3 : passive to $+3$: proactive). Once the series displayed, participants were presented with the 10 films again. They were asked for each film to choose out of eight emotional items (five target labels and three distracters) the one depicting the general emotional tone of the clip (forced choice).

Results

Data were analysed film by film in order to select the best videotapes in terms of their emotional quality. More specifically, the valence, the activation and the general emotional tone assessments of each film were compared to the means scores of all the films from the same emotional group. The personal self-report ratings of the emotional induction were also considered. The 10 films giving rise to the best pattern of scores regarding the valence, the degree of activation, the general affective tone and the quality of the emotional induction of the encoder were selected. (cf. Table 4). For example, the films of the encoders carrying out the amusement task have been globally assessed as reflecting a valence score of 1.44, an activation score of 0.95 and a percentage of recognition of 0.52 (1 = all stimuli have been given the correct affective label by all participants, 0 = none of the stimuli have been given the correct affective label). Among these amusement films, one displaying a male has gathered a valence score of 1.67, an activation score of 0.89 and a percentage of recognition of 1. The personal self-report rating regarding the emotional induction of this encoder was good (he reported experiencing a lot of amusement when undergoing the amusement task: 4, and he reported low scores on all other affective scales: 2 for interest, 1 for no particular emotion, 1 for irritation, and 2 for worry). As this pattern of data was the best among the patterns of all male encoders, this film has been chosen. This method of selection was applied to all films.

Table 4. Sample selection: emotional quality scores and self-report ratings of selected senders (Pilot 3)

Amus.										Inter.									
										No p. Emo.									
										Irrit.									
										Worr.									
Val.	Activ.	Recog.	Val.	Activ.	Recog.	Val.	Activ.	Recog.	Val.	Activ.	Recog.	Val.	Activ.	Recog.	Val.	Activ.	Recog.	Val.	Activ.
Group means	1.44	0.95	0.52	-0.08	0.79	0.36	-0.47	-0.16	0.24	0.29	0.97	0.14	-0.42	0.54	0.29	-0.31	0.25	0.08	0.58
Males	1.67	0.89	1.00	1.17	1.58	0.83	-0.33	-0.50	0.17	-1.00	1.89	0.56	-1.62	-0.31	0.25	-0.17	0.58	0.08	0.58
Females	2.44	0.67	0.78	0.00	0.44	0.33	-1.00	0.14	0.08	-1.90	1.10	0.44	-0.17	0.58	0.08	-0.17	0.58	0.08	0.58
Induct. ratings	A	In	N	Ir	W	A	In	N	Ir	W	A	In	N	Ir	W	A	In	N	Ir
Males	4	2	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Females	4	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Note: Amus. & A, amusement; Inter. & In, interest; No p. emo. & N, no particular emotion; Irrit. & Ir, irritation; Worr. & W, worry; Val., valence; Activ., activation; Recog., recognition. The induction rating lines must be read as follows: the male selected for his amusement displaying (first main column) has scored 4 on the amusement scale, 2 on the interest scale, 1 on the no particular emotion scale, 1 on the irritation scale, and 2 on the worry scale when answering the induction questionnaire (self-report rating). The male selected for his interest displaying (second main column) has reported 1, 4, 2, 1, 1, respectively on the amusement, interest, no particular emotion, irritation and worry induction scales.

Once the sample of 10 'natural and emotional enough' facial displays selected, a last study was undertaken in order to address the issue of dynamic judgments of facial expressions of emotion.

MAIN STUDY: DYNAMIC DECODING DEVICE

Since emotion is manifested in the course of time, it seems relevant to collect judgments along this same temporal dimension. The present study aims at tackling the issue of dynamic judgments of facial expressions of emotion, that is of real-time emotional recognition. To our knowledge, no existing device allows on-line emotional judgment recording. The purpose of the present study consists in the development of such a device.

In order to address the question of real-time emotional recognition, a specific user interface (cf. Figure 1) has been developed for the purpose of the study. This device collects participants' judgments in the process of visualisation, that is, gathers dynamic records, or ratings, of facial displays.

According to Russell et al. (2003), when spontaneous emotional expressions, as compared to posed expressions, are presented to observers, the recognition rates for a given emotion drops or even disappears. In this perspective, since the expressions collected are natural, we expect that they will be moderately expressed and thus that the amount agreement on a specific affective state will remain low.



Figure 1. Dynamic judgement interface. Emotion icons (from left to right): pride, worry, interest, perplexity, boredom, amusement, irritation, no particular emotion or neutral

Besides, we hypothesise that, according to literature, the positive spontaneous expressions will be more accurately identified than the negative ones (Wagner et al., 1986). In addition, we expect effects of the target gender: females' spontaneous and dynamic facial expressions will be more accurately recognised than males' ones. Indeed, an expressiveness superiority of women as compared to men has often been observed both for spontaneous and posed expressions (see Hall, Carter, & Horgan, 2000, for a review of gender differences).

Method

Participants

Decoders are 34 females and 33 males, voluntary undergraduate French students of psychology.

Material

The computer interface displays facial expressions films one after the other. Under the film part of the screen are represented several icons on which are inscribed the affective labels derived from the free responses collected in Pilot 1. The following icons are proposed: no particular emotion, amusement, interest, irritation, worry (e.g. the correct labels), pride, boredom and perplexity (i.e. distracter labels). Dynamic judgments are assessed 'on line' by having the decoder, while the film is displaying, clicking the corresponding icons with the mouse each time he/she identifies an emotion expressed by the face (if any). An icon remains clicked on as long as another icon is not clicked upon. A program allows real-time records of the number and length of clicks for each icon throughout the film.

Procedure

Participants each view the sample of 10 clips previously selected (1 minute long, each showing an encoder's facial expressions while carrying out an emotional eliciting task, with four encoders—two females and two males—for each task, cf. Pilot 3). The displaying order is randomised except for the constraint of not showing the same emotion in two consecutive films. Participants are told they will be viewing individuals facing a computer. They are asked to assess 'on line', while watching the film, the emotions expressed (if any) by the individuals' faces by clicking the corresponding icons with the mouse. Participants start with one training trial-film (this film is used only for the training trial). The training excerpt presents a man achieving an interest task. Instructions are repeated before each film.

Results

Facial Decoding Activity

A first descriptive examination was carried out in order to check the suitability of the created device with the facial decoding activity (aside from the accuracy issue). Indeed, as specified earlier, the target-emotion is not displayed continuously by the encoder, though it is the prevailing affective state (cf. Pilot 2 and Pilot 3). The interface must allow observers to indicate when they detect one or another affective state. It was thus expected that participants would use several icons while watching an excerpt. Participants, obviously, have found the task meaningful since they have clicked on several icons when watching a film. On average, each film has been clicked six times. Participants had no difficulty, during

Table 5. Number of clicks on the emotional icons for each emotional category films (Main study)

Stimuli	Icons' labels								Total
	Amusement	Interest	Irritation	Worry	No particular emotion or neutral	Pride	Perplexity	Boredom	
Amusement	397	255	5	28	76	23	93	23	900
Interest	7	238	19	65	75	4	211	65	684
Irritation	0	255	39	78	53	9	230	15	679
Worry	4	152	280	189	50	9	168	30	882
Neutral	11	172	114	55	44	4	331	166	897
Total	419	1072	457	415	298	49	1033	299	4042

the unfolding of the facial expression, to match what they were seeing with a particular emotional label and this without major inconsistency. Indeed, on the whole, the complete icons' panel has been used (Table 5). Whatever the emotional facial expression film, the number of clicks was globally equivalent (amusement = 22.26%; interest = 16.92%; irritation = 16.79%; worry = 21.82% and no particular emotion or neutral = 22.19%). The decoding activity was thus comparable. Moreover, the information decoded varies along with the type of facial expression. Participants have principally clicked the 'amusement' icon when looking at facial expressions of encoders carrying out an amusing task (397 clicks), even though they have also often clicked on the 'interest' icon (255 clicks). When looking at facial expressions of encoders carrying out an interesting task, decoders have almost always clicked on the corresponding icon and on the 'perplexity' icon (238 and 211 clicks, respectively). For the facial expressions displayed by an encoder achieving the irritation task, decoders have seldom clicked the 'irritation' icon (39 clicks only). In fact, they have attributed to these expressions the 'interest' and 'perplexity' labels (255 and 230 clicks, respectively). The facial expressions of encoders achieving the worrying task have been seen as expressing different affective states. The 'irritation' icon has been clicked the most (280 clicks), but the 'interest', the 'worry' and the 'perplexity' icons have also been selected quite often (152, 189 and 168 clicks, respectively). Finally, participants have above all clicked the 'perplexity' icon when looking at facial expressions of encoders completing the neutral task (331 clicks). The decoding activity was thus clearly different and specific for each type of emotional facial expression. Therefore, the interface's appropriateness with the decoding activity seems to be confirmed.

Judgment Accuracy

Once the suitability of the device checked, the judgment activity accuracy issue was then undertaken. An accurate judgment is the one that detects the prevailing affective state of each film. The device allows two different measures: the number and the length of clicks. As the films' length is fixed and identical for all participants and since the calculation of the clicks' length draws upon the number of clicks, the time measure was opted for. Hence, recognition of facial expressions was evaluated according to the calculation of the target-click's total length (sum) in relation to the total length of all the other clicks (length expressed in seconds).

Additionally, Wagner (1997) has recommended to use an unbiased hit rate (Hu) when studying the accuracy of facial expression recognition. Though the present judgments are real-time assessments, we

decided to follow this recommendation primarily advocated for punctual judgments, in order to take into account possible stimulus bias and response bias. We therefore adopted Wagner's calculation method. It combines 'the conditional probability that a stimulus will be recognised (given that it is presented) and the conditional probability that a response will be correct (given that it is used) into an estimate of the joint probability of both outcomes. This is done by multiplying together the two conditional probabilities [...] divided by the appropriate marginal total' (p. 50). Thus, the accuracy is a proportion of both responses and stimuli frequencies. Confusion matrixes were elaborated so that an unbiased hit rate (Hu) calculated for each participant could be used as a dependent variable. Hu ranges from 0 (no recognition at all) to 1 (complete recognition).

An ANOVA was performed with 5 emotions \times 2 sex of encoder as factors. No effect of the 'sex of decoder' has been found (M women = 0.101 vs. M men = 0.103; ns). A significant main effect for the 'sex of encoder' was observed, $F(1,65) = 79.62$, $p < .00001$. The recognition's duration of emotions displayed by female encoders is lower than the male encoders' one ($M = 0.06$ vs. 0.14). A significant main effect for the 'emotional categories' was also observed, $F(4,260) = 219.39$, $p < .0001$. Post-hoc contrasts showed that recognition rates are all significantly different one from another ($p < .001$). Aroused facial expressions (amusement and irritation) are recognised at greater length than weakly aroused ones (interest and worry).

The analysis also revealed an interaction between encoders' sex and emotional category, $F(4,260) = 25.56$, $p < .00001$. When splitting up the interaction, post-hoc analyses revealed that female versus male pairwise comparison for 'irritation' accounts for this main effect, ($F(1,65) = 41.53$, $p < .00001$), and the proportion of variance attributable to this pairwise comparison is 87%. Male targets' emotion is identified for longer than female targets' one ($M = .279$ vs. .049).

Recognition of emotional categories according to their chance level was then examined in order to compare participants performances with those to be expected by chance (Table 6). According to Wagner (1997), this means estimating 'the joint probability of the co-occurrence by chance of the stimulus and response of a particular class by multiplying together the independent probabilities of each of these' (p. 51). Repeated measures t -test indicates that obtained recognition rates of the various emotional categories are significantly different from rates expected by chance, except for the worry category (amusement: $t = 22.30$, $p < .001$; interest: $t = 6.56$, $p < .00001$; neutral: $t = 2.49$, $p < .01$; irritation: $t = 13.53$, $p < .00001$). Recognition rate of facial expressions displayed by encoders achieving the worry task does not differ from the respective chance level (whatever the stimulus's sex, $p < .01$). The very low Hu of the worry category ($M = .007$) accounts for this result (cf. Figure 2).

Finally, when examining recognition rates of the various emotional categories (worry category apart) and the corresponding chance levels (ChL) according to the sex of the stimuli, repeated measures t -tests indicate that recognition performances are different with those to be expected by chance, whatever the sex of the encoder ($p < .01$) except for the Neutral-Female stimulus (facial expressions of a woman carrying out a neutral task) (Hu = .006 vs. ChL = .004, ns). Once again, this result is accounted for by a very low Hu.

Table 6. Accuracy means (Hu) and chance levels for the different emotions (Main study)

	Hu	Chance level
Amusement	.488	.019
Interest	.102	.043
Neutral	.023	.009
Irritation	.240	.021
Worry	.007	.017

Note: All Hu significantly different from respective chance level ($p < .01$) except for worry.

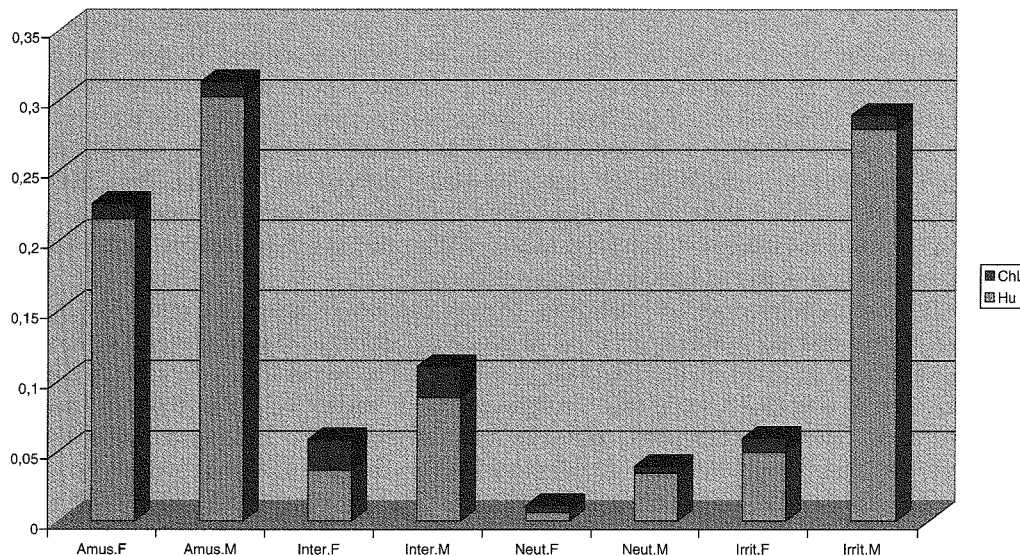


Figure 2. Emotional categories recognition rates (Hu) and corresponding chance levels (ChL) according to the sex of the stimuli (Main study)

GENERAL DISCUSSION

The present exploratory research addresses methodological considerations relevant to nonverbal communication research. More specifically, it was guided by two main objectives: The first one was to obtain natural recordings of emotional expressions in realistic settings, the second one to address the issue of dynamic judgments of facial expressions of emotion, that is of real-time emotional recognition.

The first objective is guided by the fact that, even if the premise that human face is particularly effective at communicating affective information, and that—counterpart of this premise—an observer is able to easily decode the displayed emotional message, is widely endorsed, the existing evidence does not allow in reality researchers to authenticate the two sides of this postulate. Indeed, research has essentially worked with static and posed (simulated) material, despite serious objections concerning the ecological validity and the generalisation of such results. Little is known about the issue of spontaneous and dynamic facial expressions because of the difficulty of obtaining ‘natural and emotional enough’ stimuli (Wallbott & Scherer, 1986). Yet, even if scarce, existing data underline the necessity to study facial expressions of emotion as dynamic signals, in order to improve our knowledge regarding nonverbal emotional communication. One challenge was to induce affective states without participants being aware of such an induction, in order to videotape spontaneous natural facial expressions. Computer tasks inducing affective states that are as comparable as possible to naturally occurring emotions, that is, computer tasks resembling everyday life situations, were imagined. The genuine nature of such situations is essential since experimental demand needed to be avoided. It is acknowledged that demand characteristics raise serious difficulties regarding the validity of emotion induction procedures. When one does not control for this demand effect, it can be argued that participants do not really feel the intended induced emotion. It may be that participants guess the purpose of the study, and wanting to comply with the experimental demand, pretend that they feel the desired affective state. Our results show that such an experimental demand is not effective in our induction procedure. Thus, it appears that the tasks developed for emotional induction are valid (except

for worry, see paragraph below), since they have the capacity to induce differential affective states. These states seem to be as comparable as possible to naturally occurring emotions since the eliciting conditions resemble realistic ones, even if they are minimally social ones. Finally, these tasks arouse identifiable emotional facial expressions, that is 'emotional enough' displays. Our first objective is thus reached.

As regards to the second objective, our aim was to address the issue of dynamic judgments of facial expressions of emotion, that is, to investigate the perception and attribution of emotions to these expressions in a dynamic perspective. Indeed, typical judgment studies, since they use static material, do not study dynamic recognition. This recognition investigation hence aimed at checking the suitability of a dynamic judgment procedure. A device was developed to record chronological, or real-time, judgments. This device, if validated, will allow further research to match the temporal evolution of a facial expression with the correlative subjective judgment of the observer. The facial expressions covertly videotaped were therefore submitted to a dynamic judgment recognition study. Results show that the device permits an examination of real-time decoding activity since participants were able to attribute different emotional labels during the course of an expression they were looking at. The next step consists in a closer examination of these preliminary results in order to explore the dynamic aspects of the facial expressions recorded and their relationship with the observers' interpretations. Such an examination of synchronised measures of encoding and decoding activities, that is, a moment-by-moment analysis considering simultaneously the facial changes and the observer's answer, is currently undertaken by the authors. The correlation between significant parameters such as temporal evolution, pauses and stepwise intensity changes, or phasic changes, and the decoder's emotional judgments are expected. In the long run, Wehrle et al.'s (2000) aspiration of determining 'the nature of the temporal-spatial signatures of different emotions' (p. 13) will possibly be matched.

Regarding recognition accuracy, recognition rates of the emotions expressed by the dynamic and non-deliberate stimuli, in accordance with the literature on recognition of spontaneous facial expressions, are rather low even though the levels of accuracy are generally significant. Accuracy was found to be highest for amusement followed by irritation. Thus, fairly aroused facial expressions (amusement and irritation) are better recognised than weakly aroused ones (interest and worry). Wagner et al. (1986) have already pointed out the relation between the relative strength of an emotional response and the readability of its corresponding facial display. The strength of the response yielding an interpretable facial expression seems to vary for each emotion. Thus, contrary to amusement and irritation, interest and worry could be emotional states that need to be fairly strong before being facially readable. Moreover, an effect of the sex of the encoder is found, even though it is explained by the emotional category 'irritation' only. When achieving irritating tasks, the man seems more prone than the woman to express facially his affective state. It is possible that an encoder bias operates in the present situation. It could be that the female encoder happened to be unexpressive or the male encoder to be 'over expressive'. Idiosyncratic differences, if they exist, should be controlled for by multiplying the number of encoders. Further research is needed to remedy this difficulty. Another alternative is that the female encoder offers more facial expressiveness variability. If this is the case, she displays more facial subtleties. These subtleties are detected by observers and lead them to switch from an emotional judgment to another. Length of target judgments (irritation) are therefore reduced, which results in a diminution of accurate recognition. At last, it should be stressed that gender differences in anger displays found in the present study are not so surprising. Research on gender differences indicates that men tend to outwardly express anger whereas women tend to express it more inwardly (Kring, 2000). These gender differences are usually linked to Western cultures' social norms and display rules that encourage the manifest expression of irritation in men (as it reinforces a virile image) but discourage it in women. Other research must be conducted in order to pursue the issue of sex differences, notably in

specifying the circumstances giving rise to or inhibiting such differences. Further research must also be conducted on worry expression. As a matter of fact, in the present study, spontaneous facial expressions of worry were hardly accurately decoded. Once again, different explanations exist. The emotional induction of worry is possibly ineffective. Even though the encoders have reported some worry when carrying out this task, it may be that the eliciting task is not the best one to induce such a state, or a state intense enough. As already suggested, worry, maybe, needs to be fairly strong before an interpretable facial expression is produced. Maybe another task would elicit more worry than this one and produce more facial displays. Another hypothesis is that of an operative social control. Encoders might reduce or even neutralise the expression of this affect which is not socially valued. Thus, they can report subjective feelings of worry when achieving a worry task without displaying it on their face. Finally, a label categorisation problem can account for the worry recognition rate. It is possible that observers did not find the 'worry' icon as best depicting the corresponding displays. Indeed, and this is one of the major limitations of the present study, a forced-choice response format is used to assess the dynamic judgments. Russell (1994) has documented the potential problems stemming from forced choice. He has shown that this type of response format 'can yield anything from random choice to a consensus' (p. 117) according to the lists of items given to the participants. In the case of the present study, decoders might have preferred available plausible alternatives—irritation, perplexity—to the 'correct' (predicted) icon, as Russell's (1993) participants did. In Russell's study, the predicted option was not always the modal choice. Thus, when assessing an angry face, 40% of the participants selected the frustration item, 31.7% the determination item, and only 12.5% the anger item (e.g. the 'correct' label). In our case, other response formats are needed to corroborate these preliminary results. The next scientific challenge is even to develop an instrument that allows an examination of real-time judgment without having recourse to labelling, that is, semantic recognition. Indeed, selecting a label among a list of emotions or describing a face with one or a few words (freely chosen labels response formats) cannot be considered as the most natural mode of response (Tcherkassof, 1997): it is obviously not what people usually do in everyday interactions. This is why other modes of response to facial expressions need to be developed in order to assess real-time emotional recognition. Finally, the present findings are also limited by the fact that only two films for each expression (one sender of each sex) were used. A replication with other variants of each expression is required, since the sample of 10 faces used here is very small, and therefore not representative enough of the wide variety of dynamic facial signals.

In summary, we can conclude that the induction tasks described here have successfully generated distinct facial expressions of differentiated affective states while taking ecological constraints into account. An innovative device allows us to gather dynamic judgments of the spontaneous and dynamic facial expressions. To our knowledge, this study is the first one to propose a paradigm where observers are able to make emotional judgments as the expressions are going along. The first results are stimulating. On the whole, this study shows the utility to investigate dynamic emotional judgments of spontaneous and vivid expressions since observers, who didn't have any trouble associating on-line particular emotion labels to facial movements changing over time, have recognised more than a general affective tone and seem to be sensitive to the slightest change in facial expressions. Thus, an interesting outcome of this research is that this kind of method will probably enable us to improve our knowledge regarding spontaneous emotional nonverbal communication, and this in different respects: First, as regards to the functions of facial expressions (Manstead et al., 1999; Schmidt & Cohn, 2001); second, about the different psychological processes implicated, in all likelihood, in the perception of static and posed facial expression on the one hand and of dynamic and spontaneous displays on the other hand (Cohn & Schmidt, 2004; Gepner, Deruelle & Grynfeldt, 2001; Kilts, Egan, Gideon, Ely, & Hoffman, 2003). Thus, many potential research directions and several possible applications arise from this promising paradigm.

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APPENDIX

	QUESTIONNAIRE 1 (free responses)	QUESTIONNAIRE 2 (matching task)
Sentences	Affective states elicited	Emotion labels
No. 1. A person reads jokes	Free response	Perplexity
No. 2. A person finds out her name's story on a genealogy web site	Free response	Boredom
No. 3. A person reads a game's directions for use	Free response	Pride
No. 4. A person achieves a precision task with a defective mouse	Free response	Amusement
No. 5. A person fails an I.Q. Test	Free response	Worry
No. 6. A person reads an incoherent article on a news web site	Free response	Irritation
No. 7. A person corrects a long explanatory leaflet translation	Free response	Interest
No. 8. A person succeeds in finding the key to the riddle	Free response	No particular emotion

