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The influence of facial interface design on dynamic emotional recognition

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Abstract The use of facial interfaces in distant communications highlights the relevance of emotional recognition. However researches on emotional facial expression (EFE) recognition are mainly based on static and posed stimuli and their results are not much transferable to daily interactions. The purpose of the present study is to compare emotional recognition of authentic EFEs with 11 different interface designs. A widget allowing participants both to recognize an emotion and to assess it on-line was used. Divided-face and compound-face interfaces are compared with a common full frontal interface. Analytic and descriptive on-line results reveal that some interfaces facilitate emotional recognition whereas others would decrease it. This study suggests that relevant interfaces could improve emotional recognition and thus facilitate distant communications.

Keywords Facial expression · Interface · Dynamic recognition · Emotional recognition · Spontaneous emotion

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1 Introduction

The use of visual interfaces is rising in professional, educational, and domestic environments. Thanks to the development of facilitating conditions—such as technological devices and connection speed—these interfaces allow a relevant facial recognition. For example, web platforms or mobile phone platforms displaying the face of each speaker are now commonly used in private communications (e.g. face-time devices, multiple web-conference, or web meeting, Fig. 1). This growing interest for such interfaces can be explained by the improvement of emotional communication. Seeing the speaker's face disambiguates messages and situations. It is now accepted that a physical proximity is not necessary to understand sender's emotions. Consequently it is important to understand how emotions are recognized with communication interfaces.

Evaluation of distant interactions and influence on communicative processes are precisely detailed by psycho-sociological studies. Research shows that seeing the speaker's face may help to manage users' activities under certain conditions [1,2], and [3]. For example, *task map* researches [1,4,5], and [6] show how the speaker's face helps to communicate messages and to resolve problems in negotiations. Facial information is not always relevant for communication and problem resolving. For example, neurosurgical operations [7] or object-focused task [8] and [9] are not influenced by facial recognition. To Carles [10], this distinction can be explained by an intrinsic characteristic of video-mediated interactions. He shows that mediated interactions are more formal than face-to-face ones. Thus a mental distance is building to understand the speaker face when the physical distance is ambiguous. Nevertheless, even with this mental distance people are able to assess more precisely speakers'

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Fig. 1 Some examples of the use of visual communication interfaces

reactions such as presence, attention, understanding, participation, agreement, frustration or excitement [10].

Even if facial expressions are key features in communication understanding, they are complex to investigate for two reasons. Firstly, emotions are quick and subtle. Their measure must consider their time-course (i.e. *on-set*, *apex*, and *off-set*) and their intensity. The second reason is that emotions are spontaneous. Awareness of being scrutinized is sufficient to modify emotional authenticity. Thus, research on emotional recognition has tried to handle this complex facial information.

2 Authenticity of EFE in the emotional recognition

Although the direct link between emotion and facial expression is commonly accepted this relationship is not as simple [11,12] and [13]. The emotional feeling does not necessarily mean facial expression because emotion have conscious feedback mechanisms that allow expressers to hide them such as *display rules* [14]. However spontaneous expressions refer to facial configurations displayed without conscious control [15,16] and [17]. In contrast, posed expressions results from voluntary facial movements in order to simulate a given configuration considered as being representative of a felt emotion. Therefore visual communications experiments need to be performed with spontaneous emotional facial expressions (EFEs) [18] in order to understand the influence of their temporal evolution and their authenticity [19,20], and [21].

2.1 EFE's temporal evolutions

Speakers are instinctive emotional decoders observing social signals expressed by another face. These social signals are complex and can be divided into 46 facial action patterns whose combination conveys emotions [14]. Different methodologies are used to evaluate the emotional recognition because these combinations are very subtle, [22–24], and [25]. The main one uses static EFEs. Pictures, drawings or 3D static representations facilitate the recognition of subtle emotions because they are a chosen facial pattern combination. These chosen combinations reduce the complexity of EFEs' temporal evolution and artificially increase their recognition.

In order to understand differences between static and dynamic recognition, researchers compared three kinds of temporal display of facial expressions: single-static, multi-static and dynamic display. Results show that facial movements influence emotional recognition. For example the facial shifting between two different emotions is easily discriminated whereas static stimuli cannot reflect their evolutions (see also [26]). Furthermore, Ekman and Friesen's [27] studies with dynamic EFEs reveal that people are sensitive to subtle changes of facial expressions.

Despite the importance of dynamic EFEs, static facial expressions are still commonly used as stimuli in laboratory situations (e.g. *JACFEE set* [28] or *Pictures of facial affect* [27]). They are used in spite of to artificially increase recognition rates compared to dynamic expressions [18].

2.2 Spontaneous facial expressions

To understand subtle EFEs in video-mediated interactions [29] (i.e. less prototypic and intense), spontaneous expressions should be carefully considered. Research on facial expression distinguishes two kinds of emotional material: posed and spontaneous expressions. In the first case posed facial expressions are consciously driven whereas spontaneous expressions are unconsciously produced. This difference has consequences on the emotional recognition [30]. For example, they have different temporal evolutions. It seems that posed expressions are shorter and that they have quicker on-set and off-set. A second difference is that posed expressions are more easily identifiable than spontaneous because the latter are often dazzling and/or subtle [31] and [32]. Regarding daily interactions, spontaneous expressions are less cartoonish and prototypical, and more ambiguous [20]. Consequently these expressions are less intense and typical, and more elusive than expressions displayed in pictures expressing emotional stereotypes [26]. In the same way, research reveals temporal morphological differences between posed and spontaneous expressions [33,34], and [35]. For example, static and posed expressions allow a faster and accurate recognition.

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Even if static and posed expression allow better recognition rates than dynamic and spontaneous, it would be difficult to consider these results to be extendable to the analysis of common communications. Relevant cues need to be identified in a dynamic and spontaneous way [36]. An example of this necessity is the development of new both dynamic and spontaneous EFEs' databases [37,38] and [39]. Moreover to Hess and Kleck [24] global and specific facial characteristics should be considered in communicative interface for the emotional recognition during mediated interactions [40] and [41].

3 Framework

Following this prerogatives, the growing of communicative interfaces allows new way to investigate expressive communications. This article aims to identify how EFE recognition could be improved with innovative interface designs. A second aim is to evaluate the relevance or irrelevance of particular facial areas in different emotional recognition [42]. A Previous study using innovative displays shows different facial clues for each emotion [43]. For that reason this research focuses on the design of EFEs' recognition interfaces aimed at supervising and facilitating interaction between users in distant and collaborative communications. To identify emotional recognition cues, we compared the impact of facial interface designs on emotional recognition. Therefore we created 11 facial designs in order to analyze the EFEs displayed.

In this study encoders do not directly communicate with decoders to control visual variables such as turn-talking or lip-reading which can influence emotional recognition.

4 The recording of emotional facial expressions

Our first aim was to record dynamic and spontaneous facial expressions. In a first step participants were filmed unknowingly while completing three emotion induction tasks. Forty three participants (19 females and 24 males, undergraduate French students in computer science) took part in this recording. They were covertly videotaped while achieving computer tasks (see [21] for details). They were told that they were assessing socio-educational software divertissements.

5 Emotion induction tasks

Even if the most studied emotions are basic emotions (joy, fear, disgust, surprise, sadness and anger), the aim of this research was to study mediated interaction in achieving working tasks. Indeed the emotional recognition context relates to the supervision of distant tasks such as teaching tasks for example. Recent studies on everyday facial expressions have shown that interest, boredom, anxiety, and thoughtfulness are the kinds of expressions most often observed in face-to-face interactions and computer tasks [35]. Douglas-Cowie et al. [44] refer to such daily affective states as pervasive emotions ("forms of feeling, expression and action that color most human life" p. 488). For the present research purposes, amusement, interest, perplexity, and irritation (plus a neutral expression, see Table 1) were targeted. Valence (positive vs. negative) and intensity (high vs. low) discriminate these emotional states.

Table 1 Classification of the emotional stimuli on valence and intensity

Valence/intensity	High	Low
Positive	Amusement	Interest
Negative	Irritation	Perplexity

Thus five different computer tasks inducing various affective states were created to record these spontaneous facial expressions. The *amusement task* consisted 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 *perplexity task* in failing an 'I.Q. Test'. The *neutral task* consisted in reading a game's directions for use. A last scenario was also developed to induce no emotion, the resulted videos being regarded as "neutral emotional facial expressions" (see [45] for details). Each task lasted about 5 min.

5.1 Recording method

Tasks were presented on a 17″ laptop screen at 50 cm away from the participant. Participants were recorded without their knowledge to make sure they behave authentically. Two rooms were used to design this recording: the experimentation room, where the encoder (participant expressing EFEs) performed her/his emotion induction tasks and the control room where technical experimenters launched recordings and made sure emotional inductions went smoothly.

5.2 Agreement procedure

Participants were asked to sign a first agreement which asked them to use the data issued from the test for research purposes. Then they were installed in the experiment room to achieve their induction tasks. Each participant performed only three on the five induction tasks to shorten the encoding session and to lower the cognitive load. Participants started with a randomly selected positive task (i.e. *amusement* or

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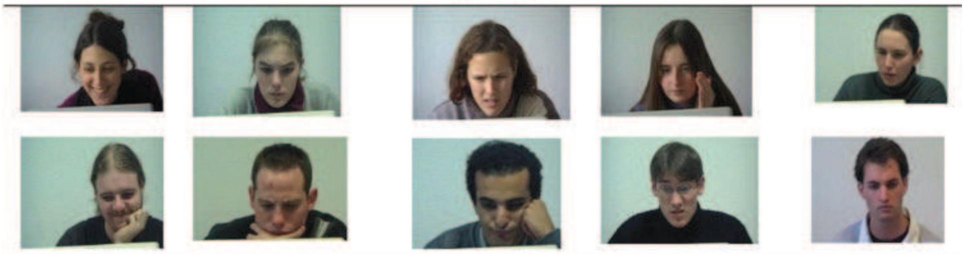
Table 2 Pictures are taken from the ten selected videos

Positive Emotion		Negative Emotion		
Amusement	Interest	Perplexity	Irritation	Neutral



interest) and ended with a randomly selected negative task (i.e. *irritation* or *perplexity*). They performed the neutral task in-between. Once the three tasks accomplished, they were debriefed. They finished by signing a second consent form allowing the use of their image in a scientific framework.

5.3 Choice of EFE stimuli

In order to end up with a good quality sample of spontaneous and dynamic facial displays, ten EFEs films (five female participants and five male participants) were chosen among the initial 129 (43 participants × 3 tasks) films (cf. Table 2). Stimuli were selected because both encoders' self-reports and decoders' assessment indicate that they strongly experienced and recognised the targeted emotion (see [21] for further explanations on stimuli construction). These EFEs recordings have been reprocessed to end up with 60 s excerpts.

6 Dynamic emotional recognition with innovative interfaces

Given the importance of emotional recognition in communication, improved innovative interfaces were designed from the common full frontal view. Then a judgment study was conducted to collect dynamic emotional recognition on each excerpt.

6.1 Emotional interface design

The 10 selected EFE excerpts were processed into 11 interface designs (Fig. 2) to compare their efficiency for emotional recognition. The design of these interfaces is based on zoomed (a) and distant (b) full frontal view. Three simple interfaces were designed to evaluate the facial areas involved in emotion recognition [35]: the eyes-only (c), the mouth-only (f) and the eyes-and-mouth interface (i). Following the assumption that adding information in an expressive interface facilitates the emotional recognition than full frontal views, composite interfaces were constructed. They are designed on zoomed and distant full frontal modalities with additional areas: eyes (d and e), mouth (g and h), eyes and mouth (j and k).

6.2 Participants

Two hundred forty two students (215 women and 27 men) participated in this study. Participants (hereafter called decoders) were divided into one out of eleven independent groups depending on the interface (that is to say a, b, c, d, e, f, g, h, i, j, k). In each interface group, the ten excerpts were displayed to decoders on a computer screen. Each excerpt has been judged by 22 decoders.

6.3 Procedure

The EFE judging protocol was implemented on a computer device called *Oudjat*. *Oudjat* enables both to display emotional videos and to collect of emotional continuous ratings (see Fig. 3). To assess the video, as soon as the decoder identifies an emotion displayed by the face, s-he clicks on the corresponding label in the tool bar [46].

The following labels were proposed: no particular emotion, amusement, interest, irritation, perplexity (e.g. the correct labels), pride, boredom and worry (i.e. distracter labels). A label remains selected on as long as another label is not selected upon. The ten EFE excerpts are displayed one after the other. Orders were randomized but same consecutive emotions were avoided.

Decoders were asked to assess 'on line' expressed emotions (if any) while watching the film. They start with a training excerpt excluded from statistical analysis. The duration of experiment is about 10 min per decoder.

With decoder's on-line recognition, *Oudjat* provides a measure of their emotional time-detection. Analyses were carried out on the number and the length of decoders' clicks for each label. Moreover dynamic comparisons were carried out with a 0.5 s time span to characterize the temporal evolution of EFE recognition.

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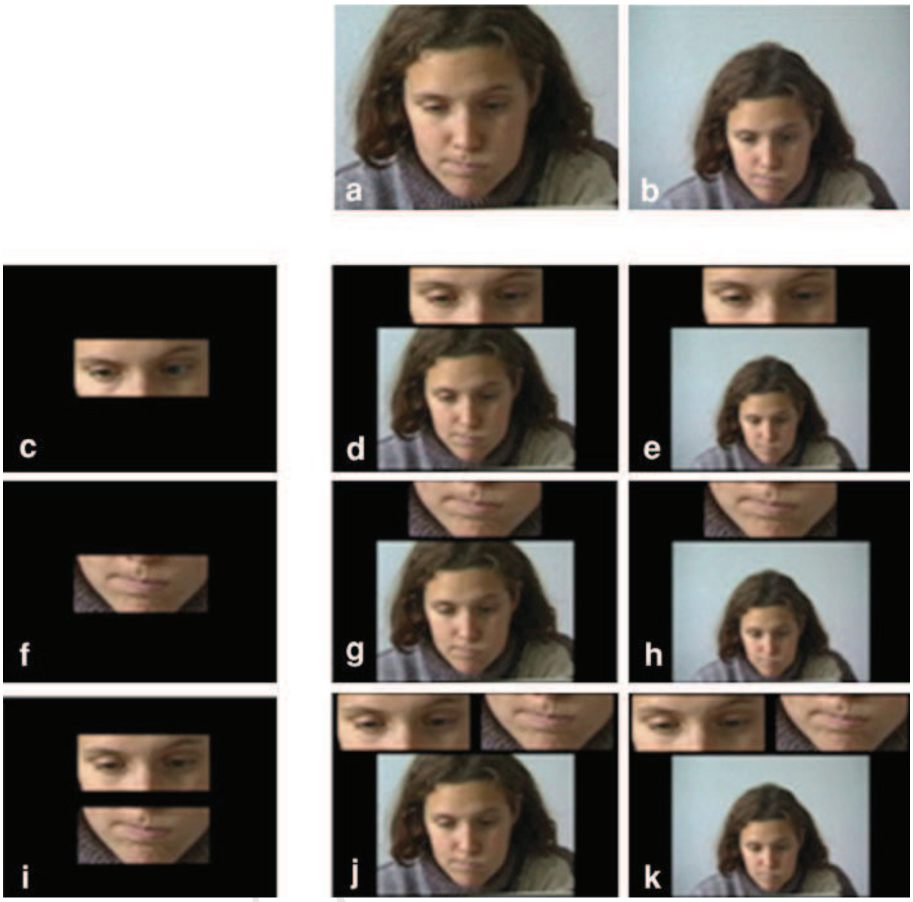

Fig. 2 The 11 interfaces were categorized in three categories: whole-face interfaces (**a**, **b**), divided-face interfaces (**c**, **f**, **i**), and compound-face interfaces (**d**, **e**, **g**, **h**, **j**, **k**)

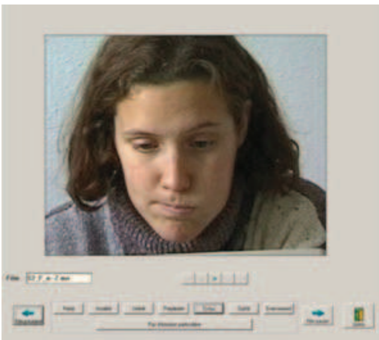

Fig. 3 Oudjat's interface for EFE on-line recognition

7 Influence of interfaces on emotional recognition

First, inter-rater agreements are calculated in order to compare the EFE recognition. Then, both zoomed and distant full frontal interface are used as references to evaluate the influence of each interfaces. This ANOVA analysis is based on average duration of correct emotion recognition. After identifying relevant interfaces, dynamic descriptive analysis are illustrating emotional recognition.

7.1 The overall recognition of EFEs

The confusion matrix indicates that target emotions are disparately recognized with dynamic spontaneous expressions (Table 3) but similar results were found with static spontaneous expressions [15].
These results show both the overall recognition and the overall label distinction of EFE. Firstly, highest recognition rate was found for amusement (in average 53 % of video time-course is recognized as expressing amusement) whereas interest, perplexity and irritation are less recognized (in average 30, 37 and 28 % of video time-course). Secondly amusement and irritation could be easily distinguished from erroneous emotions whereas interest and perplexity have more erroneous emotional recognition.

7.2 Influence of divided-face versus whole face interfaces

Is it relevant to display full frontal views compared to specific areas for the emotional recognition?

Whole-face interfaces were compared with divided face interfaces in order to evaluate the configuration's effect (Table 3). Results show differences with negative or neutral

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Table 3 Confusion matrix of emotional recognition regardless interfaces

The main index is the average time recognition on the 60 s in each film and its standard deviance in italic

Video EFEs	Emotional labels			
	Amusement	Interest	Perplexity	Irritation
Amusement	**53.5 %** (*14.06*)	20.7 % (*12.57*)	5.6 % (*6.05*)	0.1 % (*0.25*)
Interest	0.6 % (*2.08*)	**30.3 %** (*15.26*)	30.1 % (*14.05*)	2.1 % (*4.10*)
Neutral	0.1 % (*0.44*)	28.0 % (*15.90*)	29.9 % (*16.10*)	5.1 % (*8.45*)
Perplexity	0.9 % (*3.30*)	10.3 % (*9.15*)	**37.1 %** (*15.15*)	7.3 % (*8.90*)
Irritation	0.7 % (*1.94*)	9.3 % (*9.32*)	13.7 % (*11.15*)	**28.2 %** (*17.70*)

Table 4 Mean duration of EFE recognition in seconds with divided-face and whole-face interfaces

	Divided-face interfaces			Whole-face interfaces	
	Mouth-only	Eyes-only	Eyes-and-mouth	Distant face	Zoomed face
Amusement	38.6	22.9	36.45	28.3	33.95
Interest	16.9	13.2	20.35	18.95	15.75
Neutral	29.1	11.8	13.6	8.95	11.5
Perplexity	11.55	21.65	25.9	26.95	19.7
Irritation	14.85	4.45	11.55	15.6	21.05

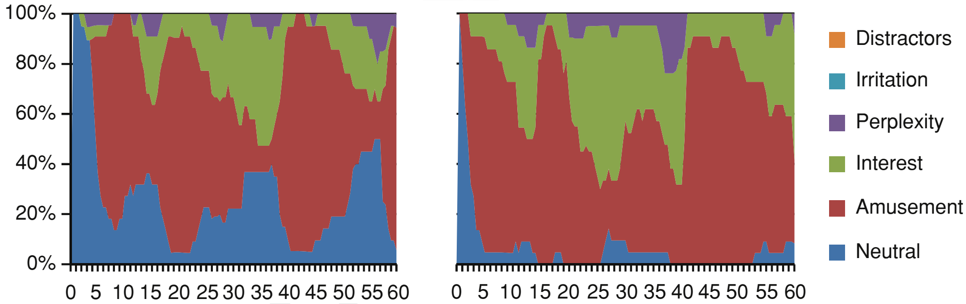

Fig. 4 Temporal agreement evolutions for male (*right*) and female (*left*) amusement EFE with the full frontal interface. The video time-course (in s) is displayed in abscissa; the ordinate is the inter-rater agreement

emotions. Recognition of irritation and perplexity are facilitated with whole-face interfaces (perplexity: $F_{(2,477)} = 5.67$; $p < 0.05$; irritation: $F_{(2,477)} = 13.39$; $p < 0.001$). The facial configuration also influences the recognition of neutral facial expression. Divided-face interfaces allow decoders to have less false recognition ($F_{(2,477)} = 5.95$; $p < 0.05$).

7.3 Specific influence of divided-face interfaces

The analysis of divided-face interfaces (i.e. mouth only, eyes only and eyes and mouth interfaces, see c., f., i. in Fig. 2) reveals distinct results depending on EFEs. Results show a difference for amusement recognition of with the mouth-only interface compared to whole-face interfaces ($F_{(3,172)} = 12.62$; $p < 0.05$). The presence of the mouth facilitates the amusement recognition in divided-face interface whether or not with eyes (f. and i. in Fig. 2). However the eyes-only interface decreases the recognition of amusement EFEs (Table 4). Regarding the recognition of interest EFEs, results do not indicate any significant difference between facial interfaces. The recognition of the neutral expression is significantly different according to facial areas ($F_{(3,172)} = 20.07$; $p < 0.05$). The mouth-only interface allows less false recognition than whole-face interfaces. However, the recognition of perplexity is inversely affected by interfaces ($F_{(3,172)} = 20.07$; $p < 0.05$). Eyes interfaces facilitate the recognition whether or not with mouth whereas the mouth-alone does not. Finally, irritation recognition is facilitated by the presence of mouth in divided-face interfaces whether or not with eyes ($F_{(3,172)} = 5.35$; $p < 0.05$).

7.4 Dynamic descriptive analysis

Decoders' temporal agreement evolutions were modelled to illustrate these results according each interface (see Fig. 4).

This dynamic analysis was carried out for each video and for each emotional label to summarise the inter-rater agreement and its evolution. Another advantage of this dynamic time course is to compare interfaces relevance for correct recognition. Thus, inter-agreement matrixes show the

Fig. 5 Dynamic agreements for amusement recognition of a female amusement EFE (the first 5 s)

Interfaces/ Time code	0	0,5	1	1,5	2	2,5	3	3,5	4	4,5	5
Mouth only	0.00	0.00	0.14	0.24	0.52	0.62	0.76	0.86	0.86	0.86	0.90
Eyes only	0.00	0.00	0.00	0.00	0.04	0.04	0.04	0.09	0.09	0.13	0.13
Mouth-and-Eyes	0.00	0.00	0.00	0.14	0.55	0.59	0.64	0.68	0.73	0.73	0.82
Zoomed-face	0.00	0.00	0.14	0.36	0.41	0.45	0.50	0.59	0.59	0.64	0.64
Distant face	0.00	0.00	0.00	0.14	0.41	0.50	0.59	0.55	0.59	0.55	0.59

Fig. 6 Dynamic agreement for irritation recognition with female irritation EFE (2–6 s)

Interfaces/ Time code	2	2,5	3	3,5	4	4,5	5	5,5	6
Mouth only	0.00	0.00	0.05	0.14	0.14	0.19	0.19	0.19	0.19
Eyes only	0.00	0.00	0.27	0.27	0.32	0.36	0.36	0.36	0.36
Mouth-and-Eyes	0.00	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05
Zoomed-face	0.00	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05
Distant face	0.00	0.00	0.00	0.05	0.05	0.05	0.05	0.05	0.05

temporal evolution of correct emotion recognition according interfaces. For example in Fig. 5, mouth-only and mouth-and-eyes interfaces facilitate the amusement recognition.

Another example in Fig. 6 shows that the eyes-only interface facilitates the irritation recognition (Fig. 6).

8 Emotional recognition with compound-face interfaces

The influence of compound-face interfaces on emotional recognition was evaluated in a second step. The effects of the number and the kind of displayed elements in the interface were analyzed (Table 5).

8.1 Influence of the number of elements

Results show that emotional recognition is influenced by interface configurations. The emotional recognition is facilitated with several elements rather than one ($t_{(2,399)} = 2.95$, $p < 0.05$). For example, the recognition of expressions of interest, perplexity and irritation is facilitated with two elements rather than one (interest: $M = 16.2$ vs. $M = 19.9$; $p < 0.05$; perplexity: $M = 19.9$ vs. $M = 24.3$; $p < 0.05$; irritation: $M = 14$ vs. $M = 18.7$; $p < 0.05$). However, recognition decreases with a three-elements interface for interest ($M = 17.6$; $p < 0.05$), perplexity ($M = 22.4$; $p < 0.05$) and irritation ($M = 18.7$; $p < 0.05$).

8.1.1 Influence of displayed elements category

Results show a selective effect of the mouth displayed on whole face interfaces. Thus, the mouth facilitates the recognition of the amusement expression ($F_{(1,478)} = 16.15$; $p < 0.001$).

However compound eyes interfaces decrease the recognition of amusement ($F_{(1,478)} = 4.04$; $p < 0.05$) and irritation recognition ($F_{(1,478)} = 4.23$; $p < 0.05$) compared to whole-face interfaces.

Finally, compound interfaces with mouth-and-eyes do not reveal a better emotional recognition as compared to whole-face interfaces. As indicated below, three-element interfaces could even reduce recognition advantages provided by two-element interfaces.

Table 5 Mean duration of EFE in seconds recognition with compound interfaces

	Compound mouth interfaces		Compound eyes interfaces		Compound mouth and eyes interfaces	
	With distant-face	With zoomed-face	With distant-face	With zoomed-face	With distant-face	With zoomed-face
Amusement	34.6	32.2	30.65	31.05	32.5	32.65
Interest	18.6	19.5	14.9	26.55	18.75	16.45
Neutral	12.65	12.85	16.85	14.65	15.8	10.9
Perplexity	27.1	22.75	22	23.65	24.7	20.15
Irritation	19.7	22.5	20.45	18.35	18.9	18.4

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9 Discussion

Present results indicate that both number and nature of facial elements in interfaces must be considered to facilitate the emotional recognition. From a psychological point of view it is clear that dynamic analysis allow to identify relevant emotional pattern to crate innovate increase interface [35]. Overall, this research illustrates that alternative to common full frontal view could be relevant for emotional recognition [3]. However EFE specificities require selective interface designs to be accurately recognized. On the one hand regarding divided-face designs, the use of mouth-only interface is appropriate for recognizing amusement and irritation but not for recognizing more passive expressions such as interest and perplexity. Moreover divided-face interfaces designs decrease erroneous emotional recognition. These results could find an application in high demanding situations in which supervision must be parsimonious, such as the control of vehicles or meticulous operations. On the other hand, regarding combined interfaces, an advantage is observed in displaying a complex two-element interface compared to common full frontal interface. Consistent with previous studies the mouth area is relevant in emotional recognition especially for amusement expression. These complex configurations can be used not only in daily communicative devices such as smartphones or computers but also in learning supervision where positive emotions are essential.

However in video communication the face is not the only clue to recognize emotional state [35]. Other social signals such as turn-taking or lip-reading improve not only the speech understanding but also the decoding of social messages. Communication interfaces should take into account emotional facial expressions specificities as well as other communicative feature to build innovative increased interfaces.

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