**Emotion Recognition: The Role of Featural and Configural Face Information**

*Running Header:* Facial emotion recognition

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**Abstract**

Several studies investigated the role of featural and configural information when processing facial identity. A lot less is known about their contribution to emotion recognition. In this study, we addressed this issue by inducing either a featural or a configural processing strategy (Experiment 1) and by investigating the attentional strategies in response to emotional expressions (Experiment 2). In Experiment 1, participants identified emotional expressions in faces that were presented in three different versions (intact, blurred, and scrambled) and in two orientations (upright and inverted). Blurred faces contain mainly configural information and scrambled faces contain mainly featural information. Inversion is known to selectively hinder configural processing. Analyses of the discriminability measure (A’) and response times (RTs) revealed that configural processing plays a more prominent role in expression recognition than featural processing, but their relative contribution varies depending on the emotion. In Experiment 2, we qualified these differences between emotions by investigating the relative importance of specific features by means of eye movements. Participants had to match intact expressions with the emotional cues that preceded the stimulus. The analysis of eye movements confirmed that the recognition of different emotions rely on different types of information. While the mouth is important for the detection of happiness and fear, the eyes are more relevant for anger, fear and sadness.

*Keywords:* emotion recognition; facial expression; featural processing; configural processing; eye movements.

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**Introduction**

Accurate and fast recognition of facial expressions is fundamental to efficiently interpret and predict people’s behaviour (e.g., Keltner & Kring, 1998). Like facial identity, facial expressions are processed rapidly (Prkachin, 2003) and can be recognized independently of other dimensions of face processing (e.g., age, gender, attractiveness) (Bruce & Young, 1986). Yet the information on the basis of which emotions are recognized remains unclear. Haxby, Hoffman, and Gobbini (2000) proposed that identity and expression recognition share some underlying neural mechanism, at least for early visual analysis. Face identity recognition has been widely studied and a lot is known about its underlying processing mechanisms (e.g., Collishaw & Hole, 2000; Leder & Bruce, 2000; Lobmaier & Mast, 2007; Young, Hellawell, & Hay, 1987).

Numerous face identity recognition studies distinguish between configural and featural processing. Features (or components) concern detailed information about face parts, such as the colour of the eyes or the shape of the nose. Configurations (or relational information) are defined by the interrelationships between face parts, such as the distance between the mouth and the eyes. The majority of studies reported that configural information plays a more prominent role in face identity recognition than featural information. Note that our definition of configurations includes both the first-order relations (i.e., the eyes are above the nose, which is above the mouth) and second-order relations (i.e., metric distances), as described by Young et al. (1987). Some authors have suggested that faces are processed holistically, whereas other object classes are processed on a part based level. The term holistic processing is related to that of configural processing, however, according to Bartlett, Searcy, and Abdi (2003), holistic processing involves the processing of all the features at once. This is not necessarily the case for configural processing (e.g., the distance between the nose and the mouth is configural but not holistic). The relative contribution of featural and configural processing in face identity recognition has been demonstrated in many behavioural (e.g., Bombari, Mast, & Lobmaier, 2009; Cabeza & Kato, 2000; Leder & Bruce, 1998) and neuroimaging (Lobmaier, Klaver, Loenneker, Martin, & Mast, 2008; Rossion et al., 2000) studies. To date, only a few studies have addressed the question to what extent featural and configural processing mechanisms are involved in emotion recognition.

Different approaches have been put forward to study the relative role of configural and featural information. A common approach is to use inverted and upright stimuli. Inversion has been shown to hamper configural processing (Valentine & Bruce, 1988), while impairing featural processing to a much lesser degree (Leder & Bruce, 2000). The use of scrambled and blurred faces is yet another approach (Collishaw & Hole, 2000; Lobmaier & Mast, 2007; Schwaninger, Lobmaier, & Collishaw, 2002; Schwaninger, Lobmaier, Wallraven, & Collishaw, 2009). Scrambled faces contain detailed information about face parts but no cues about their spatial interrelationships. In blurred faces the detailed information about features is largely disrupted while saving configural information.

Another approach that can be used to study face processing is the analysis of eye movements. Eye movements reflect how overt attention is strategically deployed to select relevant information and can therefore shed light on facial expressions processing. For instance, Jack, Blais, Scheepers, Schyns, and Caldara (2009) studied eye movements to show the influence of culture on emotion recognition. They found that while Western observers distributed their fixations evenly across the faces, Eastern observers persistently looked at eyes.

As mentioned above, less is known about the relative contribution of featural and configural information when processing emotional facial expressions. Some studies have addressed the role of configurations on emotion recognition by using upright and inverted stimuli (Derntl, Seidel, Kainz, & Carbon, 2009; McKelvie, 1995; Prkachin, 2003). These studies found a general decrease in sensitivity when facial expressions were presented upside down, suggesting that configural information plays an important role in emotion recognition. The results, however, are rather heterogeneous with respect to the specific effect inversion can have on individual expressions.

Calder, Young, Keane, and Dean (2000) reported a composite face effect for emotion recognition. The composite effect results from combining the top half of one face with the bottom half of another face. Emotion recognition is impaired when the two halves are aligned and is improved when the halves are misaligned (i.e., shifted sideways) (Young et al., 1987). Calder et al. (2000) combined the top half of a face depicting one expression with the bottom half depicting another expression. The authors found that recognition performance when identifying the expression of one half was much faster when the two halves were misaligned than when they were aligned. The fact that the configuration of the new composite expression cannot be ignored provides further evidence that facial configurations are automatically drawn upon during emotion recognition.

Other approaches have promoted the role of facial features. For instance, Ellison and Massaro (1997) and White (2000) proposed part-based models that combine the analysis of the features with their integration in subsequent steps of information processing. Furthermore, in some cases it is sufficient to see a single feature (e.g., a smiling mouth) to correctly guess the corresponding emotion (e.g., happiness) whereas other parts (e.g., eyes) play a secondary role (Leppanen & Hietanen, 2007). Yet another possibility is that facial emotional processing does not (or not exclusively) follow the featural and configural pathway (e.g., Lobmaier et al., 2008; Rossion et al., 2000) but instead is processed separately by a different emotion-specific mechanism. In support of this hypothesis, a case study by Pegna, Khateb, Lazeyras, and Seghier (2005) showed that a cortically blind patient could correctly guess the expressed emotion of faces. Right amygdala was activated in this kind of unconscious recognition without the involvement of brain areas known to be associated to featural and configural processing (Lobmaier et al., 2008). It is important to note, however, that the right amygdala might still selectively process featural or configural information.

In sum, previous evidence on the role facial features and configurations can play in emotion recognition is rather inconclusive. One reason could be the use of indirect methods, such as composite faces (Calder et al., 2000) or face inversion alone (McKelvie, 1995; Prkachin, 2003). Indeed, inverted and misaligned faces hamper configural processing, but some simple configural judgments (e.g., the distance between the eyes, horizontal distances), although only a few, might be unimpaired (Butler & Harvey, 2005; Sekuler, Gaspar, Gold, & Bennett, 2004). In this study, we investigated the role of features and configurations in emotion processing by means of more direct methods which involve the use of scrambled and blurred emotional expressions (Experiment 1) and the analysis of participants’ eye movements (Experiment 2). In Experiment 1 the stimuli manipulations induced a processing strategy (i.e., featural or configural) whereas in Experiment 2 we analyzed natural processing strategies in response to emotional expressions.

**Experiment 1**

In the present experiment we used scrambled (featural information) and blurred (configural information) faces to investigate the role of features and configurations in facial emotion recognition. This method has been previously used to investigate the relative contribution of featural and configural processing in identity recognition (Bombari et al., 2009; Collishaw & Hole, 2000; Lobmaier & Mast, 2007; Schwaninger et al., 2002; Schwaninger et al., 2009). This method is advantageous over the simple inversion of faces or using composite faces in that featural and configural information can be manipulated independently (for an overview, see Rakover, 2002). We combined the use of scrambled and blurred expressions with face inversion, thus enabling a clearer conclusion of the role of features and configurations in facial emotion recognition. We presented faces expressing four emotions (happiness, sadness, anger, and fear) in blurred, scrambled, and intact versions and we displayed them in upright and inverted orientation. Participants were asked to identify the emotion displayed. If expression recognition is based on featural processing, we expect to find higher accuracy for scrambled faces compared to blurred faces. Conversely, if configural processing plays a predominant role in emotion recognition we expect to find higher accuracy for blurred expressions than for scrambled expressions. We would also expect that inversion would impair expression recognition. As to the relative importance of featural and configural processing for different emotional expressions, we make the following predictions: A smile might be enough to recognize the expression of happiness, therefore we expect this expression to be processed in a more featural way and thus expect an advantage for scrambled faces over blurred faces (in line with Leppanen & Hietanen, 2007). Several studies showed that individuals who have difficulties to recognize fear due to brain damage, improve when instructed to focus on the eyes (Adolphs et al., 2005; Dadds et al., 2006). The wide-open eyes might therefore be a key feature for fear recognition, which is why we expect featural information to be particularly relevant for fear recognition. In expressions such as anger or sadness the emotion might not be extracted simply by looking at one single feature (Smith, Cottrell, Gosselin, & Schyns, 2005). Hence, we predict that angry and sad faces are treated in a more configural way (McKelvie, 1995; Prkachin, 2003), which may become evident in an advantage for blurred expressions.

**Method**

*Participants*. Twenty-four participants (18 female, 6 male) ranging in age between 22 and 33 years (*M* = 25.12, *SD* = 2.89) took part in return for payment (20 CHF). All reported normal or corrected-to-normal vision and all provided informed consent. They were naive regarding the purpose of the experiment and were treated according to the declaration of Helsinki.

*Stimuli.* The stimulus faces were modified versions of the Adult Facial Expressions set of the Diagnostic Analysis of Nonverbal Accuracy 2 (DANVA 2-AF: Nowicki & Duke, 1994). This set contains 24 intact faces expressing four different emotions (anger, fear, happiness, sadness) by different male and female individuals. The internal consistency for these expressions is high (*alpha* = .75). By modifying the original DANVA2 faces we obtained 24 intact, 24 blurred, and 24 scrambled faces (see Fig. 1). For intact stimuli all background information including hair and clothing was eliminated using the elliptic tool in Adobe Photoshop CS2. Scrambled faces were obtained from intact faces by cutting out right and left eye regions (including the eyebrows), nose and mouth. These four parts were placed on a black background in a non-natural position (e.g., the nose above the right eye and the mouth next to the left eye), but their orientation was not changed. Four different versions of scrambled expressions were created for each face identity and one of these versions was selected randomly for the experiment. Blurred versions were created from the intact faces in two steps: we first discarded colour information, because it was crucial that our stimuli were as purely configural as possible. Since colour does not contain any spatial information, we discarded all colour information from our configural stimuli (cf., Bombari et al., 2009; Lobmaier & Mast, 2007; Schwaninger et al., 2002). In a second step we applied a Gaussian filter using a radius of 15 pixels, resulting in images low-pass filtered at approximately 6.5 cycles per face. Both of these manipulations left the spatial-related cues untouched. The blur level was determined in a pre-test. The difficulty of scrambled and blurred facial stimuli was matched in an unrelated identity matching task to ensure that all the differences found between blurred and scrambled emotional expressions are related only to the emotion recognition task and not to low-level properties of the stimuli (e.g., level of blurring). Ten participants were asked to match the identity of a cue and a test face. Using a sequential same-different matching task, we presented 14 cue faces (7 scrambled and 7 blurred) from the DANVA2 set each of which was followed by an intact test face. This test face could be the same or a different identity as the cue face. Both cue and test faces were presented during 5 seconds. Pre-test participants were asked to decide whether the identity of the test (intact) face matched the identity of the cue face. We gradually increased the blur level until the difficulty between blurred and scrambled faces was comparable (*t*(9) = .514, *p* = .619). Moreover, to control that our manipulations were effective, we tested a separate group of 14 participants in a condition in which the same emotional expressions used in this study were both scrambled and blurred. These stimuli were created by scrambling the facial parts of the blurred stimuli, as described above. Twenty-four expressions were presented both in the upright and inverted orientation. We analysed A’ and found that participants were at chance level (*A*’ = .54; *SD* = .12; *p* = .22). Thus, we confirmed that performance is reduced to chance level when faces are low-pass filtered and scrambled at the same time. This way we showed that our image manipulations effectively eliminated featural and configural information. Finalized faces had a size of 14 x 21 cm (resolution: 75 dpi), subtending a visual angle of approximately 16° x 24° on a 17’ monitor positioned 60 cm from the participants.

(Insert Figure 1 about here)

*Procedure and data analysis*. Four keyboard keys (V, B, N, M) were labelled with the four emotional expressions (angry, fearful, happy, and sad). The arrangement of the labels was counterbalanced across participants. The experiment started with a response-key learning phase in which the labels of the emotions were displayed on the screen and participants had to press the corresponding key without looking at the keyboard. They received feedback about their performance. After this learning phase of approximately 3 minutes, all participants were perfectly familiar with the keys. In the actual experiment, each trial began with a central fixation cross which was replaced after 1000 ms by a face displaying one of four emotional expressions. The face stimulus remained on the screen until the participant responded. Each of the 24 original DANVA2 faces was presented six times, once in each possible combination of the factors orientation (upright, inverted) and information (blurred, scrambled, intact) resulting in a total of 144 trials per session. No feedback was given to the participants about their performance at this time. All the stimuli were presented in three blocks in a pseudo-random order (blurred, scrambled, and intact versions of the same expression and identity were presented in different blocks). Block order was counterbalanced across participants. We recorded and analysed accuracy (A’) and RTs for correct responses.

**Results and Discussion**

*Accuracy.* A’ is a non-parametric measure of discriminability which varies from 0 to 1, with a value of 0.5 indicating chance performance. A’ was calculated with the formula suggested by Snodgrass, Levy-Berger, and Haydon (1985): *A*' = 1/2 + [(pHit -pFA)\*(1+pHit-pFA)]/[4pHit\*(1-pFA)]. One sample *t*-tests revealed that emotions were recognized above chance level in all conditions (all *p*’s < .001). We analysed A’ in a 3 (Information: blurred, scrambled, intact) x 2 (Orientation: upright, inverted) x 4 (Emotion: happiness, sadness, anger, fear) ANOVA. Results showed a main effect of Information, *F*(2, 46) = 18.39, *MSE* = .020, *p* < .001, *ηp2* = .44: intact expressions (*M* = .87) were recognized better than blurred (*M* = .81) and scrambled (*M* = .78) expressions (both *p’s* < .001 in Bonferroni corrected pairwise comparisons). Blurred and scrambled expressions did not differ (*p* = .47). There was a main effect of Orientation, *F*(1, 23) = 47.34, *MSE* = .033, *p* < .001, *η p2* = .67, showing that upright expressions were recognized more reliably than inverted expressions (*p* < .001). Finally, there was a main effect for Emotion, *F*(3, 69) = 30.24, *MSE* = .016, *p* < .001, *ηp2* = .57. Bonferroni-corrected pairwise comparisons revealed that overall angry and sad expressions were recognized less reliably than happy and fearful expressions (both *p*’s < .01). Results are depicted in *Figure 2*.

The interaction Emotion x Orientation reached statistical significance: *F*(3, 69) = 7.75, *MSE* = .013, *p* < .001, *ηp2* = .25, while none of the other two-way interactions was significant (all *p’*s > .06). The interaction between Orientation and Emotion is explained by the fact that inversion dramatically reduced recognition of all emotions except fear.

The three-way interaction Information x Emotion x Orientation was also significant, *F*(6, 138) = 2.50, *MSE* = .022, *p* < .05, *ηp2* = .10. To qualify this interaction we ran separate ANOVAs on the upright and inverted condition. For upright expressions, the Information x Emotion interaction reveals that scrambling and blurring had a differential effect on the four emotions, *F*(4.43, 102.01) = 2.91, *MSE* = .007, *p* < .05, *ηp2* = .11 (Huyn-Feldt correction for sphericity was applied). Happiness was recognized equally well when the stimuli were intact, scrambled, or blurred (all *p’*s > .44), whereas anger was recognized more reliably when the faces were intact compared to scrambled (*p* < .01) or blurred (*p* < .05). Likewise, fearful faces were recognized better when they were presented in the intact version compared to scrambled (*p* < .05) or blurred versions (*p* < .01). Sadness was recognized more reliably when the stimuli were intact than when scrambled (*p* < .01), but there was no difference between blurred and intact sad stimuli (*p* = .348). In order to better understand how the type of processing affected emotion recognition, we further qualified the three-way interaction by means of post-hoc tests for upright expressions within the three levels of the factor Information. For intact expressions there was no statistical difference between the emotions, with the only exception of fear, which was recognized significantly better than anger (*p* < .01). In the blurred condition the emotion of happiness was recognized significantly better than all other emotions (all *p*’s < .01). Moreover, fearful expressions were recognized more reliably than angry expressions (*p* < .05). In the scrambled condition happy, sad and fearful stimuli were recognized equally well, whereas angry expressions were recognized less reliably than happiness (*p* < .01) and fear (*p* < .05). The ANOVA for inverted faces revealed no interaction between Information x Emotion *F*(6, 138) = 2.01, *MSE* = .029, *p* = .07.

*Response Times.* We analysed RTs in a 4 (happiness, sadness, anger, fear) x 3 (blurred, scrambled, intact) x 2 (upright, inverted) ANOVA. The three main effects were significant: Emotion, *F*(3, 27) = 8.92, *MSE* = 616256, *p* < .001, *ηp2* = .50, Information, *F*(2, 18) = 16.112, *MSE* = 747789, *p* < .01, *ηp2* = .64, and Orientation, *F*(1, 9) = 6.11, *MSE* = 1241670, *p* < .05, *ηp2* = .40. Emotional expressions were identified faster when they were upright compared to inverted (*p* < .05) and scrambled stimuli were recognized slower than blurred and intact stimuli (both *p*’s < .01). The RTs of blurred and intact stimuli did not differ (*p* = .99). Bonferroni corrected pairwise comparisons revealed that happiness (*M* = 1491 ms, *SE* = 174) was recognized faster than sadness (*M* = 2154 ms, *SE* = 240) (*p* < .01), while the mean RTs of anger (*M* = 2086 ms, *SE* = 291) and fear (*M* = 1801 ms, *SE* = 178) did not differ from either other emotions. None of the interactions were significant.

(Insert Figure 2 about here)

We examined the role of featural and configural information on emotion recognition and found that the latter plays a more prominent role. First, recognition of inverted expressions was more difficult and slower than upright expressions, suggesting that configural processing is important for reliable emotion recognition. Second, RTs were slower for scrambled than for blurred and intact expressions, suggesting that the unavailability of configural information renders emotion recognition more difficult. The results of this study are therefore in line with some of the previous studies emphasizing the importance of configural processing in emotion recognition (Bassili, 1978; Calder et al., 2000; McKelvie, 1995; Prkachin, 2003). Despite the fact that emotion recognition benefits from configural information, some of the present findings call for more cautious interpretations. First, we found that inverted blurred expressions were recognized above chance level, even though this manipulation was supposed to dramatically reduce the availability of both configural and featural information. This may suggest yet another processing mechanism which is unaffected by inversion and is - at least partially - distinct from featural and configural processing (cf. Pegna et al., 2005). Second, the fact that intact expressions were identified more accurately than blurred and scrambled expressions might indicate that it is beneficial for the perceptual system to simultaneously process featural and configural information. Alternatively, since the blurring manipulation degrades to a smaller extent also configural information, this loss might have sufficed to more accurately recognize intact than blurred stimuli.

Our manipulations affected emotions in different ways. While the recognition of happiness was relatively unaffected by blurring and scrambling, anger and sadness were particularly impaired. Moreover, fearful expressions were less affected by inversion than other emotions. This outcome could suggest that – in line with our hypotheses - happiness and fear are less dependent on configural information than anger and sadness. In Experiment 2 we further investigate these differences between emotions by determining which facial information is important for the recognition of a specific expression.

Blurred and scrambled emotional expressions are an efficient way of studying featural and configural processing. However, these manipulations cannot reveal which specific information is relevant and actively sought when processing emotional expressions. In addition, this approach introduces manipulations that are rarely ever seen in everyday life. In Experiment 2, we further investigate the processing difference between emotions by analysing eye scan pattern strategies during the recognition of intact facial expressions. Indeed, recent evidence has shown that eye movements are an efficient method to study face processing (Bindemann, Scheepers, & Burton, 2009; Bombari et al., 2009) and emotion recognition (Jack et al., 2009). To our knowledge, however, the evidence showing relevant information in facial expressions by means of eye movements is scarce.

**Experiment 2**

Experiment 1 suggests that some emotions are processed using a rather configural processing mode, while others seem to be processed more on the basis of individual features. It still remains unclear, however, which features might be important for the recognition of different emotions and how relevant facial information is selected. In Experiment 2, we more thoroughly examine the relative importance of specific features when processing emotions. Specifically, we examine which features are sought in an emotion detection task. In addition, we will investigate whether a more configural or more featural processing strategy is adopted when recognizing emotional expressions, following a recent study on face identity recognition. In this study we showed that featural, configural, and holistic processing are associated with different scanning strategies (Bombari et al., 2009).

In Experiment 2, we presented cue words describing one of the four emotions (i.e., "happy", "sad", "angry", "fearful") followed by a target face that appeared in one of the four quadrants of the computer screen. The task was to determine whether the expressed emotion corresponded to the cued emotion type. This emotion could either be congruent (i.e., the same as the cue emotion) or incongruent. We hypothesize that the eye movements will differ depending on the cued emotion. Since the recognition of each emotion relies on different kinds of information (i.e., featural or configural), we expect that the cue will trigger a top-down modulation on the scan patterns. In line with the findings from Experiment 1, we expect that the emotional cues of anger and sadness will elicit a more configural scanpath (e.g., longer fixations on the centre of the face), while happiness and fear cues will trigger part based processing (e.g., more and longer fixations on specific features). To make the position where the target face would appear on the screen unpredictable, we presented the target face in one of the four quadrants of the screen. Thus, participants would then first have to find the face, and would then search for the feature that would most likely provide the information needed to solve the task. According to our findings in Experiment 1, we expect that the mouth might be most important for happiness and that the eyes will be most informative for the recognition of fear. For the other emotions, we expect that the features will be inspected more evenly.

**Methods**

*Participants*. Twenty-six participants (14 female, 12 male) ranging in age between 22 and 30 years (*M* = 25.5, *SD* = 2.23) voluntarily took part in our experiment in return for a small snack. All reported normal or corrected-to-normal vision and all provided written informed consent. They were naive regarding the purpose of the experiment and were treated according to the declaration of Helsinki.

*Stimuli.* We included a total of 32 stimulus faces. The original pictures were taken from the Karolinska database KDEF (Lundqvist, Flykt, & Öhman, 1998). Stimuli consisted of four face identities (2 female, 2 male), each expressing four emotions (angry, happy, fearful and sad). In addition, to these 16 full-emotion stimulus pictures, we created weaker versions of them by morphing the full expression with the neutral expression of the same actor using Psychomorph computer graphics software (Tiddeman, Burt, & Perrett, 2001). All faces were cropped using the elliptic tool provided by Adobe Photoshop and were 130 mm high and 100 mm wide. These stimulus faces were randomly presented in one of the four quadrants of the screen, in order to prevent anticipation of where the facial features will appear.

*Apparatus.* Eye movements were registered with a SMI-SensoMotoric Instruments RED eye tracking system, (Teltow, Germany). Only data of the left eye were recorded, with a sampling rate of 50 Hz, spatial resolution of 0.1 deg and a gaze position accuracy of 0.4 deg, the gaze position was determined by using pupil and corneal reflection. Stimuli were presented using Experiment Center 2.5 (SMI-SensoMotoric Instruments, Teltow, Germany) and were projected on a 17 inch computer screen, with a resolution of 1280 x 1024 pixels and a refresh rate of 60 Hz. The viewing distance was approximately 60 cm. The face stimuli (12.5 x 15.5 cm, resolution: 72 dpi) appeared in one of the four quadrants of the screen, covering a visual angle of approximately 9.5 deg (horizontal) x 12.4 deg (vertical), and were surrounded by a uniform white background. Eye data were recorded on a second computer with iView X software.

*Procedure and data analysis*. Each trial began with a fixation cross presented for 500 ms followed by a centrally presented word cueing for an emotional expression (i.e., "happy", "sad", "angry", "fearful") (1000 ms). A second central fixation cross again presented for 500 ms replaced the cue to ensure that participants started their eye scanpaths in the centre of the screen. Then an emotional face was randomly presented in one of the four quadrants of the screen. Participants had to determine whether the expressed emotion corresponded to the cued emotion type by pressing either the “j” or “n” key, which were labelled with “Yes” and “No”. Responses were always given with the right hand. The emotional face was presented as long as the participants responded. Participants underwent a total of 256 trials, half were congruent (i.e., cue and emotion were matching) and half were incongruent, and the order of the trials was randomized across participants. No feedback was given to the participants about their performance.

Prior to analyses, areas of interest (AOIs) were defined on the eye regions (including the eyebrows), the mouth, and the nose, separately for each stimulus face. All parameters detecting eye movements were computed with Be-Gaze 2.5 software (SensoMotoric Instruments). Fixations were detected when i) the duration exceeded 80 ms and ii) the sum of the dispersion of the gaze stream on x and y axis was below 100 pixels. Saccades were calculated by subtracting fixations and blink events from the original gaze stream.

We analyzed both eye movements (mean fixation duration on the AOIs, location of first and second fixations, and proportion of time spent on the AOIs) and behavioural data (d’ and RTs) as a function of the cue label that preceded the actual emotional expression. The mean fixation duration was calculated by averaging the duration of all fixations performed in one specific AOI across participants and emotions. The mean fixation duration and the time spent on a feature are commonly used as measures of visual interest. Moreover, in Bombari et al. (2009) we showed that long fixation durations on the centre of the face were associated with a holistic strategy. The location (proportion of times) of the first and second fixation on the facial stimulus was analysed. The early stages of visual inspections of the emotional expressions are particularly important to understand how participants seek the relevant information for different emotions and to examine the temporal dynamics of emotion recognition. The first fixation following stimulus onset was discarded since it was always detected on the centre of the screen (participants’ attention was still focused on the location of the fixation cross).

*D’* values were calculated by subtracting the z-transformed false-alarm rates from the z-transformed hit rates. The data of one participant was excluded from the d’ and proportion of time on AOI analyses because of technical problems (too many missing data), thus the data of a total of 25 participants went into those analyses.

**Results and Discussion**

*Mean fixation duration on the AOIs*. In a 4 x 2 x 3 repeated measures ANOVA with the factors Cue Emotion, Congruency, and AOI we analyzed the mean fixation duration on the AOIs. The main factor Cue Emotion turned out to be significant, *F*(3, 75) = 6.12, *MSE* = 2462.02, *p* < .01, *η p2* = .20. Fixations performed on fearful expressions (*M* = 298, *SD* = 77) were longer compared to angry (*M* = 282, *SD* = 83) and happy (*M* = 277, *SD* = 89) expressions (both *p*’s < .05). The interaction Cue Emotion x Congruency, *F*(3, 75) = 2.97, *MSE* = 3421.40, *p* < .05, *η p2* = .11, and the three-way interaction between Cue Emotion, Congruency and AOI were significant, *F*(6, 150) = 5.22, *MSE* = 3326.39, *p* < .001, *η p2* = .17. Pairwise comparisons (Bonferroni corrected) revealed that in the congruent condition the mean fixation duration on the nose was longer for angry (*M* = 323, *SD* = 77) expressions than for happy (*M* = 300, *SD* = 70) expressions (*p* < .05). Moreover, the fixations on the mouth were longer for happy (*M* = 297, *SD* = 97) emotions than for angry (*M* = 235, *SD* = 111) and sad (*M* = 234, *SD* = 105) faces (both *p*’s < .05). In the incongruent condition, no pairwise comparison turned out to be significant.

*Location of first and second fixations*. We analyzed the location of the first and second fixations performed on the facial stimulus. Specifically, we calculated the proportion of how many times an AOI was looked at during the first and second fixation. For each the first and second fixation, we ran a separate 4 x 2 x 3 repeated measures ANOVA with the factors Cue Emotion (anger, fear, happiness, sadness), Congruency (congruent, incongruent), and AOI (eyes, nose, mouth). In terms of location of the first fixation, we found a main effect of AOI, *F*(2, 50) = 14.92, *MSE* = .20, *p* < .001, *η p2* = .37. The eyes (*M* = .22, *SD* = .14) and the nose (*M* = .29, *SD* = .19) attracted overall a significantly higher proportion of fixations compared to the mouth (*M* = .06, *SD* = .08). The interaction between Emotion and AOI was significant, *F*(6, 150) = 3.03, *MSE* = .004, *p* < .01, *η p2* = .11. Bonferroni-corrected pairwise comparisons revealed that the eyes were looked at more often for sad than for happy cued expressions (*p* < .05). None of the other pairwise comparisons reached statistical significance. However, the three-way interaction was significant, *F*(6, 150) = 3.02, *MSE* = .004, *p* < .001, *η p2* = .11. Pairwise comparisons revealed that in the congruent condition the mouth was fixated more often in fearful than in angry expressions (*p* < .05).

In terms of location of the second fixation, we found an effect of AOI, *F*(2, 50) = 3.82, *MSE* = .20, *p* < .05, *η p2* = .13. The nose (*M* = .30, *SD* = .16) was looked at more often than the mouth (*M* = .14, *SD* = .17). None of the other pairwise comparisons reached statistical significance. In addition, the three-way interaction Congruency x Cue Emotion x AOI was significant, *F*(6, 150) = 5.50, *MSE* = .007, *p* < .001, *η p2* = .18. We qualified this three-way interaction by means of Bonferroni pairwise comparisons. In the congruent condition, the eyes were looked at significantly less often in the happy cued expressions than in all the other emotions (all *p*’s < .01). The mouth instead was fixated more often in happy than in sad and angry cued expressions (both *p*’s < .05). In the incongruent condition, the mouth was looked at more often in sadness than in anger and happiness (both *p*’s < .05). All the other comparisons did not reach statistical significance.

*Proportion of time spent on the AOIs*. We analyzed the proportion of time spent on each AOI (see Fig. 3 for a map of the distribution of fixations) in an ANOVA with the factors Cue Emotion, Congruency, and AOI. All main effects reached statistical significance: Cue Emotion, *F*(3, 72) = 9.13, *MSE* = .001, *p* < .001, *η p2* = .28; Congruency, *F*(1, 24) = 16.04, *MSE* = .001, *p* < .001, *η p2* = .40, and AOI, *F*(2, 48) = 6.12, *MSE* = .113, *p* < .01, *η p2* = .20. The interaction Emotion Cue x AOI turned out to be significant, *F*(6, 144) = 6.39, *MSE* = .001, *p* < .001, *η p2* = .21. The time spent on the eyes was shorter when the emotion was cued with happiness than for the other emotions (all *p*’s < .01). The other two-way interactions were also significant: Congruency x AOI, *F*(2, 48) = 4.46, *MSE* = .01, *p* < .05, *η p2* = .16; Congruency x Emotion Cue, *F*(3, 72) = 4.19, *MSE* = .001, *p* < .01, *η p2* = .15. Moreover, the three-way interaction was significant, *F*(6, 144) = 6.75, *MSE* = .001, *p* < .001, *η p2* = .22. Post-hoc comparisons revealed that in the congruent condition the time spent on the eyes was shorter for happy than for other expressions (all p’s < .01). In addition, the time spent on the mouth was longer for happiness and fear than for sadness and anger (all p’s < .05).

*Accuracy and RTs.* We calculated d’ values separately for each of the four cue emotions (anger, fear, happiness, sadness) by subtracting the z-transformed false-alarm rates from the z-transformed hit rates. A response was counted as a hit when a participant correctly answered “yes” in a congruent trial, and a false alarm counted when a participant responded “yes” in an incongruent trial. One sample *t*-tests revealed that all emotions were detected well above chance level (all *p*’s < .001). A one-way ANOVA including all four emotions revealed a significant effect of Cue Emotion, *F*(3, 72) = 58.04, *MSE* = .432, *p* < .001, *η p2* = .71. Happiness (*M* = 3.72, *SD* = 1.17) was detected more accurately than the other emotions (all *p*’s < .001). Anger (*M* = 1. 97, *SD* = .59) was detected more accurately than sadness (*M* = 1.49, *SD* = .46), *p* < .01. Accuracy for fear did not differ from both anger and sadness (both *p*’s > .40)

RTs for correct responses were analyzed in a 4 x 2 ANOVA with the factor Cue Emotion (anger, fear, happiness, sadness) and Congruency (congruent, incongruent). The factor Emotion was significant, *F*(3, 75) = 52.66, *MSE* = 116407.87, *p* < .001, *η p2* = .68. Happiness was detected faster (*M* = 1595, *SD* = 380) than other emotions (all *p*’s < .001). Anger showed shorter RTs (*M* = 1854, *SD* = 481) compared to fear (*M* = 1989, *SD* = 517) and sadness (*M* = 1961, *SD* = 430), both *p*’s < .01. The main effect of Congruency and the interaction were not significant.

(Insert Figure 3 and Table 1 about here)

We examined emotion processing by analyzing eye scan pattern strategies (see Table 1 for a summary of the main findings). The emotion cues that preceded the expressions had an influence on how the facial information was selected. This effect, emerging from the analysis of three measures of eye movements (mean fixation duration on the AOIs, location of first and second fixations, and proportion of time spent on the AOIs), enables us to make inferences on the relevance of specific facial information for each emotion, thus complementing the findings of Experiment 1.

In Bombari et al., (2009) we argued that the mean fixation duration on the centre of the face (i.e., on the nose region) can be considered a measure of holistic scanpath. Indeed, it likely reflects the enlargement of focus of attention to grasp the information from the whole face rather than the relevance of the nose region. This is line with Miellet, Caldara, and Schyns (2011), who suggested that fixations on the centre of the face are likely performed to sample holistic/global information. Although the exact definition of holistic processing is rather ambiguous in the literature, it can be considered as a special case of configural processing that involves the relationships between all the features (Bartlett et al., 2003). In the present study, we found that the mean fixation duration on the nose region was higher for expressions cued with anger than for happiness. This may be taken as evidence that anger is processed more holistically and hence, more configurally than happiness. The overall fixation duration, independent of the fixated feature, was higher for fear than for other emotions. This finding might suggest a rather featural type of processing.

The analysis of location of first and second fixations and the analysis of the proportion of time spent on AOI highlighted that different features are important for the processing of different emotions. The eyes are more important for anger, fear, and sadness, whereas the mouth region is more important for the detection of happiness and fear.

Some studies using the Bubbles paradigm investigated the diagnostic facial information associated to the recognition of each emotion (Smith et al., 2005; Smith & Schyns, 2009). This paradigm involves the presentation of portions (i.e., bubbles) of the image of variable size which are randomly placed and filtered to isolate a range of spatial frequencies. This allows to identify the critical locations and spatial frequencies used to discriminate between stimuli. Because of the nature of the Bubbles paradigm, information is available only through the bubbles and thus participants are not enabled to freely inspect the facial expressions. In contrast, in our paradigm, participants can actively seek for the relevant information. Thus, our study provides new insight into which relevant facial features are actively sought when participants inspect more naturalistic stimuli.

**General Discussion**

The aim of the present study was to investigate the role of featural and configural information in facial emotion recognition. One of our major findings is that configural information plays a more prominent role than featural information in facial emotion processing. While this finding is in line with some of the previous studies on emotion recognition (Bassili, 1978; Calder et al., 2000; Prkachin, 2003), the results from this study demonstrate that features are still sufficient to produce accurate recognition of emotions. Just as facial identity can be reliably recognized when faces are scrambled, blurred, inverted, or simultaneously scrambled and inverted (e.g., Collishaw & Hole, 2000; Lobmaier & Mast, 2007), we showed that, after using these same manipulations, facial expressions were still recognized well above chance level. The dual-code view claims that facial identity is processed on the basis of features and configurations (Cabeza & Kato, 2000; Leder & Bruce, 2000; Lobmaier & Mast, 2007). Our findings suggest that also for emotion recognition both the featural and the configural route can be used and either route can reliably process facial emotions. Nonetheless, some of the present results question the interpretation that featural and configural processing in facial identity is comparable to featural and configural processing in emotional expression recognition. In contrast to studies on face identity recognition, which show that processing of facial features is relatively orientation invariant (Collishaw & Hole, 2000; Leder & Bruce, 1998; Lobmaier & Mast, 2007), we found that scrambled emotions were indeed affected by inversion. This might suggest an emotion processing system that is orientation sensitive for features. Alternatively, the features themselves may contain some kind of configural information and this local configural information could be important for emotion processing, thus explaining the impaired recognition of inverted scrambled stimuli. Furthermore, as mentioned above, we found that inverted blurred expressions were recognized above chance level. This outcome suggests that, while the reduced featural and configural information contained in inverted blurred stimuli makes recognition of the identity of a face impossible (Collishaw & Hole, 2000), it is still sufficient to reliably identify emotional expressions. Likewise, even though our scrambling manipulation in Experiment 1 was more systematic than that used by Collishaw and Hole (2000), scrambling affected emotion recognition to a lesser extent compared to identity recognition. Overall these findings might support the idea that emotion recognition is more robust to alterations than identity recognition. Interestingly, using the same parameter for scrambling and blurring the faces, participants were not able to recognize them (pilot study mentioned above). This shows that participants are able to extract information for emotion recognition in faces in which all information about familiarity is no longer available.

In Experiment 1 we found that the role of featural and configural information depends on the emotional expression and in Experiment 2 we further qualified this finding. In Experiment 1, happiness was identified more easily and rapidly than the other emotions, regardless of whether featural, configural, or both kinds of information were provided. This happy face advantage has already been reported by other authors (e.g., Leppänen & Hietanen, 2004). Leppänen and Hietanen suggested that positive and neutral emotions differ to a greater extent than negative and neutral emotions because the configuration of facial features may change more significantly from neutral to happy expression than from neutral to negative emotions. A happy expression can be correctly identified either by looking at the global configuration of the facial expression or just by looking at the smiling mouth (Adolphs, 2002). In fact, recognition of happy expressions was less affected by blurring than all other emotions and was also hardly affected by scrambling. Moreover, in Experiment 2 we found that the eye region is inspected less often than in other emotions in the early stages of visual scanning. Even though this might suggest that the eyes are not considered a diagnostic feature for happiness, it is noteworthy that cultural differences might influence this pattern, since Eastern observers persistently look at the eyes more often than Western observers for all expressions (Jack et al., 2009). Likewise, the teeth visibility (Horstmann, Lipp, & Becker, 2012) in the smiles might attract attention and thus influence the time spent inspecting the eyes. Indeed, both the location of the second fixation and the total time spent on the AOI analyses revealed that the mouth region is particularly important for the detection of happiness. These findings are in line with Smith et al., (2005). Using the Bubble paradigm, they found that the mouth region is diagnostic for the recognition of happiness for both human and model observers.

Recognition of sadness was more dependent on configural information and less on featural information: scrambled sad faces were more difficult to recognize than when they were intact or blurred. It can be argued that sad expressions have no highly distinctive features (e.g., compared to a smile in a happy expression), and thus the interrelationships between features have to be captured in order to recognize sadness. Srinivasan and Gupta (2011) examined the effect of global and local processing on the recognition of sad and happy faces. Participants had to focus either on the global or the local level of a digit, while emotional faces were presented in the background as distractors. In a subsequent task, participants were asked to indicate whether the faces had been presented before. Narrowing attention to local processing facilitated the recognition of sad faces, while broad scope of attention facilitated the recognition of happy faces. Even though these findings might seem in contrast with our results, some aspects need to be pointed out. First, the concepts of local and global processing are not overlapping with featural and configural processing. While it might be true that featural processing could imply narrowed attention, configural processing might not necessarily involve broadening attention to the whole face, for instance in the case of the inter-eye distance. Second, in Srinivasan and Gupta’s study (2011) gaze position was not monitored and therefore it remains unknown whether participants had different preferred gaze locations for global and local processing. Our study suggests that looking at different features might affect emotion recognition. For instance, focusing on the upper region of a happy face in the local condition might be more disruptive than focusing on the lower region of the face because the eyes are not as relevant as the mouth for the detection of happiness.

Angry faces showed a different pattern altogether. With the overall lowest recognition accuracy, intact angry expressions were recognized more accurately than scrambled and blurred angry faces, suggesting that the concurrent presence of both featural and configural information is important for a correct identification of this emotion. One possibility might be that anger is perceived more holistically than other emotions. Indeed, scanpath analysis revealed that anger elicits longer fixation duration on the centre of the face compared to happiness and this property might be associated to holistic processing strategy. An alternative explanation might be that the recognition of anger is very subtle, and in fact it can be confused with other emotions, such as sadness or disgust (Prkachin, 2003). As a consequence, disrupting the available information severely reduces accuracy. Indeed, anger was the emotion with the lowest accuracy when the expressions were either blurred or scrambled. Using the Bubbles paradigm, Langner, Becker, and Rinck (2009) found that non-anxious participants (contrary to anxious participants) did not process low spatial frequencies in angry expressions to extract discriminative information. This finding is in line with the fact that blurred angry expressions showed the worst performance in our study (Experiment 1). Moreover, for both the anxious and non-anxious participants the detailed information contained in the eyes was discriminative. In our study, eyes were fixated longer in anger than in happiness. In addition, we found that the mouth does not seem to be a relevant feature for the recognition of anger.

Finally, for fearful expressions there was a pronounced difference in accuracy between intact faces, which were recognized with high reliability, and scrambled and blurred expressions, which were difficult to recognize. Inversion affected recognition of fear to a lesser extent than other emotions (happiness, anger, and sadness). Robustness to inversion is in line with the evolutionary importance and the social relevance of fear (Adolphs et al., 2005). A possible explanation is that expression of fear is mainly recognized by the openness of the eyes, and this does not change with inversion. Note that Prkachin (2003) reported inversion to strongly reduce sensitivity to fearful faces. However her study differed from ours in that she presented emotional expressions only for 100 ms, while we presented them until the participants responded. Thus, in Prkachin’s study the short presentation time could have biased participants towards a configural mode of processing, as detailed analysis of features requires more time (Schwaninger et al., 2009). This could explain the different sensitivity to inversion in the two studies. The finding that fear relies more than other emotions on featural processing is confirmed by the fact that fear cued expressions showed overall longer fixation duration, independently of the fixated feature. This is also in line with Smith and Schyns (2009) who found that fear relies on high spatial frequencies and that its recognition decreases with increasing distance more than other emotion. In an fMRI study, Vuilleumier, Armony, Driver, and Dolan (2003) showed that amygdala activation in response to low-frequency fearful faces was greater than for high-frequency faces. They suggested that the subcortical pathways might provide coarse inputs to the amygdala. Although in principle this would speak against the importance of featural processing in fear recognition, it has to be noted again that faces were shown for 200 ms, which might not be enough time for detailed featural processing.

The use of blurred and scrambled faces might have common aspects with low and high spatial frequency faces. Indeed, our blurred stimuli correspond to low-spatial frequency faces in which the frequencies higher than 6.5 cycles per face have been excluded. This cut-off value matches that of other studies using low-spatial frequency faces (e.g., Vuilleumier et al., 2003). However, our scrambled stimuli retain both high and low spatial frequencies. We used scrambled faces instead of high spatial stimuli because the critical point in Experiment 1 was to isolate featural information by disrupting configural information. The use of scrambled faces has been proven to be an efficient way to study featural processing by several studies on face perception (Bombari et al., 2009; Collishaw & Hole, 2000; Lobmaier et al., 2008; Schwaninger et al., 2002).

One limitation of the present study might be that only four emotions were tested. We did not include surprise and disgust because they are often confused with anger and fear respectively (McKelvie, 1995; Prkachin, 2003). Further experiments might extend the present findings to other and more complex emotions (e.g., mixed emotions).

In sum, in Experiment 1 we found that emotional expressions were recognized even when the stimuli were inverted, scrambled or blurred. Reliably recognizing and interpreting other people’s emotions is crucial in everyday social interactions; this calls for a solid and dependable system for emotion recognition. Such a system should also work when featural or configural information is less available (e.g., when some features are occluded or when the distance does not allow to resolve featural details). Despite a main role of configural processing, the involvement of features and configurations depends on the emotion expressed, as further investigated in Experiment 2. While happiness can be recognized either by featural (i.e., the mouth) or configural information, anger requires the presence of both. Configural processing plays a dominant role in the recognition of sadness, while fear relies more on featural information, presumably the eyes and the mouth.

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