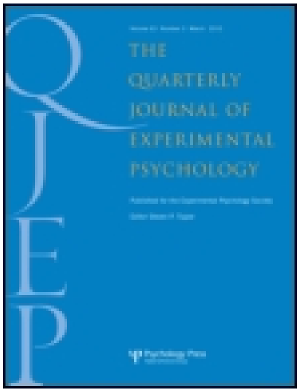

The Quarterly Journal of Experimental Psychology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pqje20

A smile biases the recognition of eye expressions: Configural projection from a salient mouth

Manuel G. Calvo [a] , Andrés Fernández-Martín [a] & Lauri Nummenmaa [b c]

[a] Department of Cognitive Psychology , University of La Laguna , Tenerife , Spain

[b] Department of Biomedical Engineering and Computational Science, and Brain Research Unit, O.V. Lounasmaa Laboratory, School of Science , Aalto University , Espoo , Finland

[c] Turku PET Centre , Turku , Finland

Accepted author version posted online: 27 Sep 2012.Published online: 09 Nov 2012.

To cite this article: Manuel G. Calvo , Andrés Fernández-Martín & Lauri Nummenmaa (2013): A smile biases the recognition of eye expressions: Configural projection from a salient mouth, The Quarterly Journal of Experimental Psychology, 66:6, 1159-1181

To link to this article: http://dx.doi.org/10.1080/17470218.2012.732586

THE QUARTERLY JOURNAL OF EXPERIMENTAL PSYCHOLOGY, 2013
Vol. 66, No. 6, 1159–1181, http://dx.doi.org/10.1080/17470218.2012.732586

A smile biases the recognition of eye expressions: Configural projection from a salient mouth

Manuel G. Calvo[1], Andrés Fernández-Martín[1], and Lauri Nummenmaa[2,3]

[1]Department of Cognitive Psychology, University of La Laguna, Tenerife, Spain
[2]Department of Biomedical Engineering and Computational Science, and Brain Research Unit, O.V. Lounasmaa Laboratory, School of Science, Aalto University, Espoo, Finland
[3]Turku PET Centre, Turku, Finland

A smile is visually highly salient and grabs attention automatically. We investigated how extrafoveally seen smiles influence the viewers' perception of non-happy eyes in a face. A smiling mouth appeared in composite faces with incongruent non-happy (fearful, neutral, etc.) eyes, thus producing blended expressions, or it appeared in intact faces with genuine expressions. Attention to the eye region was spatially cued while foveal vision of the mouth was blocked by gaze-contingent masking. Participants judged whether the eyes were happy or not. Results indicated that the smile biased the evaluation of the eye expression: The same non-happy eyes were more likely to be judged as happy and categorized more slowly as not happy in a face with a smiling mouth than in a face with a non-smiling mouth or with no mouth. This bias occurred when the mouth and the eyes appeared simultaneously and aligned, but also to some extent when they were misaligned and when the mouth appeared after the eyes. We conclude that the highly salient smile projects to other facial regions, thus influencing the perception of the eye expression. Projection serves spatial and temporal integration of face parts and changes.

Keywords: Facial expression; Smile; Saliency; Projection; Configural; Recognition.

The smile is a universal facial expression (Russell, 1994) that is characterized mainly by changes in the mouth region of a face, i.e., lip corners turned up and pulled backwards, often with a raised upper lip and exposed upper teeth (Ekman & Friesen, 1978; Kohler et al., 2004). These changes are both visually highly salient in a face and highly diagnostic of the expression of happiness (see below). We investigated whether, due to visual saliency, a smile *projects* to the eye region from extrafoveal vision, even before the mouth is looked at, and, as a consequence, the diagnostic value of the smile can make the eyes look happy, even if they do not really convey happiness.

People often smile without actually being happy (e.g., in social or polite smiles, nervous or

Correspondence should be addressed to Manuel G. Calvo, Department of Cognitive Psychology, University of La Laguna, 38205 Tenerife, Spain. E-mail: mgcalvo@ull.es

This research was supported by Grant PSI2009-07245 from the Spanish Ministerio de Ciencia e Innovación, and the Agencia Canaria de Investigación, Innovación, y Sociedad de la Información (Neurocog Project), and the European Regional Development Fund, to MGC and AFM, and by the Academy of Finland Grant #217995, and the AivoAalto grant from Aalto University, to LN.

embarrassed smiles, dominant or sarcastic smiles; Ambadar, Cohn, & Reed, 2009; Johnston, Miles, & Macrae, 2010; Krumhuber & Manstead, 2009). In these cases, a smiling mouth appears in a face with non-happy eyes (e.g., neutral, fearful, angry). An important issue is how such blended expressions are processed in the visual system. As faces can be identified when there is time for only one fixation and they are too large to be fixated in their entirety (Richler, Mack, Gauthier, & Palmeri, 2009; Richler, Mack, Palmeri, & Gauthier, 2011), we can assume that they are perceived holistically, with face parts being extrafoveally integrated. In this context, we propose that the saliency of a smile makes it especially accessible to extrafoveal vision, and the conveyed happiness can thus spread out to other, currently fixated areas in a face. If so, viewers could be misled to interpret blended expressions with a smile but non-happy eyes as happy, even when they are looking at the eyes.

ROLE OF THE SMILE IN FACIAL EXPRESSION RECOGNITION: DISTINCTIVENESS AND SALIENCY

Among the six basic emotional expressions (happiness, fear, anger, sadness, disgust, and surprise; Ekman & Friesen, 1976), a recognition advantage has been found for happy faces when face stimuli are singly presented (Calvo & Lundqvist, 2008; Leppänen & Hietanen, 2004; Milders, Sahraie, & Logan, 2008; Palermo & Coltheart, 2004; Tottenham et al., 2009), and when presented simultaneously with neutral (Calvo & Nummenmaa, 2009) or other emotional (Calvo & Nummenmaa, 2011) faces. Such an advantage has been attributed to the diagnostic value or *distinctiveness* of the smile (Adolphs, 2002; Leppänen & Hietanen, 2007). The smiling mouth region is a necessary and sufficient feature for categorizing faces as happy, whereas the eye region makes a modest contribution (Calder, Young, Keane, & Dean, 2000; Fiorentini & Viviani, 2009; Kontsevich & Tyler, 2004; Leppänen & Hietanen, 2007; Nusseck, Cunningham, Wallraven, & Bülthoff, 2008; Smith, Cottrell, Gosselin, & Schyns, 2005). As a distinctive feature, the smile is systematically and uniquely associated with facial happiness, whereas features overlap to some extent across the other expressions (Calvo & Marrero, 2009; Kohler et al., 2004). The smile can thus be used as a shortcut for a quick categorization of a face as happy. In contrast, the non-happy expressions would require processing of particular combinations of facial features, and therefore the process would be slower and more prone to errors.

A smiling mouth is also visually more conspicuous or *salient* than any other region of happy and non-happy faces (Calvo & Nummenmaa, 2008). Saliency can be assessed computationally as a combination of physical image properties such as local contrast, energy, and spatial orientation (Itti & Koch, 2000; Walther & Koch, 2006). Saliency can account for the happy face advantage in extrafoveal locations of the visual field (i.e., beyond 2.5° from fixation), both in recognition (Calvo, Nummenmaa, & Avero, 2010; Goren & Wilson, 2006) and discrimination (Calvo & Nummenmaa, 2009, 2011) tasks. As both covert and overt visual attention modulate sensory gain partly on the basis of the input signal saliency (Itti & Koch, 2000), a smiling mouth becomes more accessible to processing than other facial features, even before the viewer looks at the mouth directly. In fact, in recognition and detection tasks, the happy mouth region is more likely to capture the first eye fixation than any other region of emotional faces, with temporal correspondence between the onset of the saliency peak and the time of first fixation on the face (Calvo & Nummenmaa, 2008). Presumably, visual saliency allows viewers to detect the smiling mouth in extrafoveal vision, which would then guide attentional orienting and would thus facilitate the early recognition of happy expressions.

DOES THE SMILE MODULATE CONFIGURAL PROCESSING OF BLENDED FACIAL EXPRESSIONS?

From the previous consideration of the smile saliency and distinctiveness, we can draw the main research question driving the current study: Is the smiling mouth so salient and distinctive that it projects outwards to other facial regions and biases their evaluation towards happiness when faces are not really happy, as is the case with many types of blended expressions? Given that the eye region is the other major informative source in a face, the question pertains especially to the influence of the smiling mouth on the eye expression: Does the smile make non-happy eyes look happy—thus inhibiting or interfering with the accurate recognition of their actual expression—even when only the eyes, but not the mouth, are directly looked at?

The proposed influence of the smile is hypothesized to occur through an extrafoveal projection mechanism. The concept of *projection* from the smiling mouth towards the eyes was initially suggested by Kontsevich and Tyler (2004). This mechanism is illustrated in Figure 1. The smiling mouth is visually salient, which would make it radiate to surrounding regions. Due to visual saliency, the smile would be resistant to visual acuity degradation when it appears outside of foveal vision, and could thus be perceived extrafoveally when the surrounding regions are looked at. As a consequence, and given that the smiling mouth is highly diagnostic of happy expressions, *non-happy* eyes could convey an impression of *happiness* to the viewer even when only the eyes are foveally fixated.

Extrafoveal projection is assumed to be a central characteristic of holistic or configural processing, according to which faces and facial expressions are coded as unitary objects in an integrated representation that combines the different parts of a face (Calder et al., 2000; Richler et al., 2009). The projection mechanism adds to this view by specifying that integration can be performed during the fixation on a single face part, without requiring overt attention to all parts. Faces could be processed holistically precisely because of projection of non-fixated regions towards a fixated region. Importantly, by favouring integration of non-fixated regions, projection would allow them to *influence* the perception of the fixated region. A distant, extrafoveally available region (e.g., the mouth) can thus affect the perception of an overtly attended region (e.g., the eyes). Projection

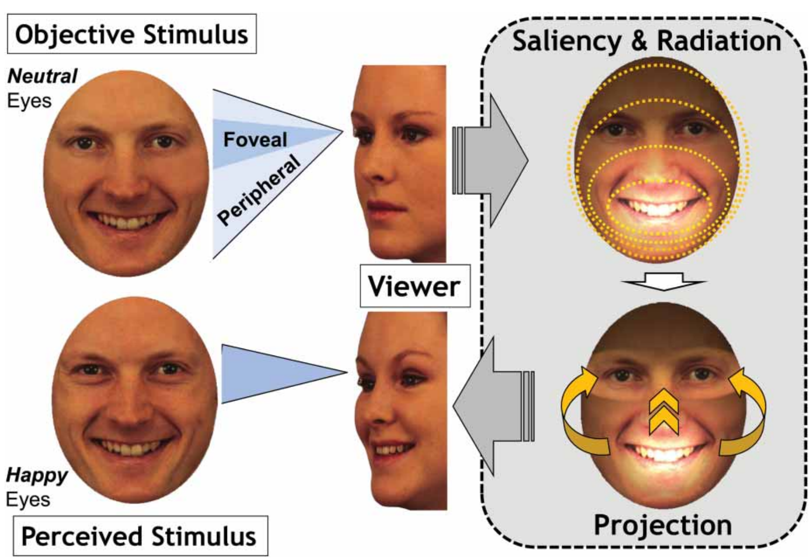

Figure 1. *Illustration of a conceptual model of saliency and projection of the smile. Photos taken from the Karolinska Directed Emotional Face database (Lundqvist et al., 1998). The objective stimulus face involves* neutral *eyes and a smile; the perceived stimulus face involves* happy *eyes and a smile.*

would be enhanced for expressions in which there is a visually salient feature (e.g., the smiling mouth), which would automatically attract covert attention (even before overt attention). As a consequence, a salient feature would be integrated in the holistic processing of a face.

This conceptualization is relevant to the debate on the relative contribution of featural versus configural processing in facial expression recognition (see Calder et al., 2000; Ellison & Massaro, 1997; Fiorentini & Viviani, 2009; Tanaka, Kaiser, Butler, & Le Grand, 2012). Although faces and facial expressions are typically processed configurally (Calder et al., 2000; Richler et al., 2009), expressions can also be recognized on the basis of single, diagnostic features (Ellison & Massaro, 1997; Fiorentini & Viviani, 2009). This raises the issue of the relative projection of a smiling mouth towards the eye region through configural vs. featural mechanisms. As we have argued, the projection mechanism seems more compatible with the configural than with the featural view. It is, nevertheless, possible that the smiling mouth projects to other regions, such as the eyes, also when they are presented separately—thus disrupting their integration into a unitary facial configuration. An influence of the smile under such conditions would provide support for a featural projection mechanism.

OVERVIEW OF THE PRESENT STUDY

To investigate the effects of a smile on the perception of the eye expression, we used a composite face paradigm (Calder et al., 2000; Leppänen & Hietanen, 2007; Tanaka et al., 2012). Participants viewed faces in which a non-happy (e.g., angry, neutral) eye region was fused with the mouth region of a happy face. This produced (a) ambiguous *blended* expressions in which the eyes were incongruent with the mouth (e.g., a frown with a smile). For comparison, participants also viewed (b) intact faces with *genuine* expressions, either *happy* (i.e., congruent happy eyes and a smiling mouth) or *non-happy* (e.g., congruent angry eyes and an angry mouth), as well as (c) *no-mouth* control faces, in which the upper half of the face (containing the eyes) was visible, while the lower half (containing the mouth) was scrambled. The eyes were always task-relevant: They were visually pre-cued to guide the viewers' attention to them, and participants were asked to categorize their expression.

In Experiment 1, the *spatial* projection of the mouth was investigated by preventing fixations on the mouth by means of gaze-contingent foveal masking, although the mouth remained accessible to extrafoveal vision. In Experiment 2, the backward *temporal* integration of the mouth was investigated by presenting the task-relevant eyes before the whole face with the extrafoveal mouth. If, in these conditions—where the mouth region is not attended to overtly—the mouth expression influences the categorization of the eye expression, we can infer that smiles spatially project to the eyes, and are temporally integrated with them. The probability of wrongly judging non-happy eyes as happy should be greater, and reaction times in correctly judging them as not happy should be longer, for blended expressions with a smile than for genuinely non-happy and for no-mouth expressions, even though all these stimuli have exactly the *same* eyes. In Experiment 3, we examined whether projection occurs via configural versus featural processing. To this end, the top (with eyes) and bottom (with mouth) halves of the face stimuli were aligned versus misaligned. Misalignment is assumed to disrupt configural but not featural processing (see Calder et al., 2000; Richler, Tanaka, Brown, & Gauthier, 2008). Accordingly, featural projection of the smile would make the eyes look happy both when the bottom half of the face is aligned and when it is misaligned. In contrast, if projection occurs configurally, the effect will be reduced or disappear in the misaligned condition.

EXPERIMENT 1: PROJECTION FROM A SALIENT SMILE

We investigated whether the smile biases the judgment of non-happy eyes as happy when the mouth is extrafoveally accessible but cannot be fixated. To this end, (a) we presented genuine or blended expressions, for 150 ms, to allow for only one fixation, (b) visual attention was pre-cued to the eye region by means of an abrupt visual onset, (c) fixations on the mouth were prevented by means of gaze-contingent masking, and (d) participants categorized the eyes as happy or not happy. Visual saliency of the eye and the mouth regions was computed to explore whether the smile remained salient in the blended expressions and could thus bias their categorization as happy.

Recently, we conducted a related study that was, nevertheless, conceived of as an extension of the current Experiment 1 (Calvo & Fernández-Martín, in press). The two studies share their general aims (i.e., the mouth projection and biasing effects on the eyes) and some methodological aspects (visual cueing and categorization of the eye region expression). However, there were important differences. First, Calvo and Fernández-Martín (in press) investigated the specialness of the smile effects in comparison with those of other mouth expressions (angry and sad). Second, these authors did not use gaze-contingent masking, and eye movements were not recorded in the main experiment examining projection effects, but rather in an auxiliary study. Third, all three mouth conditions (i.e., congruent vs. incongruent vs. no mouth) were not compared in the same design, but rather the congruent and the incongruent condition were compared separately with the no-mouth condition. This limitation was imposed by the addition of a new within-subjects factor, i.e., type of task (judge whether the eyes were angry, or sad, or happy). The results of this previous study indicated that a smile affected the evaluation of eye expressions more than an angry or a sad mouth did. The current experiment makes a contribution: The strict and direct control of eye movements will allow us to determine whether the effects occur through projection, and the simultaneous comparison of the three mouth conditions will allow us to separate the facilitation (congruence) from the interference (incongruence) effects.

Method

Participants

In this and the following experiments, psychology undergraduates from La Laguna University (between 19 and 25 years old) received course credit for their participation. In Experiment 1 there were 24 (19 female) participants.

Stimuli

We selected 168 digitized colour photographs from the Karolinska Directed Emotional Faces (KDEF; Lundqvist, Flykt, & Öhman, 1998) stimulus set. Nonfacial areas (e.g., hair, neck) were removed. The faces portrayed 12 females and 12 males, each posing seven basic expressions (neutral, happiness, anger, disgust, sadness, fear, and surprise). The faces with happy expressions included a smiling mouth and the *Duchenne marker* in the eye region. This marker (bulges below the eyes, crow's feet wrinkles at the outer corners of the eyes, a lowering of the eyebrows and a narrowing of the eye aperture) is typically associated with genuine smiles but frequently absent in fake smiles (Krumhuber & Manstead, 2009; Miles & Johnston, 2007).

In addition to these *genuine* expressions, we constructed faces with six *blended* expressions for each of the 24 selected KDEF models, thus producing 144 new face stimuli. The upper half of each non-happy face was combined with the lower half of the happy face of the same individual, by cutting each face along a horizontal line through the bridge of the nose and smoothing the junction by Adobe® Photoshop® CS5. We produced the following blends: NeHa (Neutral eyes + Happy mouth, i.e., smile), AnHa (Angry eyes + Happy mouth), DiHa (Disgusted eyes + Happy mouth), SaHa (Sad eyes + Happy mouth), FeHa (Fearful eyes + Happy mouth), and SuHa (Surprised eyes + Happy mouth). Finally, another 168 stimuli (24 of each category) were generated by Fourier phase scrambling the bottom half of the faces, leaving the upper half with the eye region visible. These stimuli were used in the *no-mouth*, control condition. Figure 2

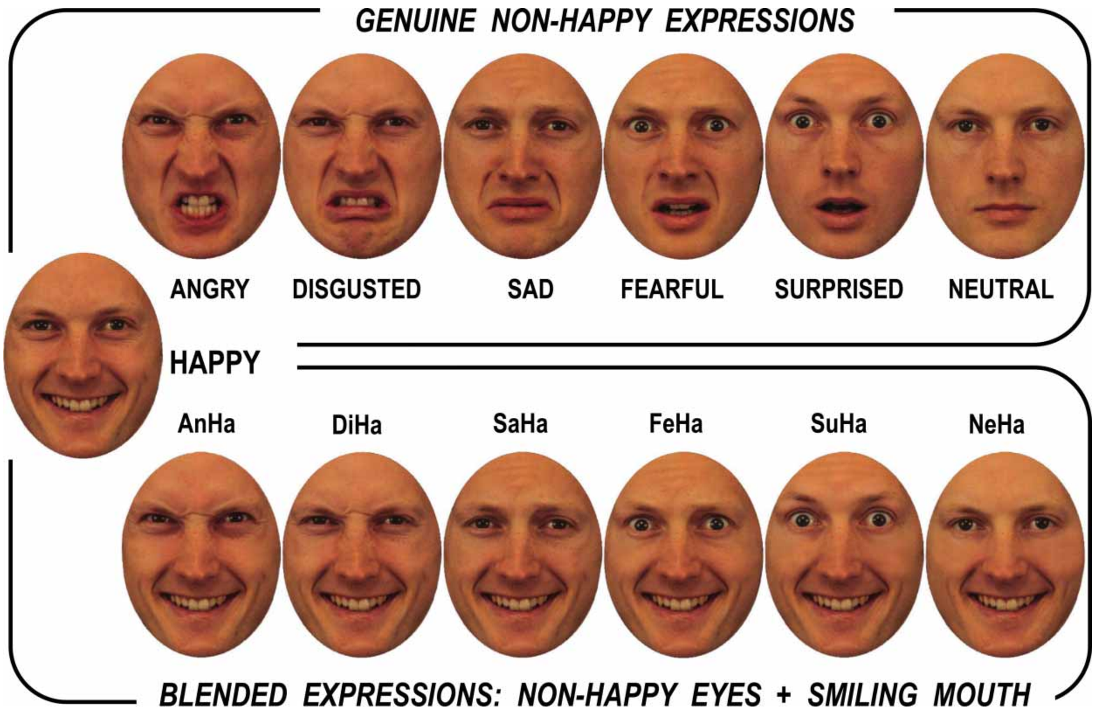

Figure 2. *Sample of face stimuli with truly happy, truly non-happy, and blended expressions used in Experiments 1 to 3. Blended expressions: AnHa = angry eyes + smiling mouth (i.e., angry upper part of face with happy lower part of face); DiHa = disgusted eyes + happy mouth; SaHa = sad eyes + happy mouth; FeHa = fearful eyes + happy mouth; SuHa = surprised eyes + happy mouth; NeHa = neutral eyes + happy mouth. Photos taken and adapted from the Karolinska Directed Emotional Face database (Lundqvist et al., 1998).*

shows some examples of the genuine and the blended expressions (see an example of the no-mouth faces in Figure 3).

Apparatus and procedure

The stimuli were presented on a 21 inch monitor with a 120 Hz refresh rate. Participants' eye movements were recorded with an EyeLink II tracker (SR Research, Mississauga, Ontario, Canada). The sampling rate was 500 Hz and the spatial accuracy was better than 0.5°, with a 0.01° resolution in pupil tracking mode. Participants had their head positioned on a chin rest at a 60 cm viewing distance, at which each face stimulus subtended visual angles of 9° (width) × 12° (height). The distance between the eyes and the mouth was 4.8°, which corresponds to the farther boundaries of parafoveal vision (Wandell, 1995).

At the beginning of the session, participants were told that faces with different expressions would be presented briefly, preceded by a cue rectangle on the area where the eyes of the face would appear. They were instructed to look only at the eyes and respond as quickly and accurately as possible that they conveyed a happy expression or not, by pressing a left or a right button of a response box. Categorization performance was measured by the probability of judging the eyes as happy, and by reaction times of correct responses to faces with happy eyes and correct rejection responses (i.e., faces with non-happy eyes judged as "not happy").

Each participant was presented with 480 randomly ordered trials (24 of each of the genuine, blended, and no-mouth categories) in four blocks. See Figure 3 for an overview of the trial structure. Each trial began with a drift correction circle

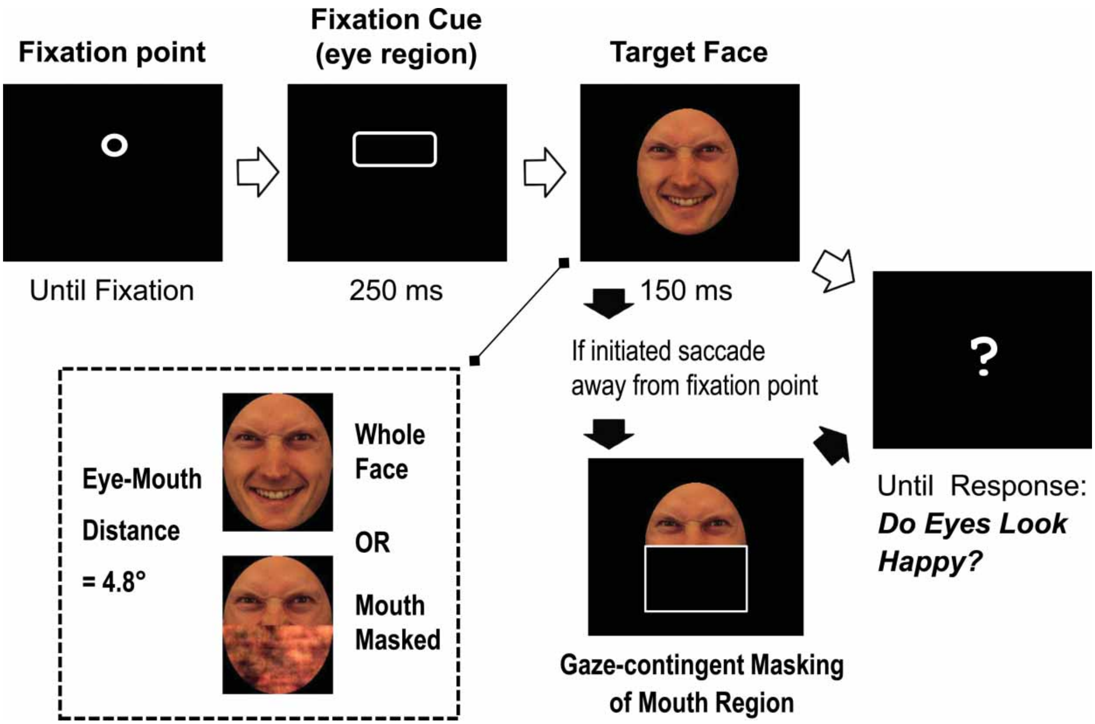

Figure 3. *Sequence of events and overview of basic characteristics of a trial in Experiment 1. The white border of the square did not appear in the gaze-contingent masking.*

(0.5°), followed by a 250 ms, bright white cue rectangle, on the location where the eye region subsequently appeared. The cue rectangle (7° × 2.5°) comprised an area between the outer edges of both eyes and eyebrows. Upon the cue offset, the face appeared for 150 ms. Gaze-contingent masking was used throughout the face display (see Calvo & Nummenmaa, 2007): If the viewer initiated a saccade away from the cued eye region towards the mouth, a black mask covered the bottom half of the face, thus the mouth always remained inaccessible to foveal vision.

Design

The experimental conditions were combined in a factorial design, with eye expression (6: angry, disgusted, sad, fearful, surprised, and neutral) and type of mouth (3: congruent with non-happy eyes vs. incongruent smile vs. no mouth) as within-subjects factors. In the congruent condition, the mouth was always non-happy and belonged to the same expression category as the eye region. In the incongruent condition, the mouth always involved a smile but the eyes conveyed a different expression. In the no-mouth, control condition, the eye region was visible but the mouth region was scrambled, thus removing any meaningful visual information, but retaining its low-level image properties. For the happy eye expression, the smiling mouth could only be congruent (not incongruent), and therefore such an eye expression could be combined only with two mouth type levels (smile vs. no mouth).

Assessment of visual saliency

We obtained the saliency values for each of five face regions (forehead, eye/eyebrows, cheek /nose, mouth, and chin) by means of the iLab Neuromorphic Vision C++ Toolkit (iNVT; Itti & Koch, 2000; see also Walther & Koch, 2006). This algorithm simulates which features in a given image attract attention as a function of physical image properties (local contrast, orientation, and color), by mimicking the response properties of retinal neurons, lateral geniculate nucleus, thalamus, and V1. Such features are then integrated for a neural saliency map that is a graded representation of the visual conspicuity of each pixel in the image. After computing the saliency map for the face, average saliency values were extracted for the two most expressive areas, i.e., mouth and eyes. In our face stimuli, each of these regions subtended a 2.4° vertical visual angle.

Results

Eye-movement data

Eye movement recordings revealed that all first fixations on the face stimuli landed within the cued eye region, only one fixation was made during the 150 ms display, and no saccades were launched towards the mouth region. This confirms that the task-relevant eye region was always looked at and, importantly, that any potential influence of the mouth region on the judgement of the eye expression occurred without overt attention to the mouth, with the mouth in parafoveal vision.

Probability of categorization of eye expressions as "happy"

Mean probability scores in categorizing eye expressions as happy and reaction times of correct responses for the congruent, incongruent, and no-mouth conditions are shown in Figure 4. For multiple comparisons in this and the following experiments, we always used post hoc contrasts with Bonferroni corrections ($p < .05$).

In a 3 (mouth expression: congruent non-happy vs. incongruent smile vs. no mouth) × 6 (eye expression: angry, sad, disgusted, fearful, surprised, neutral) analysis of variance (ANOVA) on the probability of judging the eye expression as happy, the main effects of mouth expression, $F(2, 46) = 143.79$, $p < .0001$, $\eta_p^2 = .862$, and eye expression, $F(5, 115) = 32.51$, $p < .0001$, $\eta_p^2 = .586$, were qualified by an interaction, F(10,

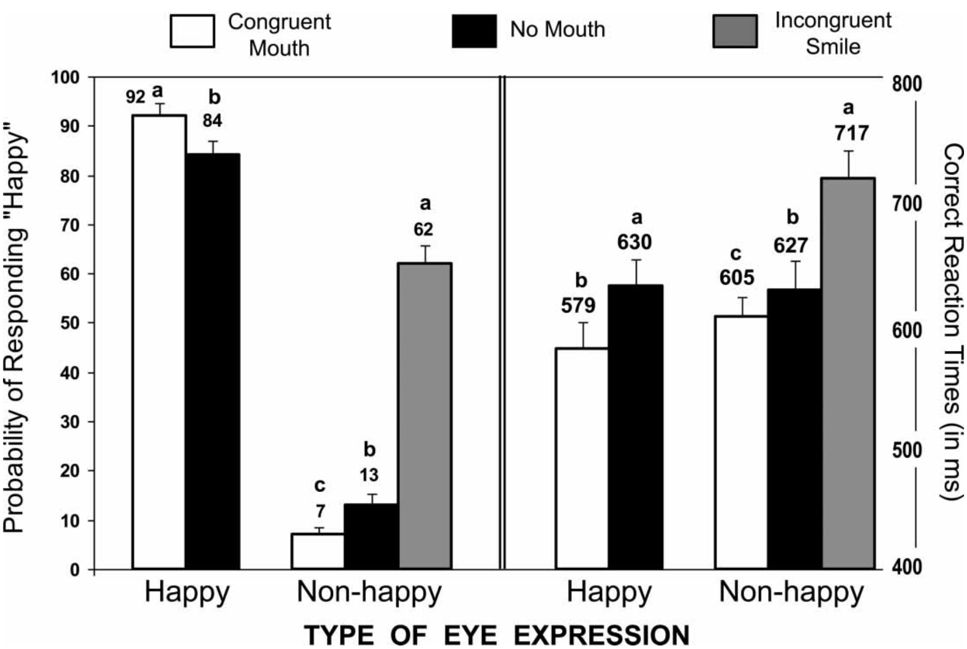

Figure 4. *Mean probability scores (percentage) in responding that the eye expression was happy, and reaction times (in ms) of correct responses, as a function of eye expression and type of mouth, in Experiment 1. Error bars represent standard errors of the mean. Means with a different letter are significantly different within each type of eye expression condition; means with the same letter or no letter are equivalent.*

Table 1. *Difference scores (blended – genuine) in the probability of categorization of non-happy eyes as "happy" for each facial expression in Experiments 1 to 3*

	Eye expression category					
Experiment	*Angry*	*Fearful*	*Disgusted*	*Sad*	*Surprised*	*Neutral*
1	$.40^{a}$	$.48^{ab}$	$.52^{bc}$	$.54^{bc}$	$.64^{cd}$	$.72^{d}$
2	$.16^{a}$	$.20^{ab}$	$.22^{ab}$	$.26^{abc}$	$.33^{bc}$	$.44^{cd}$
3	$.19^{a}$	$.28^{ab}$	$.26^{ab}$	$.30^{ab}$	$.34^{bc}$	$.47^{c}$

Note: The higher the score, the greater the biasing influence of the smile on the non-happy eye expression towards happiness. Means with a different superscript horizontally are significantly different; means with the same superscript or no superscript are equivalent.

230) = 5.24, $p < .0001$, $\eta_p^2 = .186$. Post hoc comparisons indicated that the same eye region was more likely to be judged as happy in the presence of an incongruent smiling mouth (i.e., blended expressions) than in the presence of a congruent non-smiling mouth (i.e., genuine non-happy expressions) and in the absence of a mouth (control condition). Scores were higher with no mouth than with a congruent mouth (see Figure 4). In addition, for truly happy faces, scores were higher when the eyes and the mouth were displayed than with no mouth, $t(23) = 2.40$, $p < .025$ (see Figure 4).

To decompose the interaction, we first calculated *difference scores* between the blended expressions and the corresponding genuine expressions (i.e., blended – genuine). These scores indicate how much the smiling mouth in the blended expressions increased the probability of evaluating non-happy eyes as happy, relative to the genuinely non-happy faces with the same eyes but no smiling mouth. In a one-way (6: eye expression) ANOVA, a significant effect emerged, $F(5, 115) = 10.05$, $p < .0001$, $\eta_p^2 = .304$. Post hoc comparisons showed that the neutral eyes were the most likely to be influenced by a smiling mouth, whereas the angry eyes were the least likely to be affected (see the mean scores and multiple contrasts in Table 1). As this effect also appeared in the other experiments, it will be discussed in Experiment 3.

Reaction times of correct responses

The probability of responding that the eyes of NeHa and SuHa faces looked happy was above .80, implying that there were less than 20% of correct ("not happy") responses. Accordingly, these two categories were excluded from the analysis. In a 3 (mouth expression: congruent non-happy vs. incongruent smile vs. no mouth) × 4 (eye expression: angry, sad, disgusted, fearful) ANOVA on response latencies, only main effects of mouth emerged, $F(2, 46) = 23.58$, $p < .0001$, $\eta_p^2 = .506$. Latencies were longer when non-happy eyes were judged as not happy in the presence of a smiling mouth (i.e., blended expressions) than in the presence of a congruent non-happy mouth (i.e., non-happy expressions), and longer than when the mouth was not shown (i.e., control), with no significant differences between the two latter conditions. In addition, response latencies for happy eyes were shorter in the presence of a smiling mouth than in the no-mouth condition, $t(23) = 2.18$, $p < .05$. See Figure 4.

Analysis of visual saliency

A 2 (configuration: non-happy vs. blended) × 6 (expressive eyes: angry, disgusted, sad, fearful, surprised, and neutral) × 2 (region: eyes vs. mouth) ANOVA was conducted on saliency values of the eye and the mouth regions. See the mean scores for each category in Table 2, and the average scores for the non-happy, the blended, and the happy expressions in Figure 5. Main effects of configuration, $F(1, 276) = 59.98$, $p < .0001$, $\eta_p^2 = .179$, and region, $F(1, 276) = 591.16$, $p < .0001$, $\eta_p^2 = .682$, were qualified by a configuration by region interaction, $F(1, 276) = 262.89$, $p < .0001$, $\eta_p^2 = .488$, and a three-way interaction $F(1, 276) = 2.87$, $p < .025$, $\eta_p^2 = .049$. The mouth was more salient than the eyes for all the

Table 2. *Visual saliency values of the mouth and the eye regions for each facial expression of face stimuli in Experiments 1 to 3*

	Facial expression category						
Eye region							
Genuine	Angry	Disgusted	Sad	Fearful	Surprised	Neutral	**Happy**
Mean	2.21^{ab}	2.32^{ab}	2.82^{a}	2.51^{ab}	3.47^{a}	1.81^{ab}	0.35^{b}
SD	2.30	2.30	3.56	2.95	3.27	2.41	0.80
Blended	AnHa	DiHa	SaHa	FeHa	SuHa	NeHa	
Mean	0.52	0.49	0.42	0.73	0.68	0.71	0.35
SD	1.16	0.62	1.08	1.19	1.00	1.24	0.80
Mouth region							
Genuine	Angry	Disgusted	Sad	Fearful	Surprised	Neutral	**Happy**
Mean	3.74^{bc}	6.06^{b}	2.10^{c}	4.36^{bc}	5.93^{b}	2.53^{c}	8.89^{a}
SD	2.48	3.66	1.41	2.90	3.44	0.96	1.62
Blended	AnHa	DiHa	SaHa	FeHa	SuHa	NeHa	
Mean	8.83	8.87	9.03	9.05	8.60	8.62	8.89
SD	1.64	1.64	1.97	1.82	1.85	1.75	1.62

Note: AnHa: angry eyes with happy mouth; DiHa: disgusted eyes with happy mouth; SaHa: sad eyes with happy mouth; FeHa: fearful eyes with happy mouth; SuHa: surprised eyes with happy mouth; NeHa: neutral eyes with happy mouth. Means with a different superscript horizontally are significantly different; means with the same superscript or no superscript are equivalent.

blended expressions, $t(143) = 51.15$, $p < .0001$, $d = 5.67$, $r = .94$, and the non-happy faces, $t(143) = 4.26$, $p < .0001$, $d = 0.54$, $r = .26$, except sad and neutral faces (p values>.18), which accounts for the three-way interaction. Importantly, the mouth–eye difference was much greater for the blended than for the non-happy expressions, as revealed by the Cohen's d and effect-size r values: While the percentage in saliency that was accounted for by region was 88.5% for the blended faces, it was only (though still significant) 6.8% for the non-happy faces.

The mouth was also more salient than the eyes for happy faces, $t(23) = 22.90$, $p < .0001$, $d = 6.69$, $r = .96$ (91.8% of variance). The eye and the mouth saliencies for happy faces were compared with those for the non-happy and the blended expressions in separate one-way (7: expression) ANOVAS (see Table 2 and Figure 5). The mouth of happy faces was more salient than that of all the non-happy faces, $F(6, 161) = 17.53$, $p < .0001$, $\eta_p^2 = .395$. In contrast, all the categories with a smile had equivalent mouth saliency (F<1). The eye region of happy faces was less salient than that of surprised and sad faces, $F(6, 161) = 3.26$, $p < .01$, $\eta_p^2 = .108$. No significant differences appeared between the eye region saliency of blended and happy faces (F<1).

Discussion

In blended expressions, a smiling mouth increased the probability of judging non-happy eyes as happy, and the latency in responding that the eyes were *not* happy, relative to when the same eyes appeared in truly non-happy expressions or in a no-mouth condition. Importantly, there were both facilitation and interference effects on both the probability of responses and reaction times: In comparison with the no-mouth, control condition, a congruent (either smiling or non-happy) mouth facilitated the correct identification of the eye expression, and an incongruent (smiling) mouth interfered with it. As the smile

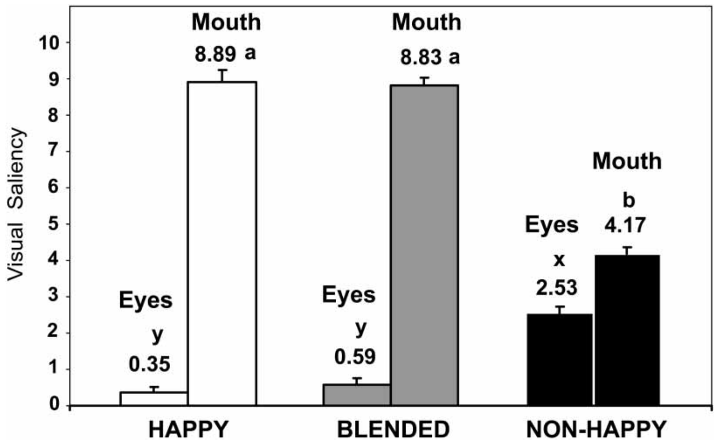

Figure 5. *Mean visual saliency of the eye and the mouth regions for happy, blended, and non-happy facial expressions, in Experiments 1 to 3. Means with a different letter (a and b, for the mouth region; x and y, for the eye region) are significantly different; means with the same letter are equivalent.*

affected the eye expression even when only the eyes were looked at, this effect can be attributed to extrafoveal projection from the mouth to the eyes. The high visual saliency of the smiling mouth is likely to underlie this effect: For both the truly happy and the blended expressions, the smiling mouth was more salient than the mouth of non-happy faces, whereas this pattern was reversed for the eye region; also, importantly, the mouth was equally salient in the happy and all the blended expressions, and always much more salient than the eyes.

EXPERIMENT 2: A BACKWARD INFLUENCE OF THE SMILE

Experiment 1 demonstrated that smiles project *spatially* to other face regions. In an extension of this approach, in Experiment 2, we investigated the *temporal* projection of the smile. More specifically, we examined whether the biasing influence of the smile can occur *backwards* in time, when the mouth appears *after* the viewer has looked at the eyes. In Experiment 1, the eyes and the mouth appeared at the same time, and thus the smiling mouth was present while the viewer was looking at the eyes for the first time. In Experiment 2, the eye region appeared alone for 300 ms *before* the whole face. The average duration of a functional fixation in face recognition is ~300 ms (Henderson, Williams, & Falk, 2005; Hsiao & Cottrell, 2008). This implies that by the time the whole face was displayed, the viewer would have already formed an impression of the eyes. If a retrospectively presented, non-fixated smiling mouth still makes the non-happy eyes look happy and slows down their correct rejection as not happy, this would support the existence of a backward-acting temporal projection mechanism: The smile would have inhibited the *already* initiated processing of the eye expression.

Method

Participants

Thirty psychology undergraduates (23 female) served as participants.

Stimuli, apparatus, procedure, and design

We used the same stimuli, apparatus, and design as in Experiment 1, with an important methodological difference in Experiment 2 (see Figure 6): Following the cue rectangle for the eye region location, the top half of a face was presented alone for 300 ms while the bottom half remained invisible, and subsequently the bottom half was uncovered, thus the whole face was finally displayed. The bottom half involved either (a) a scrambled mask, in the no-mouth control condition, (b) the corresponding intact face (i.e., genuine expression), in the congruent condition, or (c) a smile (i.e., blended expression), in the incongruent condition.

Participants were instructed to attend to the eyes, ignore the mouth, and evaluate the expression of the initially shown eyes. The whole face was displayed until the participant responded as to whether the eyes looked happy or not. Thus the eyes became the probe, while the mouth appearing *later* within the whole face was the backward prime. We did not present *only* the mouth region as a prime because this would have inevitably involved fixations on the mouth. Such fixations had to be avoided, given that we wanted to investigate the effects of the smiling mouth in extrafoveal vision. The fixation on the eyes *prior to* their appearing simultaneously with the mouth region was necessary to address the specific issue of this experiment.

Results

Eye-movement data

300 ms probe period: Fixation on the eye region. A 3 (mouth expression: congruent non-happy vs. incongruent smile vs. no mouth) $\times$ 6 (eye expression: angry, sad, disgusted, fearful, surprised, neutral) ANOVA on dwell times and number of fixations on the eye region prior to the whole face display yielded no significant effects (dwell times: $M = 285$ ms; number of fixations: $M = 1.63$). In addition, dwell times for the happy eye region (dwell times: $M = 285$ ms; number of fixations: $M = 1.60$) did not differ from those for the other

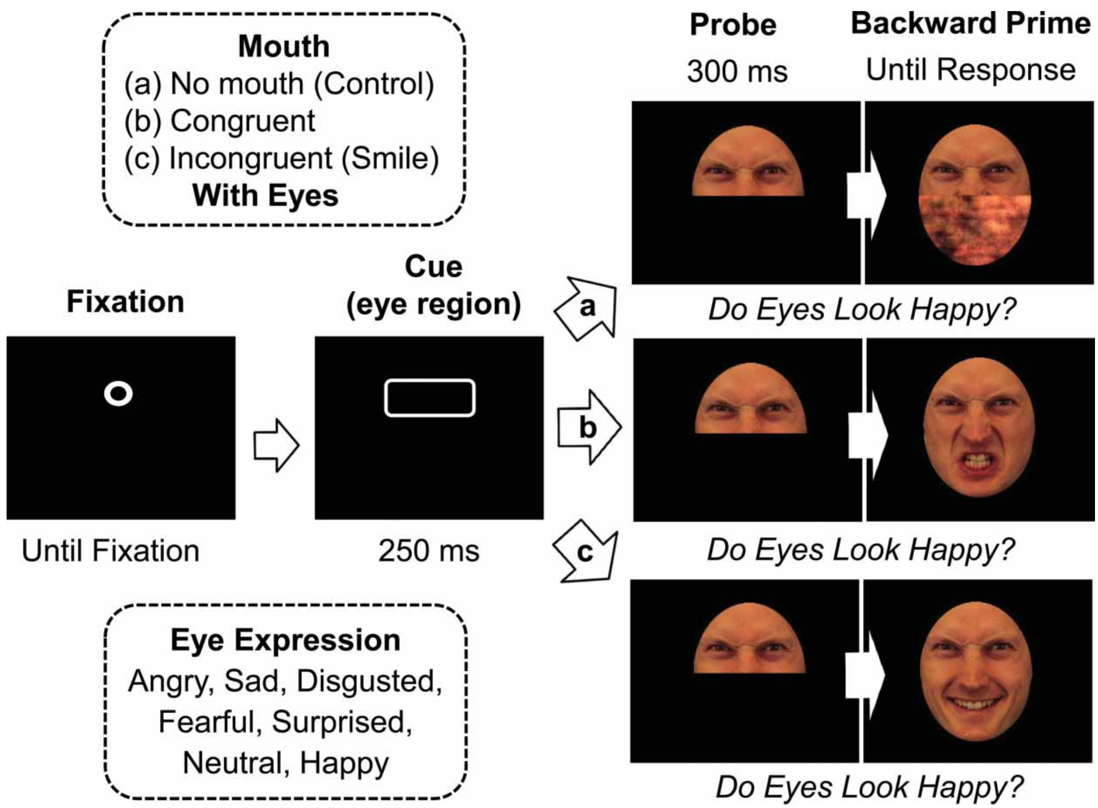

Figure 6. *Sequence of events and overview of basic characteristics of a trial in Experiment 2.*

expressions. Importantly, all the participants fixated the eye region for nearly the whole 300 ms display period.

Whole-face period: Fixation on the backward-prime mouth region. A 3 (mouth expression) × 6 (non-happy eye expression) ANOVA was initially conducted for all trials. Only main effects of mouth expression on dwell times, $F(2,\ 58) = 14.36$, $p < .0001$, $\eta_p^2 = .331$, and number of fixations, $F(2,\ 58) = 14.96$, $p < .0001$, $\eta_p^2 = .340$, emerged. Post hoc contrasts indicated that the incongruent smiling mouth was fixated longer ($M = 47$ ms) and more frequently ($M = 0.24$ fixations) than the non-happy congruent mouth ($M = 29$ ms and 0.16 fixations), which received more overt attention than the no-mouth condition ($M = 1$ ms and 0.01 fixations). Accordingly, there were few, very short fixations on the mouth.

Whole-face period: Fixation on the eye region. A 3 (mouth expression) × 6 (non-happy eye expression) ANOVA yielded main effects of mouth expression on dwell times, $F(2,\ 58) = 9.88$, $p < .0001$, $\eta_p^2 = .244$, and number of fixations, $F(2,\ 58) = 12.54$, $p < .0001$, $\eta_p^2 = .302$. Post hoc contrasts revealed longer dwell times and more fixations on the eyes in both the incongruent smiling mouth ($M = 417$ ms; 1.68 fixations) and the no-mouth ($M = 424$ ms; 1.68 fixations) conditions than in the congruent non-happy mouth condition ($M = 377$ ms; 1.52 fixations).

Probability of categorization of eye expressions as "happy". The projection hypothesis assumes that the smile influences the evaluation of the eye expression in the absence of fixations on the mouth. Accordingly, trials with fixations on the mouth region (16%) were removed from further analyses.

In a 3 (mouth expression) × 6 (eye expression) ANOVA on the probability of judging the eyes as happy, the effects of mouth, $F(2,\ 58) = 45.24$, $p < .0001$, $\eta_p^2 = .609$, and eyes, $F(5,\ 145) = 38.89$, $p < .0001$, $\eta_p^2 = .573$, were qualified by an interaction, $F(10,\ 290) = 3.68$, $p < .0001$, $\eta_p^2 = .113$. Post hoc contrasts indicated that the same non-happy eye region was more likely to be judged as happy when it was followed by an incongruent smile (i.e., blended expressions) than by a congruent non-smiling mouth (i.e., non-happy expressions), and also than in the no-mouth condition. To decompose the interaction, we obtained *difference scores* between the blended and the genuine expressions. Following a one-way ANOVA (6: eye expression), $F(5,\ 145) = 5.24$, $p < .01$, $\eta_p^2 = .153$, post hoc comparisons indicated that neutral eyes and angry eyes were, respectively, the most and the least likely to be influenced by a smiling mouth (see Table 1). For truly happy faces, scores did not differ as a function of mouth condition. See Figure 7.

Reaction times of correct responses. Reaction times were recorded from the offset of the eye region probe. The 3 (mouth expression) × 6 (eye expression) ANOVA on correct response latencies yielded main effects of mouth, $F(2,\ 58) = 15.29$, $p < .0001$, $\eta_p^2 = .345$. Response latencies for non-happy eyes were longer following an incongruent smiling mouth (i.e., blended expressions) than a congruent non-happy mouth (i.e., non-happy expressions), and longer than when the mouth was not shown. Latencies for happy eyes were equivalent in the presence of a smiling mouth and in the no-mouth condition. See Figure 7.

Discussion

A smile biased the judgment of non-happy eyes when the mouth appeared in extrafoveal vision *after* viewers had looked at the eyes for nearly 300 ms. First, a smiling mouth increased the probability of incorrectly categorizing non-happy eyes as happy, and prolonged correct response latencies. Importantly, differences occurred between the incongruent smile condition and both the non-happy mouth *and* the *no-mouth* conditions, while there were *no differences* between the two latter conditions. These findings thus reflect backward interference or inhibition caused by the incongruent smile (rather than backward priming by the congruent non-happy mouth). Second, dwell times and number of fixations on the non-happy eye

Figure 7. *Mean probability scores (percentage) in responding that the eye expression was happy, and reaction times (in ms) of correct responses, as a function of eye expression and type of mouth, in Experiment 2. Error bars represent standard errors of the mean. Means with a different letter are significantly different within each type of eye expression condition; means with the same letter or no letter are equivalent.*

region were greater in the presence of an incongruent smile than in the presence of a congruent non-happy mouth. This suggests that additional processing of the eye expression was needed in the incongruent smile condition. Altogether, these results reveal that the smile is integrated in both the spatial and the temporal domains. The recent information conveyed by the smiling mouth can influence an already established representation of the eye expression.

EXPERIMENT 3: CONFIGURAL VS. FEATURAL PROJECTION

We investigated whether the biasing influence of the smiling mouth on the eye expression involves feature analysis (i.e., independent perceptual processing of the mouth region) or configural processing (i.e., holistic integration of the mouth within the whole face). To address this issue, we used face stimuli in which the top and the bottom halves were horizontally aligned or misaligned, and assumed that misalignment disrupts configural more than feature analysis (e.g., Calder et al., 2000; Konar, Bennett, & Sekuler, 2010). Consequently, a featural projection of the smile would make non-happy eyes look happy both when the face halves are aligned and *also* when misaligned, whereas configural projection will occur *only* when the face is aligned.

With a related approach, Calder et al. (2000) found that task-irrelevant, incongruent bottom face halves interfered with the identification of task-relevant top halves, and vice versa, and that this occurred when the halves were aligned relative to when misaligned. Such effects were interpreted as a demonstration of configural processing of the task-irrelevant region while judging the task-relevant region. We aim to extend this approach in two ways. First, in the Calder et al. study, the face stimuli were displayed until the participants responded, and thus *both* the eye and the mouth regions could be attended to overtly within the available time. In contrast, to determine whether configural effects can occur through projection (i.e., without fixation on the task-irrelevant region), we designed conditions (i.e., visual cueing and a 150 ms display) that led viewers to look *only* at the task-relevant region (i.e., the eyes), while the mouth remained in extrafoveal vision. Second, Calder et al. did not examine potential differences in the configural vs. featural effects as a function of type of expression; rather, different expressions were analysed jointly. In the current study, we orthogonally combined the type of mouth and the type of eye expression with face configuration. This allowed us to explore potential interactions and determine whether the configural or featural processing effects varied as a function of expression.

Method

Participants

Twenty-eight psychology undergraduates (21 female) served as participants.

Stimuli

We used the same face stimuli as in Experiment 1, with one additional manipulation. On 50% of trials, the top and the bottom halves of each face appeared misaligned. Each face was divided into top and bottom segments by cutting each face along a horizontal line through the bridge of the nose. Then the top half was moved 2.1° to the right and the bottom half was moved 2.1° to the left, in such a way that the edge of the top half fell on the centre of the bottom half (see Figure 8 for examples). In contrast, on the other 50% of trials, the whole face appeared with a normal, intact shape, i.e., with the top and the bottom halves aligned.

Apparatus, procedure, and design

No eye-tracker was used, given that in Experiment 1, with the same 150 ms display, all fixations landed on the cued eye region. Figure 8 presents an overview of the trial structure and sample stimuli. The procedure was the same as in Experiment 1. The size of the aligned faces was the same as in Experiment 1 (9° × 12°); for the misaligned faces, the size was slightly reduced (8.4° × 11.2°), thus the distance between the midpoints of the eyes and the mouth was always the same (4.8°). The eye region was pre-cued, and participants were asked to look at the eyes and respond whether they looked happy or not. The experimental conditions were combined in a within-subjects factorial design, with eye expression (6: angry, disgusted, sad, fearful, surprised, and neutral), type of mouth (2: congruent non-happy vs. incongruent smile), and face configuration (2: aligned vs. misaligned). Face configuration was blocked, so that the aligned faces were included in two blocks of 78 trials each, and the misaligned faces were included in another two 78-trial blocks, with block being counterbalanced. Each participant was presented with 312 trials.

Results

Probability of categorization of eye expressions as "happy"

A 6 (eye expression) × 2 (mouth expression) × 2 (face configuration) ANOVA on the probability of judging the eyes as happy yielded main effects of eyes, $F(5, 135) = 43.49$, $p < .0001$, $\eta_p^2 = .617$, mouth, $F(1, 27) = 134.49$, $p < .0001$, $\eta_p^2 = .833$, and configuration, $F(1, 27) = 64.12$, $p < .0001$, $\eta_p^2 = .705$, with interactions of mouth by eye expression, $F(5, 135) = 12.29$, $p < .0001$, $\eta_p^2 = .313$, and mouth expression by face configuration, $F(1, 27) = 68.82$, $p < .0001$, $\eta_p^2 = .718$. See the mean scores in Figure 9.

To break down the mouth by eye interaction, a one-way (6: eye expression) ANOVA was conducted on *difference scores* between the blended and the genuine expressions. The effect of expression, $F(5, 115) = 12.29$, $p < .0001$, $\eta_p^2 = .313$, followed by post hoc multiple comparisons, indicated that the neutral and the angry eyes were, respectively, the most and the least likely to be influenced by a smiling mouth (see Table 1).

To decompose the mouth expression by face configuration interaction, we conducted planned contrasts between the congruent and the incongruent mouth conditions (see Figure 9). For both the

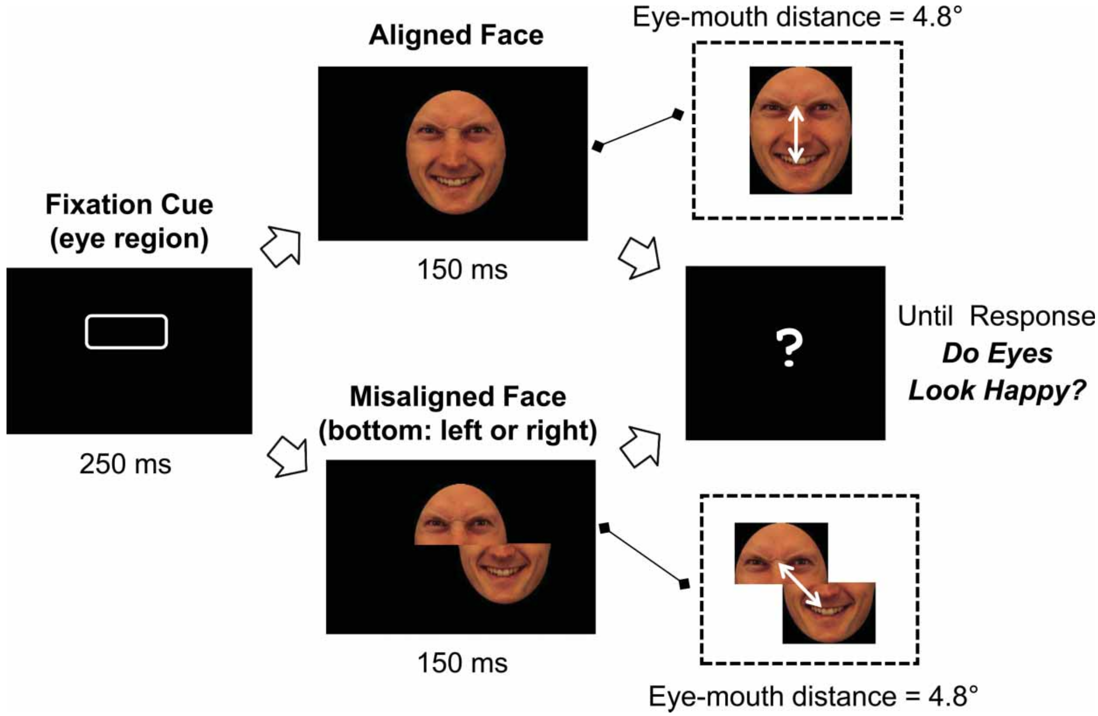

Figure 8. *Sequence of events and overview of basic characteristics of a trial in Experiment 3.*

aligned, $t(27) = 12.32$, $p < .0001$, and the misaligned, $t(27) = 6.11$, $p < .0001$, faces, the same non-happy eyes were more likely to be judged as happy in the presence of an incongruent smiling mouth than in the presence of a congruent non-smiling mouth. The interaction arises from the

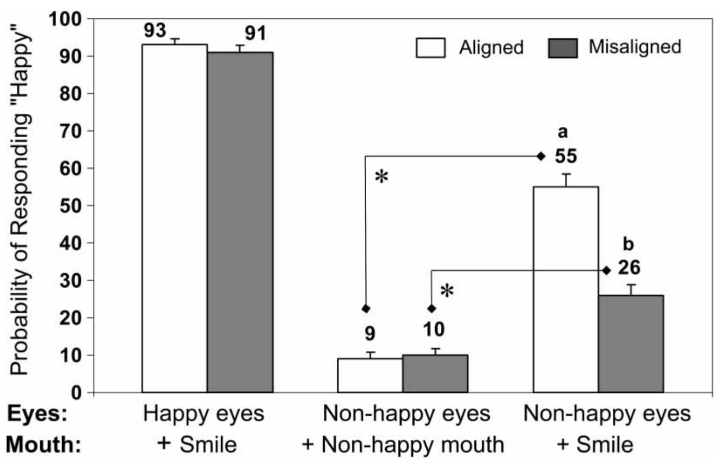

Figure 9. *Mean probability scores (percentage; and standard errors of the mean) in responding that the eye expression was happy, as a function of type of expression and facial configuration, in Experiment 3. Means with a different letter are significantly different for the aligned vs. the misaligned condition. Asterisks indicate significant differences between the congruent non-happy mouth and the incongruent smile conditions for the same non-happy eye expression and type of facial configuration.*

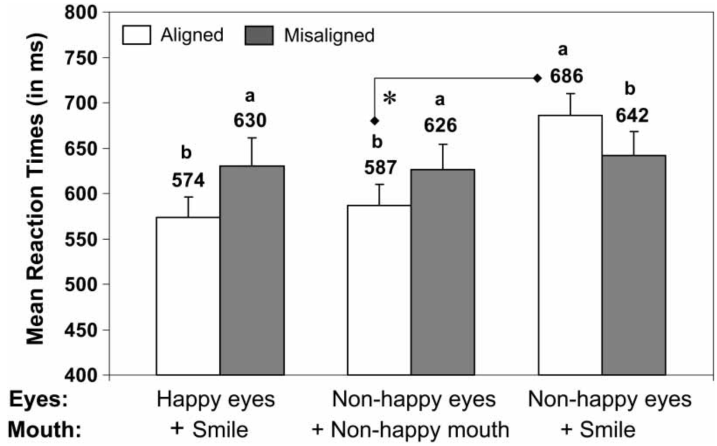

Figure 10. *Mean reaction times (ms; and standard errors of the mean) of correct responses, as a function of type of expression and facial configuration, in Experiment 3. Means with a different letter are significantly different for the aligned vs. the misaligned condition. Asterisks indicate significant differences between the congruent non-happy mouth and the incongruent smile conditions for the same non-happy eye expression and type of facial configuration.*

fact that the mouth effect was greater in the aligned, $t(27) = 13.22$, $p < .0001$, $d = 3.04$, $r = .84$, than in the misaligned, $t(27) = 6.11$, $p < .0001$, $d = 1.26$, $r = .53$, condition, as revealed by the corresponding effect sizes: The mouth expression accounted for 70.6% of judging the eyes as happy for aligned faces, but only for 28.1% for misaligned faces.

Reaction times of correct responses

In a 6 (eye expression) × 2 (mouth expression) × 2 (face configuration) ANOVA on correct response latencies, main effects of mouth, $F(1, 27) = 40.43$, $p < .0001$, $\eta_p^2 = .600$, and a mouth by configuration interaction, $F(1, 27) = 47.44$, $p < .0001$, $\eta_p^2 = .637$, emerged. For the aligned, $t(27) = 7.87$, $p < .0001$, but not for the misaligned, $t(27) = 1.75$, $p = .092$, *ns*, faces, non-happy eyes were correctly judged as not happy more slowly in the presence of an incongruent smiling mouth than when the same eyes were congruent with a non-happy mouth. When the non-happy mouth was congruent with the eyes, these were correctly recognized as not happy faster in the aligned than in the misaligned condition, $t(27) = 2.75$, $p < .025$, whereas the opposite occurred when a smiling mouth was incongruent with the eyes, $t(27) = 2.82$, $p < .01$. See Figure 10.

To compare the happy face category with the non-happy and the blended expressions, we conducted a 2 (face configuration) × 13 (expression category) ANOVA. There were main effects of expression, $F(12, 324) = 15.30$, $p < .0001$, $\eta_p^2 = .326$, and an interaction, $F(12, 324) = 5.53$, $p < .0001$, $\eta_p^2 = .170$. In the aligned condition, $F(12, 324) = 13.76$, $p < .0001$, $\eta_p^2 = .338$, correct responses were faster for happy faces than for all the blended expressions, with no significant differences between the happy and the non-happy faces. In the misaligned condition, the response latencies were equivalent for the happy faces and all the other categories. Correct responses were faster for happy faces in the aligned than the misaligned conditions. See Figure 10.

Differences in the susceptibility of the eyes to being influenced by the smile

Across three experiments, we have observed that some (especially neutral) eye expressions are influenced by the smile more than others (especially angry). To explore an explanation for this finding, we pooled the data across all three experiments (aligned conditions), and assessed the relationship between the probability of judging the same non-happy eyes as happy (a) when they appeared within composite faces with a smile and (b) when they appeared in the no-mouth condition. Spearman correlation ($\rho = .943$, $p < .01$) and linear regression ($R^2 = .929$, $p < .01$) analyses revealed that the biasing influence of the smile in blended expressions increased as the non-happy eyes themselves (i.e., alone; control condition) were judged to be more similar to (i.e., more likely to be confused with) the happy eyes.

Discussion

Non-happy eyes were more likely to be considered as happy, and took longer to be judged as not happy, in a face with a smiling mouth than in a face with a non-happy mouth. The effect on the *probability* of responses occurred not only for faces with their top and bottom halves aligned, but *also* for misaligned faces. This suggests that feature analysis of an extrafoveal smile can influence the perception of the eye expression. However, the effect was significantly larger in the aligned condition, thus implying a greater role of configural processing. This was corroborated by the *reaction time* data, as the eye–mouth incongruence influenced response times in the aligned but not in the misaligned condition. Also, an incongruent smile produced longer correct rejection times in the aligned than in the misaligned condition. This strengthens the view that projection of the smile occurs mainly when a face is perceived as a whole, although processing of single facial features can also make a contribution.

An interaction between eye and mouth expression on the probability of responding that non-happy eyes were happy revealed that the biasing effect of the smile varies with eye expression: Angry eyes were the most resistant to the influence of a smiling mouth, followed by disgusted, sad, and fearful eyes, whereas surprised and neutral eyes were the least resistant. Such a differential susceptibility to being influenced by a smile in composite faces was inversely related to the distinctiveness of each type of eye expression itself, i.e., when presented in the no-mouth condition. Accordingly, the more similar the non-happy eyes are to happy eyes, the more sensitive the former become to the influence of a smile.

GENERAL DISCUSSION

We have delineated a projection mechanism by which a smiling mouth biases the perception and evaluation of the eye expression in a face. Importantly, projection implies that a task-relevant, attended, and fixated eye region is influenced by a task-irrelevant, overtly unattended, but extrafoveally seen mouth region. To address this issue, our experimental conditions permitted fixations only on the eyes while the mouth was accessible to parafoveal or peripheral vision. We then compared blended (e.g., non-happy eyes and a smiling mouth) with genuine (congruent eyes and mouth) expressions. Results revealed that exactly the same non-happy eyes were more likely to be judged as “happy”, and categorized more slowly as “not happy”, in a face with a smiling mouth than with a non-smiling mouth or with no mouth. We will next discuss the mechanism underlying these effects.

Projection from a salient smiling mouth

The projection mechanism by means of which the smile affects how viewers perceive and judge the eye expression involves the following major characteristics: visual saliency of the mouth, online and backward integration, and configural and featural processing.

Saliency and extrafoveal vision

Models of visual attention posit that visual saliency affects the initial shifts of covert and overt attention (Itti & Koch, 2000; Torralba, Oliva, Castelhano, & Henderson, 2006), and there is evidence that this applies to both complex visual scenes (Underwood & Foulsham, 2006) and facial stimuli (Calvo & Nummenmaa, 2008). Saliency makes an image or image region highly competitive for selective attention. The present results from computational modelling of visual attention confirmed that the smiling mouth is more salient than the eyes, regardless of type of eyes in blended expressions, and also more salient than the mouth of any other expression. Even though overt attention to the mouth was blocked by gaze-contingent masking, the smile still interfered with the identification of non-happy eyes. This confirms that the extrafoveally presented smiles had been accessed by covert attention. In line with this, prior studies have shown that happy expressions are recognized more accurately than other expressions in parafoveal (2.5°; Calvo et al., 2010) and peripheral (8.1°; Goren & Wilson, 2006) vision. Presumably, this advantage is due to the high saliency of the smiling mouth, which guarantees reliable access to the visual system even from non-fixated locations of the visual field. Because of saliency, the perceptual properties of the smile would be resistant to acuity degradation due to eccentricity, and thus preserve some extrafoveal influence.[1]

Temporal integration

A smiling mouth interfered with the identification of non-happy eyes when the eyes and the mouth appeared *simultaneously*, thus suggesting spatial online projection. The fact that interference also occurred when the eyes appeared as a target for 300 ms *before* the mouth demonstrates that projection operates in the temporal domain. We have interpreted this effect (see Experiment 2) as backward inhibition (Arbuthnott, 2005): The smiling mouth that becomes extrafoveally available *after* the viewer has fixated the eyes for sufficient time to start expression recognition (Henderson et al., 2005; Hsiao & Cottrell, 2008) can act *against* the correct evaluation of non-happy eyes. These findings reveal temporal integration. It has in fact been argued that holistic processing supports integration when face parts are separated briefly in time (Anaki, Boyd, & Moscovitch, 2007; Cheung, Richler, Phillips, & Gauthier, 2011; Singer & Sheinberg, 2006). Such temporal integration is consistent with the idea that facial features become diagnostic over time (Vinette, Gosselin, & Schyns, 2004). Presumably, facial features can be stored and integrated in a temporary visual buffer, which would allow holistic processing to be performed without requiring the simultaneous presentation of facial components, as the effects of the smile on the eye expression occurred backwards in time. This integration mechanism is, in fact, highly functional, as real facial expressions are constantly changing in social interaction, and observers thus need to update their percept of other people's faces continuously.

Configural versus featural projection of the smile

Although analytic processes extract information from single facial features, expression recognition automatically engages holistic processes that integrate individual features in an overall configuration (Calder et al., 2000; Chen, Kao, & Tyler, 2007). Our findings reveal that the smile biases the eye expression mainly via configural processing: The smiling mouth produced stronger effects when the top and the bottom halves of composite faces were aligned—thus preserving the facial configuration—than when the configuration was disrupted by misalignment. This is consistent with the Tanaka et al. (2012) conclusion that, when emotional information is incongruous, as is the case for blended expressions, holistic processes are engaged. Nevertheless, in the current study, the influence of the smile also appeared when the face was misaligned, thus allowing the separate analysis of the eyes and the mouth. Although the featural effect was smaller, it can be particularly relevant for ambiguous expressions with a smile: According to Fiorentini and Viviani (2009), reliance on single facial components becomes critical when the disrupted internal coherence of a facial

[1] An alternative way of investigating the smile projection effect would involve facial inversion. Hills, Sullivan, and Pake (2012) found that more fixations of a shorter duration were made to inverted faces than to upright faces. This is consistent with Rossion's (2009) work suggesting that inversion restricts the perceptual field: Whereas an upright face can be holistically sampled from a central fixation, in an inverted face each feature has to be sampled independently. This implies that the radius of extrafoveal projection of non-fixated facial features could be reduced by inversion, thus limiting the influence of the (non-fixated) smiling mouth.

configuration makes the expression ambiguous. In such cases, the decision about the expression category is based on a maximum-likelihood logic, by considering which feature is more likely to be present for a given expression. Ambiguity would be dealt with by relying on the most distinctive cue available, that is, the salient and diagnostic smiling mouth.

Do the eyes modulate the influence of the smile?

There is indeed evidence that the eyes are important to read emotional expressions (Eisenbarth & Alpers, 2011). However, our results demonstrate that the presence of a smile increases the tendency to judge non-happy eyes as happy, even when only the eyes are directly looked at. This seems at odds with the folk belief that the eyes are "a window to the soul" or a "mirror of the soul", and so they should be a powerful and clear source of information about a person's emotional and motivational state. It is true that, in the current study, some eye expressions (particularly angry) were less susceptible to being influenced by a smiling mouth than others (particularly neutral and surprised), yet none of them was impervious to such a biasing influence. This implies that the smile can significantly distort observers' perception of the smiler's actual feelings and intentions.

We have investigated the influence of the mouth on the eyes. Alternatively, we may ask whether also the eyes can influence the perception of the mouth expression. Tanaka et al. (2012) blended the top and bottom halves of happy and angry faces. While the mouth is more diagnostic of facial happiness, the eyes are more informative of facial anger (Calder et al., 2000; Kohler et al., 2004; Smith et al., 2005). Tanaka et al. (2012) found interference with the categorization of the bottom half of happy faces when paired with the top half of an angry face, as well as interference with the recognition of the top angry expression when paired with a bottom happy expression. Thus the eyes can also affect perception of the mouth expression. Nevertheless, consistently with our own findings regarding the strong influence of the smile, Tanaka et al. noted that the smile exerted a greater and earlier interference effect on the recognition of the angry eyes than vice versa.

What is the role of the eyes in conveying expressive information in the presence of a smiling mouth then? The simulation of smiles model (SIMS; Niedenthal, Mermillod, Maringer, & Hess, 2010) posits that viewers can determine the meaning of a smile by means of embodiment, i.e., by reproducing the neural and bodily state of the emotional expression they perceive. This way the perceiver could experience what the observed smile feels like and thus infer whether it is genuine or not. Critically, eye contact between the perceiver and the expresser would activate the embodied simulation process. In our study, viewers always looked at the eyes of the face stimuli, yet in a significant proportion of cases (50% on average) the non-happy eyes of blended expressions with a smile were wrongly judged as happy. Thus eye contact does not totally immunize the viewer against the influence of a fake smile. Importantly, however, when there was free time to look at the eyes (Experiment 2; $285 + 417 = 702$ ms of viewing time, on average), the biasing effect of the smile was about half the size (33% of "happy" responses to non-happy eyes) than when viewing time was limited (Experiment 1; 150 ms; 62%). This is consistent with the role attributed to eye contact by the SIMS model and related views (mind reading from the eyes: Nummenmaa & Calder, 2009; empathy: Singer, 2006).

CONCLUSIONS

A smiling mouth is highly salient in a face regardless of the eye expression. Saliency makes the smile project to surrounding face regions, thus affecting how the eye expression looks, even when the mouth is not directly fixated, but remains extrafoveally available. When facial expressions are ambiguous, as is the case for blended expressions, decisions tend to rely on the most distinctive and salient cue. Given that the smile is highly salient and also diagnostic of happy faces, it can mislead viewers to interpret non-happy eyes as if they were happy.

The influence of the smile is powerful when the mouth appears at the same time as the eyes, but also occurs when the mouth appears after the eyes. Although the projection influence of a smile is greater when the mouth and the eyes are configurally integrated, smaller effects can also take place through separate feature analysis of the smiling mouth. Spatial and temporal projection mechanisms would thus converge in the service of integration of face parts and changes over time in a unitary visual configuration. In essence, the effect of the smiling mouth on the eyes involves a bottom-up, purely perceptual process, through which saliency makes the smile extrafoveally project to the eyes, as well as a top-down, conceptual process, through which distinctiveness reduces uncertainty about the emotion category and biases the interpretation of the eye expression. As an extension of this conceptualization, we (Calvo & Fernández-Martín, in press) have recently found that projection occurs to a significantly lesser extent for less salient and distinctive—angry and sad—mouths than for the smile.

Manuscript received 9 January 2012
Revised manuscript received 6 July 2012
First published online 9 November 2012

REFERENCES

Adolphs, R. (2002). Recognizing emotion from facial expressions: Psychological and neurological mechanisms. *Behavioral and Cognitive Neuroscience Reviews*, *1*, 21–62.

Ambadar, Z., Cohn, J. F., & Reed, L. I. (2009). All smiles are not created equal: Morphology and timing of smiles perceived as amused, polite, and embarrassed/nervous. *Journal of Nonverbal Behavior*, *33*, 17–34.

Anaki, D., Boyd, J., & Moscovitch, M. (2007). Temporal integration in face perception: Evidence of configural processing of temporally separated face parts. *Journal of Experimental Psychology: Human Perception and Performance*, *33*, 1–19.

Arbuthnott, K. D. (2005). The influence of cue type on backward inhibition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *31*, 1030–1042.

Calder, A. J., Young, A. W., Keane, J., & Dean, M. (2000). Configural information in facial expression perception. *Journal of Experimental Psychology: Human Perception and Performance*, *26*, 527–551.

Calvo, M. G., & Fernández-Martín, A. (in press). Can the eyes reveal a person's emotions? Biasing role of the mouth expression. *Motivation and Emotion*, Advance online publication. doi: 10.1007/s11031-012-9298-1

Calvo, M. G., & Lundqvist, D. (2008). Facial expressions of emotion (KDEF): Identification under different display-duration conditions. *Behavior Research Methods*, *40*, 109–115.

Calvo, M. G., & Marrero, H. (2009). Visual search of emotional faces: The role of affective content and featural distinctiveness. *Cognition and Emotion*, *23*, 782–806.

Calvo, M. G., & Nummenmaa, L. (2007). Processing of unattended emotional visual scenes. *Journal of Experimental Psychology: General*, *136*, 347–369.

Calvo, M. G., & Nummenmaa, L. (2008). Detection of emotional faces: Salient physical features guide effective visual search. *Journal of Experimental Psychology: General*, *137*, 471–494.

Calvo, M. G., & Nummenmaa, L. (2009). Eye-movement assessment of the time course in facial expression recognition: Neurophysiological implications. *Cognitive, Affective and Behavioral Neuroscience*, *9*, 398–411.

Calvo, M. G., & Nummenmaa, L. (2011). Time course discrimination between emotional facial expressions: The role of visual saliency. *Vision Research*, *51*, 1751–1759.

Calvo, M. G., Nummenmaa, L., & Avero, P. (2010). Recognition advantage of happy faces in extrafoveal vision: Featural and affective processing. *Visual Cognition*, *18*, 1274–1297.

Chen, C. C., Kao, K. L. C., & Tyler, C. W. (2007). Face configuration processing in the human brain: The role of symmetry. *Cerebral Cortex*, *17*, 1423–1432.

Cheung, O. S., Richler, J. J., Phillips, W. S., & Gauthier, I. (2011). Does temporal integration of face parts reflect holistic processing? *Psychonomic Bulletin & Review*, *18*(3), 476–483.

Eisenbarth, H., & Alpers, G. W. (2011). Happy mouth and sad eyes: Scanning emotional facial expressions. *Emotion*, *11*, 860–865.

Ekman, P., & Friesen, W. V. (1976). *Pictures of facial affect*. Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system: A technique for the measurement of facial movement*. Palo Alto, CA: Consulting Psychologists Press.

Ellison, J. W., & Massaro, D. W. (1997). Featural evaluation, integration, and judgment of facial affect. *Journal of Experimental Psychology: Human Perception and Performance*, *23*, 213–226.

Fiorentini, C., & Viviani, P. (2009). Perceiving facial expressions. *Visual Cognition*, *17*, 373–411.

Goren, D., & Wilson, H. R. (2006). Quantifying facial expression recognition across viewing conditions. *Vision Research*, *46*, 1253–1262.

Henderson, J. M., Williams, C. C., & Falk, R. J. (2005). Eye movements are functional during face learning. *Memory & Cognition*, *33*, 98–106.

Hills, P. J., Sullivan, A. J., & Pake, J. M. (2012). Aberrant first fixations when looking at inverted faces in various poses: The result of the centre-of-gravity effect? *British Journal of Psychology*, *103*, 520–538.

Hsiao, J. H., & Cottrell, G. (2008). Two fixations suffice in face recognition. *Psychological Science*, *19*, 998–1006.

Itti, L., & Koch, C. (2000). A saliency-based search mechanism for overt and covert shifts of visual attention. *Vision Research*, *40*, 1489–1506.

Johnston, L., Miles, L., & Macrae, C. (2010). Why are you smiling at me? Social functions of enjoyment and non-enjoyment smiles. *British Journal of Social Psychology*, *49*, 107–127.

Kohler, C. G., Turner, T., Stolar, N. M., Bilker, W. B., Brensinger, C. M., Gur, R. E., et al. (2004). Differences in facial expressions of four universal emotions. *Psychiatry Research*, *128*, 235–244.

Konar, Y., Bennett, P. J., & Sekuler, A. B. (2010). Holistic processing is not correlated with face-identification accuracy. *Psychological Science*, *21*, 38–43.

Kontsevich, L. L., & Tyler, C. (2004). What makes Mona Lisa smile? *Vision Research*, *44*, 1493–1498.

Krumhuber, E. G., & Manstead, A. S. R. (2009). Can Duchenne smiles be feigned? New evidence on felt and false smiles. *Emotion*, *9*, 807–820.

Leppänen, J., & Hietanen, J. K. (2004). Positive facial expressions are recognized faster than negative facial expressions, but why? *Psychological Research*, *69*, 22–29.

Leppänen, J., & Hietanen, J. K. (2007). Is there more in a happy face than just a big smile? *Visual Cognition*, *15*, 468–490.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). *The Karolinska Directed Emotional Faces – KDEF*, CD-ROM from Department of Clinical Neuroscience, Psychology section, Karolinska Institutet, Stockholm, Sweden.

Milders, M., Sahraie, A., & Logan, S. (2008). Minimum presentation time for masked facial expression discrimination. *Cognition and Emotion*, *22*, 63–82.

Miles, L., & Johnston, L. (2007). Detecting happiness: Perceiver sensitivity to enjoyment and non-enjoyment smiles. *Journal of Nonverbal Behavior*, *31*, 259–275.

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The Simulation of Smiles (SIMS) model: Embodied simulation and the meaning of facial expression. *Behavioral and Brain Sciences*, *33*, 417–433.

Nummenmaa, L., & Calder, A. J. (2009). Neural mechanisms of social attention. *Trends in Cognitive Sciences*, *13*, 135–143.

Nusseck, M., Cunningham, D. V., Wallraven, C., & Bülthoff, H. H. (2008). The contribution of different facial regions to the recognition of conversational expressions. *Journal of Vision*, *8*(8), 1–23.

Palermo, R., & Coltheart, M. (2004). Photographs of facial expression: Accuracy, response times, and ratings of intensity. *Behavior Research Methods*, *36*, 634–638.

Richler, J. J., Mack, M. L., Gauthier, I., & Palmeri, T. J. (2009). Holistic processing of faces happens at a glance. *Vision Research*, *49*, 2856–2861.

Richler, J. J., Mack, M. L., Palmeri, T. J., & Gauthier, I. (2011). Inverted faces are (eventually) processed holistically. *Vision Research*, *51*, 333–342.

Richler, J. J., Tanaka, J. W., Brown, D. D., & Gauthier, I. (2008). Why does selective attention to parts fail in face processing? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *34*, 1356–1368.

Rossion, B. (2009). Distinguishing the cause and consequence of face inversion: The perceptual field hypothesis. *Acta Psychologica*, *132*, 300–312.

Russell, J. A. (1994). Is there universal recognition of emotion from facial expression? A review of the cross-cultural studies. *Psychological Bulletin*, *115*, 102–141.

Singer, T. (2006). The neuronal basis and ontogeny of empathy and mind reading: Review of the literature and implications for future research. *Neuroscience and Biobehavioral Reviews*, *30*, 855–863.

Singer, J. M., & Sheinberg, D. L. (2006). Holistic processing unites face parts across time. *Vision Research*, *46*, 1838–1847.

Smith, M. L., Cottrell, G., Gosselin, F., & Schyns, P. G. (2005). Transmitting and decoding facial expressions of emotions. *Psychological Science*, *16*, 184–189.

Tanaka, J. W., Kaiser, M., Butler, S., & Le Grand, R. (2012). Mixed emotions: Holistic and analytic

perception of facial expressions. *Cognition and Emotion*, *26*, 961–977.
Torralba, A., Oliva, A., Castelhano, M. S., & Henderson, J. (2006). Contextual guidance of eye movements in real-world scenes: The role of global features in object search. *Psychological Review*, *113*, 766–786.
Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., et al. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*, 242–249.
Underwood, G., & Foulsham, T. (2006). Visual saliency and semantic incongruency influence eye movements when inspecting pictures. *Quarterly Journal of Experimental Psychology*, *59*, 1931–1949.
Vinette, C., Gosselin, F., & Schyns, P. (2004). Spatio-temporal dynamics of face recognition in a flash: It's in the eyes. *Cognitive Science*, *28*, 289–301.
Walther, D., & Koch, C. (2006). Modelling attention to salient proto-objects. *Neural Networks*, *19*, 1395–1407.
Wandell, B. A. (1995). *Foundations of vision*. Sunderland, MA: Sinauer Press.