

Short title: A SMILE AND NON-HAPPY EYES

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**A Smile Hampers Encoding and Memory for Non-happy Eyes in a Face:
Temporal Dynamics and Importance of Initial Fixation**

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Abstract

Blended facial expressions with a smiling mouth but non-happy eyes (neutral, sad, etc.) are often (incorrectly) judged as “happy”. We investigated the time course of this phenomenon, both forward and backward. To do this, we varied the *order of presentation* of a prime stimulus (upper half of a face) and a probe (lower half of a face) stimulus, and their *display durations*. The forward and the backward influence of the smile was assessed when the mouth was seen before or after the eyes. Participants categorised the eye expression when the mouth and the eyes were *congruent* or *incongruent*. Results showed that, as a forward prime, a smiling mouth biased the recognition of incongruent (non-happy) eyes as if they were happy. The effect started as early as 100 ms and dissipated by 1,000 ms. As a backward prime, the smile also biased recognition of non-happy eye expressions as happy for at least the first 300 ms. These results suggest, respectively, that the presence of a smiling mouth impairs the accurate encoding and memory for non-happy eyes. Angry eyes are the least susceptible to this effect, probably due to their distinctiveness. An alternative response (rather than sensitivity) bias was partially ruled out.

Word count: 200

Keywords: Smile; facial expression; non-happy eyes; blended expressions; time course.

A Smile Hampers Encoding and Memory for Non-happy Eyes in a Face: Temporal Dynamics and Importance of Initial Fixation

Studies based on naturalistic observations have shown that the smile is the most prevalent facial expression in social contexts (Calvo, Gutiérrez-García, Fernández-Martín, & Nummenmaa, 2014, for actual frequencies; see also Somerville & Whalen, 2006, for retrospective estimates of occurrence; see Fernández-Dols & Crivelli, 2013, for a review). Given its pervasiveness in a wide variety of situations, the smile must be imbued with a vast array of multifarious social functions (Girard, Cohn, Yin, & Morency, 2021; Krumhuber & Kappas, 2022; Wood, Sievert, & Martin, 2022). It is thus understandable that smiling faces can actually adopt many “faces”, with “mixed smiles” (Harris & Alvarado, 2006; Martin et al., 2021; Perron, Roy-Charland, Chamberland, Bleach, & Pelot, 2016). The present study investigates how a smiling mouth can influence the encoding and memory for non-happy eye expressions.

The (positive and “negative”) power of the smile

People who smile are perceived as more attractive and trustworthy (Centorrino, Djemai, Hopfensitz, Milinski, & Seabright, 2015; Gutiérrez-García, Beltrán, & Calvo, 2019). Consistently, happy face stimuli capture and draw attention, as evidenced by measures of selective initial orienting and gaze direction (Calvo & Nummenmaa, 2008), rapid detection in visual search tasks (Bachmann, Jappe, Merriam, & Liu, 2024), impaired inhibitory control in no-go tasks (Mancini, Falciati, Maioli, & Mirabella, 2022), or slower dot-probe discrimination in invalid relative to valid trials (Wentura, Messeh, & Wirth, 2024). (It is not assumed here that these effects arise from affective rather than purely perceptual processing).

Such attentional capture and engagement by the smile generally benefit the expresser. A smiling face serves to initiate and maintain social bonds, to maximize the

receipt of reward from other people, and to establish alliance and collaboration.

However, the smile is also used to mask negative emotions and motives. In such cases, the smile's attentional attraction can have adverse consequences for the viewer. Firstly, a smiling mouth could interfere with the accurate recognition of non-happy eyes in faces with mixed or blended expressions. Then this would lead the viewer to misunderstand the expresser's actual feelings and intentions. Consequently, observers may be prompted to adopt approach behaviours that could lead to them being cheated and manipulated. Thus, this issue, i.e., the effects of a smile in misjudging blended expressions, is worthy of investigation: The reason is that expressions with a smile but non-happy eyes, i.e., faces that may not convey genuine happiness, are ubiquitous and influential in social situations (and politics, and interpersonal relationships, etc.).

The smiling mouth and the non-happy eyes

With this in mind, we aim to investigate the manner and timing by which a smile can influence the interpretation of non-happy eye expressions. The smile is characterised by morphological changes around the mouth, with lip corners pulled backwards and turned up. This is often associated with raised cheeks and exposed teeth. In addition to such changes, smiling is sometimes accompanied by a narrowing of the eye opening, bulges below the eyes, and wrinkles at the outer corners (i.e., the Duchenne marker). Importantly, the changes around the mouth are perceptually highly salient, whereas those around the eyes are much less noticeable (Calvo & Nummenmaa, 2008). As a result, people tend to rely on the (simple) changes in the mouth region to “recognize” happiness. It is noteworthy that a single facial feature, i.e., a smiling mouth, can nevertheless be taken to infer such an otherwise complex, multifaceted, facial expression and internal emotion.

Of course, in addition to the mouth and the eyes, many sources of information

are available in social situations, including the tone of voice and speech content, as well as hand movements and body posture. Additionally, there are contextual cues and the implicit information the perceiver has about social norms, and the perceiver's own goals (Aviezer, Ensenberg, & Hassin, 2017; Day, Krumhuber, & Shore, 2023; Hess & Hareli, 2015). All this information can be used to accurately judge the meaning of a smile.

However, our cognitive system (and the sensory and attentional systems that feed into it) is highly selective. Often, observers do not consider and weigh information from a wide range of options at the time of forming impressions, and do not usually make well-balanced decisions in dynamic or complex situations. Rather, due to limitations on the use of online resources, the most perceptually salient and diagnostically distinctive sources are selected. Consequently, the smiling mouth becomes a potent source of information that people rely on in social interaction.

External expression and internal emotion

However, facial expressions do not directly reflect a person's emotional experience. It is possible to be happy without smiling, and to smile without being happy. Individuals may display a smile in conjunction with a vast array of emotional states that are starkly divergent from, or even antithetical to, the experience of happiness. And yet, in facial expression categorisation tasks, happiness is much more likely and faster to be “recognised” than other basic emotional expressions (anger, fear, sadness, disgust, and surprise; see Calvo & Nummenmaa, 2016, for a review; and Nummenmaa & Calvo, 2015, for a meta-analysis). Importantly for the current aims and rationale, this recognition advantage of happy faces depends on the smiling mouth (Beaudry, Roy-Charland, Perron, Cormier, & Tapp, 2014; Bombari et al., 2013; Calder, Young, Keane, & Dean, 2000; Nusseck, Cunningham, Wallraven, & Bülthoff, 2008; Smith, Cottrell, Gosselin, & Schyns, 2005).

To some extent, this is understandable with regard to prototypical facial expressions. Nevertheless, it is questionable whether such prototypes exist. In social settings, idiosyncrasies and variations are numerous (Calvo et al., 2014; Fernández-Dols & Crivelli, 2013; Krumhuber & Scherer, 2011). It is possible to experience disparate emotions concurrently (Larsen & McGraw, 2014), which can result in blended facial expressions. Also, smiles can be used for very different purposes (e.g., from friendliness to sarcasm, from enjoyment to embarrassment, etc.), including functions related to reward, affiliation, and dominance (Martin et al., 2001). In all of these instances, similar changes may manifest in the mouth region, yet notable discrepancies may appear in the eye region. If so, then reliance on the smiling mouth would result in observers misinterpreting the actual affect, motives, and intentions of the expressers.

Prior research on the biasing influence of the smile

In fact, research has found that a smile can bias and interfere with the accurate recognition of blended facial expressions (i.e., with a smiling mouth but non-happy eyes). This effect has been demonstrated in studies where *whole* faces were judged (Calvo, Fernández-Martín, & Nummenmaa, 2012; Calvo, Gutiérrez-García, Averó, & Lundqvist, 2013), and also when the *eyes* were judged (Calvo & Fernández-Martín, 2013; Calvo, Fernández-Martín, & Nummenmaa, 2013). More specifically, for blended expressions with a smile but neutral, angry, fearful, sad, disgusted, or surprised eyes, viewers are often misled (a) to incorrectly identify them as happy, and (b) to slow down their (correct) rejection as not happy; in comparison with a control, no-mouth condition, and relative to non-smiling mouth expressions.

To account for this biasing interference, an explanation has been proposed, which involves convergent perceptual, conceptual, and affective mechanisms (Calvo, Gutiérrez-García, & Del Líbano, 2018). Firstly, the high *visual saliency* of the smiling

mouth would make it selectively accessible to early processing stages. Saliency could then overshadow other facial regions, including the eyes, thereby causing inattentional blindness for non-happy facial features. Secondly, the high *diagnostic value* (or distinctiveness) of the smile with respect to facial happiness would predispose observers to perceive happiness in the rest of the face. This would prime the semantic categorisation of any smiling face as happy, thereby disregarding potential incongruences with the eye expression. Thirdly, the smile is distinguished by its *affective uniqueness*, as it is associated with the only positively valenced basic emotional expression among those that are negatively valenced. Consequently, the smile would affectively prime a typically pleasant emotion, namely happiness, thereby bypassing any other non-happy (even unpleasant) features in a face.

The current study: Specific issues, approach, and predictions

Within this theoretical framework, we investigated the *time course* of the effect of viewing a smile on the interpretation of non-happy eye expressions. Two major approaches were used. Firstly, the hypothesised influence of the smile (whether it be perceptual overshadowing, categorical priming, or affective priming) requires that the mouth be presented (and seen) *before* (or, at least simultaneously with) the eyes. In such a scenario, the effects would occur *forward* in the processing stream, thus affecting encoding. In addition, such effects could also occur *backwards*: The presence of a smiling mouth that is shown (and seen) *after* the non-happy eyes could lead viewers to *re-interpret* (reconstruct and remember) the eyes as happy. This would reveal that the smile causes memory disruption.

Secondly, questions arise regarding the precise points in the temporal dynamics of the biasing effects of the smile. Within the forward process, it is important to determine when the effect *begins*. Or for how long the smile has to be present to trigger

the flow. Or how the process *develops* over time and how long it *lasts*. Regarding the backward process, there are also specific issues, such as whether the distorting effect of the smile can be prevented if the non-happy eyes are seen *first*, i.e., before the smiling mouth. Or, *how long* the non-happy eyes (i.e., opposite, incongruent evidence) have to be initially available to neutralise the smile impact. Or, for how long the smile can impede the memory consolidation of the previously seen non-happy eyes.

These issues were addressed by varying the *order* of presentation of a prime stimulus (i.e., the lower half of the face, with the mouth) and a probe stimulus (i.e., the upper half, with the eyes), and their display *durations*. Participants judged the eye expression when the prime (mouth) and the probe (eyes) were either (1) *congruent* or (2) *incongruent*, compared to (3) a no-mouth (masked) *control* condition. If the smile interferes with the accurate processing or memory of non-happy eye expressions by biasing recognition towards happiness, we predict that: (a) viewers will tend to incorrectly judge non-happy eyes as “happy” and (b) delay their correct recognition as “not happy”. This will occur in the incongruent condition (i.e., when the prime, either forward or backward, includes a smiling mouth) relative to the no-mouth and the congruent conditions.

Experiment 1: Forward Priming

We investigated whether a smile biases the interpretation of non-happy eyes as happy when the mouth is looked at *before* the eyes. Participants were presented with a *prime* stimulus consisting of the bottom half of either (a) a smiling face, (b) a non-happy face (with an angry, sad, etc., mouth), or (c) a scrambled face (with no visible mouth). This was followed by a *probe* consisting of the top half of the face in which the eyes were either (a) congruent with the previously seen mouth (i.e., prototypical expression), (b) incongruent with the mouth (i.e., non-happy eyes but a smiling mouth;

blended expression), or (c) unrelated to the prime (i.e., the no-mouth control condition). Participants categorised the probe eye expression as happy or not happy.

In order to ascertain the time course of the smile's influence on the viewers' evaluation of the eyes, we varied the display duration of the prime stimulus, which was 100, 300, 600, or 1,000 ms. This allowed us to determine at what point after the onset of a smile prime the biasing effect starts, and how long it lasts; and when disconfirming (i.e., non-happy) cues in the eye region begin to counteract the influence of the smile.

Method

Participants

Forty-eight psychology undergraduates (34 female) gave informed consent as participants and received course credit. The study (both Experiments 1 and 2) was approved by the University of La Laguna ethics committee (CEIBA, protocol number 2017-0227), and conducted in accordance with the WMA Declaration of Helsinki 2013.

A priori power analysis using G*Power 3.1.9.7 (see Faul, Erdfelder, Lang, & Buchner, 2007) determined that a sample of 48 participants was sufficient to detect a medium effect size of $f = 0.25$ (Cohen's $d = 0.5$), at $\alpha = 0.05$, with statistical power $P(1 - \beta \text{ err prob}) = 0.80$, for an F test repeated-measures ANOVA in an experimental design involving four groups of prime display duration with 3 (mouth prime) $\times 6$ (eye expression) measurements.

Stimuli

We selected 168 digitised colour photographs from the KDEF stimulus set (Lundqvist, Flykt, & Öhman, 1998). The face stimuli portrayed 24 individuals (12 females: KDEF no. 01, 02, 07, 11, 14, 19, 20, 22, 26, 29, 31, 35; and 12 males: KDEF no. 03, 05, 06, 10, 11, 12, 22, 23, 24, 25, 31, 35), each posing seven *prototypical* basic facial expressions (original KDEF: neutral, happiness, anger, disgust, sadness, fear, and

surprise). Non-facial areas (e.g., hair, neck, etc.) were removed by applying an ellipsoidal black mask.

As measured by Emotient FACET SDK v6.1 (iMotions, A/S, Copenhagen, Denmark, 2016; <http://emotient.com/index.php>), the selected KDEF models that served as happy faces included Action Unit AU 6 (i.e., the Duchenne marker around the eyes), in addition to AU 12 (lip corner puller) and AU 25 (open mouth and exposed teeth) (see Calvo et al., 2018). Accordingly, the eyes, even if *posed* by the models, showed the morphological changes that are typical of real happy faces.

For the actual stimulus presentation, each face was sliced along a horizontal axis through the bridge of the nose. This created top and bottom face halves, totaling 336 stimuli (168 faces by two halves). A further 168 stimuli, comprising 24 of each expression, were generated for the control condition, in which the mouth was absent, by scrambling the bottom half. An example of the half-face stimuli is shown in Figure 1. For different examples of whole-face mixtures with a smile, see Calvo and Fernández-Martín (2013), Calvo et al. (2012), or Calvo, Gutiérrez-García et al. (2013).

Apparatus and Procedure

Stimuli were presented on a computer screen using E-Prime software. Figure 1 shows an overview of the procedure.

On each trial, after a 500-ms central fixation point, a 250-ms visual cue (a rectangle) was displayed at the location where the mouth would subsequently appear. The cue was followed, in the *prime period*, by the lower half of an intact or a scrambled face for 100, 300, 600, or 1,000 ms. The 300-ms display was used as a criterion because the average duration of a functional fixation in face recognition is ~300 ms (Henderson, Williams, & Falk, 2005; Hsiao & Cottrell, 2008). In the other displays, the span was shortened (100 ms) or lengthened (600 and 1,000 ms) to examine time course

boundaries. Following the prime stimulus, the *probe period* began, with the upper half of a face. The eye region replaced the mouth region in the same location. The probe remained visible until the participant judged the eye expression, by pressing a key.

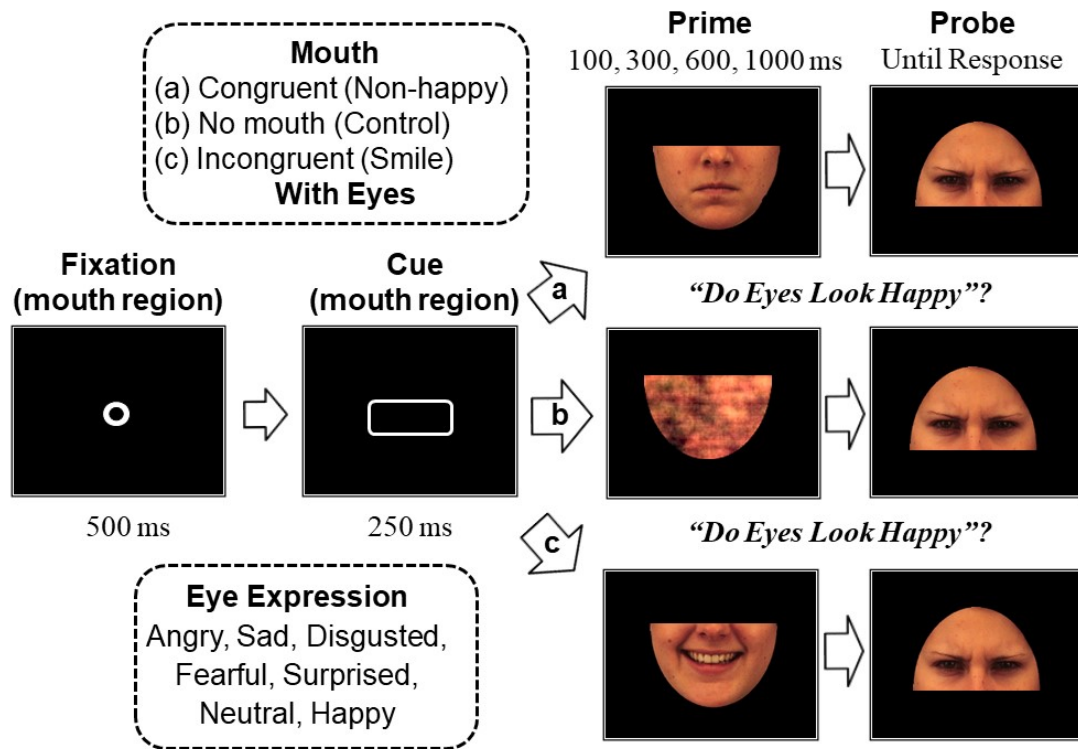


Figure 1. Overview of the procedure in Experiment 1. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

Experimental Design

The experimental conditions were combined in a within-subjects factorial design, with type of prime mouth (3: congruent with eyes vs. no mouth vs. incongruent), probe eye expression (6: angry, disgusted, sad, fearful, surprised, and neutral), and prime mouth display duration (4: 100, 300, 600, or 1,000 ms). In the *congruent* condition, the mouth belonged to the same expression category as the eyes (e.g., both angry, etc.). In the *incongruent* condition, the mouth was smiling but the eyes conveyed a different expression (e.g., angry). In the no-mouth control condition, the face bottom-half was replaced by a Fourier-phase mask. A happy-eyes-and-congruent-

smile condition was also added, as well as a happy-eyes-and-no-mouth condition, for comparison. Figure 2 illustrates the different conditions of mouth and eye expression, with stimuli in whole-face format (instead of the actual half-face format).



Figure 2. An example of stimuli (in whole-face format) for the different conditions of mouth and eye expression. Mouth: (a) congruent with eyes; (b) no-mouth control; (c) incongruent (happy) mouth. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

Each participant was presented with 168 experimental trials (144 blends with non-happy eyes plus 24 with happy eyes) in four blocks, one for each prime duration condition. To increase the number of trials with happy eyes, a combination of happy eyes and a neutral mouth was presented in 24 additional filler trials. Block order was counterbalanced. For each participant, KDEF models were randomly assigned to the prime and the probe factors in the experimental design.

To avoid stimulus repetition across all the 72 experimental combinations of the three experimental factors, each participant was presented with two different (out of the

24) KDEF models in each experimental cell, in addition to the 24 experimental trials corresponding to truly happy faces, and the 24 aforementioned filler trials.

Measures

Participants responded whether the eyes looked “happy” or “not happy”, by pressing one of two keys on a computer keyboard. The probability of judging the eye expression as happy and the latencies (from probe onset) of correct responses (either hits, for happy eyes, or correct rejections, for non-happy eyes), were recorded as categorisation performance measures.

In addition, we obtained Signal Detection Theory (SDT) measures, to differentiate between perceptual *sensitivity* (or discrimination) and response *bias* (or criterion). From the probability of hits (PH) and false alarms (PFA)¹, we computed the non-parametric A' index, where $A' = 0.5 + (PH - PFA) \times (1 + PH - PFA) / (4 \times PH) \times (1 - PFA)$, and the non-parametric B'' index, where $B'' = [(1 - PH) \times (1 - PFA) - (PH) \times (PFA)] / [(1 - PH) \times (1 - PFA) + (PH) \times (PFA)]$. A' scores vary from low to high sensitivity in a 0–1 scale, where 0.5 represents the chance level. B'' scores vary from –1.0 to 1.0: A positive value indicates a strict or conservative criterion, a zero value indicates a neutral criterion, and a negative value indicates a liberal or lenient criterion.

Results

Probability of Categorisation of Eye Expressions as “Happy”

In a 3 (mouth expression) $\times$ 6 (eye expression) $\times$ 4 (mouth display duration) ANOVA on the probability of judging the *non-happy* eye expressions as “happy”, the main effects of mouth expression, $F(2, 94) = 28.16, p < .0001, \eta_p^2 = .375$, and eye expression, $F(5, 235) = 28.49, p < .0001, \eta_p^2 = .377$, were qualified by interactions between mouth expression and display, $F(6, 282) = 3.58, p < .01, \eta_p^2 = .071$, and between mouth expression and eye expression, $F(10, 470) = 6.19, p < .001, \eta_p^2 = .116$,

with no three-way interaction ($F < 1$). See Table 1.

INSERT TABLE 1 ABOUT HERE

The *mouth* expression by mouth *display* interaction was further analysed in separate one-way (3: mouth expression) ANOVAs for each display duration, followed by Bonferroni-corrected ($p < .05$) multiple comparisons across mouth condition. The interaction reflected the fact that the probability of categorising the same non-happy eyes as happy was higher following an incongruent smiling mouth than following both a congruent non-happy mouth and a no-mouth condition in the 100-ms, $F(2, 94) = 18.98$, $p < .0001$, $\eta_p^2 = .288$, the 300-ms, $F(2, 94) = 20.29$, $p < .0001$, $\eta_p^2 = .301$, and the 600-ms display, $F(2, 94) = 18.68$, $p < .0001$, $\eta_p^2 = .284$, whereas differences did not reach significance in the 1,000-ms display. See Figure 3.

To decompose the *mouth* expression by *eye* expression interaction, we calculated *difference scores* between the incongruent and the control conditions (i.e., incongruent – control), and further between the incongruent and the congruent conditions (i.e., incongruent – congruent). These scores indicated how much the smiling mouth increased the probability of judging each type of eyes as happy. Separate one-way (6: eye expression) ANOVAs were then performed, followed by Bonferroni-corrected ($p < .05$) multiple comparisons across eye expressions. For *incongruent – control* scores, $F(5, 235) = 5.78$, $p < .001$, $\eta_p^2 = .110$, both neutral and surprised eyes were more likely than angry eyes to be mistaken for happy. For *incongruent – congruent* scores, $F(5, 235) = 9.46$, $p < .0001$, $\eta_p^2 = .168$, neutral eyes were more likely to be confused than all others, except the surprised eyes; and the angry eyes were less likely to be confused than the surprised eyes. See Table 1, for all the comparisons.

A separate 2 (mouth expression: smile vs. no mouth) $\times$ 4 (mouth display) ANOVA was performed on the probability of categorising *happy eyes* as happy. The

reason for this separate comparison is that there was no proper incongruent mouth condition for the happy eyes. The analysis yielded an effect of mouth expression, $F(1, 47) = 22.95, p < .0001, \eta_p^2 = .328$, with no interaction ($F < 1$). Happy eyes were more likely to be recognised as such following a smiling mouth than in the no-mouth condition. See Table 1.

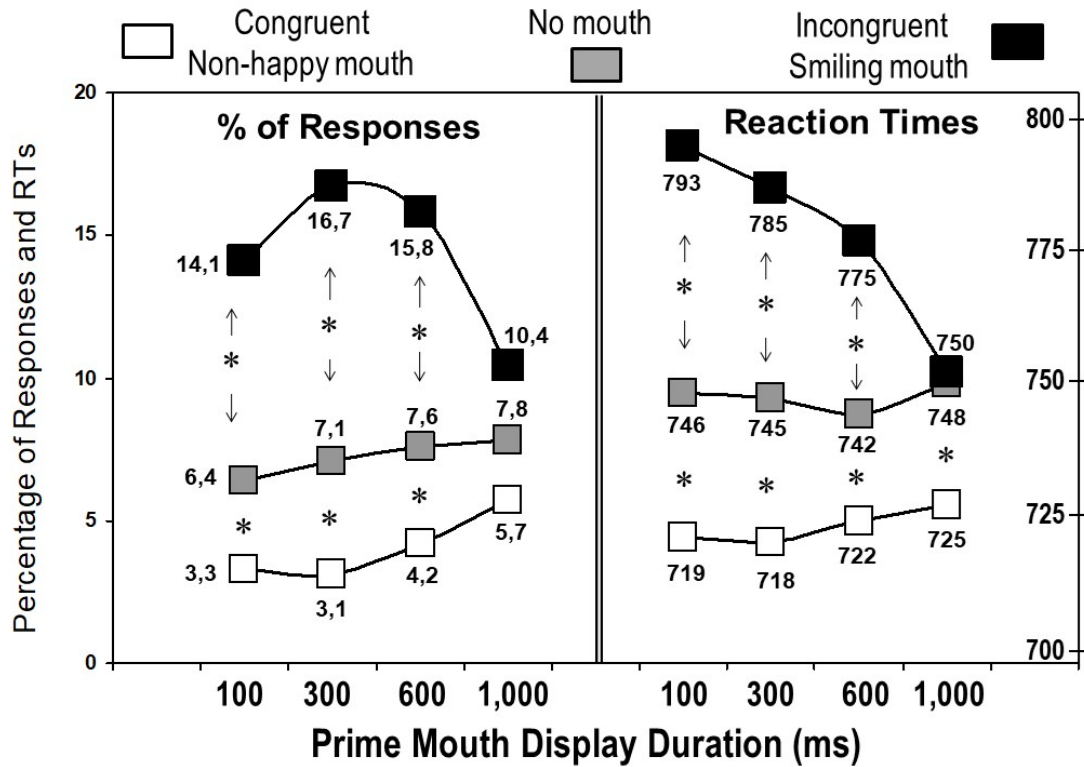


Figure 3. Mean probability (%) of responding (incorrectly) that the probe non-happy eyes were “happy” in the prime-congruent (i.e., with a congruent mouth expression), prime-incongruent (i.e., with a smiling mouth), and no-mouth conditions across prime display durations; and mean response latencies of correct responses as “not happy”; in Experiment 1. Asterisks between mouth conditions indicate significant differences.

A' Sensitivity and B'' Criterion

A 2 (mouth: congruent vs. no-mouth) $\times$ 7 (eye expression: angry, disgusted, sad, fearful, surprised, neutral, and happy) $\times$ 4 (mouth display duration) ANOVA on A' scores yielded main effects of mouth, $F(1, 47) = 27.35, p < .0001, \eta_p^2 = .368$, and eye expression, $F(6, 282) = 24.52, p < .0001, \eta_p^2 = .343$. Sensitivity was higher in the congruent than in the no-mouth condition ($M = .938$ vs. $.919$), and was higher for angry,

disgusted, sad, fearful, and happy eyes ($M = .979, .961, .962, .963, .954$, respectively; which did not differ) than for surprised and neutral eyes ($M = .860$ vs. $.819$; which did not differ).

The same ANOVA on B'' scores yielded main effects of mouth, $F(1, 47) = 12.71$, $p < .001$, $\eta_p^2 = .213$, and eye expression, $F(6, 282) = 27.06$, $p < .0001$, $\eta_p^2 = .365$. The response criterion was more lenient in the congruent than in the no-mouth condition ($M = -.103$ vs. $-.066$), and was more lenient for neutral eyes ($M = -.312$) than for the rest (angry, disgusted, sad, and fearful eyes: $M = -.052, -.112, -.094, -.096$, respectively; which did not differ), except for surprised eyes ($M = -.208$). In contrast, a strict or conservative criterion was used for happy eyes ($M = .284$).

Reaction Times of Correct Responses

The 3 (mouth expression) $\times 6$ (eye expression) $\times 4$ (mouth display duration) ANOVA on correct response latencies yielded main effects of mouth expression, $F(2, 94) = 32.15$, $p < .0001$, $\eta_p^2 = .406$, and eye expression, $F(5, 235) = 41.01$, $p < .0001$, $\eta_p^2 = .466$. See Table 2.

INSERT TABLE 2 ABOUT HERE

For mouth expression, post-hoc multiple comparisons (Bonferroni-corrected, $p < .05$) indicated that the latencies in categorising non-happy eyes as “not happy” were longer after an incongruent smiling mouth ($M = 776$ ms; $SE = 17$) than after both a congruent non-happy mouth ($M = 721$; $SE = 17$) and the no-mouth condition ($M = 745$; $SE = 19$), albeit there were no differences between the incongruent smiling mouth and the no-mouth condition in the 1,000-ms display. See Figure 3.

Regarding the main effect of eye expression, post-hoc multiple comparisons revealed longer latencies for neutral eyes than for the rest, followed by surprised eyes, which were longer than for disgusted, sad, and fearful eyes, with latencies being

shortest for angry eyes (see the comparisons in Table 2).

A separate 2 (mouth expression: smile vs. no mouth) $\times$ 4 (mouth display) ANOVA on the latencies in categorising *happy eyes* as happy, showed an effect of mouth expression, $F(1, 47) = 20.92, p < .0001, \eta_p^2 = .308$, with no interaction ($F < 1$). Happy eyes were recognised faster following a smiling mouth than in the no-mouth condition. See Table 2.

Discussion

Non-happy eyes (angry, fearful, sad, disgusted, surprised, and neutral) were (1) more likely to be misidentified as happy and (2) more slowly recognised (correctly) as not happy, (a) after viewing an incongruent smiling mouth than (b) after viewing a congruent (i.e., same expression as the eyes) non-smiling mouth, and also than (c) after viewing a meaningless no-mouth mask. Accordingly, the smile interfered with and impaired the detection of non-happy eyes. At the same time, congruence facilitated the accurate identification of both non-happy and happy eyes. This suggests that a smiling mouth biases the evaluation of subsequently appearing eyes towards happiness.

The current study and findings extend prior research in two important ways. First, in previous studies, the *entire face* was presented and was visible while viewers judged either the facial expression as a whole (Calvo et al., 2012; Calvo, Gutiérrez-García et al., 2013) or the *eye expression* specifically (Calvo & Fernández-Martín, 2013; Calvo, Fernández-Martín et al., 2013). However, in the latter case (which is the most comparable to the current conditions), the mouth was not foveally fixated (only the eye region was), but, given the high salience of the smiling mouth, it remained accessible to extrafoveal vision. In contrast, in the current Experiment 1, we avoided this influence by presenting the mouth and the eyes separately, during a prime (mouth) and a probe (eyes) period. This allowed us to determine the effects of the smile when it was no longer

present, *after* the viewer had *looked* at it.

The second contribution concerns the temporal dynamics of these effects. In prior research, the face stimulus was either freely visible until the participant responded (Calvo et al., 2012; Calvo, Gutiérrez-García et al., 2013), or was shown for 150 ms (Calvo & Fernández-Martín, 2013; Calvo, Fernández-Martín et al., 2013). The two free-viewing studies involved a natural presentation, but did not inform about the processing time course. The two 150-ms display studies showed that the process is already triggered 150 ms after stimulus onset. However, the whole face was presented, and thus it was not possible to isolate the effects of the smiling mouth specifically. Also, the use of a single 150-ms display did not indicate how effects develop over time. The present study revealed that the biasing process is already active 100 ms after the onset of a smiling mouth and continues to develop. One second later, the disconfirming (non-happy) evidence in the eye region begins to counteract the influence of the smile.

Two further issues are also relevant, and are related to each other. One of them relates to the manner in which the type of eye expression modulates the effects of the smiling mouth. While some eye expressions (e.g., angry eyes) appear impervious to the influence of the smile, others (e.g., neutral eyes) seem to be more permeable. The other issue concerns whether recognition sensitivity is implicated in such differences, or if shifts in the response decision threshold for making a “happy” judgment are the primary factor. Both issues will be discussed in the General Discussion, in combination with the results of Experiment 2.

Experiment 2: Backward Priming

A critical difference between Experiments 1 and 2 was the temporal order of the prime and the probe. Experiment 2 investigated whether the smiling mouth biases the judgement of non-happy eyes as happy when the mouth is viewed *after* the eyes. The

eye expression had to be judged earlier and held in memory until after the mouth was shown. This enabled us to assess backward priming from the mouth to the eyes.

Another difference involved the display time of the probe eyes. This allowed us to examine the time course of backward priming, and answer questions such as how long the non-happy eyes must initially be available for processing in order to prevent the smile influence. This is pertinent to the evaluation of the potential impact of viewing a smile on memory for previously observed non-happy eyes.

Method

Participants

Forty-eight psychology undergraduates (34 female), different from those in Experiment 1, served as participants, with informed consent. A priori power analysis using G*Power 3.1.9.7 (see Faul, Erdfelder, Lang, & Buchner, 2007) determined that a sample of 48 participants was sufficient to detect a medium effect size of $f = 0.25$ (Cohen's $d = 0.5$), at $\alpha = 0.05$, with statistical power $P(1 - \beta \text{ err prob}) = 0.85$, for an F test repeated-measures ANOVA in an experimental design involving two groups of probe display duration with 3 (mouth prime) $\times$ 6 (eye expression) measurements.

Stimuli, Apparatus, Procedure, Design, and Measures

The same stimuli, apparatus, and measures as in Experiment 1 were used. In Experiment 2, however, the order of presentation of the prime mouth and the probe eyes was reversed. The (probe) upper half of the face appeared before the (prime) lower half. The display duration of the eye region was either 300 or 600 ms, whereas the mouth region was displayed until the participant categorised the eye expression. See Figure 4 for an overview of the procedure.

We chose a probe display of 300 ms because this exposure has been shown to be sensitive to the effects of the prime in previous research (Calvo, Fernández-Martín et

al., 2013). By extending the time during which the probe eyes were available, up to 600 ms, we wanted to determine the time span of such effects; or how much time the non-happy eyes should be seen earlier in order to resist the interference caused by the subsequent smile.

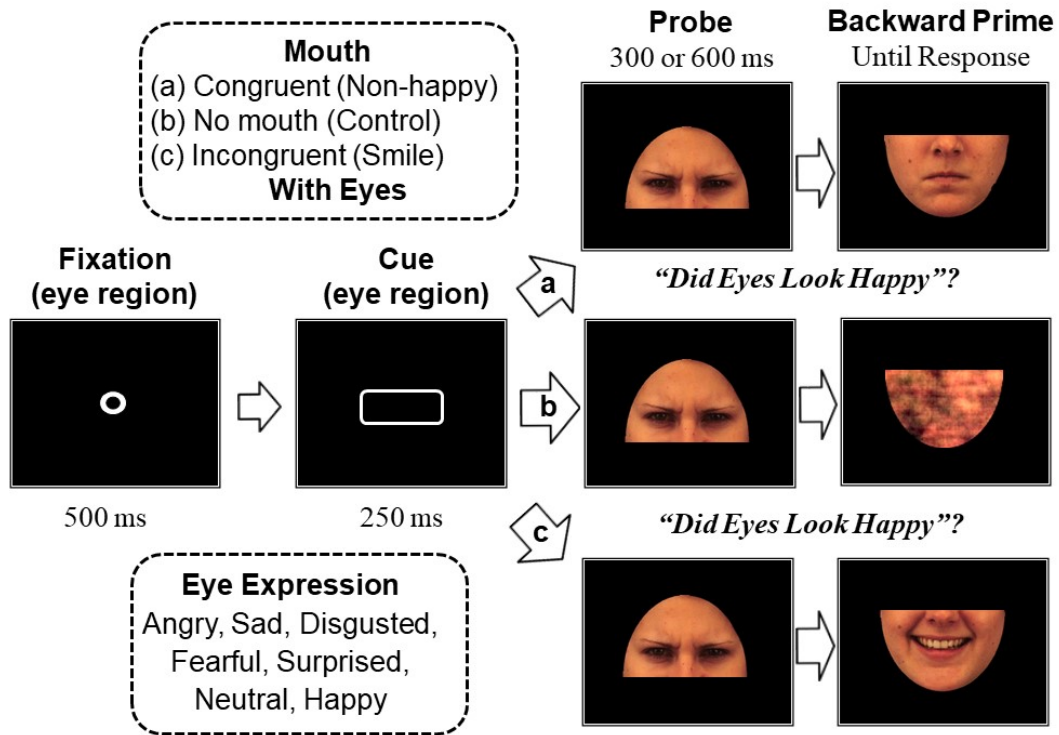


Figure 4. Overview of the procedure in Experiment 2. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

The experimental conditions were combined in a fully within-subjects factorial design, with type of prime mouth (3: congruent with non-happy eyes vs. incongruent smile vs. no mouth), probe eye expression (6: angry, disgusted, sad, fearful, surprised, and neutral), and eye region display duration (300 vs. 600 ms). Each participant was presented with 168 experimental trials (plus the 24 filler trials; see Experiment 1) in two blocks, one for each display duration condition, counterbalanced in order.

Categorisation responses for the probe eye expression were measured after the eyes disappeared, when the mouth prime was displayed. Thus, response latencies were

computed from the onset of the prime. This additional time may explain the shorter response latencies in Experiment 2, compared to Experiment 1. Presumably, viewers initiated their decision during the probe display, before the onset of the prime; hence the fast responses once the prime appeared. (And yet, importantly, these decisions were retroactively influenced by the subsequent prime, as the results show).

Results

Probability of Categorisation of Eye Expressions as “Happy”

In a 3 (mouth expression) $\times$ 6 (eye expression) $\times$ 2 (eye display duration) ANOVA on the probability of judging *non-happy* eye expressions as happy, the main effects of mouth expression, $F(2, 94) = 19.52, p < .0001, \eta_p^2 = .293$, eye expression, $F(5, 235) = 12.82, p < .0001, \eta_p^2 = .214$, and duration, $F(1, 47) = 9.50, p < .01, \eta_p^2 = .168$, were qualified by interactions between mouth expression and display duration, $F(2, 94) = 7.61, p < .001, \eta_p^2 = .139$, and mouth expression by eye expression, $F(10, 470) = 2.28, p < .05, \eta_p^2 = .046$, with no three-way interaction ($F < 1$). See Table 3.

INSERT TABLE 3 ABOUT HERE

The *mouth* expression by *display* interaction was analysed in separate one-way (3: mouth expression) ANOVAs for each display duration, followed by Bonferroni-corrected ($p < .05$) multiple comparisons across type of mouth condition. In the 300-ms display, $F(2, 94) = 21.55, p < .0001, \eta_p^2 = .314$, the probability of categorising non-happy eyes as happy was higher for the incongruent smiling mouth than for both the non-happy mouth and no-mouth conditions, whereas for the 600-ms display differences were not significant. See Figure 5.

To decompose the *mouth* expression by *eye* expression interaction, we calculated *difference scores* between the incongruent and control conditions (i.e., incongruent – control), and between the incongruent and congruent conditions (i.e., incongruent –

congruent). These scores indicated how much the smiling mouth increased the probability of judging each type of eye expression as happy. Separate one-way (6: eye expression) ANOVAs were performed on these scores, followed by Bonferroni-corrected ($p < .05$) multiple comparisons. For *incongruent – control* scores, $F(5, 235) = 3.77$, $p < .01$, $\eta_p^2 = .074$, the neutral eyes were more likely than angry eyes to be mistaken for happy. For *incongruent – congruent* scores, $F(5, 235) = 2.43$, $p = .05$, $\eta_p^2 = .049$, the same trend appeared, although the differences did not reach significance ($p > .10$) after Bonferroni corrections. See Table 3.

A separate 2 (mouth expression: smile vs. no mouth) $\times$ 2 (mouth display) ANOVA on the probability of categorising *happy eyes* as happy yielded an effect of mouth expression, $F(1, 47) = 6.56$, $p < .025$, $\eta_p^2 = .123$, with no interaction ($F < 1$). Happy eyes were more likely to be identified as such following a smiling mouth than in the no-mouth condition. See Table 3.

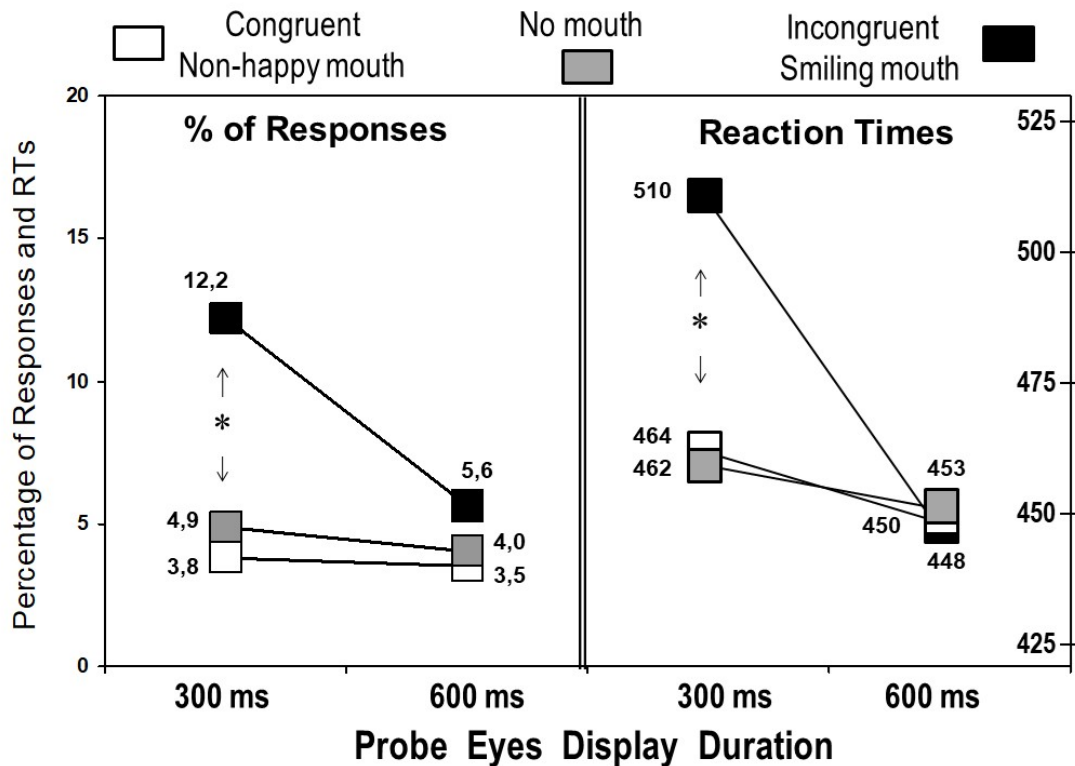


Figure 5. Mean probability (%) of responding (incorrectly) that the probe non-happy eyes were “happy” in the prime-congruent (i.e., with a congruent mouth expression), prime-incongruent

(i.e., with a smiling mouth), and no-mouth conditions across prime display durations; and mean response latencies of correct responses as “not happy”; in Experiment 2. Asterisks between mouth conditions indicate significant differences.

A' Sensitivity and B'' Criterion

A 2 (mouth: congruent vs. no mouth) $\times$ 7 (eye expression: angry, disgusted, sad, fearful, surprised, neutral, and happy) $\times$ 2 (eye display duration) ANOVA on A' scores yielded main effects of display duration, $F(1, 47) = 9.50, p < .01, \eta_p^2 = .168$, and eye expression, $F(6, 282) = 13.48, p < .0001, \eta_p^2 = .223$. Sensitivity was higher in the 600- vs. the 300-ms condition ($M = .966$ vs. $.942$), and was higher for angry, disgusted, sad, and fearful eyes ($M = .988, .976, .981, .971$, respectively; which did not differ) than for surprised and neutral eyes ($M = .933$ vs. $.906$; which did not differ from happy eyes $M = .924$).

The same ANOVA on B'' scores yielded main effects of display duration, $F(1, 47) = 13.33, p < .001, \eta_p^2 = .221$, and eye expression, $F(6, 282) = 18.94, p < .0001, \eta_p^2 = .287$. The response criterion was more lenient in the 300- vs. the 600-ms condition ($M = -.063$ vs. $.031$), it was more lenient for neutral, surprised, angry, disgusted, sad, and fearful eyes ($M = -.213, -.125, -.042, -.062, -.047, -.042$, respectively; which did not differ), whereas it was strict for happy eyes ($M = .418$).

Reaction Times of Correct Responses

The 3 (mouth expression) $\times$ 6 (eye expression) $\times$ 2 (eye display duration) ANOVA on correct response latencies showed effects of mouth expression, $F(2, 94) = 5.14, p < .01, \eta_p^2 = .100$, and display duration, $F(1, 47) = 7.28, p < .01, \eta_p^2 = .134$, qualified by their interaction, $F(6, 282) = 5.34, p < .01, \eta_p^2 = .102$. See Table 4.

INSERT TABLE 4 ABOUT HERE

To decompose the interaction, separate one-way (3: mouth condition) ANOVAs were conducted for each display condition, followed by Bonferroni-corrected ($p < .05$)

multiple comparisons. In the 300-ms display, $F(2, 94) = 10.43$, $p < .0001$, $\eta_p^2 = .182$, latencies in categorising non-happy eyes as “not happy” were longer for the incongruent smiling mouth condition than for the non-happy mouth and the no-mouth conditions, whereas differences were not significant in the 600-ms display. See Figure 5.

Discussion

A smiling mouth appearing *after* non-happy eyes biased the interpretation of the eye expression towards happiness. This was reflected in an increased probability of incorrectly categorising non-happy eyes as “happy”, and in prolonged response latencies when the eyes were correctly judged as “not happy”. This reveals a backward effect of the prime mouth on the probe eyes. The findings regarding recognition sensitivity and response bias will be considered (alongside those of Experiment 1) in the General Discussion, in connection with alternative explanations.

Importantly, first, differences emerged between the *incongruent* smile condition and both the congruent non-happy mouth and no-mouth conditions, which did not differ from each other. These findings thus reflect a true *interference* caused by the incongruent smile, rather than facilitation caused by the congruent non-happy mouth. In contrast, in Experiment 1, also forward facilitation (in addition to interference) effects occurred in the congruent relative to the control condition (see General Discussion).

Second, the effects appeared when the probe eyes were shown for 300 ms and disappeared by 600 ms. This suggests that looking at the eyes first may “immunise” the viewer against the influence of a subsequent smiling mouth. Nevertheless, such a counter-effect takes time to develop (more than 300 ms, at least; i.e., longer than a functional fixation: Henderson et al., 2005). Thus, the smile may impede the recollection of the eye expression at early stages. However, extended processing of the eyes (up to 600 ms) can avoid such an outcome.

General Discussion

The current findings reveal the importance and implications of the initial fixation on either the (non-happy) eyes or the (smiling) mouth. They also show the amount of processing time on the eyes that is required for preventive protection (from a misleading smile) during encoding, and for the consolidation of memory (of the true eye expression).

Forward and backward effects of smiles and alternative explanation

The study yielded significant findings related to the current aims. Firstly, the perception of a smiling mouth as a *forward* prime interferes with the accurate recognition of subsequently seen incongruent non-happy eyes. In contrast, unsurprisingly, there is facilitation when the mouth expression is congruent (either happy or non-happy) with the eyes. The interference effects started as early as 100 ms after the onset of the smile stimulus, they lasted until after 600 ms, and disappeared by 1,000 ms. Importantly, however, even in this case, at least another 750 ms or more were required for recognition, as reflected by the latencies of correct responses. Thus an accurate interpretation of non-happy eyes takes sizeable time before the smile interference is thwarted.

Secondly, the smile interference extends *backwards*. It occurred when incongruent eyes were previously shown for 300 ms, but not if shown for 600 ms. A strict time course comparison between the forward and the backward effects cannot be made, as variations in display duration affected *either* the prime (Experiment 1) *or* the probe (Experiment 2). Nevertheless, the forward effects appeared to be considerably stronger than the backward ones, as shown by the longer (forward) reaction times. Also, *both* facilitation and interference occurred with forward priming, whereas only interference (but not facilitation) was evident in the case of backward priming.

The *forward* effects reveal that the smiling mouth biases the on-going *encoding and interpretation* of the eyes. Instead, the *backward* effect implies that the smiling mouth causes an interruption or breakdown in the on-going *memory consolidation* of the eye expression representation. Only when additional time was available to build it following a functional 300-ms fixation (Henderson et al., 2005; Hsiao & Cottrell, 2008), did it resist the smiling mouth interference. These effects are compatible with the explanation that we proposed in the introduction. Nevertheless, the current experimental conditions do not allow us to distinguish between the three mechanisms involved, i.e., (a) perceptual overshadowing and attentional distraction, (b) semantic/categorical priming, and (c) affective priming; nor was this an aim of the study. This issue has recently been addressed in detail (Gutiérrez-García, Fernández-Martín, Alguacil, & Calvo, in press).

An alternative interpretation must be considered with regard to errors (i.e., interference) in the judgement of non-happy eyes due to the presence (before or after) of a smiling mouth. SDT analyses were utilised to differentiate between changes in perceptual sensitivity and shifts in response bias. Results indicated that sensitivity (A' index) was significantly higher for all the negatively valenced eyes (angry, disgusted, sad, and fearful) than for neutral and surprised eyes, consistently in both experiments. In addition, the response criterion (B'' index) was more stringent for truly happy eyes compared to all other categories, in both experiments; and it was particularly lenient for neutral eyes, but only in the forward conditions of Experiment 1. This indicates that errors in the judgement of non-happy eyes as happy, and differences among the eye expressions, may reflect shifts in the response decision threshold to some extent. However, it is important to note that sensitivity differences persist and are consistent across both forward and backward conditions. This suggests that any misjudgements are

likely to reflect genuine encoding and memory processes, as well as (and not merely) response biases.

The modulating effect of eye expression

The type of eye expression modulates the influence of the smiling mouth. Some eyes (especially, angry eyes) were more resistant to the smile influence, while others (especially, neutral eyes) were more vulnerable. The fact that the impact was most pronounced for neutral eyes, and also for surprised eyes, and least pronounced for angry eyes, is understandable: (a) Angry eyes are particularly distinctive (i.e., specific and unique of anger) (Calder et al., 2000; Nusseck et al., 2008; Smith et al., 2005), and therefore can more easily counteract the influence of the smile; (b) in contrast, neutral eyes are not expressive, and surprised eyes are ambiguous (Mendolia, 2007), and therefore cannot compete with the high diagnostic value of a smile (Calder et al., 2000; Nusseck et al., 2008; Smith et al., 2005), and, consequently, they are particularly liable to bias.

In line with the current results, Gosselin, Beaupré, and Boissonneault (2002) found that adult participants were especially sensitive to traces of anger in smiles (compared with traces of fear, surprise, sadness, and disgust). With different masking smiles, Perron et al. (2016) reported greater sensitivity to traces of anger in the mouth than in the eyes, and greater sensitivity to masking smiles with fearful, disgusted, and sad eyes than those with angry eyes. The Perron et al. (2016) results were not consistent with those in the current study. It must, nevertheless, be noted that the methods and goals were different in several ways. For example, we asked participants to judge the “happiness” of eye expression specifically, rather than the whole face (as was the case in the study by Perron et al.). These authors acknowledged that their results were difficult to explain in light of the current literature.

The findings of Calvo et al. (2018) offer a potential explanation for the enhanced resilience of angry eyes to the influence of a smile. The explanation for this phenomenon lies in the distinctiveness or diagnostic value of the eye region. That is, the extent to which particular features in the eye region are specifically associated with an expression category and not shared by others. These authors found that, for whole-face stimuli with a smiling mouth and various non-happy eyes (i.e., angry, disgusted, sad, fearful, surprised, and neutral), A' sensitivity scores assessing distinctiveness were highest for blended expressions with angry eyes. Furthermore, an analysis of Action Units in the eye region (AUs 1, 2, 4, 5, 6, 7, and 9) showed that faces with angry eyes and a smile were the only ones that differed from happy eyes in *all* the AUs. Accordingly, angry eyes exhibit distinctive physical features in the eye region that allow for efficient discrimination from happy eyes.

Practical and theoretical implications

In social situations, we often see *mixed smiles* (Harris & Alvarado, 2005): A smiling mouth appears in faces with a variety of non-happy eyes (from neutral to threatening), thus not conveying genuine happiness or enjoyment. In fact, smiles can accompany a wide variety of emotions, such as embarrassment, surprise, failure, nervousness, disappointment, frustration, etc. (see Wood et al., 2022). And, of course, people often smile in the absence of any strong feelings; for example, to be reassuring, or simply to initiate a conversation (Kaukomaa, Peräkylä, & Ruusuvuori, 2013). The present results suggest that, in such a variety of cases, observers might judge the facial expressions as happy to a significant extent, especially when looking first at the smiling mouth. If so, this would lead to misunderstandings of the actual emotions, motives, and intentions of the expressers, with potentially undesirable consequences for the viewer in social interaction and personal relationships. This highlights the importance of paying

attention to the eyes (Friesen et al., 2019) and of eye contact (Niedenthal, Mermillod, Maringer, & Hess, 2010), when distinguishing between true and false smiles.

Beyond this general claim, the current findings show that the bias towards unrealistic perceptions of happiness in other people's faces depends on where an observer looks first and for how long. If observers initially look at the smiling mouth, 100 ms (i.e., a *micro*-fixation) are sufficient to extract an impression of happiness, albeit potentially inaccurate. Additional fixation time (1 second or more) may allow viewers to see the contrast with the non-happy eyes. This would facilitate the detection of incongruencies and then thwart the smile effect. Conversely, looking first at the non-happy eyes and then at the smiling mouth would make it easier to prevent the bias. Nevertheless, in this case, a normal 300-ms fixation on the eyes may prove insufficient to resist the smile: The still on-going memory representation of the eye expression could be disrupted backwards, before consolidation. However, shortly after fixation on the eyes (i.e., within 600 ms), the representation would be sufficiently established to withstand the influence of the smile.²

Potential limitations

Needless to say, the particular time course figures resulting from constrained experimental conditions may not be strictly applicable to real-life situations. It may also be argued that the conditions were somewhat “artificial” in that the eye and the mouth regions were presented separately. This was necessary to isolate the role of the factors. Interestingly, however, convergent conclusions can also be drawn from a *free-viewing* eye movement study, in which *whole faces* were presented *without* temporal constraints (Calvo, Gutiérrez-García et al., 2013). In such relatively natural conditions, it was found that the interpretation of expressions with smiling mouths, but non-happy eyes, was dependent on whether the mouth or the eyes were looked at earlier (spontaneously and

without guidance): When the *mouth* of faces with fake smiles was fixated *before* the eyes, the face was more likely to be misjudged as genuinely happy, compared to when the *eyes* were fixated first. An initial focus on the smiling mouth can create an erroneous impression of happiness. This impression inhibits the processing of non-congruent information provided by later fixations on other face regions. In contrast, an initial focus on the eyes counteracts this impression, thereby facilitating discrimination and thus improving recognition accuracy.

As a related potential limitation, it might be argued that we used “artificial” blended expressions as stimuli; and that such combinations of eye and mouth expressions may not represent ecologically valid depictions of “fake” smiles produced socially (see work on micro-expressions and emotional leakage, by Porter & ten Brinke, 2008, and Porter, ten Brinke, & Wallace, 2012). However, in the current study, such combinations were never presented as complete faces. Instead, face halves, whether top or bottom, were shown separately. Even if displayed in close temporal succession, the two halves never appeared in the same configuration. Furthermore, each face half was actually obtained from a genuine basic, intact, facial expression. Consequently, the expressions depicted were authentic and not artificially distorted. Obviously, the presentation of stimuli as half-faces lacked ecological validity. Nevertheless, this approach was deemed necessary to address the various research questions and to identify specific processes, with methodological controls.

Conclusion

The current study adds to previous research by showing that the time course (i.e., when and for how long) of fixation on the eyes is important. When the non-happy eyes of faces are looked at before the smiling mouth, eye contact facilitates the discrimination between genuine and fake smiles. However, fixation should last for more

than 300 ms (a functional fixation) to be effective; i.e., to allow the first impression to be consolidated in memory. In contrast, if the mouth is fixated earlier, even for just 100 ms, a fake smile may look like genuine. Such a biased first impression may be challenged later if disconfirming evidence is detected in non-happy eyes. Nevertheless, this corrective process is, at best, time-consuming. Furthermore, the susceptibility to bias by a smile depends on the nature of the eye expression, with neutral eyes and angry eyes being most and least susceptible to bias, respectively.

Footnotes

¹Footnote: *A'* and *B''* scores were based on hits and false alarms. Hits occurred when the eyes were not happy (e.g., angry, etc.) and the actual participant's response was "not happy"; or when the eyes were happy and the response was "happy". False alarms occurred when the eyes were not happy (e.g., angry) and the actual participant's response was "happy"; or when the eyes were happy and the response was "not happy".

²In the present study, the face stimuli were always presented in two halves. Consequently, even if one part was shown immediately after the other, the biasing effects of the smiling mouth were likely to be featural (rather than holistic). This adds to research in which effects also occurred with whole face stimuli, thereby implicating configural processing (e.g., Calvo, Gutiérrez-García, et al., 2013).

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Disclosure statement

The authors declare no conflict of interest.

Data availability statement

The authors confirm that the data supporting the findings of this study are available within the (article and) Electronic Supplementary Materials (ESM).

ESM 1 Dataset_A Smile Hampers Processing and Memory_Experiment 1

ESM 2 Dataset_A Smile Hampers Processing and Memory_Experiment 2

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Table 1

Mean Probability (in %) and Standard Errors (SE) of Judging Eye Expressions as Happy, as a function of the Actual Eye Expression and Mouth Condition, in Experiment 1. Difference Scores: Incongruent minus No-Mouth (Control) Condition, and Incongruent minus Congruent Condition.

Type of Mouth	Eye Expression						
	Angry	Sad	Disgusted	Fearful	Surprised	Neutral	Happy
Congruent							
<i>M</i>	0.78	1.82	1.56	1.30	8.89	10.16	94.1
<i>SE</i>	0.44	0.64	0.60	0.67	1.78	2.43	1.2
Incongruent							
<i>M</i>	4.43	8.59	9.37	8.07	23.96	30.99	--
<i>SE</i>	1.37	2.27	2.09	2.12	3.24	4.23	--
No Mouth							
<i>M</i>	2.60	3.91	5.21	3.65	13.02	15.10	83.1
<i>SE</i>	0.83	0.92	1.43	0.98	2.14	3.20	2.2
<i>Difference Scores</i>							
Incongruent – No Mouth	1.83 ^b	4.68 ^{ab}	4.16 ^{ab}	4.43 ^{ab}	10.94 ^a	15.89 ^a	
Incongruent – Congruent	3.65 ^c	6.77 ^{bc}	7.81 ^{bc}	6.77 ^{bc}	15.09 ^{ab}	20.83 ^a	

Note. For Difference Scores, means with a different superscript horizontally (i.e., across eye expressions) are significantly different; means with the same letter (or no superscript) are equivalent.

Table 2

Mean Reaction Times (in ms) and Standard Errors (SE) of Correctly Judging Eye Expressions (as “Not Happy”, for Non-happy Eyes; and as “Happy”, for Happy Eyes), as a function of the Actual Eye Expression and Mouth Condition, in Experiment 1.

Type of Mouth	Eye Expression						
	Angry	Sad	Disgusted	Fearful	Surprised	Neutral	Happy
Congruent							
<i>M</i>	676	708	696	708	763	775	710
<i>SE</i>	16	20	19	19	20	20	17
Incongruent							
<i>M</i>	719	755	766	749	797	870	---
<i>SE</i>	18	20	21	17	18	24	---
No Mouth							
<i>M</i>	699	731	736	733	771	802	772
<i>SE</i>	18	20	20	22	20	22	19
<i>Mean Average</i>	698 ^d	731 ^c	732 ^c	730 ^c	777 ^b	816 ^a	
<i>SE</i>	16	18	18	18	17	20	

Note. For *Mean Average* scores, means with a different superscript horizontally (i.e., across eye expressions) are significantly different; means with the same letter (or no superscript) are equivalent.

Table 3

Mean Probability (in %) and Standard Errors (SE) of Judging Eye Expressions as Happy, as a function of the Actual Eye Expression and Mouth Condition, in Experiment 2. Difference Scores: Incongruent minus No-Mouth (Control) Condition, and Incongruent minus Congruent Condition.

Type of Mouth	Eye Expression						
	Angry	Sad	Disgusted	Fearful	Surprised	Neutral	Happy
Congruent							
<i>M</i>	0.52	2.60	1.56	2.60	6.25	8.33	84.9
<i>SE</i>	0.52	1.11	0.88	1.11	2.04	2.61	2.31
Incongruent							
<i>M</i>	3.12	4.69	5.73	6.25	13.02	20.31	---
<i>SE</i>	1.21	1.42	2.00	1.75	2.35	3.62	---
No Mouth							
<i>M</i>	1.56	2.08	2.60	5.73	6.77	7.81	74.4
<i>SE</i>	0.88	1.01	1.11	1.86	1.62	2.25	3.11
<i>Difference Scores</i>							
Incongruent – No Mouth	1.56 ^b	2.60 ^{ab}	3.12 ^{ab}	0.52 ^{ab}	6.25 ^a	12.50 ^a	
Incongruent – Congruent	2.60	2.08	4.17	3.65	6.77	11.98	

Note. For *Difference Scores*, means with a different superscript horizontally (i.e., across eye expressions) are significantly different; means with the same letter (or no superscript) are equivalent.

Table 4

Mean Reaction Times (in ms) and Standard Errors (SE) of Correctly Judging Eye Expressions (as “Not Happy”, for Non-happy Eyes; and as “Happy”, for Happy Eyes), as a function of the Actual Eye Expression and Mouth Condition, in Experiment 2.

Type of Mouth	Eye Expression						
	Angry	Sad	Disgusted	Fearful	Surprised	Neutral	Happy
Congruent							
<i>M</i>	460	463	452	452	456	460	446
<i>SE</i>	15	17	16	16	18	17	14
Incongruent							
<i>M</i>	481	482	474	470	475	492	---
<i>SE</i>	16	18	20	18	19	20	---
No Mouth							
<i>M</i>	462	453	457	454	458	462	450
<i>SE</i>	18	14	16	19	15	18	16
<i>Mean Average</i>	468	466	461	459	463	471	
<i>SE</i>	13	14	15	14	14	14	

Figure Captions

Figure 1. Overview of the procedure in Experiment 1. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

Figure 2. An example of stimuli (in whole-face format) for the different conditions of mouth and eye expression. Mouth: (a) congruent with eyes; (b) no-mouth control; (c) incongruent (happy) mouth. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

Figure 3. Mean probability (%) of responding (incorrectly) that the probe non-happy eyes were “happy” in the prime-congruent (i.e., with a congruent mouth expression), prime-incongruent (i.e., with a smiling mouth), and no-mouth conditions across prime display durations; and mean response latencies of correct responses as “not happy”; in Experiment 1. Asterisks between mouth conditions indicate significant differences.

Figure 4. Overview of the procedure in Experiment 2. Faces obtained, adapted, and reprinted from the Karolinska Directed Emotional Faces database. Copyright by Daniel Lundqvist, Anders Flykt, and Arne Öhman. Reprinted with permission.

Figure 5. Mean probability (%) of responding (incorrectly) that the probe non-happy eyes were “happy” in the prime-congruent (i.e., with a congruent mouth expression), prime-incongruent (i.e., with a smiling mouth), and no-mouth conditions across prime

display durations; and mean response latencies of correct responses as “not happy”; in Experiment 2. Asterisks between mouth conditions indicate significant differences.