Journal of Experimental Psychology: General
2015, Vol. 144, No. 2, 392–399

0096-3445/15/$12.00 http://dx.doi.org/10.1037/xge0000059

Automatic Integration of Social Information in Emotion Recognition

Christian Mumenthaler and David Sander
University of Geneva

This study investigated the automaticity of the influence of social inference on emotion recognition. Participants were asked to recognize dynamic facial expressions of emotion (fear or anger in Experiment 1 and blends of fear and surprise or of anger and disgust in Experiment 2) in a target face presented at the center of a screen while a subliminal contextual face appearing in the periphery expressed an emotion (fear or anger) or not (neutral) and either looked at the target face or not. Results of Experiment 1 revealed that recognition of the target emotion of fear was improved when a subliminal angry contextual face gazed toward—rather than away from—the fearful face. We replicated this effect in Experiment 2, in which facial expression blends of fear and surprise were more often and more rapidly categorized as expressing fear when the subliminal contextual face expressed anger and gazed toward—rather than away from—the target face. With the contextual face appearing for 30 ms in total, including only 10 ms of emotion expression, and being immediately masked, our data provide the first evidence that social influence on emotion recognition can occur automatically.

Keywords: emotion recognition, automaticity, social inference, social appraisal, appraisal theories

Supplemental materials: http://dx.doi.org/10.1037/xge0000059.supp

Most psychological theories acknowledge that our thoughts and behaviors are influenced by the presence—or even the representation—of other people. In everyday situations, social information interacts with our goals and helps us to appraise the affective meaning of many events that we encounter in our environment (Bodenhausen & Todd, 2010; Lieberman, 2007; Manstead & Fischer, 2001). For instance, when confronted with ambiguous situations, relevant information can be inferred from the facial expressions of others to correctly evaluate the situation (Mumenthaler & Sander, 2012; see also de Melo, Carnevale, Read, & Gratch, 2014).

Evidence collected by developmental psychologists on the so-called social referencing process even supports the idea that such integration of socioaffective information could operate without strong executive control: Children as young as a year old are able to perform social referencing (i.e., use facial expressions of others to appraise situations that are uncertain or ambiguous, such as crossing a visual cliff) without concurrent explicit reasoning processes being evident (e.g., Klinnert, Campos, Sorce, Emde, & Svejda, 1983; see Parkinson, 2011).

Automatically integrating emotional information conveyed by others in our evaluation of situations is crucial to rapidly adapt to fast-changing environments. Current accounts of automaticity suggest that mental processes do not need to exhibit all four standard criteria of automaticity (unintentionally, unawareness, uncontrollability, and high efficiency) to be considered automatic (Bargh, 1994; Kahneman & Treisman, 1984), and which features of automaticity might underlie the integration of socioaffective information during the emotion recognition process remains virtually unexplored (see De Houwer & Moors, 2012; Moors & De Houwer, 2006).

Numerous lines of research have shown that contextual information can strongly modulate the perception of facial expressions (for a review, see Wieser & Brosch, 2012). In fact, because we often perceive people when they are surrounded by other people, the faces of the others are habitual contextual cues in social situations and provide crucial information. Even so, it is important to make a distinction between the general affect expressed by others and a more specific inferential process in which the apparent emotional reaction of others is directed at a certain person. Evidence suggests that such a socioaffective inferential mechanism, as present for instance during social appraisal, may exert specific influences on the perception of emotional stimuli, including facial expressions (see Mumenthaler & Sander, 2012). The differentiation between what we refer to here as the *mere contextual effect* and a social inference effect was, for example, observed by Bayliss, Frischen, Fenske, and Tipper (2007). They studied the joint effects of gaze direction and emotional facial expression on the affective evaluation of neutral objects (e.g., a mug). Results indicated that objects looked at with a happy expression were liked more than objects looked at with an expression of disgust. However, object preference was influenced only when the gaze of the face was directed to the objects. Therefore, the mere presentation of a facial expression (happiness vs. disgust) did not influence

This article was published Online First February 16, 2015.

Christian Mumenthaler and David Sander, Laboratory for the Study of Emotion Elicitation and Expression, Department of Psychology, and Swiss Center for Affective Sciences, University of Geneva.

This work was supported by the National Centre of Competence in Research for the Affective Sciences, financed by the Swiss National Science Foundation Grant 51NF40-104897, and hosted by the University of Geneva. We thank Vanessa Maendly and Elena Rossi for their contributions to data acquisition.

Correspondence concerning this article should be addressed to Christian Mumenthaler or David Sander, Department of Psychology, University of Geneva, 40 Boulevard du Pont d'Arve, 1205 Geneva, Switzerland. E-mail: christian.mumenthaler@unige.ch or david.sander@unige.ch

object preference. This indicates that an evaluative process can be inferred from the combined information provided by the facial expression and the gaze direction.

The purpose of our study was to directly test the hypothesis that such social inferences unconsciously influence the recognition of emotion. Participants were asked to recognize dynamic facial expressions of emotion presented at the center of the screen (target face). A contextual face appeared simultaneously in the periphery of the screen and was immediately masked so that it did not reach participants' awareness. Before being masked, the face either gazed toward the target face or not and then expressed an emotion. We varied gaze direction as a way of manipulating whether the emotional expression of the contextual face was directed to the target face. Therefore, we herein refer to a *social inference effect* (as opposed to a mere contextual effect), comparing a condition in which a contextual facial expression gazes toward the target face with a condition in which the same contextual facial expression does not gaze toward the target face. The social inference effect was predicted to be more much more specific than a mere contextual effect because an evaluative process is inferred from combined information provided by the facial expression and gaze direction of the subliminal contextual face. Conversely, the mere contextual effect could be explained by a congruency effect between the two emotional stimuli (i.e., the target stimulus and the contextual stimulus) that modulates the categorization processes. Therefore, two hypotheses were tested. The first hypothesis predicted a general effect of contextual information on the recognition of emotion expressed by the target face. This effect was expected when there was a congruency between the emotion expressed by the target and the contextual faces. This process may work as affective priming, increasing the recognition of the target emotion when the target and the contextual faces express the same emotions (fear–fear or anger–anger) or pairs of emotions that share a functional relation (anger–fear or fear–anger) in comparison with our control condition (i.e., when the contextual face was neutral). More critically, the second hypothesis was that such recognition improvement with the presence of an emotional contextually congruent face would be stronger in the social inference condition than in the mere contextual condition. This social inference effect was principally expected when there was a functional relationship between the emotional expression of the contextual and the target faces—in particular, when the contextual face expressed anger and the target face expressed fear. Operationally, we expected that the target facial expression of fear would be better recognized when a contextual angry face gazed toward the target face in comparison with when it gazed away.

Given that the contextual expression was presented subliminally (i.e., for a very short time, visually masked, and not reported to reach awareness by participants), we were able to test the unconscious nature of socioaffective inferences in two experiments. We manipulated the mode of response between both experiments. In Experiment 1, participants had no time limit and were free to use several visual analogue scales to indicate the extent to which different emotions were perceived in the target face. In Experiment 2, we investigated the rapid categorization of the emotion perceived in the target face by using a forced-choice paradigm. In both experiments, participants performed another experimental session that allowed us to establish whether they consciously perceived the emotional expressions displayed by the contextual faces.

Experiment 1

Method

Participants. Forty-six[1] undergraduate students (36 female, 10 male; mean age = 21.9 years, SD = 2.71) from the University of Geneva (Geneva, Switzerland) participated in the experiment to fulfill a course requirement.

Stimuli. Thirty-two synthetic male faces displaying an emotional expression of anger, fear, or a neutral state, with either a straight gaze or an averted gaze to the left or to the right, were created by using FACSGen (software developed by the Swiss Center of Affective Sciences; see Krumhuber, Tamarit, Roesch, & Scherer, 2012; Roesch et al., 2011). Faces and emotional expressions were validated in previous work (Mumenthaler & Sander, 2012; Roesch et al., 2011).

Procedure

Emotion recognition task. Each trial[2] started with a fixation cross for 300 ms, followed by a target face appearing in the center of the screen and displaying a synthetic dynamic facial expression of fear or anger with a straight gaze. Targets were created by superimposing 21 static images (frames) corresponding to the unfolding of the expression from a neutral state to the apex of the emotion. Given that each frame was presented for 10 ms, the total duration of each sequence in all conditions was 210 ms. The sequence started, and after 50 ms, a contextual face appeared in the periphery of the screen that showed a neutral expression for 10 ms, followed by a gaze shift toward the target face (social inference condition) or toward the outside of the screen (mere context condition) for 10 ms, and then expressed an emotion (fear or anger) or not (neutral) for another 10 ms. Thus, the contextual face was presented for only 30 ms and then masked by superimposing six mask images[3] with a duration of 10 ms each (see Figure 1). Of note is that the duration of the emotional expression presented in the contextual face was only 10 ms. After the sequence ended, a response window composed of five visual analogue scales was presented. The emotion labels used for these scales were the French terms for anger, fear, surprise, disgust, and sadness. Participants had to use these scales to indicate the extent to which the five different emotion types were perceived in the target face (ranging between 0 on the left pole and 10 on the right pole). Participants were free to answer using none, one, or all of the emotion scales and were informed that if they did not use a given scale, this would mean that the face displayed in the center of the screen did not express this emotion

[1] The sample size was defined before collecting data and on the basis of results obtained in previous experiments (see Mumenthaler & Sander, 2012).

[2] Participants completed the task on a MacBook Pro connected to an external 17-in. (431.8-mm) Dell screen with a resolution of 1,024 × 768 and a refresh rate of 100 Hz. The experiment was developed and administered by using MATLAB with the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997).

[3] Six mask images were created by randomly reassembling each pixel of the face with MATLAB.

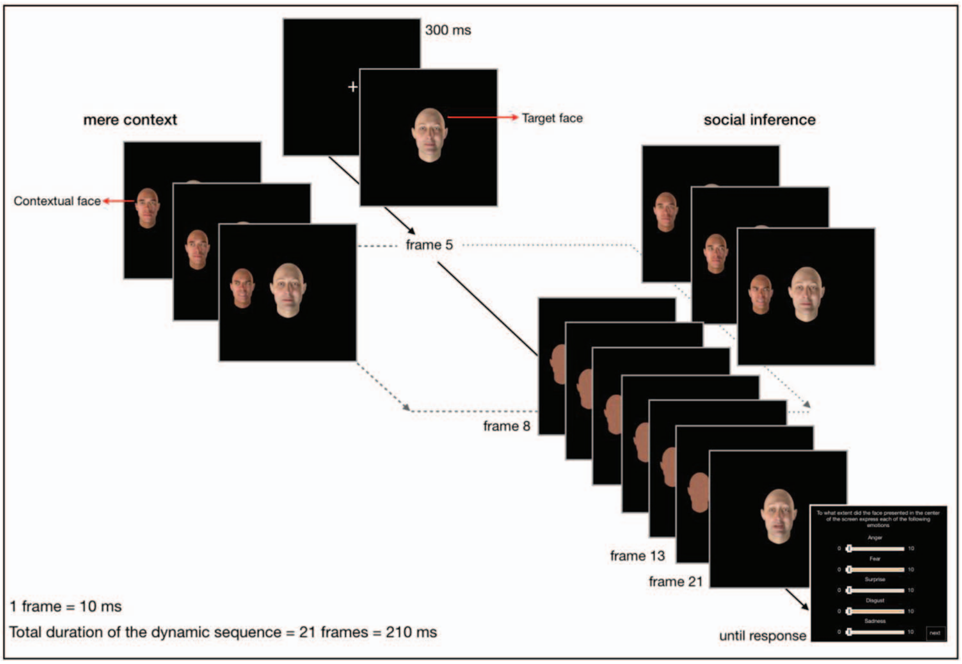

Figure 1. Illustration of an experimental trial in Experiment 1. See the online article for the color version of this figure.

at all. Different male identities were used for the target and contextual faces (24 for the target and eight for the contextual faces). All participants performed the 12 experimental conditions: 2 (context condition: social inference and mere context) $\times$ 2 (target emotion: anger and fear) $\times$ 3 (contextual emotion: anger, fear, and neutral). Each condition was measured eight times, for a total of 96 trials per participant.

Awareness check. At the conclusion of the emotion recognition task, participants also performed another experimental session that allowed us to establish whether they consciously perceived the emotional expressions displayed by the contextual faces. We used the same paradigm as in the emotion recognition task, with the exception that at the end of each trial, participants were asked two questions: (a) Did you see a face in the periphery of the screen? (*yes* or *no*). (b) Did you perceive an emotion on this face? (*none*, *fear*, *sadness*, *anger*, *surprise*, or *disgust*). Each participant performed 24 trials (each of the 12 experimental conditions was measured twice). Of importance, participants were instructed to focus on the target face as they did in the emotion recognition task. Individual response patterns revealed that 25 of 46 participants reported seeing a face in context, a result above chance (one-tailed binomial test chance level = .50, $p < .05$ for 25 participants), possibly explained by the fact that masks had the shape of the contextual face. However, and most important, no participant correctly reported the contextual emotion, again above chance, whether it was fear or anger (one-tailed binomial test chance level = .17, $p > .10$ for all participants). In fact, when participants were asked which emotion was expressed by the contextual face, 43 of 46 responded "none," which was significantly above chance (one-tailed binomial test chance level = .17, $p < .01$ for 43 participants).[4] In sum, our awareness check suggested that participants perceived that a face was presented in the periphery of the screen for the 30-ms display but were unable to consciously report the 10-ms emotional expression of this face.

Results and Discussion

Recognition of fear. A repeated-measures analysis of variance (ANOVA) was performed on the mean rating of the visual analogue scale of fear with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors. This analysis revealed significant main effects of context condition, $F(1, 45) = 13.43$, $p = .001$, $\eta_p^2 = .23$, and contextual emotion, $F(2, 90) = 5.38$, $p = .006$, $\eta_p^2 = .107$, and a Context Condition $\times$ Contextual Emotion interaction, $F(2, 90) = 5.95$, $p = .004$, $\eta_p^2 = .117$. Confirming our primary hypothesis, a subsequent planned contrast analysis revealed that fear recognition was improved when the contextual subliminal expression was anger and gazed toward—rather than away from—the target fearful face. As shown in Figure 2, when the contextual face expressed anger, scores on the visual analogue scale of fear were significantly higher in the social inference condition than in the mere context condition, $F(1, 45) = 20.173$, $p < .001$, $\eta_p^2 = .31$. Moreover, results revealed that this effect was specific to the visual analogue scale of fear. In fact, when the contextual face expressed anger, scores on the visual analogue scale of surprise, sadness, or disgust did not differ significantly between the social inference and

[4] The confusion matrix for the categorization of the contextual face and the individual data can be found in the supplemental materials.

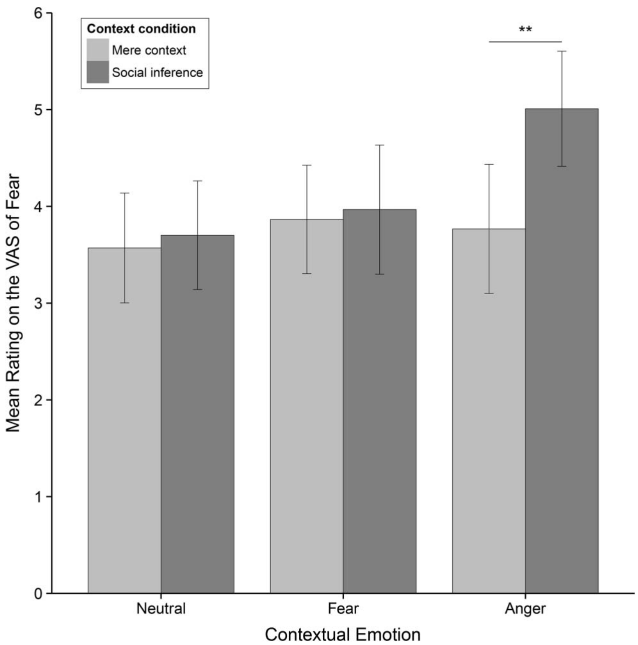

Figure 2. Results of Experiment 1. Mean rating on the visual analogue scale (VAS) of fear for the target emotion of fear when the contextual face was neutral or was expressing fear or anger and when the gaze of the contextual face was directed toward the target face (social inference condition) or away from it (mere context condition). Error bars indicate within-subject 95% confidence intervals. ** $p < .01$.

mere context conditions (all *p*s > .10).[5] Results also revealed that the effect of social inference was specific to the contextual emotion of anger, as the scores on the visual analogue scale of fear were not significantly different between a social inference and a mere context condition when the contextual emotion was fear, $F(1, 45) = 0.16$, $p = .688$, $\eta_p^2 = .00$, or neutral, $F(1, 45) = 0.311$, $p = .580$, $\eta_p^2 = .01$.

Results also revealed that, in the social inference condition, scores on the visual analogue scale of fear were significantly higher when the contextual emotion was anger than when it was neutral, $F(1, 45) = 13.21$, $p = .001$, $\eta_p^2 = .23$, or when it was fear, $F(1, 45) = 10.17$, $p = .003$, $\eta_p^2 = .18$. Results did not provide evidence of an automatic mere contextual effect. In the mere context condition, scores on the visual analogue scale of fear were not significantly different when the contextual face expressed fear or anger than when it was neutral (both *p*s > .10).

Recognition of anger. A repeated-measures ANOVA was performed on the mean rating of the visual analogue scale of anger with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors. These analyses did not reveal any significant effect (all *p*s > .10). Moreover, planned comparisons did not reveal a mere context or a social inference effect on the mean rating of the visual analogue scale of anger when the contextual face expressed fear or anger or when it was neutral (all *p*s > .10).

Experiment 2

In Experiment 2, we aimed to replicate the effect observed in Experiment 1 with different stimuli and a different mode of response. Therefore, we investigated the rapid categorization of facial expression blends of fear–surprise and anger–disgust by using a forced-choice paradigm.

Method

Participants. Forty-eight undergraduate students (42 female, 6 male; mean age = 21.2 years, *SD* = 2.2) from the University of Geneva participated in the experiment to fulfill a course requirement.

Stimuli. Photorealistic skin textures were mapped onto FACSGen faces by using FaceGen Modeller (2007). These photofits gave a humanlike appearance to the faces (see Krumhuber et al., 2012). Seven photofits were generated on the basis of seven male human faces selected from the Radboud Faces Database (Langner et al., 2010). Four of seven were used for the target face and displayed three facial expression blends of fear–surprise and three facial expression blends of anger–disgust created with FACSGen (Krumhuber et al., 2012; Roesch et al., 2011). Information about the experiment conducted to control the ambiguity of these expressions is presented in the supplemental materials. The other three photofits were used for the contextual face and displayed an emotional expression of anger, fear, or a neutral state with either a straight gaze or an averted gaze to the left or to the right. These emotional facial expressions were validated in previous work (Krumhuber et al., 2012).

Procedure

Emotion recognition task. The procedure[6] was the same as in Experiment 1, with the exception that the target face displayed three expression blends of fear and surprise in one block and three expression blends of anger and disgust in the other. Participants were asked to rapidly categorize the emotion expressed by the target face into one of two categories, labeled *fear* and *surprise* or *anger* and *disgust*, depending on the block. The contextual face displayed an emotional expression of fear or anger or a neutral expression. Unlike in Experiment 1, in which the masks had the shape of a face, in Experiment 2, the pixels of the face were reassembled into a rectangular shape to create the masks.

All participants performed the 12 experimental conditions: 2 (context condition: social inference and mere context) × 2 (target emotion: facial expression blends of fear–surprise and of anger-disgust) × 3 (contextual emotion: anger, fear, and neutral). Each condition was measured 12 times, for a total of 144 trials per participant divided into two blocks of 72 trials. The presentation order of the blocks was counterbalanced.

Awareness check. To test whether participants consciously perceived the emotional expression displayed by the contextual face, for 36 trials (selected from the 72 trials of the emotion recognition task), participants were asked just after each trial (a) whether they had seen a succession of images in the periphery of the screen (*yes* or *no*), (b) whether they had seen a face in the

[5] Means and standard errors of the mean for each visual analogue scale can be found in the supplemental materials.

[6] In Experiment 2, the last frame of the target face stayed on the screen for 300 ms before the response window was presented. Therefore, the total duration of each sequence was 510 ms.

periphery of the screen (*yes* or *no*), and (c) whether they had perceived an emotion on this face (*none*, *fear*, *sadness*, *anger*, *surprise*, *disgust*, or *happiness*). Individual response patterns revealed that 26 participants (of 48) reported seeing a succession of images in the periphery of the screen (one-tailed binomial test chance level = .50, $p < .05$ for 26 participants). Only four participants, however, were able to see that a face was presented in the periphery of the screen (one-tailed binomial test chance level = .50, $p < .05$ for four participants). None of the participants correctly reported the contextual emotion, whether it was fear or anger, a result above chance (one-tailed binomial test chance level = .14, $p > .10$ for all participants). In fact, as in Experiment 1, when participants were asked which emotion was expressed by the contextual face, they all responded "none," which was significantly above chance (one-tailed binomial test chance level = .14, $p < .01$ for all participants).

Results and Discussion

From reaction time (RT) analysis, all responses that were more than 2 standard deviations from the mean were removed (3.3% of the trials).

Recognition of expression blends of fear and surprise. A repeated-measures ANOVA was performed on the percentage of responses categorized as fear with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors. This analysis revealed a significant Context Condition × Contextual Emotion interaction, $F(2, 94) = 3.49$, $p = .035$, $\eta_p^2 = .069$, but no main effect of context condition or contextual emotion (both *p*s $> .10$). Replicating our findings obtained in Experiment 1, planned contrast analysis revealed that target facial expression blends of fear and surprise were categorized more often as expressing fear when the contextual subliminal expression was anger and gazed toward—rather than away from—this target face. Indeed, as shown in Figure 3, when the contextual face expressed anger, the percentage of responses categorized as fear was significantly higher in the social inference condition than in the mere context condition, $F(1, 47) = 7.98$, $p = .007$, $\eta_p^2 = .15$. We did not observe any significant difference between a social inference and a mere context condition when the contextual emotion was neutral, $F(1, 47) = 0.51$, $p = .479$, $\eta_p^2 = .01$, or when it was fear, $F(1, 47) = 0.14$, $p = .709$, $\eta_p^2 = .00$.

In addition, in the social inference condition, the percentage of responses categorized as fear was significantly higher when the contextual emotion was anger than when it was neutral, $F(1, 47) = 11.09$, $p = .002$, $\eta_p^2 = .19$, but the percentage was not higher when the contextual emotion was anger than when it was fear ($p > .10$). However, in the mere context condition, the percentage of responses categorized as fear did not differ significantly when the contextual face expressed fear or anger than when it was neutral (both *p*s $> .10$).

Moreover, we also tested the percentage of responses categorized as fear for each contextual emotion in each context condition against chance level (.50) with a one-sample *t* test. Analyses showed that participants categorized responses as fear at an above-chance level when the contextual emotion was anger and in a social inference condition, $t(47) = 2.20$, $p = .033$. However, responses were not significantly different from chance level in the other conditions (all *p*s $> .10$).

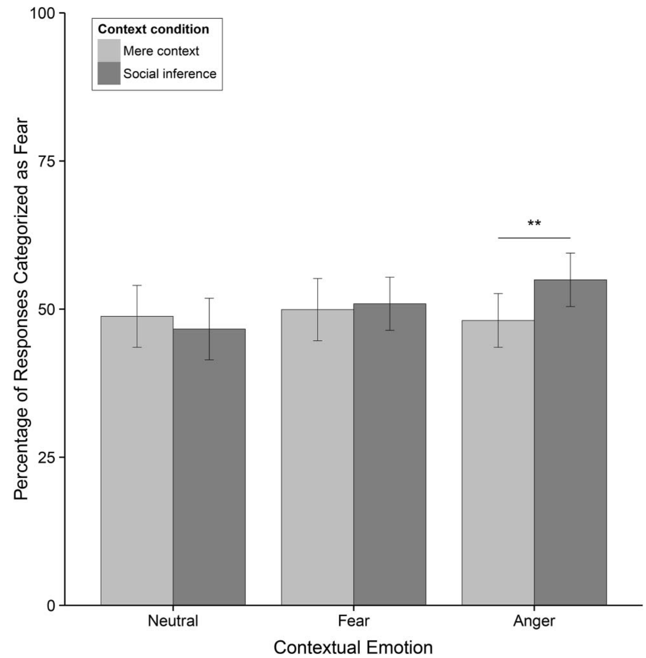

Figure 3. Results of Experiment 2. Percentages of responses categorized as fear for the target expression blends of fear and surprise when the contextual face was neutral or was expressing fear or anger and when the gaze of the contextual face was directed toward the target face (social inference condition) or away from it (mere context condition). Error bars indicate within-subject 95% confidence intervals. ** $p < .01$.

A repeated-measure ANOVA was performed on the RTs of the responses categorized as fear with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors. This analysis revealed significant main effects of context condition, $F(1, 47) = 4.75$, $p = .035$, $\eta_p^2 = .092$, but neither a main effect of contextual emotion nor a significant interaction between factors (both *p*s $> .10$). Supported by the results of the categorization task, planned contrasts were performed on RTs to test our hypotheses and the consistency of our findings. These analyses revealed that, when the contextual face expressed anger, expression blends of fear and surprise were categorized as expressing fear faster when the contextual face gazed toward—rather than away from—the target face, $F(1, 47) = 7.77$, $p = .008$, $\eta_p^2 = .14$ (see Figure 4). This effect was not observed when the target expression was categorized as expressing surprise, $F(1, 47) = 0.06$, $p = .808$, $\eta_p^2 = .00$. Moreover, we did not observe a significant difference in RTs of expressions categorized as fear between a social inference and a mere context condition when the contextual emotion was fear or neutral (both *p*s $> .10$).

Recognition of expression blends of anger and disgust. A repeated-measures ANOVA was performed on the percentage of responses categorized as anger with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors. These analyses did not reveal any significant effect (all *p*s $> .10$). Moreover, planned comparisons did not reveal a mere context or a social inference effect on the percentage of responses categorized as anger when the contextual face expressed fear or anger or when it was neutral (all *p*s $> .10$).

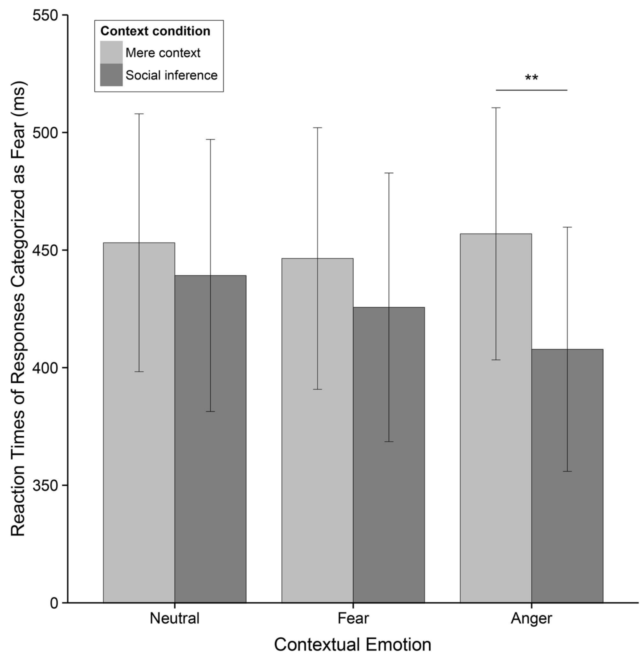

Figure 4. Results of Experiment 2. Mean reaction times of responses categorized as fear for the target expression blends of fear and surprise when the contextual face was neutral or was expressing fear or anger and when the gaze of the contextual face was directed toward the target face (social inference condition) or away from it (mere context condition). Error bars indicate within-subject 95% confidence intervals. ** $p < .01$.

Analyses also showed that the categorization of responses as anger was not significantly different from chance level (.50) for each contextual emotion in each context condition (one-sample *t* test, all *p*s $>$ .10).

A repeated-measures ANOVA performed on the RTs of the responses categorized as anger with context condition (mere context, social inference) and contextual emotion (neutral, fear, anger) as within-subject factors did not reveal any significant effect (all *p*s $>$ .10). Moreover, planned contrasts performed on RTs of the responses categorized as anger did not reveal any significant effect (all *p*s $>$ .10).

General Discussion

We aimed to test the hypothesis that socioaffective inferences automatically shape the emotion recognition process. We interpret our results as supporting this hypothesis, as shown in Experiment 1, in which the recognition of facial expressions of fear was improved when an angry contextual face gazed at—rather than away from—the fearful face, even though participants were not aware of the presence of the angry face. We replicated this effect in Experiment 2, with facial expression blends of fear and surprise being more often categorized as expressing fear and with shorter RTs when the contextual face expressed anger and gazed toward the target face rather than away from it. Although the difference between the two angry faces was perceptually subtle, with only the gaze direction being different between the two conditions and with the angry face being visually masked, our results indicate that participants were still able to infer a functional relationship between the contextual angry face and the target fearful face.

Results also suggested that the automatic effect of social inferences was not driven by a mere attentional shift produced by the gaze of the contextual face. In fact, using an adaptation of Posner's cuing paradigm, several studies (see Frischen, Bayliss, & Tipper, 2007) have shown that gaze direction of a face can be used as a cue to direct attention. However, in our findings, recognition of the target facial expression was not only dependent on the gaze direction of the contextual face, but, critically, it was shaped by the interaction between the gaze and the emotional expression of the contextual face.

Although the critical results support our primary hypothesis, neither experiment revealed evidence of an automatic mere contextual effect when the target and the contextual faces expressed the same emotions (fear–fear or anger–anger) or emotions that share a functional relation (anger–fear or fear–anger) or evidence of an automatic effect of social inference when both faces expressed the same emotion. One reason that such effects have been found when peripheral expressions are available to consciousness (Mumenthaler & Sander, 2012), but not in the current study when the peripheral expressions were subliminal, may be that only strongly disambiguating signals have an unconscious effect. Indeed, in our study, the functional relationship between a facial expression of anger and its targeted facial expression of fear provided clear information that allowed strong disambiguation, which is not the case in the fear–fear or anger–anger pair.

Our findings revealed an automatic effect of social inference on the perception of facial expression of fear and expression blends of fear and surprise. This finding may be specific, as it appears not to generalize to the perception of all ambiguous facial expressions. In fact, in Experiment 2, we did not find any effect of social inference on the recognition of expression blends of anger and disgust when the contextual face was expressing anger or fear.

Of importance, our hypothesis concerning the automaticity of social inference was based on the fact that participants were not able to consciously report the emotional expression of the contextual face. Even without being aware of it, participants inferred a functional relationship when the contextual angry face was gazing at the target fearful face. Extracting a causal socioaffective inference from two combined subliminal cues is a complex cognitive process that occurred unconsciously in our experiments, a finding that supports the proposal that cognitive systems are able to automatically integrate different sources of information (Mudrik, Faivre, & Koch, 2014) and perform complex causal inferences without the involvement of conscious deliberated processes (see Hassin, 2013).

More generally, the concept of *social appraisal*, derived from the theoretical framework of appraisal theories of emotion, provides a possible interpretation of our findings. Social appraisal is characterized by the process according to which "behaviors, thoughts or feelings of one or more other persons in the emotional situation are appraised in addition to the appraisal of the event per se" (Manstead & Fischer, 2001, p. 222). In this framework, our results may indicate that, during their appraisal of the target face, participants automatically include the information about a potential threat derived from the facial expression of the contextual face. This interpretation may provide new perspectives on how social inferences can automatically influence emotional processing at an early stage of processing.

Our results suggesting that social inference takes place without the involvement of a conscious deliberated process are consistent with recent work revealing that the evaluation of faces on the social dimension of dominance or trustworthiness is not restricted to conscious processing but extends to preconscious stages of perception (Stewart et al., 2012). Moreover, also consistent with our findings, other lines of research have revealed that the integration of emotional facial expressions and their body contexts is unintentional and uncontrollable and that it consumes few processing resources (Aviezer, Bentin, Dudarev, & Hassin, 2011). Further studies should directly investigate which other features of automaticity could apply to the social inference process (see Moors & De Houwer, 2006).

Considering the fact that our sample was mainly composed of female participants in both experiments, we cannot be sure that the observed effects can be generalized to male participants. Although it has been suggested that there is a slight female advantage in nonverbal sensitivity (e.g., Hall, Murphy, & Schmid Mast, 2006) and emotion recognition (e.g., Hoffmann, Kessler, Eppel, Rukavina, & Traue, 2010), we are not aware of any theoretical prediction according to which a gender effect would be observed in the social inference process involved in the perception of emotions.

In sum, our study highlights the importance of relevant social inferences, which are automatically integrated into the dynamic emotion recognition process, providing useful information for processing uncertain situations. These results build a bridge between evidence suggesting that many aspects of social cognition seem to rely on automatic mechanisms, on one hand (see Bargh & Williams, 2006; Greenwald & Banaji, 1995), and that the emotional processes involved may operate automatically, on the other (Moors, 2010). Emotion recognition models should incorporate the notion that inferences about the social situation may be automatically integrated at an early stage of information processing during facial emotion recognition.

References

Aviezer, H., Bentin, S., Dudarev, V., & Hassin, R. R. (2011). The automaticity of emotional face–context integration. *Emotion, 11,* 1406–1414. http://dx.doi.org/10.1037/a0023578

Bargh, J. A. (1994). The four horsemen of automaticity: Awareness, efficiency, intention, and control in social cognition. In R. S. Wyer Jr., & T. K. Srull (Eds.), *Handbook of social cognition* (2nd ed., pp. 1–40). Hillsdale, NJ: Erlbaum.

Bargh, J. A., & Williams, E. L. (2006). The automaticity of social life. *Current Directions in Psychological Science, 15,* 1–4. http://dx.doi.org/10.1111/j.0963-7214.2006.00395.x

Bayliss, A. P., Frischen, A., Fenske, M. J., & Tipper, S. P. (2007). Affective evaluations of objects are influenced by observed gaze direction and emotional expression. *Cognition, 104,* 644–653. http://dx.doi.org/10.1016/j.cognition.2006.07.012

Bodenhausen, G. V., & Todd, A. R. (2010). Social cognition. *Wiley Interdisciplinary Reviews: Cognitive Science, 1,* 160–171.

Brainard, D. H. (1997). The Psychophysics Toolbox. *Spatial Vision, 10,* 433–436. http://dx.doi.org/10.1163/156856897X00357

De Houwer, J., & Moors, A. (2012). How to define and examine implicit processes? In R. Proctor & J. Capaldi (Eds.), *Implicit and explicit processes in the psychology of science* (pp. 183–198). New York: Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780199753628.003.0008

de Melo, C. M., Carnevale, P. J., Read, S. J., & Gratch, J. (2014). Reading people's minds from emotion expressions in interdependent decision making. *Journal of Personality and Social Psychology, 106,* 73–88. http://dx.doi.org/10.1037/a0034251

FaceGen Modeller (Version 3.2) [Computer software]. (2007). Retrieved from http://www.facegen.com

Frischen, A., Bayliss, A. P., & Tipper, S. P. (2007). Gaze cueing of attention: Visual attention, social cognition, and individual differences. *Psychological Bulletin, 133,* 694–724. http://dx.doi.org/10.1037/0033-2909.133.4.694

Greenwald, A. G., & Banaji, M. R. (1995). Implicit social cognition: Attitudes, self-esteem, and stereotypes. *Psychological Review, 102,* 4–27. http://dx.doi.org/10.1037/0033-295X.102.1.4

Hall, J. A., Murphy, N. A., & Schmid Mast, M. (2006). Recall of nonverbal cues: Exploring a new definition of interpersonal sensitivity. *Journal of Nonverbal Behavior, 30,* 141–155. http://dx.doi.org/10.1007/s10919-006-0013-3

Hassin, R. R. (2013). Yes it can: On the functional abilities of the human unconscious. *Perspectives on Psychological Science, 8,* 195–207. http://dx.doi.org/10.1177/1745691612460684

Hoffmann, H., Kessler, H., Eppel, T., Rukavina, S., & Traue, H. C. (2010). Expression intensity, gender and facial emotion recognition: Women recognize only subtle facial emotions better than men. *Acta Psychologica, 135,* 278–283. http://dx.doi.org/10.1016/j.actpsy.2010.07.012

Kahneman, D., & Treisman, A. (1984). Changing views of attention and automaticity. In R. Parasuraman & R. Davies (Eds.), *Varieties of attention* (pp. 29–61). New York: Academic Press.

Klinnert, M. D., Campos, J. J., Sorce, J. F., Emde, R. N., & Svejda, M. (1983). Emotions as behavior regulators. In R. Plutchik & H. Kellerman (Eds.), *Emotions: Theory, research, and experience* (Vol. 2, pp. 57–86). New York: Academic Press.

Krumhuber, E. G., Tamarit, L., Roesch, E. B., & Scherer, K. R. (2012). FACSGen 2.0 animation software: Generating three-dimensional FACS-valid facial expressions for emotion research. *Emotion, 12,* 351–363. http://dx.doi.org/10.1037/a0026632

Langner, O., Dotsch, R., Bijlstra, G., Wigboldus, D. H. J., Hawk, S. T., & van Knippenberg, A. (2010). Presentation and validation of the Radboud Faces Database. *Cognition and Emotion, 24,* 1377–1388. http://dx.doi.org/10.1080/02699930903485076

Lieberman, M. D. (2007). Social cognitive neuroscience: A review of core processes. *Annual Review of Psychology, 58,* 259–289. http://dx.doi.org/10.1146/annurev.psych.58.110405.085654

Manstead, A. S. R., & Fischer, A. H. (2001). Social appraisal: The social world as object of and influence on appraisal processes. In K. R. Scherer, A. Schorr, & T. Johnstone (Eds.), *Appraisal processes in emotion: Theory, method, research* (pp. 221–232). New York: Oxford University Press.

Moors, A. (2010). Automatic constructive appraisal as a candidate cause of emotion. *Emotion Review, 2,* 139–156. http://dx.doi.org/10.1177/1754073909351755

Moors, A., & De Houwer, J. (2006). Automaticity: A theoretical and conceptual analysis. *Psychological Bulletin, 132,* 297–326. http://dx.doi.org/10.1037/0033-2909.132.2.297

Mudrik, L., Faivre, N., & Koch, C. (2014). Information integration without awareness. *Trends in Cognitive Sciences, 18,* 488–496. http://dx.doi.org/10.1016/j.tics.2014.04.009

Mumenthaler, C., & Sander, D. (2012). Social appraisal influences recognition of emotions. *Journal of Personality and Social Psychology, 102,* 1118–1135. http://dx.doi.org/10.1037/a0026885

Parkinson, B. (2011). Interpersonal emotion transfer: Contagion and social appraisal. *Social and Personality Psychology Compass, 5,* 428–439. http://dx.doi.org/10.1111/j.1751-9004.2011.00365.x

Pelli, D. G. (1997). The VideoToolbox software for visual psychophysics: Transforming numbers into movies. *Spatial Vision, 10,* 437–442. http://dx.doi.org/10.1163/156856897X00366

Roesch, E. B., Tamarit, L., Reveret, L., Grandjean, D., Sander, D., & Scherer, K. R. (2011). FACSGen: A tool to synthesize emotional facial expressions through systematic manipulation of facial action units. *Journal of Nonverbal Behavior, 35,* 1–16. http://dx.doi.org/10.1007/s10919-010-0095-9

Stewart, L. H., Ajina, S., Getov, S., Bahrami, B., Todorov, A., & Rees, G. (2012). Unconscious evaluation of faces on social dimensions. *Journal of Experimental Psychology: General, 141,* 715–727. http://dx.doi.org/10.1037/a0027950

Wieser, M. J., & Brosch, T. (2012). Faces in context: A review and systematization of contextual influences on affective face processing. *Frontiers in Psychology, 3,* 471. http://dx.doi.org/10.3389/fpsyg.2012.00471

Received April 27, 2014
Revision received January 9, 2015
Accepted January 9, 2015 ■