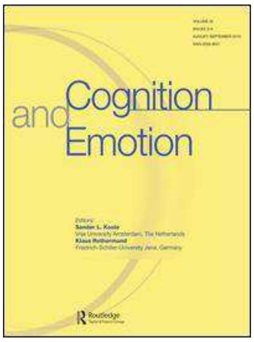

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Influence of violent contexts on facial reactions elicited by angry and neutral faces

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ABSTRACT

This study focuses on determining whether violent contexts influence the perception of aggressiveness in faces analysing spontaneous *corrugator supercilii* activity. Participants viewed pictures of neutral and angry faces preceded by a contextual sentence describing either violent or neutral actions. They were instructed to judge each face according to whether it was aggressive or non-aggressive. Results show a higher level of perceived aggressiveness for neutral faces preceded by violent contexts, accompanied by longer reaction times, and a significant increase of corrugator activity. Angry faces preceded by neutral contexts were judged as less aggressive and elicited less corrugator activity. In conclusion, our results provide evidence that facial reactions and aggressiveness judgment for faces are context-dependent. With this work, we contribute to the view that contextual cues guide the face's emotional meaning, under top-down processing.

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Evidence from electromyographic (EMG) recordings shows that, when individuals observe emotional facial expressions in other persons, they react with spontaneous facial muscle activations, even at subperceptual levels (Philip et al., 2017). First studies showed congruent activations between muscles involved in observed facial expression and the corresponding muscles in the observer's face, suggesting that automatic emotional mimicry processing is involved in social cognition (i.e. Sonnby–Borgström, 2002). For example, presentation of angry faces triggers an enhanced *corrugator supercilii activity*, compared to happy and neutral faces (Dimberg et al., 2000). Nevertheless, studies about the contextual influence in emotional perception have shown that perception and muscle activations are not always consistent with the observed emotional facial expression, suggesting that top-down processes influence emotional processing at the level of facial mimicry, even for presentation of neutral faces (Hess et al., 2014). In the study, we aimed at determining whether contextual scenarios could influence the emotional perception and facial reactions triggered by angry and neutral faces. More specifically, our goal was to determine whether violent context influences the perception of aggressiveness in angry and neutral faces and if this relates to corrugator activity. If facial reactions and judgment of aggressiveness for angry and neutral faces change according to whether they are in a neutral or violent context, then the assumption that top-down processes influence emotional processing holds. This could be especially relevant for the processing of neutral faces, because the neutral face perception could be influenced by the emotional content of its context, which ultimately would provide the emotional meaning to the face.

Many experiments present isolated faces, observing high levels of agreement between participants regarding perceived emotions (e.g. Calvo & Lundqvist,

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2008). However, in everyday life, emotions happen inside a situational context, which influences their perception and social meaning (Fischer & Hess, 2017). In the case of face processing, many studies have shown interactions between context and the face's emotional expression, even at early stages of face processing (Wieser et al., 2014), supporting a top-down influence in emotional perception (Aldunate et al., 2018). Accordingly, the information provided by the context is important to judge faces with a lack of emotional expressivity, such as neutral faces. For example, in an ERP study, Wieser et al. (2014) observed that threatening contexts affect the visual processing of neutral faces, which were also evaluated with higher arousal ratings when they were presented in self-related contexts.

EMG studies have shown that facial mimicry reactions depend on a variety of social contextual factors (Bourgeois & Hess, 2008). Such evidence challenged what has been called the matched motor hypothesis as the classic view on mimicry according to which emotional mimicry would be only a simple matching of motoric activity in a bottom-up process (Hess & Fischer, 2013). In contrast, the evidence supports the hypothesis that emotional cues available in the specific context influence face processing. For example, Philip et al. (2017) observed that the mimicry response to expressions like angry faces, traditionally related to corrugator activity (Larsen et al., 2003), was suppressed when they were preceded by incongruent words. Moody et al. (2007) found that the *frontalis* muscle activity, usually related to fear, was modulated when angry, fear and neutral faces were presented in a fear-inducing setting compared to a neutral one. More specifically, they found that fear and angry faces were related to more frontalis activation in the fear induction condition than in the neutral condition, but they did not find differences for neutral, concluding that the facial reactions are not just an automatic motor mimicry, but an emotional response (Moody et al., 2007). In line with this, some authors have stated that facial reactions depend on how we attribute intentions based on contextual information during the perception of emotional expressions in faces (Fischer & Hess, 2017). However, there is limited evidence on how the intentional cues provided by contextual information can affect the facial reactions to neutral faces (for an exception, see Hess et al., 2014).

Traditionally, neutral faces have been considered as stimuli that lack emotional content. Nevertheless, the studies cited above suggest that context provides affective information in perception. In order to understand the emotional character of perceptual processing, it is important to better understand the contextual influence in the processing of neutral stimuli. In the present study, we aimed to determine how corrugator activity, elicited by observing angry and neutral faces, varies according to affective cues contained in preceding contextual sentences describing violent actions. We also measure the contextual influence on subjective ratings of aggressiveness judgments and reaction times in order to know how these contextual affective cues influence the perception of angry and neutral faces. Previous evidence suggests that the detection of the angry expression is different when they are on male faces than when they are on female faces, for example with shorter reaction times for angry male faces than for angry female ones (Aguado et al., 2009). Hence, we included only male faces to control the influence of face gender in emotion expression. We predict that if contextual information influences the emotion perceived in faces, then we would expect an increase of activity for angry and neutral faces preceded by violent scenarios, supporting the view that facial reactions are not a simple matched motor response, but rather the expression of the emotional influence of the context on the emotional meaning of faces. We also expect that the context affects the judgment of aggressiveness, resulting in more perceived aggressiveness for angry and neutral faces when they are in violent contexts than when they are in neutral contexts. Moreover, if we observe an increase in corrugator activity and in judgment of aggressiveness for neutral faces when they are preceded by violent contexts compared to when they are preceded by neutral ones, then we could suggest that neutral faces have emotional meaning, due their sensitivity to contextual influences.

Methods

Participants

Twenty-eight participants (14 women; Mean age = 20.40; SD = 3.08) were recruited to this study. According to similar studies (Gálvez-García et al., 2020), sample size was calculated using a statistical power analysis (G*power 3.1.9.2) for repeated measures ANOVA 2×2 with small-medium effect size ($d = 0.3$; and an appropriate 1- β), and setting statistical significance to $\alpha = 0.05$ and a power of 0.80. All participants had normal or corrected to normal vision. They provided informed consent before their participation.

Materials

A set of 120 sentences describing actions performed by a man was created. Sixty of them described violent actions (e.g. "*He pushed her intentionally*"), and were adapted from the Index of Spouse Abuse ([ISA], Hudson and McIntosh (1981)); the Conflict Tactics Scale-2 ([CTS-2], Straus et al. (1996)); the Conflict in Adolescent Dating Relationships Inventory ([CADRI], Wolfe et al. (2001)); and the Violence Scale and Severity Index (Valdez-Santiago et al., 2006). The other 60 sentences described neutral actions (e.g. "*He handed her the chair*").

A pretest was run to control the degree of perceived violence for each action. Seventy-eight participants (59 women; Mean age = 19.67, SD = 1.55) completed a questionnaire with all the sentences. They were instructed to indicate the degree of violence for each sentence with a 7-point Likert scale, where 0 meant "nothing violent," and 7 meant "extremely violent." The mean of perceived violence in violent sentences (Mean = 6.45; SD = 0.49) was statistically different from that obtained by neutral sentences (Mean = 0.42; SD = 0.10) ($t(118) = 96.717$; $p < 0.001$).

Photographs of 30 models' faces (men) were selected from the Karolinska Directed Emotional Faces database (KDEF), designed by Lundqvist et al. (1998). To select the models, 35 photographs were presented to 30 participants (18 women; Mean age = 21.47; SD = 1.55). They were instructed to look at the angry and neutral face of each one, and rate their aggressiveness expressed with a 7-point Likert scale, where 0 meant "nothing aggressive," and 7 meant "extremely aggressive." Selected faces shown statistically significant differences in perceived aggressiveness ($t(29) = 23.49$; $p < 0.001$), between their angry (Mean = 4.86; SD = 0.73) and neutral (Mean = 1.07; SD = 0.32) conditions.

Procedure

All procedures were carried out in accordance with the ethical guidelines of the Human Research Advisory Committee from the Pontificia Universidad Católica de Chile. Once in the laboratory, the participants were instructed to respond in each trial if the presented face expressed aggressiveness or not. Half of the participants had to press "z" to respond "expresses aggressiveness," and "m" to respond "does not express aggressiveness." To counterbalance, the other half of participants had the same response keys, with the inverted meaning.

The software used to build the experiment was Presentation (Neurobehavioral Systems). Each trial began with a fixation-cross during 150 msec, followed by a sentence describing an action (violent or neutral) during 2000 msec. After that, a fixation-cross was presented during 200 msec, followed by the face (angry or neutral) during 200 msec. Finally, participants had 2500 ms to respond on a black screen (See Figure 1). In order to avoid very slow responses, participants who did not respond within the 2500 msec response window received a warning message for 1000 ms with a text indicating that he/she had to respond faster ("*responda más rápido*" – "respond faster"). The experiment had 240 trials distributed randomly in six blocks (40 in each block). After each block, participants had one minute of rest. Participants viewed the same 30 models with their angry and neutral faces in both contexts (violent and neutral sentences), so each face appeared twice in each condition. In addition, before the first block, participants performed 12 practice trials, which were excluded from the analyses.

Electromyography recording

EMG was recorded at 2000 Hz with a module of BIOPAC Inc., using a gain of 1000. Two disposable bipolar Ag/AgCl electrodes were placed at corrugator supercilii site, 4 mm in diameter and 2 cm between them. The ground electrode was placed over the dorsum of the carpus. Additionally, prior to the experimental session, we recorded the EMG of the voluntary maximum isometric contraction (MVIC). This procedure allows normalisation in the amplitude of the signals and allows inter-subject comparisons (Halaki & Ginn, 2012).

Data analysis

Three dependent variables were measured: aggressiveness judgment rates in faces (i.e. the percentage of trials that were responded as aggressive in each condition), reaction times (RTs), and mean muscular activation (defined as the percentage of muscular activation related to MVIC). Repeated-measures ANOVA were conducted, using as factors context (violent/neutral), and face emotion (angry/neutral). Planned

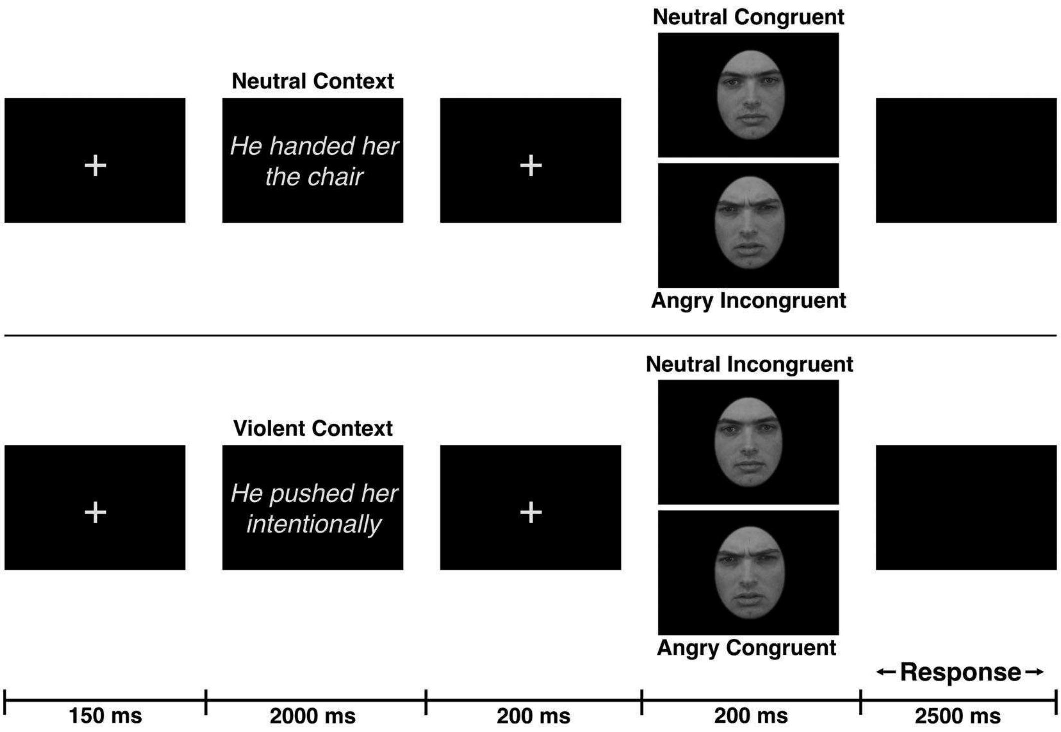

Figure 1. Schema of an experimental trial.

comparisons were conducted to explain the interactions among different levels of the studied variables.

EMG data processing was performed through an algorithm in MatlabR2016a software. The arithmetic mean was subtracted from each signal to centre at zero. Next, a 50 Hz notch filter was applied to eliminate electromagnetic noise due to AC power. Additionally, a high-pass and low-pass fourth-order Butterworth filter with cut-off frequencies of 20 and 450 Hz respectively were used. Twenty samples sliding window technique was used to calculate root mean square (RMS) of the signal, resulting in a signal with positive values. Afterwards, an amplitude normalisation of each data sample was performed, multiplying by 100 and dividing it by the MVIC. After preparing the signal, each EMG burst was isolated, and the mean and maximum amplitude values of the EMG recorded time window were calculated. In order to isolate the EMG activation elicited by faces from that elicited by contexts, and thus specifically analize the facial reaction responses, we subtracted the EMG activation elicited by the presentation of the sentences (interval of 2000 ms) from the EMG activation elicited by the face (interval of 200 ms). Trials with RT slower than 2,500 ms were excluded from the analysis (1.42%).

Results

Aggressiveness judgment rates

The main effect for face emotion was significant [F(1, 27) = 179.57, $p < 0.001$, $\eta_p^2 = 0.869$] with higher aggressiveness judgment rates in the angry face condition (88.5%, 95% CI = 83.6– 93.5) compared to the neutral face condition (22.5%, 95% CI = 15.1–29.8). There was a main effect of context (F(1, 27) = 28.47, $p <$ 0.001, $\eta_p^2 = 0.513$), with higher rates of perceived aggressiveness in violent context (66.8%, 95% CI = 56.7–77.0) than in neutral context (44.2%, 95% CI = 33.4–55.0). A face emotion x context interaction was observed [F(1, 27) = 4.56, $p = 0.042$, $\eta_p^2 = 0.144$]. Planned comparisons showed that attribution of aggressiveness to angry and neutral faces varied according to context. Specifically, the context effect was higher in neutral faces than in angry faces, observing a large increase in the attribution of aggressiveness when neutral faces appeared in violent contexts (36.5%, 95% CI = 24.2–48.8) than when they appeared in neutral contexts (8.5%, 95% CI = 4.3–12.6) ($p < 0.001$). Even so, the attribution of aggressiveness for angry faces also decreased when they appeared in neutral contexts (79.9%, 95%

CI = 71.0– 88.8), compared when they appeared in violent contexts (97.2%, 95% CI = 95.8–98.6) ($p < 0.001$) (See Figure 2A).

Reaction times

A main effect of face emotion was observed [F(1, 27) = 18.941, $p < 0.001$, $\eta_p^2 = 0.412$], where angry faces elicited faster responses (756 msec, 95%, CI = 708–804) than neutral faces (928 msec, 95% CI = 848–1009). A main effect for context was also present [F(1, 27) = 8.52, $p < 0.001$, $\eta_p^2 = 0.240$]. Violent context condition had slower RTs (871 msec, 95% CI = 787–954) than neutral context condition (814 msec, 95% CI = 761–867). A face emotion x context interaction was observed [F(1, 27) = 157.045, $p < 0.001$, $\eta_p^2 = 0.853$]. Specifically, RTs were faster when angry faces appeared in violent contexts (676 msec, 95% CI = 612–739) than in neutral contexts (836 msec, 95% CI = 774–897) ($p < 0.001$). However, this effect was especially notable for neutral faces, where RTs were faster when they appeared in neutral contexts (791 msec, 95% CI = 702–881) than when they appeared in violent contexts (1065 msec, 95% CI = 948–1183) ($p < 0.001$) (See Figure 2B).

%MVIC for corrugator

There was a significant main effect for face emotion [F(1, 27) = 135.25, $p < 0.001$, $\eta_p^2 = 0.834$], where angry faces elicited higher activation (5.7%, 95% CI = 4.9–6.6) than neutral faces (2.2%, 95% CI = 1.4–3.0). A main effect of context was also present [F(1, 27) = 63.84, $p < 0.001$, $\eta_p^2 = 0.702$], where violent contexts had higher activity (5.1%, 95% CI = 4.3–6.0) than neutral contexts (2.8%, 95% CI = 1.8–3.7). A face emotion x context interaction was observed [F(1, 27) = 35.787, $p < 0.001$, $\eta_p^2 = 0.570$]. Planned comparisons showed that corrugator activity to angry and neutral faces varied according to context. The corrugator activity for angry faces was higher when they were in violent contexts (5.9%, 95% CI = 4.8–7.2) than when they appeared in neutral contexts (5.4%, 95% CI = 4.2–6.68) ($p < 0.001$). Even so, the contextual influence was greater on neutral faces, which elicited greater corrugator activity when they were in violent contexts (4.3%, 95% CI = 3.1–5.5) than when they were in neutral contexts (0.13%, 95% CI = 0.12–0.14) ($p < 0.001$) (See Figure 2C).

Discussion

The present study examined facial reactions elicited by neutral and angry faces when they are preceded by violent or neutral contextual sentences, analysing the corrugator activity. We hypothesised that affective cues (violent or neutral) presented in the contextual sentences would impact the facial EMG response of the observer and the judgment of the aggressiveness of angry and neutral faces. Our results show higher levels of perceived aggressiveness, faster responses and larger corrugator activity in angry faces than in neutral ones. The nature of the context (neutral or violent) also significantly impacted the perceived aggressiveness, RT and corrugator activity elicited by the faces. More importantly, the current results indicate a higher level of perceived aggressiveness for neutral faces preceded by violent contexts that were also accompanied by a significant increase of corrugator activity and longer RTs, and exactly the opposite for angry faces preceded by neutral contexts.

A previous study registered different judgments and facial reactions for neutral faces after associative learning (Aguado et al., 2013). In our study, facial neutrality may pose an additional burden on the task of judging aggressiveness due to its potential ambiguity, especially when presented after a violent contextual sentence. The enhanced corrugator activity accompanied by higher levels of perceived aggressiveness for neutral faces preceded by violent contexts indicates that neutral faces can be processed as emotional under the influence of contextual information. Thus, our results support the hypothesis that facial reactions depend on how we attribute emotional intentions based on contextual information when we perceive faces (Fischer & Hess, 2017), even when they are neutral faces. Previous studies have shown different contextual influences in face processing at different neural levels (e.g. Wieser et al., 2014). For example, studies have shown different amygdala activations for neutral faces in different contexts (Cooney et al., 2006), and different ERPs for neutral faces in threatening contexts (Wieser et al., 2014). Altogether, this evidence suggests that neutral faces in context have emotional content based on contextual cues. Furthermore, larger RTs for neutral faces in violent contexts as compared to neutral contexts could reflect a higher complexity in the judgment of the face when context is violent with a subsequent increase of RTs in our task.

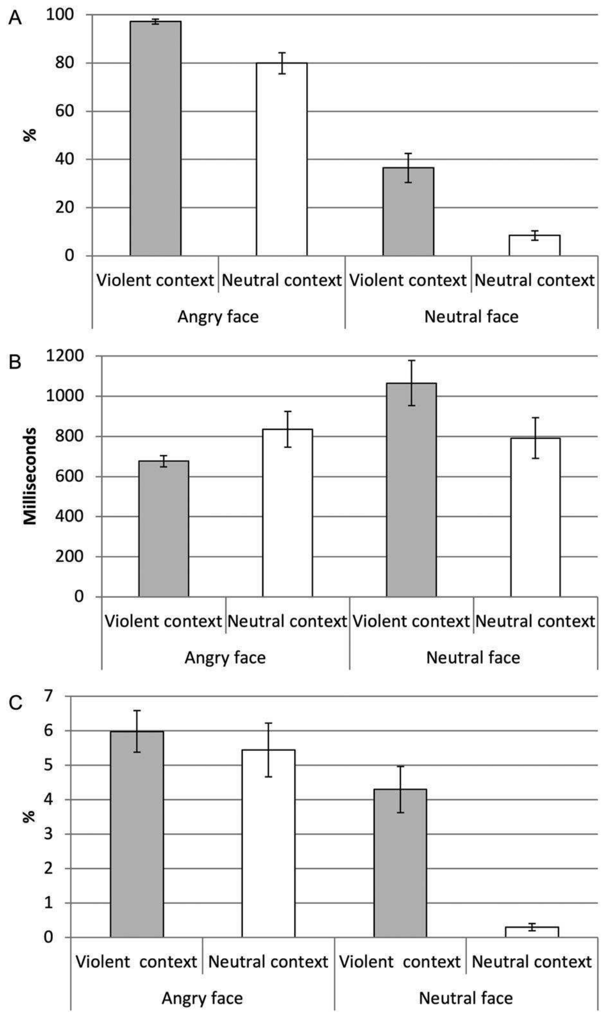

Figure 2. Responses to viewing angry and neutral facial expressions, according to whether they are preceded by violent or neutral contexts. Separate graphs are shown for the different measures and errors bars represent standard errors of the mean. (A) Aggressiveness judgment rates. (B) Reaction times. (C) Corrugator activity (%MVIC).

The context had also a significant effect on the processing of angry faces. When angry faces were preceded by neutral contexts, their perceived aggressiveness was lower and they were responded more slowly than neutral faces. The higher rate of aggressiveness perception in angry faces and the overall shorter RTs for these stimuli have been reported in previous studies (LoBue, 2009). Although there are also reports regarding shorter RTs for happy and neutral faces compared to angry faces (Calvo & Lundqvist, 2008), the nature of the task can account for these seemingly different results. Additionally, it has been suggested that the rapid detection of angry faces has an adaptive value (Fox et al., 2000). In line with this, the corrugator activity showed that angry faces elicited higher activation when they were preceded by violent contexts compared to when the preceding context was neutral. The influence of a preceding context on the facial reactions elicited by angry faces has been previously reported by Philip et al. (2017), with a suppression of corrugator activity when angry faces were preceded by incongruent subliminal words.

In conclusion, these results show that facial reactions and aggressiveness judgments for neutral and angry faces are contextually dependent, where context guides their emotional meaning, probably under top-down control processing. Our results support previous evidence that the observed facial reactions are not a simple matched motor response, but rather indicative of the emotional context framing the meaning of faces (Fischer & Hess, 2017; Hess & Fischer, 2013). Concerning neutrality, seemingly neutral faces may appear as less neutral when framed by aggressiveness context, leading to facial reactions one would expect towards faces that convey such aggressiveness (i.e. angry faces), that is, corrugator activity. Regarding the relation between aggressiveness judgment rates and facial reactions for neutral faces, we propose that facial reactions are a behavioural expression of emotional processing, which involves perception and action. This hypothesis is in line with previous studies that suggest a neural network that integrates sensorimotor information (Caruana, 2019), as a mechanism for emotional processing, resulting in a unification of emotional experience with emotional expression. More research is needed to fully explain the relationship between emotional perception and bodily expression. For instance, more experiments are needed to analyse the effect for other emotional expressions, such as happy faces. Additionally, it is important that future research focuses specifically on the mechanism through which the contextual emotional information influences the perception of the stimuli that are presented.

Disclosure statement

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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