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Stimulus appraisal modulates cardiac reactivity to briefly presented mutilation pictures

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ABSTRACT

Emotional reactions to threatening situations can be either advantageous for human adaptation or unfavorable for physical and mental health if sustained over prolonged periods of time. These contrasting effects mostly depend on the individual's capacity for emotion regulation. It has been shown, for example, that changing appraisal can alter the course of emotional processing. In the present study, the influence of stimulus appraisal over cardiac reactivity to briefly presented (200 ms) mutilation pictures was tested in the context of an affective classification task. Heart rate and reaction time of twenty-four undergraduate students were monitored during the presentation of pictures (neutral or mutilated bodies) in successive blocks. In one condition (*real*), participants were told that the pictures depicted real events. In the other condition (*fictitious*), they were told that the pictures were taken from movie scenes. As expected, the results showed a more pronounced bradycardia to mutilation pictures, in comparison to neural pictures, in the real context. In the fictitious context, a significant attenuation of the emotional modulation (defensive bradycardia) was observed. However, this attenuation seemed to be transient because it was only observed in the first presentation block of the fictitious context. Reaction time to classify mutilation pictures, compared to neutral pictures, was slower in both contexts, reflecting the privileged processing of emotionally laden material. The present findings show that even briefly presented mutilation pictures elicit a differential cardiac reactivity and modulate behavioral performance. Importantly, changing stimulus appraisal attenuates the emotional modulation of cardiac reactivity (defensive bradycardia).

1. Introduction

Current research on stress has focused on the negative aspects of sustained physiological activation induced by situations that represent a threat to the organism (Dhabhar and McEwen, 1999; Low et al., 2009; Lupien and McEwen, 1997; McEwen and Sapolsky, 1995; Sapolsky, 1992). In contrast, research on short-term reactions to threatening stimuli has emphasized the adaptive nature of physiological responses (Dhabhar and McEwen, 1999; McGaugh, 2000; Roozendaal, 2000). It has been demonstrated, for example, that threatening signals that trigger negative emotional reactions receive increased attention resources, modulating autonomic, somatic, and central physiological responses that facilitate stimulus processing (e.g., Azevedo et al., 2005; Bradley, 2009; Erthal et al., 2005; Mocaiber et al., 2010; Oliveira et al., 2009; Pereira et al., 2010; Schupp et al., 2000, 2004). Therefore, whether a negative emotional reaction will be protective and beneficial for human adaptation or will be harmful and promote mental and physical illness strongly depends on the transient or sustained characteristics of the response (Parrot and Schulkin, 1993) and, mostly, on the capacity of the organism to *regulate* the emotional reaction.

Emotion regulation has been defined as the *deliberate* or *automatic* attempts to influence the emotions that individuals experience, when they experience these emotions, and how they experience and express them (e.g., Bargh and Williams, 2007; Gross, 1998a; Gross and Thompson, 2007). Emotion regulation can be achieved through a number of strategies. In general, regulation strategies can be classified as either response-focused or antecedent-focused strategies (Ochsner and Gross, 2005; Gross, 1998b; Ochsner et al., 2004). Response-focused strategies occur relatively late in the emotion-generation process and involve the inhibition of emotional response tendencies once the emotion has been generated. However, antecedent-focused regulation

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strategies occur before the emotion-generation process has been triggered and involve the modification of either the situation or the cognitions about the situation. The cognitive *appraisal* of a situation can be considered an antecedent-focused regulation strategy that refers to altering the meaning of an emotional situation or engaging in particular beliefs about the situation (Mauss et al., 2007). *Appraising* a situation in a different way is considered by various researchers as one of the most effective strategies in decreasing the experience of negative emotions (Moser et al., 2006; Ochsner and Gross, 2005; Ochsner et al., 2002).

It is important to note that the majority of studies on appraisal have focused on *deliberate* emotion regulation, which is voluntary, volitional, and driven by explicit goals. Little is known about *non-deliberate* appraisal processes. It is evident that more often than not, people regulate their everyday emotions without exerting deliberate efforts to do so (Bargh and Williams, 2007; Williams et al., 2009). This effortless emotion regulation mechanism may be particularly important for clinical populations (e.g., anxious individuals) that exhibit failures in the ability to voluntarily down-regulate negative emotions (Mennin et al., 2005) and frequently use maladaptive emotion regulation strategies (Cloitre et al., 2002). In this vein, the present study extends the research on *non-deliberate* appraisal processes. Specifically, it investigates whether the appraisal of negative emotional stimuli (mutilation pictures) as fictitious (originating from movie scenes) affects the well-investigated phenomenon of emotional modulation known as defensive bradycardia. This type of influence can also be referred to as *incidental emotion regulation*, which occurs when contextual factors alter an affective response without one's intentional effort (Berkman and Lieberman, 2009).

A variation of the *picture-viewing paradigm* (Lang, et al., 1993), a procedure that is extensively used to elicit negative emotions in laboratory settings, was employed here. In this paradigm, the modulation of emotional reactivity, indexed by peripheral and central physiological measures, is examined during the passive viewing of emotional pictures selected from the *International Affective Picture System* (Bradley et al., 1996, 2001; Lang et al., 1993). Highly arousing unpleasant pictures (compared to highly arousing pleasant and low arousing neutral pictures) consistently produce a larger heart rate deceleration, interpreted as a vagally-mediated defensive bradycardia (Lang et al., 2000), in addition to other physiological responses (e.g., startle potentiation). This cardiac effect has been demonstrated using long exposure presentations (3–6 s), although similar modulatory effects concerning other physiological responses (e.g., evoked potentials) have been reported using very brief exposure times (120–500 ms) (Codispoti et al., 2001; Schupp et al., 2004; Smith et al., 2006). Thus, the question of cardiovascular modulation by emotional pictures with short exposure times remains open.

In the present study, participants viewed briefly presented (200 ms) neutral and unpleasant pictures that were preceded by antecedent descriptions. Participants were first informed that pictures of mutilated bodies would be presented in the experiment. In the *fictitious* condition, they were instructed that the unpleasant pictures had been taken from movie productions, whereas in the *real* condition, they were instructed that the pictures corresponded to real scenes. Thus, the key manipulation consisted of a subtle and *non-deliberate* appraisal of stimuli triggered by precedent descriptions (Foti and Hajcak, 2008; Oliveira et al., 2009; Mocaiber et al., 2009, 2010). This manipulation has been previously interpreted as a safety signal presentation prior to picture onset (Oliveira et al., 2009). A recent study by our group used a similar paradigm and showed attenuated autonomic reactions (heart rate and skin conductance) to mutilation pictures (exposed for 3 s) when participants with high positive affect scores believed that the pictures had been obtained from movie productions (Oliveira et al., 2009). This was not observed in participants who scored low on positive affect, suggesting that positive affect trait potentiates emotion regulation resulting from the use of safety cues.

Finally, in the present study, an additional element was introduced into the standard picture-viewing paradigm to further accentuate the subtle nature of the appraisal strategy. Participants performed a reaction time *affective picture classification task*, categorizing each picture as affective or non-affective. It was hypothesized that the altered appraisal of the mutilation pictures in the fictitious context would result in an attenuation of the expected cardiac deceleration. Additionally, it was anticipated that the reaction time to mutilation pictures would be slower than that to neutral pictures during the real context (reflecting the capture of attention resources) and that this effect would be attenuated in the fictitious context.

2. Method

2.1. Participants

Twenty-four right-handed undergraduate students (15 female) with a mean age of 21.5 years (±1.76) participated in the current study. Volunteers were selected among students from the Federal Fluminense University, Brazil, and had normal or corrected-to-normal vision. They reported no psychiatric or neurologic problems and were not on medication that acted on the nervous system. Participants were naive as to the purpose of the experiment. The local ethics committee approved the experiment, and participants gave informed consent. Data from 5 additional students were excluded due to excessive electrocardiogram (ECG) artifacts.

2.2. Stimuli and procedure

The experiment was conducted in a sound-attenuated room with indirect lighting. Subjects sat at a distance of 57 cm from the display (distance was fixed via the use of a chinrest). All stimuli were presented using Presentation software (Neurobehavioral Systems, Inc.; Albany, CA). After electrode placement, task instructions were given, and the experimental session was initiated. Participants completed four experimental blocks, two under the *fictitious* and two under the *real* context, in counterbalanced order (half of the participants had one order, and the other half had the inverse order). For each subject, fictitious (F) and real (R) blocks were invariably given one after another (RRFF or FFRR), resulting in *first* and *second block for each context*. In the fictitious context, participants read the following text prior to the task: "… *The pictures that will be shown to you in the next trials were obtained from movies with the aim of convincing the audience… therefore, the pictures were produced by means of diverse techniques such as make-up, and do not correspond to real situations*". In the real context, participants read the following text: "…*The IAPS is a set of standardized colored photographs of a wide range of daily-life situations… All the pictures are real and were obtained from the web, media, or taken by the group that developed the IAPS*". The precedent descriptions were given before the first block of each context. Before the second block of the same context, participants were given a reminder about the origin of pictures (fictitious or real).

Each block included 72 trials that were divided into four sub-blocks of 18 trials (half of the trials with unpleasant pictures, and the other half with neutral pictures) in random order. Neutral images consisted of photographs of people in typical life situations, and unpleasant images consisted of photographs of mutilated bodies. Different neutral and unpleasant pictures were used in each block (18 neutral and 18 unpleasant), and they were repeated twice within the block. Each trial began with a fixation cross, which was displayed for 500 to 900 ms. Then, a central picture ($9° \times 12°$) was presented for 200 ms. A whole-screen gray-scale checkerboard mask was then displayed until the subject responded. After the response was emitted, a black whole-screen remained visible until 3 s from fixation cross elapsed. The next trial began after this black whole screen (intertrial interval). Subjects were instructed to judge whether the pictures were affective or not and to respond as quickly and accurately as possible by pressing one of two keys. Buttons (right or left index finger) corresponding to neutral/affective judgments were counterbalanced across subjects. Reaction time and error rate were recorded.

The images used in the experiment were drawn from the *International Affective Picture System* (IAPS) (Lang et al., 1999) and from the World Wide Web. Following the protocol developed by Lang and colleagues, all images were assessed on a 1–9 scale in terms of valence (from negative to positive) and arousal (from low to high) by a separate group of graduate students ($N = 20$) with ages comparable to the current participants ($M = 22.3$, SD = 1.81). A paired *t*-test showed that unpleasant and neutral images differed significantly from each other on IAPS normative valence ($M = 2.02$, SD = 0.46 and 5.16, SD = 0.42, respectively; $t = 42.09$, df = 71, $p < 0.001$) and arousal ($M = 6.65$, SD = 0.61 and 3.52, SD = 0.64, respectively; $t = 29.59$, df = 71, $p < 0.001$) ratings.

2.3. Physiological recording

A Biopac ECG recorder, model MP100, was used to record the electrocardiogram at lead II using silver/silver chloride electrodes with hypertonic electrolyte paste. A band filter of 0.5–35 Hz and a sampling rate of 1000 Hz were used. Heart rate was obtained from the ECG, which measured the time interval between consecutive R waves (cardiac period). R-wave detection and artifact correction were performed with *Ecglab* toolbox (Carvalho et al., 2002). *KARDIA* (Perakakis et al., 2010), a Matlab software designed for cardiac interbeat interval analysis, was used to obtain heart rate post-stimulus responses. A *fractional cycle counts* algorithm (Dinh et al., 1999) was applied to calculate weighted average heart rate values at 200 ms time windows, during the 2.2 s following picture onset (11 values). The mean heart rate for a baseline period of 6 s prior to each block was subsequently subtracted from the obtained heart rate responses within the block. This procedure avoids carryover effects if the baseline is obtained before each picture due to the short time interval between trials.

2.4. Data analysis

Heart rate data were analyzed by means of 2 × 2 × 2 × 11 repeated-measures ANOVA with *Order* (first versus second block of each context), *Context* (fictitious versus real), *Valence* (negative versus neutral) and *Time* (11 heart rate values) as repeated measure factors. The Greenhouse–Geisser correction was used to account for violations of the assumption of sphericity in the ANOVA analysis. Due to a significant interaction effect of *Order* × *Context* × *Valence* ($F(1, 23) = 5.016$, $p < 0.04$, $\varepsilon = 1.00$, $\eta^2 = 0.179$), separate analysis were performed for the first and second blocks of each context using 2 (*Context*) × 2 (*Valence*) × 11 (*Time*) ANOVAs. For the reaction time and error rate data we also conducted separate 2 (Context) × 2 (Valence) ANOVAs for the first and second blocks. The level of significance was set at $p < 0.05$ for all analyses.

3. Results

3.1. Heart rate

In the *first block of each context*, there was a significant main effect of *Time* with a progressive decelerative response followed by a return toward baseline along the 11 heart rate values ($F(10, 230) = 26.04$, $p < 0.001$, $\varepsilon = 0.184$, $\eta^2 = 0.531$). No significant main effects for *Context* ($F(1, 23) = 0.002$, $p = 0.96$, $\varepsilon = 1.00$, $\eta^2 = 0.00$) or *Valence* ($F(1, 23) = 1.00$, $p = 0.32$, $\varepsilon = 1.00$, $\eta^2 = 0.042$) were observed. Importantly, a significant *Context* × *Valence* interaction was observed ($F(1, 23) = 7.55$, $p < 0.02$, $\varepsilon = 1.00$, $\eta^2 = 0.247$). In the real context (see Fig. 1 left panel), the mutilated pictures elicited a significantly larger deceleration than the neutral pictures ($p < 0.04$). However, in the fictitious context (see Fig. 1 right panel), the difference was not significant ($p > 0.37$).

In the *second block of each context*, a significant main effect of *Time* was found ($F(10, 230) = 26.43$, $p < 0.001$, $\varepsilon = 0.178$, $\eta^2 = 0.535$). However, main effects of *Context* ($F(1, 23) = 0.34$, $p = 0.56$, $\varepsilon = 1.00$, $\eta^2 = 0.015$) and *Valence* ($F(1, 23) = 0.72$, $p > 0.40$, $\varepsilon = 1.00$, $\eta^2 = 0.03$) were not observed. The critical *Context* × *Valence* interaction was not significant ($F(1, 23) = 0.92$, $p > 0.35$, $\varepsilon = 1.00$, $\eta^2 = 0.038$); rather, a significant *Valence* × *Time* interaction was observed ($F(10, 230) = 5.81$, $p < 0.005$, $\varepsilon = 0.21$, $\eta^2 = 0.202$). As illustrated in Fig. 2, mutilation pictures generated a more pronounced bradycardia toward the end of the cardiac response, independently of the context. Significant differences between mutilation and neutral pictures are found only after 1800 ms (all ps < 0.008).

3.2. Behavioral results

Reaction time: In the *first block of each context*, a marginally significant effect of *Context* was found ($F(1, 23) = 3.82$, $p < 0.06$, $\varepsilon = 1.00$, $\eta^2 = 0.149$). As shown in Fig. 3 (left panel), the fictitious context produced a faster response to the pictures (both mutilation and neutral) than the real context. No other effect was found. In the *second block of each context*, a significant main effect of *Valence* was found ($F(1, 23) = 4.88$, $p < 0.04$, $\varepsilon = 1.00$, $\eta^2 = 0.174$). Mutilation pictures, independent of the context, produced slower reaction times than neutral pictures (see Fig. 3 right panel).

Error rate: In the *first block of each context*, a marginally significant main effect of *Valence* was found ($F(1, 23) = 4.23$, $p < 0.06$, $\varepsilon = 1.00$, $\eta^2 = 0.155$). The error rate in the judgment of mutilation pictures ($M = 11.9\%$) was higher than that of neutral pictures ($M = 3.7\%$) ($p < 0.06$). There was no main effect of *Context* ($F(1, 23) = 0.82$, $p = 0.37$, $\varepsilon = 1.00$, $\eta^2 = 0.035$). In the *second block of each context*, no main effects of *Context* ($F(1, 23) = 0.51$, $p = 0.47$, $\varepsilon = 1.00$, $\eta^2 = 0.022$) or *Valence* were found ($F(1, 23) = 1.82$, $p = 0.18$, $\varepsilon = 1.00$, $\eta^2 = 0.074$).

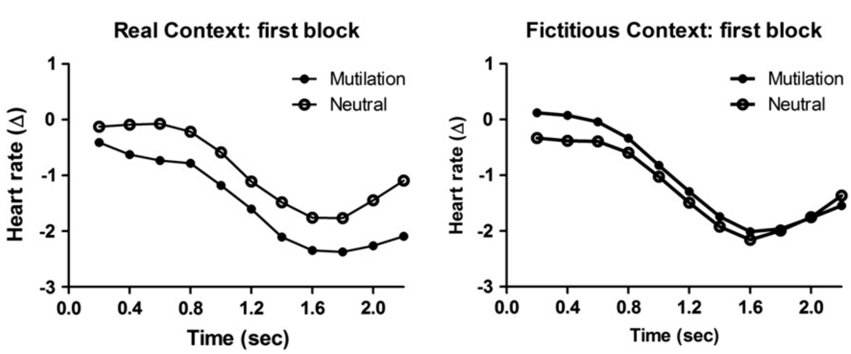

Fig. 1. Heart rate response to mutilation and neutral pictures in the real (left panel) and fictitious (right panel) context during the first block of each experimental context.

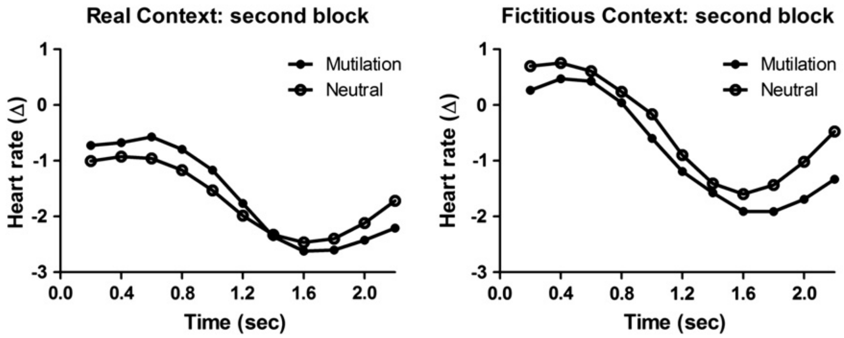

Fig. 2. Heart rate response to mutilation and neutral pictures in the real (left panel) and fictitious (right panel) context during the second block of each experimental context.

4. Discussion

The current results replicate previous findings confirming the validity of the picture-viewing paradigm to modulate physiological and behavioral reactions (Bradley et al., 1996; Lang et al., 1993; Low et al., 2008; Oliveira et al., 2009; Pereira et al., 2006; Sarlo et al., 2002). Heart rate responses varied as a function of picture valence. In the non-fictitious context, mutilation pictures produced a larger decelerative response compared to neutral pictures, as previously reported in various studies (Azevedo et al., 2005; Bradley et al., 1993, 1996, 2001; Facchinetti et al., 2006; Low et al., 2008). This finding is innovative in the sense that previous studies have shown the cardiac modulation with long exposure times, ranging from 3 to 6 s (Azevedo et al., 2005; Bradley et al., 1993, 1996, 2001). Here, it is evidenced that even briefly presented pictures (200 ms) are capable of modulating cardiac reactivity to emotional pictures, exhibiting the classical defensive bradycardia that has been previously described for mutilation images (Bradley et al., 2001).

This larger decelerative response typically observed in humans during the perception of aversive pictures has been interpreted as an attentional defensive reaction analogous to the freezing response observed in animals in natural settings (Azevedo et al., 2005; Bradley, 2009; Bradley et al., 2001; Low et al., 2008; Oliveira et al., 2009). In this context, freezing is the initial stage of the defense cascade, which occurs when the danger is first detected at a safe distance. Freezing is characterized by immobility, increased attention to environmental cues, and heart rate deceleration.

In the present study, this modulatory effect of the aversive pictures on the heart rate response disappeared under the fictitious context (when participants were told that the observed mutilation images were not real but taken from movie pictures). Although this attenuation effect occurred only in the first block of the fictitious context, the presentation of distinct antecedent descriptions likely altered the appraisal of the pictures and, consequently, the emotional reactivity to the perceived aversive stimuli. It is highly probable that the precedent text in the fictitious condition functioned as a safety cue, reducing or eliminating the perception of danger (Lohr et al., 2007; Oliveira et al., 2009), similar to the findings in the original work by Lazarus and Alfert (1964). Analogous effects of antecedent descriptions on central processing have also been reported (Foti and Hajcak, 2008; Mocaiber et al., 2010). Specifically, modulation of the Late Positive Potential (LPP) was found in a context in which a prior description stated that pictures were taken from either movie scenes (Mocaiber et al., 2010). These findings provide further support of the effectiveness of the emotion regulation strategy (distinct appraisal) employed in the present study.

The following two issues in the current data should be considered: the fast habituation of the emotional regulation strategy and the exposure time of the affective pictures shown to modulate the cardiac response. Regarding the habituation issue, the emotional regulation strategy that was employed here was effective in reducing the physiological impact of the mutilation pictures *only* in the first block of the fictitious context. This pattern suggests a transient characteristic of the regulation of cardiac deceleration by altering stimulus appraisal. However, the decreased influence of the fictitious context in the second block might also be explained by the fact that the complete information about the origin of the pictures was only given before the first block. Before the second block, participants received only a reminder. Thus, the capacity of this regulation strategy to attenuate the emotional modulation of cardiac reactivity could have been affected by the reduced information given to participants in the second block.

Exposure time for effective emotional modulation is also a relevant issue. Our results provide new evidence, in the picture-viewing paradigm context, of heart rate emotional modulation using brief exposure presentations (200 ms). This effect has been previously demonstrated using longer exposure times (3–6 s). Codispoti and colleagues found effective modulation of some physiological responses using brief exposure times (500 ms), but they failed to observe the expected heart rate modulation (Codispoti et al., 2001). A relevant methodological difference between the two studies is that the current study required participants to view the pictures and make an active emotional judgment, rather than passively observe the pictures. It is probable that the requirement to perform the affective

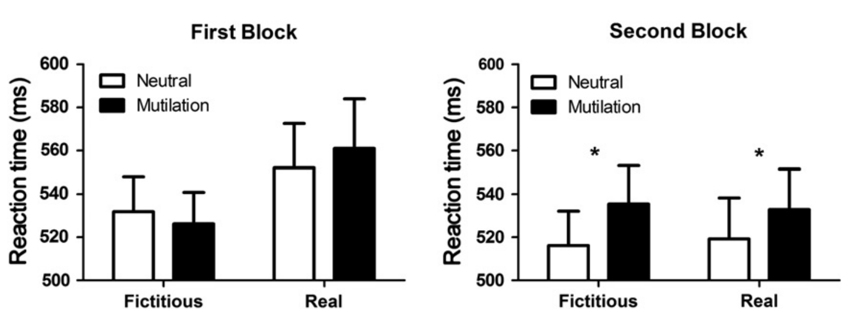

Fig. 3. Mean Reaction time to the mutilation and neutral pictures in the fictitious and real context during the first (left panel) and the second blocks (right panel) of each experimental context.

classification task caused participants to allocate more attentional resources to the pictures, therefore favoring the emotional modulation of heart rate.

Behavior (RT and error rate) was also modulated in the present study. As expected, RT to mutilation pictures was slower than that to neutral pictures in both contexts but only in the second presentation block. Participants also tended to make more errors when judging mutilation pictures, but this effect was only marginally significant. It is important to note that the emotional interference on reaction time was associated with a larger cardiac deceleration to mutilation pictures, relative to neutral pictures, in the same presentation block (second block). A similar emotional interference (indexed by RT) has been reported by previous studies when affective pictures were presented as distractors while subjects performed a primary cognitive task (Carretie et al., 2009; Erthal et al., 2005; Pessoa et al., 2005). For example, one study found that when participants performed a perceptual discrimination task (e.g., judging whether two bars presented in the periphery of the screen are parallel or not), irrelevant unpleasant images presented in the center of the screen, compared to neutral images, slowed the reaction time (Erthal et al., 2005). However, the opposite effect (faster reaction times to unpleasant pictures) was reported when participants performed affective classification as the primary task (Calvo and Avero, 2009). In this case, the participant's task involved assessing the emotional valence of pictures that represented different categories and responding as quickly as possible as to whether they were unpleasant, neutral or pleasant. In both cases, the different reaction time patterns (slowing or acceleration) were interpreted as reflecting the greater attentional resources elicited by the negative pictures, in line with the interpretation of the heart rate deceleration mentioned above.

In summary, the present study shows that even briefly presented mutilation pictures are sufficient to produce a deceleratory response, indicative of defensive bradycardia. The emotional modulation of this response can be attenuated by antecedent descriptions that guide volunteers to appraise negative pictures as “safe”. Thus, this subtle alternative stimulus appraisal seems to be capable of reducing the physiological impact of negative emotional events. The ability to down-regulate negative emotional reactions is a relevant issue in clinical practice. In cognitive therapy, for example, changing appraisal of emotional situations is commonly attempted through deliberate and effortful restructuring of the patient's beliefs and ideas. However, deficits in emotion regulation skills seem to be critical to the development and maintenance of a wide range of mental disorders (Gross and Muñoz, 1995). Thus, the manipulation employed here can be seen as external information, which safely drives one's reactivity to emotional challenges. In this vein, patients who frequently manifest reduced ability to voluntarily control their own emotions (Meninn et al., 2005) could take advantage of the exposure to safety signals during stressful events recall. Over time, this could have the potential role to teach patients the use of particular strategies that may be useful for the reduction of emotion arousal. The current study suggests that simpler and less effortful cognitive strategies may prove beneficial for down-regulation and attenuation of harmful emotional reactions.

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