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Divergent attentional effects of nondeceptive placebo treatment and cognitive reappraisal during visually induced emotional distress: an eye-tracking study

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Abstract

Background: Emotion regulation often involves shifting attentional focus. This eye-tracking study with a divided attention task compared nondeceptive placebo treatment and cognitive reappraisal for reducing emotional distress. It was investigated whether the two types of interventions would differ in attentional processes (directing attention toward the external environment vs. one's body).

Method: A total of 116 participants (mean age = 26.5 years; 50% female) were randomly allocated to one of three groups that were each exposed to images depicting body parts with or without injuries. One group received a placebo pill to reduce emotional distress, while another group engaged in cognitive reappraisal. The third group passively viewed the images. Half of the images were coupled with an electrocutaneous stimulus (at the perceptual threshold level) that was administered to participants' forearms. The task was to view these images with eye-tracking glasses while also responding as quickly as possible to the tactile sensation evoked by the electrocutaneous stimulus (pressing a response button).

Results: Cognitive reappraisal provoked a relative increase in total gaze time for injuries as predicted. The majority of participants in this group responded accurately to the electrocutaneous stimuli administered during injury images (no omissions). In contrast, the maximal number of omission errors was most prevalent in the placebo group.

Limitations: Participants reported a low level of fear concerning injuries, which could indicate a self-selection bias.

Conclusion: Both regulation strategies exerted a protective effect against emotional distress. However, cognitive reappraisal heightened attention, while a reverse pattern was found for placebo treatment. To assess the clinical implications of these findings, future studies should target patients with blood-injury phobia.

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1. Introduction

An effective management of negative emotions is crucial for both our mental and physical well-being (Aldao et al., 2010; Gross, 1998; 2015; Fiaschi et al., 2019; Tsujimoto et al., 2024). On the one hand, successful emotion regulation (ER) can enhance well-being and is crucial when seeking to alleviate emotional distress in nonclinical contexts (Brockman et al., 2016; Koval et al., 2023; Iannattone et al., 2023; Magalhães et al., 2023). On the other hand, difficulties in ER are central to the development and maintenance of psychopathology (Daros et al., 2021; Gratz et al., 2015; Hu et al., 2014; Kraiss et al., 2020; Riepenhausen et al., 2022). These difficulties have been widely acknowledged as transdiagnostic factors in common diagnoses such as anxiety disorders and depression (e.g., Sloan et al., 2017).

ER is a multidimensional construct that refers to a diverse array of processes involved in modifying emotional experiences. However, attention processes are of central importance for ER, and it is generally agreed upon that attention (re)direction can be used to change the affective state of a person. A change in attentional focus has been conceptualized as a separate ER strategy (Gross, 1998), but also as a process that accompanies different forms of ER (Koole, 2009). It has been shown that cognitive reappraisal (CR), a strategy for ER, is associated with shifts in visual attention (Bardeen & Daniels, 2017; Manera et al., 2014; van Reekum et al., 2007, but also see Bebko et al., 2014). CR is one of the most studied ER strategies; this strategy aims to change the meaning of an emotion elicitor (Gross, 1998). For example, when individuals are confronted with an unpleasant image, they can use CR and reassess the authenticity of what is being depicted ('this is not real'), psychologically distance themselves from the emotional stimulus ('this negative situation will not happen to me in the near future'), or apply perspective taking ('this negative situation will turn out well'). These examples demonstrate that mechanisms of reappraisal implementation include active engagement with the emotion elicitor, linguistic elaboration, and cognitive control (McRae & Gross, 2020).

A valuable method for investigating the role of visual attention in ER is eye-tracking. An experiment by Manera et al. (2014) studied participants' gazes as they were presented with videos that depicted people in a sad mood. They found that, after having been asked to down-regulate their emotions, participants spent less time looking at the emotional regions in the face of the person in the video (eyes and mouth). Using a similar approach, van Reekum et al. (2007) instructed participants in their study to either passively view aversive images or to up-regulate or down-regulate the negative affect elicited by the images. During down-regulation (implemented by imagining that the situation in the picture was not real), it was found that

participants' attentional focus was directed to areas depicting the least relevant parts of the scenes. The eye-tracking experiments described here demonstrate that using CR is accompanied by shifts in externally directed attention (see Strauss et al., 2016).

An alternative approach for the regulation of emotional distress is the use of placebos. Placebo interventions include different forms of sham treatments, for instance, pills not containing any pharmacologically active ingredients ('sugar pills'). Eye-tracking investigations on the effects of placebo treatment are still scarce and those carried out have mainly focused on so-called 'deceptive' placebos, where an inert treatment is introduced as being an active intervention, such as a medical procedure (Schienle et al., 2016; Gremsel et al., 2018; Potthoff et al., 2019). For example, in a study by Schienle et al. (2016) which used a retest design, participants looked at picture pairs (disgust, neural) which were viewed once with and once without a placebo (introduced as an 'antinausea medication'). The placebo provoked a marked decrease in experienced disgust and enhanced the number of fixations for disgusting images. Gremsel et al. (2018) used a similar design. In that study, participants with spider phobia viewed picture pairs (spider, neutral), once with and once without the administration of a placebo (introduced as an 'anxiolytic medication'). The placebo increased the fixation count and the total fixation duration on spiders. These changes might reflect a greater willingness of participants to view the aversive stimuli while on the placebo. Thus, it would appear that the use of deceptive placebos can also elicit shifts in visual attention (attentional engagement).

To the best of our knowledge, there has been no eye-tracking study carried out thus far that has evoked emotional distress and tested the effects of a nondeceptive placebo. This type of placebo treatment circumvents ethical issues associated with the administration of 'deceptive' placebos (lack of transparency/ informed consent) and therefore can be used in clinical practice.

In the present investigation, all participants were presented with negative and neutral images (body parts with/ without injuries; see Supplementary Figure S1). Half of the pictures (50% neutral, 50% negative) were coupled with an electrocutaneous stimulus (administered to the left forearm at the perceptual threshold level). Participants were asked to look at the images and also to react to the occurrence of the electrocutanous stimulus (pressing a response button as fast as possible). Thus, the task required divided attention between picture viewing (directing attention to the external environment) and detection of a somatic (tactile) sensation (directing attention to one's body). Before the experiment, participants were randomly allocated to one of three groups: a passive-viewing group (PV), a group that received nondeceptive placebo treatment (a placebo pill: PP), or a group that engaged in cognitive reappraisal (CR). The active

treatments (PP, CR) were introduced as strategies for the down-regulation of emotional distress. All participants assessed their emotional state (valence and arousal) both before and after the experiment, as well as following each presentation of a picture.

1.1 Hypotheses and research questions

The emotion regulation strategies CR and PP have been linked to successful downregulation of negative affect (e.g., McRae & Gross, 2020; Jurinec & Schienle, 2022). Therefore, it was hypothesized that implementation of the two strategies would lead to a reduction in self-reported emotional distress (valence, arousal) compared to passive viewing. Previous eye-tracking research has revealed that participants who are instructed to downregulate their emotions when presented with negative images tend to direct their attention towards these images, albeit spending less time looking at the emotionally arousing regions. Consequently, it was hypothesized that fixation duration for the injury images (relative to no injury) would be longer for CR compared to PV (van Reekum et al., 2007; Manera et al., 2014).

To the best of our knowledge, no previous investigation has focused on changes in attention due to nondeceptive placebo treatment. Therefore, two exploratory research questions were posed concerning possible group differences between CR and PP concerning the visual exploration of the negative images (number of fixations, total fixation duration) and the performance in the reaction time task (reaction times, omission/commission errors).

Finally, in a previous investigation, CR was evaluated as a more effective and plausible emotion regulation method than nondeceptive placebo treatment (Schienle et al., 2023). It was analyzed, whether participants of the present study would give similar ratings. In an exploratory analysis, comparisons were made between the PP and CR groups regarding the perceived effort required when utilizing the two ER strategies.

2. Method

2.1 Sample

Data were analyzed from 116 healthy participants (mean age = 26.5 years, SD = 5.6; 50% female) who were randomly assigned to three groups: Cognitive Reappraisal (CR), non-deceptive placebo treatment with a placebo pill (PP), or Passive Viewing (PV). Five participants from the PV group of the original sample (n = 121) were excluded from further analysis because they had reported no emotional distress at all during the presentation of the negative images (the remaining sample size was n = 116). The groups did not differ in mean age ($F(2,113) = 0.92$, $p = .403$, partial $eta^2 = .016$), gender ratio ($Chi(2)^2 = 1.12$, $p = .572$), scores on the Mutilation

Questionnaire (MQ; Kleinknecht et al., 1990; $F(2,113) = 0.55$, $p = .577$, partial $eta^2 = .010$), and the cognitive reappraisal scale of the Emotion Regulation Questionnaire (ERQ; Gross & John, 2003; $F(2,113) = 0.87$, $p = .423$, partial $eta^2 = .015$; see Table 1). The MQ (Cronbach's $\alpha = .81$) measures blood/injury fears with 30 items (e.g., "I feel sick at the sight of blood", "I dislike pictures of injuries"; answer mode: yes/no). Validation studies have shown that high MQ scores are associated with a diagnosis of blood-injury phobia (Kleinknecht et al., 1990). The ERQ has 10 items and is one of the most widely used measures to assess individual differences in the habitual use of two emotion regulation strategies: expressive suppression (not included here) and cognitive reappraisal ("When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about"; answer mode: strongly disagree (1) – strongly agree (7); Cronbach's $\alpha = .87$). The ERQ is positively correlated with other self-report measures to assess ER: the Difficulties in Emotion Regulation Scale (DERS; Gratz & Roemer, 2004).

The sample size was based on a power analysis for three groups and two picture types (Faul et al., 2007). It was determined that for an effect size of .18 (partial eta^2) together with an alpha error probability of .05 and a power of .95, 120 participants would be needed. Of the participants, 65% were students. All participants reported having normal or corrected-to-normal vision (with contact lenses).

Exclusion criteria were reported diagnoses of mental disorders (e.g., affective disorders, anxiety disorders including blood-injury phobia), neurological disorders (e.g., neuropathy, resulting in symptoms such as pain, and numbness), intake of psychotropic medication, and contraindications for eye-tracking (glasses). All participants provided informed consent and the study followed the Declaration of Helsinki and received approval from the ethics committee of the University of Graz (G2.39/82/63 ex2022/23). The study was preregistered at the German Clinical Trials Register (https://drks.de/search/de/trial/DRKS00031578, 25/04/2023).

2.2 Images

Participants were presented with a total of 20 pictures. Ten images depicted body parts (hand, forearm, face, neck, leg) with injuries, whereas the other ten images depicted the same body parts without injuries (see Supplementary Figure S1). Pictures were selected from the International Affective Picture System (IAPS, Lang et al., 2008), as well as free databases (Pixabay, Unsplash). The images from the injury/ non-injury condition were comparable in physical features, such as complexity, color composition, and brightness.

Following the presentation of a central fixation cross, each picture was displayed for 10 seconds. Images were projected on a white wall in a dimly lit room in a size of 160 cm by 120 cm at a

viewing distance of 250 cm (visual angle of 36° horizontally and 27° vertically). The sequence of images was randomized. After each picture presentation, participants rated their emotional distress. They were asked to answer the questions: "How negative do you feel right now?" (negative valence), and "How aroused do you feel right now?" (arousal). The responses were given via a slider (0 "not aroused/not negative" to 100 "very aroused/ negative").

Table 1. Comparison of the three experimental groups (means, standard deviations)

		Placebo Pill *n* = 41 23 female, 18 male	**Cognitive Reappraisal** *n* = 41 19 female, 22 male	**Passive Viewing** *n* = 34 16 female, 18 male
Age (years)		25.68 (4.31)	27.34 (7.31)	26.35 (4.39)
Questionnaires				
Mutilation Questionnaire		8.83 (4.63)	8.76 (4.85)	9.76 (4.03)
Cognitive Reappraisal		4.13 (0.86)	3.87 (1.01)	4.00 (0.78)
Affective state before and after the experiment				
Negative Valence	(before)	11.32 (17.64)	15.95 (19.29)	11.03 (15.59)
	(after)	11.56 (17.36)	11.70 (16.04)	18.41 (18.91)
Arousal	(before)	20.34 (22.62)	32.41 (23.60)	34.29 (22.50)
	(after)	14.17 (18.15)	16.73 (19.72)	24.35 (23.05)
Affective state during the viewing of no/injury images				
Negative valence	(injury)	23.27 (22.45)	16.80 (16.84)	22.90 (18.68)
	(no injury)	13.21 (15.93)	9.75 (13.18)	9.25 (11.59)
Arousal	(injury)	22.12 (21.11)	26.81 (19.99)	27.27 (21.26)
	(no injury)	14.70 (16.69)	20.96 (19.70)	15.30 (16.81)
Eye-tracking				
Fixation duration [ms] (injury)		9328 (952)	9448 (581)	9441 (603)
(no injury)		9407 (723)	9272 (686)	9346 (643)
Fixation count (injury)		17.10 (4.79)	17.08 (4.62)	17.14 (4.11)
Fixation count (no injury)		15.14 (4.80)	15.45 (4.77)	15.17 (4.00)
Responses to electrocutaneus stimulation: Reaction times (s)				
Injury		1.71 (0.30)	1.78 (0.68)	1.80 (0.37)
No injury		1.35 (0.79)	1.30 (0.42)	1.30 (0.38)
Correct responses (hits)				
Injury		3.85 (1.62)	4.42 (1.20)	4.35 (1.07)
No injury		4.02 (1.51)	4.61 (1.00)	4.32 (1.32)

2.3 Tactile stimulus

The participants received electrocutaneous stimulation to the skin on the medial side of their left forearm (using two self-adhesive Ag/AgCl surface electrodes (Ternimed; 2 cm) with the DS8R biphasic direct current stimulator (Digitimer, Letchworth Garden City, SG6 9BL, UK).

For each participant, the intensity of the stimulus was individually determined at the perceptual threshold level via a staircase method. The stimuli were administered during the presentation of five images with injuries and five images without injuries (at random time points). Participants were asked to react as fast as possible via a mouse click (with the right hand) to the stimulus. Mean reaction times per picture (in ms) were recorded as well as the number of missed responses and false alarms (omission/commission errors).

2.4 Eye-Tracking

Gaze data during the free-viewing task were recorded at a 200 Hz sampling rate with Pupil Labs Invisible eye-tracking glasses. In the Pupil Labs Cloud, rectangular areas of interest (AOIs) were defined for the 20 images using the Reference Image Mapper. Fixation data (location and duration) were exported from the Pupil Labs Cloud and a custom R-code was used to calculate the total fixation duration (dwell time) and the number of fixations (fixation count) for each AOI and each participant. The total fixation duration indicates how long each image was looked at overall, and the number of fixations indicates how many details of an image were viewed (e.g., Bortolla et al., 2023; Höfler et al., 2018, 2019; Potthoff et al., 2024).

2.5 Procedure

The participants were recruited through mass mailings at the University and via social media channels. They were invited to a study on the processing of affective images (depicting injuries) focusing on changes in pupil diameter. We did not mention the use of eye-tracking for studying visual attention so that the participants would not try to willingly influence their eye movements during the picture viewing.

In the lab, participants first rated their affective state (negative valence, arousal) on scales ranging from 0 (not negative, not aroused) to 100 (very negative, aroused). Then they were randomly assigned (random number table) to one of three groups (CR, PP, PV). Each group received different information sheets (one page) including instructions for the picture viewing task and a brief background about the specific method.

The PP group was first informed about the concept of placebos (deceptive, nondeceptive) and associated neurobiological correlates. Instructions followed established recommendations for the administration of open-label placebos (Kaptchuk et al., 2010). Participants were informed (1) that placebos can have beneficial effects on various symptoms, (2) that the body can respond automatically to the placebo, and (3) that an optimistic attitude towards the placebo is beneficial but not necessary. Subsequently, OLP participants received a white 1cm long capsule filled with

starch for oral intake. They were instructed that the placebo could help to reduce emotional distress.

Participants of the CR group received information about emotion regulation and associated neurobiological correlates. They were asked to imagine that the shown scenes and objects within the images were not real but created by a special-effects artist (e.g., fake blood; this instruction has been used in several investigations (e.g., van Reekum et al., 2007; Schienle et al., 2017; 2023).

The PV group received information on pupillometry (e.g., that changes in pupil diameter are indicative of emotional processes) and was asked to view the images passively (without trying to change the elicited emotions).

After the instructions, the PP group and the CR group rated the expected effectiveness of the intervention (0 = not effective; 100 = very effective). Then, the electrodes were attached to the forearm of the participants, which had been cleaned with alcohol. The participants were then provided with eye-tracking glasses.

Directly before the picture presentation, the group-specific instructions were repeated verbally by the experimenter (PP: "Please remember that the placebo you received can help you to reduce your negative emotional reactions to the images"; CR: "Please remember that the objects and situations shown in the pictures are not real, but have been created by a special-effects artist"; PV: "Please remember to watch each image carefully for the entire duration of the presentation").

After the study, participants again rated their affective state (negative valence, arousal) on scales ranging from 0 (not negative, not aroused) to 100 (very negative, aroused). The CR/PP groups additionally rated the perceived effectiveness of the intervention, the plausibility of the rationale, and the effort associated with CR/PP on a scale ranging from 0 to 9 (9 = very effective, very plausible, great effort).

2.6 Statistical analysis

Ratings for negative valence and arousal before and after the experiment (Factor Time: before, after) were compared between the Groups (PP, CR, PV) via a 2x3 analysis of variance (ANOVA). We additionally computed 2x3 ANOVAs to test the effects of Picture Type (injury, no injury) and Group on the affective ratings (negative valence, arousal) during the image presentation, reaction times to the electrocutaneous stimuli as well as the eye-tracking parameters (total fixation duration, number of fixations).

An additional ANOVA was conducted to compare the two active groups (PP, CR) concerning the expected/ perceived effectiveness of the intervention (before, after). Ratings for the plausibility of the rationale and effort related to PP/CR were compared between the two groups via t-tests.

Finally, we compared the number of missed responses to the electrocutaneous stimuli as well as false alarms between the groups (separately for images depicting injuries vs. no injury. Because of violations of assumption for the Chi^2 test (value of cells < 5), we report the likelihood coefficient. Effects were considered statistically significant when the observed p-value was below .05. The analyses were computed with SPSS (version 29).

3. Results

3.1 Affective ratings before and after the experiment

For negative valence, the ANOVA revealed a significant interaction effect for Group x Time ($F(2,113) = 4.86$, $p = .009$, partial $eta^2 = .079$). The main effects for Time ($F(1,113) = 0.56$, $p = .455$, partial $eta^2 = .005$) and Group ($F(2,113) = 0.46$, $p = .634$, partial $eta^2 = .008$) were not significant (Table 1). While negative valence increased throughout the experiment in the PV group (M(diff) = 7.38, SD =17.89, $t(33) = 2.41$, $p = .022$), this increase was absent in the two other groups (CR: M(diff) = -4.24, SD = 19.16, $t(40) = 1.42$, $p = .16$; PP: M(diff) = 0.24, SD = 10.20, $t(40)= 0.15$, $p = .88$).

For arousal, the main effects for Time ($F(1,113) = 30.17$, $p <.001$, partial $eta^2 = .211$) and Group ($F(2,113) = 3.88$, $p = .024$, partial $eta^2 = .064$) were statistically significant (Table 1). The interaction Group x Time, was not significant ($F(2,113) = 2.19$, $p = .117$, partial $eta^2 = .037$). Reported arousal decreased over time (Before experiment: M = 28.70, SD = 23.58; after experiment: M = 18.06, SD = 20.50, $t(115) = 5.48$, $p < .001$). The PP group (M = 17.26, SD = 18.46) reported lower arousal than the PV group (M = 29.32, SD = 19.95; $t(73)= -2.72$, $p = .008$). The other comparisons were not significant (all $p > .078$).

3.2 Affective ratings during the picture viewing

For negative valence, the main effect for Picture Type was significant ($F(1,113) = 79.67$, $p < .001$, partial $eta^2 = .414$). The affective state during the viewing of injury pictures was rated as more negative. The Group effect was not significant ($F(2,113) = 1.02$, $p = .362$, partial $eta^2 = .018$). The interaction Picture x Group was marginally significant ($F(2,113) = 2.67$, $p = .074$, partial $eta^2 = .045$). The valence difference scores (injury minus no injury) differed significantly between the CR group (M = 7.05, SD = 8.11) and the PV group (M = 13.65, SD = 15.10;

t(48.40) = -2.29, p =.026). The other group comparisons were not statistically significant (all p > .218).

For arousal, the main effect for Picture was significant (F(1, 113) = 92.48, p<.001, partial eta^2 = .450) as well as the interaction Picture x Group (F(2, 113)= 4.16, p=.018, partial eta^2 = .069). Injury pictures induced more arousal than pictures without injury (injury: M = 25.29, SD = 20.72, no injury: M = 17.09, SD = 17.93, t(115) = 9.16, p < .001). The difference score (injury minus no-injury) was higher in the PV group (M = 11.97, SD = 11.20) compared to CR (M = 5.85, SD = 7.54; t(55.93) = 2.72, p = .009) and PP (M = 7.42, SD = 9.41; t(73) = 1.97, p = .050).

3.3 Responses to the electrocutaneous stimulation

On average, participants correctly responded to M = 8.52 electrocutaneous stimuli (SD = 2.54; max score = 10). The groups did neither differ concerning their hit rates (correct responses to electrocutaneous stimuli; F(2,113) = 2.23, p = .112, partial eta^2 = .038), nor reaction times (F(2,106) = 0.03, p = .967, partial eta^2 = .001).

The proportion of omission errors during the presentation of injury images differed between the groups (likelihood coefficient LC(10) = 18.73, p = .044; see Table 2). No omissions were most frequent in the CR group, whereas the highest number of omissions was associated with PP. The proportion of omissions did not differ between groups for non-injury images (likelihood coefficient LC(10) = 7.57, p = .671). There was no difference in the proportion of committed false alarms between the groups for either injury pictures (likelihood coefficient LC(8) = 4.17, p = .842) or non-injury pictures (likelihood coefficient LC(2) = 4.17, p = .803).

Table 2. Distribution of committed omission errors (OE) per group during the presentation of injury images

	Placebo Pill (n = 41)	**Cognitive Reappraisal (n = 41)**	**Passive Viewing (n = 34)**
OE (sum)			
0	23	30	21
1	4	5	8
2	7	2	3
3	3	2	0
4	0	1	2
5	4	1	0

3.4 Eye-Tracking

For the total fixation duration (dwell time), the interaction Picture x Group was significant (F(2,110) = 3.02, p = .050, partial eta^2 = .058). There were no main effects of Group or Picture

Type on total fixation duration (Group: F(2, 110) =.014, p = .986, partial eta^2 <.001; Picture Type: F(1,110)=2.33, p = .130, partial eta^2 =.021). The difference score (injury minus no-injury) was higher in the CR group (M(diff) = 216 ms, SD = 501) than in the PP group (M(diff) = -79 ms, SD = 657, t(78) = 2.26, p = .027); the other group comparisons were not significant (all p > .09).

For the number of fixations, we found a statistically significant main effect for Picture Type (F(1, 110)= 38.93, p < .001, partial eta^2 = .261), with the number of fixations being higher for injury pictures compared to non-injury pictures (M = 17.10, SD = 4.50 vs. M = 15.26, SD = 4.53). Neither the main effect Group nor the interaction Picture x Group reached statistical significance (Group: F(2,110) =.01, p = .988, partial eta^2 < .001; Picture x Group: F(2,110) = .150, p = .861, partial eta^2 = .003).

3.5 Efficacy, Plausibility, and Effort

For efficacy, the ANOVA indicated a significant main effect for the type of intervention (F(1,80) = 50.41, p < .001, partial eta^2 = .387). Ratings for expected and perceived efficacy were higher in the CR group than in the PP group (for expected efficacy: t(80) = 6.19, p < .001; for perceived efficacy, t(80) = 6.58, p < .001; see Table 3).

The plausibility of the rationale was assessed as higher for CR than PP (t(75.30) = 5.44, p <.001; Table 3). The estimated effort to engage in both interventions did not differ between the groups (t(74.28) = 0.25, p = .803).

Table 3. Comparison of Groups: Placebo Pill and Cognitive Reappraisal

	Placebo Pill	Cognitive Reappraisal
Efficacy (expected)	2.95 (1.84)	5.56 (1.98)
(perceived)	2.49 (1.73)	5.44 (2.29)
Plausibility	4.12 (2.54)	6.85 (1.97)
Effort	5.90 (3.14)	6.05 2.77)

4. Discussion

This eye-tracking study with combined electrocutaneous stimulation explored the effects of nondeceptive placebo treatment and cognitive reappraisal on attentional and affective processes during visually induced emotional distress.

It was found that CR produced the predicted changes in participants' self-reports (Gross, 1998; Gross, 2015; McRae & Gross, 2020). Specifically, the difference in negative valence when looking at images depicting injury vs. those without injury was smaller in the CR group compared to the PV group. Consequently, participants engaging in CR experienced the negative and neutral stimuli as being more alike than the PV participants. Additionally, only in the PV

group, negative valence increased throughout the experiment (as indicated by the pre- and post-experiment valence measures). In other words, repeated exposure to the images depicting blood and mutilation increased the negative mood of the participants who did not employ any regulation strategy; in contrast, CR was even characterized by the reverse trend. These findings are in line with the well-established beneficial effects of CR (Gross, 1998; Gross, 2015; McRae & Gross, 2020; Schienle et al., 2023).

As hypothesized, both CR and PP exhibited a positive impact on reported arousal levels during the viewing of the pictures (e.g., McRae & Gross, 2020; Jurinec & Schienle, 2022). In both groups (CR/PP), the differences in ratings of arousal for injury vs. no-injury stimuli were smaller than in the PV group.

The analysis of the eye-tracking data revealed a differential effect of the interventions on total fixation duration. CR was associated with more time spent fixating on the injury images relative to no injury. This was in line with the prediction (van Reekum et al., 2007; Manera et al., 2024). In contrast, the PP group tended to look longer at the non-injured body parts. The latter finding is not in line with previous findings on the effects of deceptive placebos (e.g., Gremsl et al., 2018). In that study, the placebo increased the total fixation duration for negative (relative to neutral) images. However, it is important to note that a direct comparison between these findings is difficult since Gremsl et al. (2018) presented picture pairs, while the current investigation presented individual images sequentially.

In contrast, the effects observed for the CR group align with previous eye-tracking investigations (Manera et al., 2014; van Reekum et al., 2007). In these studies, participants who engaged in CR were found to focus their attention on the aversive images and changed their style of visual inspection (spending less time looking at the emotional regions of the images). The limitations of the eye-tracking glasses employed in this study prevented us from performing an area of interest (AOI) analysis, which would have allowed the comparison of fixation counts for various sections of the images. Consequently, we were unable to determine whether the CR group actively avoided focusing on blood within the images or if the CR instruction (the depicted content is not real) led them to engage in a more detailed examination of the blood to confirm its artificial nature. In contrast, the PP suggestion "The placebo can help you to reduce emotional distress" does not promote in-depth processing of visual stimulus information.

A very interesting finding was observed concerning the responses to the electrocutaneous stimulation, particularly the response omissions. The CR group had the highest number of participants who made no omission errors at all, while the maximal number of errors (five omissions) was most prevalent in the PP group. A high rate of omission errors is thought to

reflect attentional lapses due to task disengagement (Cheyne et al., 2009; Perri et al., 2017). In contrast, a low omission rate is considered an index of alertness, a state of active attention characterized by high sensory awareness.

Finally, the present study was able to replicate findings concerning the perceived plausibility and efficacy of PP compared to CR (Schienle et al., 2023). In that study, CR was also rated as a more plausible and effective intervention than PP. In the current study, commentaries from some participants after the experiment indicated that they found the rationale of swallowing a pill without any active ingredients to be unconvincing. Thus, for future investigations, it could be important to identify nonresponders to this type of placebo treatment beforehand.

Moreover, future investigations should include physiological measures such as heart rate, or skin conductance that are objective indicators of alertness. Alertness refers to a general state of vigilance and readiness to respond to stimuli in the environment. It is possible that the placebo treatment decreased physiological arousal and associated alertness, which led participants to respond less accurately to the mild electrocutaneous stimulation. This is an alternative parsimonious explanation of the findings (see Myles & Jonsen, 2023).

4.1 Strengths and limitations of the present study

We need to mention the following limitations of the present study. The selected pictures of injury inflicted only low levels of emotional distress. This is surprising as some of the pictures do show severe damage to the body. The picture set that was used has been validated previously (IAPS, Lang et al., 2008), and received higher ratings for negative valence and arousal in other samples. One reason for the low negative valence elicited by the pictures in this study may be the participants' relatively low scores on the Mutilation Questionnaire (M = 9 from 30 possible points). Participants were informed prior to the experiment that they would be exposed to images depicting injuries, as mandated by the ethics committee. This information likely contributed to a self-selection bias. Furthermore, static images were presented. The use of videos could potentially induce emotional distress more effectively.

Both ER strategies influenced the affective state in the predicted direction. However, CR was perceived as a more effective and plausible method for emotion regulation. Previous research has utilized more comprehensive materials, such as reading articles, to provide information on the effects and underlying mechanisms of nondeceptive placebos before the experiment (e.g., Guevarra et al., 2020). This approach could be necessary because laypersons are often unfamiliar with the concept of nondeceptive placebos (Haas et al., 2021).

Assets of this research include the large sample of participants tested in a controlled laboratory environment. The study not only relied on self-reports but also utilized eye-tracking and a

reaction-time task to investigate the effects of CR and PP. The study's findings highlight the role of different forms of attention modification in emotion regulation (Myles, 2021).

5. Conclusion

CR and PP exerted a protective effect against emotional distress. However, attentional processes differed between the two regulation strategies. While CR heightened visual attention to the aversive images and alertness, a reverse pattern was found for PP.

Future research now needs to investigate which specific individual characteristics (e.g., individual goals, preferences for using specific regulation techniques) and context variables (e.g., situations/ stressors) are associated with greater regulation success concerning PP and CR.

Moreover, to assess the clinical implications of the present findings, subsequent studies should target patients with blood-injury phobia. This patient group may profit more from the nondeceptive placebo treatment than the low-fearful participants of the present investigation. Existing evidence has already demonstrated that the effects of nondeceptive placebos tend to be more pronounced in clinical as opposed to nonclinical samples (Buergler et al., 2023).

Ethical approval

The study followed the Declaration of Helsinki and received approval from the ethics committee of the University of Graz (G2.39/82/63 ex2022/23). The study was preregistered at the German Clinical Trials Register (https://drks.de/search/de/trial/DRKS00031578, 25/04/2023).

Informed Consent Statement

Informed consent was obtained from all subjects involved in the study.

Data Availability Statement

Data are available from the corresponding author via email

Conflict of interest statement

The authors declare no conflict of interest**.**

Authors' Contribution

Conceptualization, AS; formal analysis (eye-tracking), J.P.; investigation, K.H., W.K.; writing—original draft preparation, A.S.; writing—review and editing, J.P., K.H., W.K., All authors have read and agreed to the published version of the manuscript.

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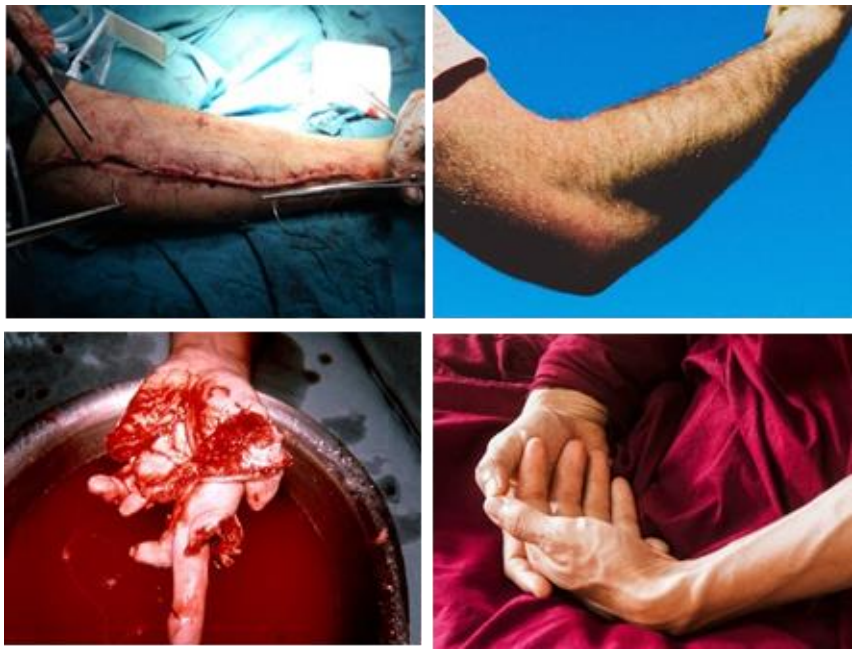
Supplementary Materials



Supplementary **Figure S1**: Images with and without injury (examples)