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Susceptibility to others' emotions moderates immediate self-reported and biological stress responses to witnessing trauma

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ABSTRACT

Background: The peri-traumatic stress response is a strong predictor of symptom development after trauma exposure. Regarding witnessing trauma, the stress response might depend on the susceptibility to others' emotions (emotional contagion, EC). This study investigated whether EC moderates the immediate stress response using a trauma film paradigm.

Methods: Ninety-five healthy participants were randomly exposed to a trauma or a neutral film. Perceived stressfulness of the film and pre-to post-film changes in self-reported anxiety, heart rate and saliva cortisol levels were assessed. EC towards negative and positive emotions was measured using the emotional contagion scale and its emotion-specific subscales.

Results: Overall, the trauma film was perceived as distressing and elicited an increase in self-reported anxiety, heart rate and saliva cortisol levels relative to the neutral film. EC towards negative emotions was positively related to the perceived stressfulness of the film, increased anxiety and increased heart rate. The association with saliva cortisol levels was also in the expected direction, but not statistically significant. These associations were not found for EC towards positive emotions.

Discussion: EC towards negative emotions may be an important predictor of trauma exposure outcomes. Further research should clarify its specific contribution in witnessing and undergoing trauma.

1. Introduction

Traumatic events have a high lifetime prevalence ranging between 60.7% and 76.2% across different countries (Benjet et al., 2015). Exposure to traumatic events is associated with a higher risk for various mental disorders such as posttraumatic stress disorder (Karam et al., 2014; McLaughlin et al., 2015), anxiety disorders (Asselmann, Wittchen, Lieb, Perkonigg, & Beesdo-Baum, 2017), depressive disorders (Suliman et al., 2009) and substance use disorders (Fetzner, McMillan, Sareen, & Asmundson, 2011), but also for somatic morbidity and decreased quality of life (Mölsä et al., 2014; Nicol et al., 2016). However, the majority of trauma-exposed individuals do not develop any disorder (Breslau, 2009; Wittchen et al., 2012). Therefore, knowledge about factors associated with the probability of developing trauma-related psychopathology is of vital importance for the development of targeted interventions.

Since the third revision of the Diagnostic and Statistical Manual of Mental Disorders, the definition of traumatic events explicitly includes not only events that are personally experienced but also events that are witnessed (DSM−III−R, American Psychiatric Association, 1987). These events include witnessing someone being seriously hurt, seeing atrocities or witnessing dead bodies. Witnessing traumatic events are among the most frequent traumatic experiences (Benjet et al., 2015) and are of high current relevance in the context of natural disasters, terrorist attacks and military crises (Holman, Garfin, & Silver, 2014; Monfort & Afzali, 2017; Weems et al., 2007; Wittchen et al., 2012).

The reasons why individuals can develop psychopathological reactions to events that are actually experienced by others has become an important focus of social and neurobiological sciences (Hein & Singer, 2008; Patki, Salvi, Liu, & Salim, 2015). An important mechanism in the

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link between witnessing traumatic events and adverse mental health consequences is the ability to share affective experiences of others. This ability is based on shared neural networks for first-hand and observed emotional experiences through activation in neural structures that are also active during direct experience (Singer & Lamm, 2009; Wild, Erb, & Bartels, 2001; Zaki, Wager, Singer, Keysers, & Gazzola, 2016). As a result, witnessing and personally experiencing an adverse event can elicit similar patterns of emotional (e.g. distress, anxiety, sadness) and biological (e.g. elevated heart rate, increased cortisol levels) (Chou, La Marca, Steptoe, & Brewin, 2014; Holz, Lass-Hennemann, Streb, Pfaltz, & Michael, 2014; Weidmann, Conradi, Gröger, Fehm, & Fydrich, 2009) responses which are in turn robustly associated with the development of mental disorders such as PTSD (de Quervain, Aerni, Schelling, & Roozendaal, 2009; McFarlane, Barton, Yehuda, & Wittert, 2011; Ozer, Best, Lipsey, & Weiss, 2003).

A crucial process associated with the ability to share affective experiences is the multifaceted construct of empathy. While empathy is usually described as a capacity with positive consequences for social interaction, prosocial behavior and mental health outcomes, it may also confer risk for personal distress, depression and anxiety when witnessing the suffering of other persons (Tone & Tully, 2014). The latter is the case when self-other distinction is impaired, e.g. because of individual predispositions or as a consequence of strong negative emotions (Kanske, Böckler, Trautwein, Parianen Lesemann, & Singer, 2016; Klimecki & Singer, 2012). A crucial construct in this context is the susceptibility to others' emotions, also called emotional contagion (EC). EC has been defined as the tendency to automatically mimic the expressions, postures and behaviors of others, and thereby to feel a reflection of others' emotions generated by afferent feedback (Hatfield, Rapson, & Le, 2011). The result is an emotional and physiological state matching between a target and an observer (de Waal & Preston, 2017). EC and empathy are proposed to be distinct but partially overlapping constructs (de Vignemont & Singer, 2006; Luckhurst, Hatfield, & Gelvin-Smith, 2017; Stavrova & Meckel, 2017). In particular, EC can be seen as a precursor of empathy, which does not involve self-other distinction (Klimecki & Singer, 2013). Thus, EC might be a valuable construct for the explanation of personal distress after witnessing suffering in others as described above. Importantly, EC is conceptualized as a stable trait (Lundqvist, 2006; Rueff-Lopes & Caetano, 2012) that is supposed to vary between individuals as a result of genetics, early experiences and personality (Doherty, 1997). This variability has been shown for EC towards emotions in general but also for EC towards emotions with either negative or positive valence (Lundqvist, 2006, 2008). Especially EC towards negative affect is associated with harm avoidance (Lundqvist, 2008), emotional fragility (Coco, Ingoglia, & Lundqvist, 2014), trait anxiety and neuroticism (Doherty, 1997), which in turn are also related to autonomic and endocrine activity (Hauner et al., 2008; Kao et al., 2016; Xin et al., 2017). Although it seems likely that variability in EC also influences the emotional and biological response to witnessed traumatic events, we are not aware of studies that have empirically tested this association.

This study aimed at investigating whether EC moderates the self-reported and biological stress response to a witnessed traumatic event in young, healthy individuals within a randomized controlled analogue design. Specifically, we used the trauma film paradigm (TFP), in which non-clinical participants watch films containing scenes, which depict stressful or traumatic events (Holmes & Bourne, 2008). The TFP has been shown to reliably elicit strong stress responses in self-reported and biological stress measures such as increased anxiety, heart rate and saliva cortisol (James et al., 2016). The used film scene can be seen as a model of witnessed traumatic events because it shows a women being raped and hurt. We hypothesized that with increasing EC, the perceived stressfulness of the film as well as the immediate stress reaction (state anxiety, heart rate, saliva cortisol) would increase in those subjects watching a trauma film relative to a non-emotional control condition (neutral film). Since previous research suggests associations between EC and emotional processing for EC towards negative emotions rather than for EC towards emotions in general, we expected a moderation of stress reactivity for EC towards negative emotions (fear, sadness, anger) but not for EC towards positive emotions.

2. Methods

2.1. Participants

The study population was defined as healthy individuals aged between 18 and 40 years. Participants were recruited in a university environment through advertisements and social media. To prevent negative long-term consequences of watching a trauma film, we applied the following exclusion criteria: history of sexual or violence trauma exposure (including experiences of close relatives), history of psychotic symptoms or substance use disorder, and current mood or anxiety disorder. We also excluded subjects with a current somatic disease (e.g. adrenocortical dysfunction) or medication (e.g. corticosteroids) that could interfere with the biological stress measures, as well as subjects being familiar with the used film material. Of 353 screened individuals, 101 subjects could be included in the study. Among individuals which had to be excluded, 53.6% screened positive for a current mental and 14.3% for a current alcohol use disorder, 16.7% reported current illegal drug use, 21.8% had a history of violent trauma, 5.2% had a current somatic disease or medication and 7.5% were familiar with the study film material. Five individuals did not respond to the invitation. Ninety-six volunteers finally agreed to participate and were randomized to either one of the film conditions while assuring equal group size (n = 48). During the study, one participant in the trauma film condition refused further participation resulting in a final trauma film condition group size of n = 47. Demographic and baseline sample characteristics are shown in Table 1. The mean age of participants was 23.7 years (SD = 3.9) with a roughly equal gender distribution (54.7% females). There were no differences between participants in the trauma and the

Table 1
Demographic and baseline sample characteristics.

	Trauma film		Neutral film		Trauma vs Neutral		
					χ^2/t value	df	p
Demographics							
Female, n (%)	26	55.3	26	54.2	0.01	1	0.910
Age, mean (SD)	24.5	4.2	22.9	3.4	−2.09	93	0.040
Baseline characteristics							
Lifetime traumatic events, mean (SD)	2.0	1.6	2.3	2.1	0.87	93	0.384
Trait anxiety, mean (SD)	36.6	9.0	35.6	8.4	−0.53	93	0.596
Self-reported anxiety, mean (SD)	34.9	6.9	32.2	9.2	−1.63	93	0.107
Heart rate[a], mean (SD)	76.0	11.9	74.8	12.9	−0.43	86	0.665
Saliva cortisol, mean (SD)	9.9	6.2	9.5	5.6	−0.34	93	0.734
Emotional contagion							
Negative, mean (SD)	7.6	1.8	7.4	1.6	−0.80	93	0.425
Positive, mean (SD)	8.3	1.5	7.9	1.9	−1.12	93	0.267

Lifetime traumatic events: Trauma History Questionnaire, trait anxiety: trait version of the State Trait Anxiety Inventory, self-reported anxiety: state version of the State Trait Anxiety Inventory, emotional contagion: Emotional Contagion Scale and its subscales.
T tests were conducted for dimensional and chi square tests for binary outcomes.
[a] Mean value of a 3-min baseline interval.

neutral film condition regarding demographic and baseline characteristics except that participants in the trauma film condition were slightly older (difference: 1.6 years, t (93) = -2.1 p = .040) (Table 1).

2.2. Measures

2.2.1. In− and exclusion criteria

History of trauma exposure was assessed using the Trauma History Questionnaire (THQ, Hooper, Stockton, Krupnick, & Green, 2011). The THQ consists of 24 questions on a range of traumatic events that can be answered with yes or no. The THQ has good reliability and validity in clinical and non-clinical samples (Hooper et al., 2011). To screen for current (past 12 months) and past mental disorders, we used the screening scale of the Munich Comprehensive International Diagnostic Interview, which has been widely used in epidemiological and clinical studies (Wittchen & Perkonigg, 1997). Current somatic diseases and medication that could interfere with the study measures were assessed according to a standardized protocol according to previous studies (e.g. Trautmann et al., 2018).

2.2.2. Emotional contagion

We used the Emotional Contagion Scale (ECS, Doherty, 1997) to measure EC. The ECS is a 15-item scale, which aims to measure 'individual differences in susceptibility to catching the emotions of other individuals' (Doherty, 1997). Each item describes a specific emotional expression of another person and a congruent emotional reaction from a first-person perspective (e.g. 'If someone I'm talking with begins to cry, I get teary-eyed.') to which individuals respond on a 4-point scale (from 'never true' to 'always true'). The ECS correlates positively with interpersonal reactivity (which covers the aspects personal distress, empathic concern and perspective taking) but can be discriminated from general perceived distress (Rueff-Lopes & Caetano, 2012). The ECS has a hierarchical structure with 5 subscales (representing EC towards different emotions: fear, sadness, anger, happiness and love), which can be allocated to two higher order factors: ES towards negative (fear, sadness, anger) and towards positive affect (happiness and love) (Lundqvist, 2008). The ECS total score and the two higher order subscores show good consistency and reliability (Doherty, 1997; Rueff-Lopes & Caetano, 2012) while the consistency of the emotion-specific subscales is partially low ($\alpha < 0.70$) (Lundqvist & Kevrekidis, 2008). Although our sample was much smaller compared to these validation samples, we found the same pattern of higher consistency for the ECS total score and the two higher order subscores (α between 0.68 and 0.75) compared to the five emotion-specific subscores (α between 0.49 and 0.64). Thus, we used the two higher order subscales to test our hypotheses that EC, particularly to negative emotions, moderates the immediate stress response to the film material. Although we had no hypothesis regarding EC towards the five specific emotions, we also report the findings for these emotion-specific subscales in the supplementary material as exploratory analyses.

2.2.3. Perceived stressfulness of the film

Following the presentation of the film scene, participants rated how distressing they experienced the film on a visual analogue scale ranging from 0 (not at all) to 100 (extremely).

2.2.4. Trait and state anxiety

As peri-traumatic anxiety seems to be among the most important distress symptoms in the prediction of symptoms occurring after watching trauma film material (Hagenaars, Brewin, van Minnen, Holmes, & Hoogduin, 2010), we assessed change in self-reported state anxiety in response to the films using the state subscale of the State Trait Anxiety Inventory (STAI-S, Spielberger, 1983). The STAI-S consists of 20 items that are rated on a 4-point Likert scale and has excellent psychometric properties (Spielberger, 1983). The 20-item trait component of the STAI (STAI-T) was also used as a control measure (see data analysis).

Table 2
Pairwise correlations of baseline sample characteristics and emotional contagion.

		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Baseline characteristics								
(1)	Lifetime traumatic events	1						
(2)	Trait anxiety	-.03	1					
(3)	Emotion dysregulation	.15	.71***	1				
(4)	Self-reported state anxiety	-.10	.40***	.30**	1			
(5)	Heart rate[a]	.12	-.01	-.06	.08	1		
(6)	Saliva cortisol	.12	.09	.06	.21*	.23*	1	
Emotional contagion [b]								
(7)	Negative affect	-.07	.27**	.21*	.22*	.09	.13	1
(8)	Positive affect	-.09	-.26**	-.28**	-.17	.15	.19	.33**

*p < .01, **p < .01,***p < .001.
[a] Mean value of a 3-min baseline interval.
[b] Emotional contagion scale (ECS) scores.

2.2.5. Emotion dysregulation

As control measure, emotion dysregulation was measured using the 36-item Difficulties in Emotion Regulation Scale (DERS, Gratz & Roemer, 2004). This instrument has a five-point response format and comprises difficulties in the regulation of emotions regarding six dimensions (non-acceptance, goal-directed behavior, impulsivity, awareness, use of strategies and clarity). The DERS has high internal consistency, good test–retest reliability, and adequate construct and predictive validity (Gratz & Roemer, 2004) and has already been associated with symptom development after exposure to traumatic stress (Tull, Barrett, McMillan, & Roemer, 2007).

2.2.6. Heart rate

Heart rate was assessed as a marker for the autonomic stress reactivity to the film. Electrocardiogram (ECG) was measured continuously during the 15 min of the film sequence and in a 3-min interval directly before the film (baseline interval) using an Eindhoven Lead II setup with two standard Ag/AgCL electrodes (8 mm; Marquette Hellige, Freiburg, Germany). The ECG signal was filtered online with an 8–13 Hz bandpass filter, amplified with the factor 2000, and sampled at a rate of 100 Hz using a Coulbourn V75-04 bioamplifier (Allentown, PA). Then, the ECG signal was visually inspected and artifact-corrected using ANSLAB (Blechert, Peyk, Liedlgruber, & Wilhelm, 2016). ECG R-R intervals (converted to beats per minute) were reduced into half-second bins and averaged across blocks of 10 s. For the subsequent analyses, the 10-s blocks were collapsed into means of a baseline interval (3 min before the film), an immediate film reaction (first minute) and three further blocks ending after 5, 10 and 15 min of the film. ECG was not available for 5 individuals in the neutral film condition and 2 individuals in the trauma film condition due to technical difficulties.

2.2.7. Saliva cortisol

We assessed salivary cortisol levels as a marker of the endocrine stress reactivity since it is thought to play a vital role in the etiology of trauma-related symptoms (de Quervain et al., 2009; McFarlane et al., 2011; Ozer et al., 2003). Saliva samples were collected immediately before the film as well as 1, 10, 20 and 30 min after the film using Salivettes 'code blue' devices (Sarstedt, Germany). Samples were stored at −20 °C in a laboratory freezer until analyses. After thawing, saliva samples were centrifuged for 10 min at 4000 rpm. Salivary cortisol levels were determined by using a commercially available luminescence assay (LIA, IBL-Hamburg, Germany).

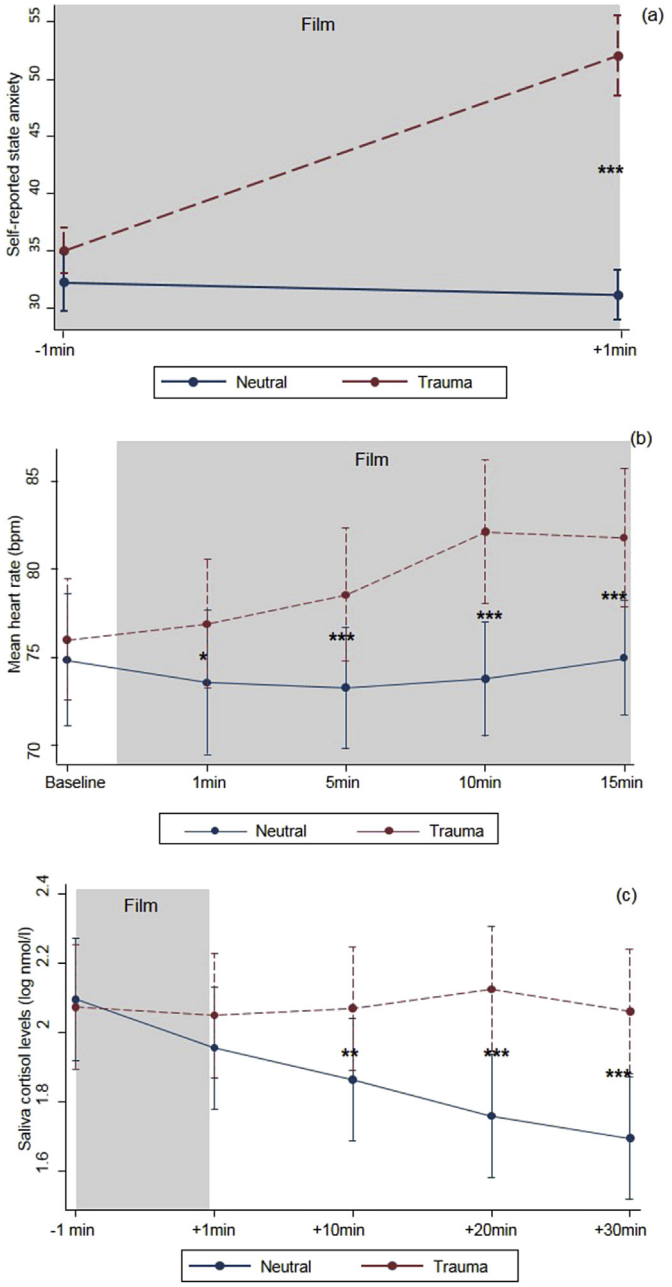

Fig. 1. Effects of the trauma film on self-reported anxiety, heart rate and saliva cortisol levels.
Results from mixed effects regressions including a two-way interaction film condition x time with first time point as reference. Self-reported anxiety: state version of the Trait State Anxiety Inventory, Mean heart rates: dots represent the mean value of the interval to the preceding time point except for baseline which is the mean of a 3-min interval before the film; * < 0 .05, **p < .01. ***p < .001.

2.3. Film material

The chosen trauma scene from the movie 'Irreversible' (Feldner, Zvolensky, Eifert, & Spira, 2003) by Gaspar Noé is widely used in TFPs and was shown to elicit a strong immediate stress response (self-reported distress, heart rate) as well as short-term trauma-related symptoms (i.e. intrusions) in both male and female participants (Arnaudova & Hagenaars, 2017; Weidmann et al., 2009). The 15-min scene shows a young woman leaving a party and being assaulted on her way home, brutally raped and beaten up by a man. As it is recommended to control for the potentially arousing effects of watching a film when using the trauma film paradigm (Arnaudova & Hagenaars, 2017), we chose a control condition showing an emotionally neutral film where a young woman gives systematic instructions on how to build a garden house. This film was comparable to the trauma film in terms of an equal length and having a female person as the main actor.

2.4. Procedure

All participants were instructed to refrain from smoking, eating and drinking anything but water 60 min prior to the assessment to avoid confounding of biological stress measures. First, participants completed STAI-S, STAI-T and ECS after providing informed consent. Then, they were led into the laboratory room and sat before a 22″ computer screen, 80 cm away from the monitor, and ECG electrodes were attached. After a 3-min interval during which baseline heart rate was measured while participants were looking at a neutral screensaver, the first saliva sample was taken, room lights were switched off and participants watched a 15-min neutral or trauma film sequence according to their randomized condition. Heart rate was continuously measured during the film. After the film, participants in both conditions completed the STAI-S and saliva cortisol levels were repeatedly measured. At the end of the study, participants received either a compensation of 10 Euros or credit points if they were psychology students (20% of the sample). All participants were assessed between 1p.m. and 8p.m. to reduce variability in cortisol measures due to circadian rhythms (Debono et al., 2009). The entire study procedure was approved by the Ethics Board of the Technische Universität Dresden (EK 23022008).

2.5. Data analysis

A skew-normal linear regression (Azzalini & Capitanio, 1999) was used to test whether saliva cortisol levels were considerably skewed. Since this was the case ($\alpha = 9.2$ [8.7–9.7] $p < .001$), saliva cortisol levels were first log transformed to reduce skewness. To test for differences between participants of the trauma and the neutral film condition in demographics and baseline characteristics T Tests and Chi Square Tests for dimensional and categorical outcomes, respectively, were conducted. We further checked for associations between ECS scores and baseline variables by computing a pairwise correlation matrix.

To test for differences in the perceived stressfulness of the film between groups, linear regression analyses were conducted. For all other indicators of the immediate stress response (self-reported anxiety, heart rate, saliva cortisol), mixed effects regressions with random intercept parameter were fitted. This means that for each individual observation, scores on the dependent variable are predicted by the intercept that varies across groups (Garson, 2012). The use of a mixed effects model with random intercept parameter addresses regression to the mean, which could otherwise yield biased results (Oberg & Mahoney, 2007). We fitted models that added the main effect term and a two-way interaction term film condition (between subject) x time (within subject) with the first time point (baseline) as reference. To analyze the moderating role of EC, the above-mentioned analyses were repeated with adding the three-way interaction terms film condition x time x ECS scores to the models. Models were fitted separately for EC towards negative and towards positive emotions while consistent findings across both dimensions were taken as evidence for general rather than emotion-specific effects of EC. All models were adjusted for age and gender. We also tested whether results would change when additionally adjusting for the number of previous traumatic event experiences, trait anxiety and emotion dysregulation because those factors were previously demonstrated to be potential confounders of immediate stress reactions (de Veld, Riksen-Walraven, & de Weerth, 2012; James et al., 2016; Kudielka, Hellhammer, & Wüst, 2009).

To assure that the sample size provides sufficient statistical power to

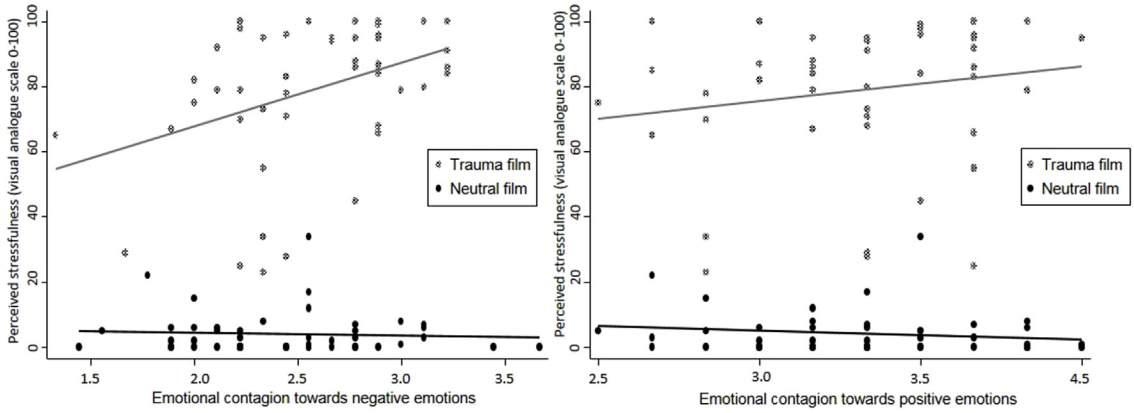

Fig. 2. Perceived stressfulness (visual analogue scale 0–100) of the film by levels of emotional contagion towards negative and positive emotions.
Results from linear regressions including a two-way interaction term film condition x emotional contagion adjusted for sex, age, history of traumatic events, trait anxiety and emotion dysregulation. The two-way interaction film condition x emotional contagion towards negative emotions is statistically significant (p = .005).

be able to detect effects even for three-way analyses, we ran several power analyses using the procedure SIMPOWER. Given our sample size and data distributions, a simulation of F tests with 1000 replications assuming a 5% significance level as well as 8 groups for the subjective, 20 groups for the heart rate and 24 groups for the cortisol measures (group x time x EC) revealed a statistical power of > .99.

Results are reported as beta values with 95% confidence intervals. Statistical significance was evaluated at the two-sided 5% level. In graphical illustrations of results, the procedure MARGINS was used to calculate predicted probabilities and EC was categorized into tertiles (low, moderate, high). All analyses were conducted with Stata 14.1 (Stata Corp., 2015).

3. Results

3.1. Baseline measures and emotional contagion

EC towards negative and positive emotions were (in opposite directions) correlated with trait anxiety (negative: r = 0.27, p = .007, positive: r = −0.26, p = .010) and emotion dysregulation (negative: r = 0.21 p = .043, positive: r = −0.28, p = .005). EC towards negative emotions was also correlated with state anxiety at baseline (r = 0.22 p = .030). (Table 2). All other correlations between EC and baseline measures were not significant (p > .05).

3.2. Stress response to the film

Participants in the trauma film condition rated the film as more distressing (M = 78.7, SD = 21.9) than participants in the neutral film condition (M = 4.0, SD = 6.6, difference: b = 74.7 [67.8–81.3] p < .001). Relative to the neutral film condition, the trauma film condition was associated with an increase in self-reported state anxiety (b = 18.3 [14.7–21.9] p < .001) and an increase in heart rate for 1 min (b = 2.2 [0.1–4.3] p = .042), 5 min (b = 4.1 [2.0–6.3] p < .001), 10 min (b = 7.2 [5.0–9.3] p < .001) and 15 min (b = 5.7 [3.5–7.8] p < .001) of the film. The trauma film condition was also associated with higher increase in saliva cortisol levels 10 min (b = 0.2 [0.1–04] p = .001), 20 min (b = 0.4 [0.3–0.5] p < .001) and 30 min (b = 0.4 [0.3–0.5] p < .001) after the films (Fig. 1a–c) compared to the neutral film condition. The differences between experimental conditions did not change after additionally adjusting for the number of lifetime traumatic events, trait anxiety and emotion dysregulation.

3.3. Moderation of the stress response to the film by EC

In the trauma film condition, the distress rating of the film increased with increasing EC towards negative emotions (b = 18.1 [7.1–29.2] p = .002). This association was not found in the neutral film condition (b = −2.0 [-11.8-7.9] p = .689) with a significant film condition x EC towards negative emotion interaction (b = 20.1 [6.0–34.2] p = .006). EC towards positive emotions was not related to the distress rating of the film in any of the film conditions (ps > .150) (Fig. 2).

Increase in self-reported state anxiety from pre to post film was positively associated with EC towards negative emotions in the trauma film (b = 6.4 [0.5–12.2] p = .034) but not in the neutral film condition (b = 0.1 [-5.2-5.4] p = .971), although this difference did not reach statistical significance (b = 6.3 [-1.7-14.2] p = .122). EC towards positive emotions was not related to pre to post film changes in state anxiety in any of the film conditions (ps > .463) (Fig. 3).

Increase in heart rate compared to baseline was positively related to EC towards negative emotions in the trauma film condition for measures 5 min (b = 4.7 [1.4–8.1] p = .006), 10 min (b = 6.8 [3.5–10.2] p < .001) and 15 min (b = 3.5 [0.2–6.8] p = .040) of the film (Fig. 3). These associations were not found in the neutral film condition with significant three-way interactions film condition x time x EC towards negative emotions for measures 5 min (b = 5.6 [1.1–10.2] p = .015) and 10 min (b = 7.3 [7.8–11.8] p = .002) of the film. EC towards positive emotions was not related to increase in heart rate in any of the film conditions (ps > .173).

Increase in saliva cortisol levels compared to baseline was related to EC towards negative emotions in the expected direction, but not statistically significant, in the trauma film condition 30 min after the film (b = 0.2 [-0.02-0.5] p = .074) (Fig. 3). EC towards negative emotions was also negatively related to cortisol levels in the neutral film condition 20 min after the film (b = −0.3 [-0.5-(-0.1)] p = .010). There were no associations between EC towards positive emotions and increase in saliva cortisol in any of the film conditions (p > .198).

There were no main effects of EC scores on any measure of stress reactivity to the trauma film (p > .101). All results regarding the moderating role of EC remained stable after additionally adjusting for the number of lifetime traumatic events, trait anxiety and emotion dysregulation.

Exploratory analyses on the association between the five emotion-specific subscales and the stress response to both film conditions are shown in the supplemental material.

4. Discussion

This analogue study investigated whether EC moderates the immediate stress response to a witnessed trauma in healthy individuals. We used the trauma film paradigm within a randomized controlled design. Our main finding was that the stress reaction to a witnessed

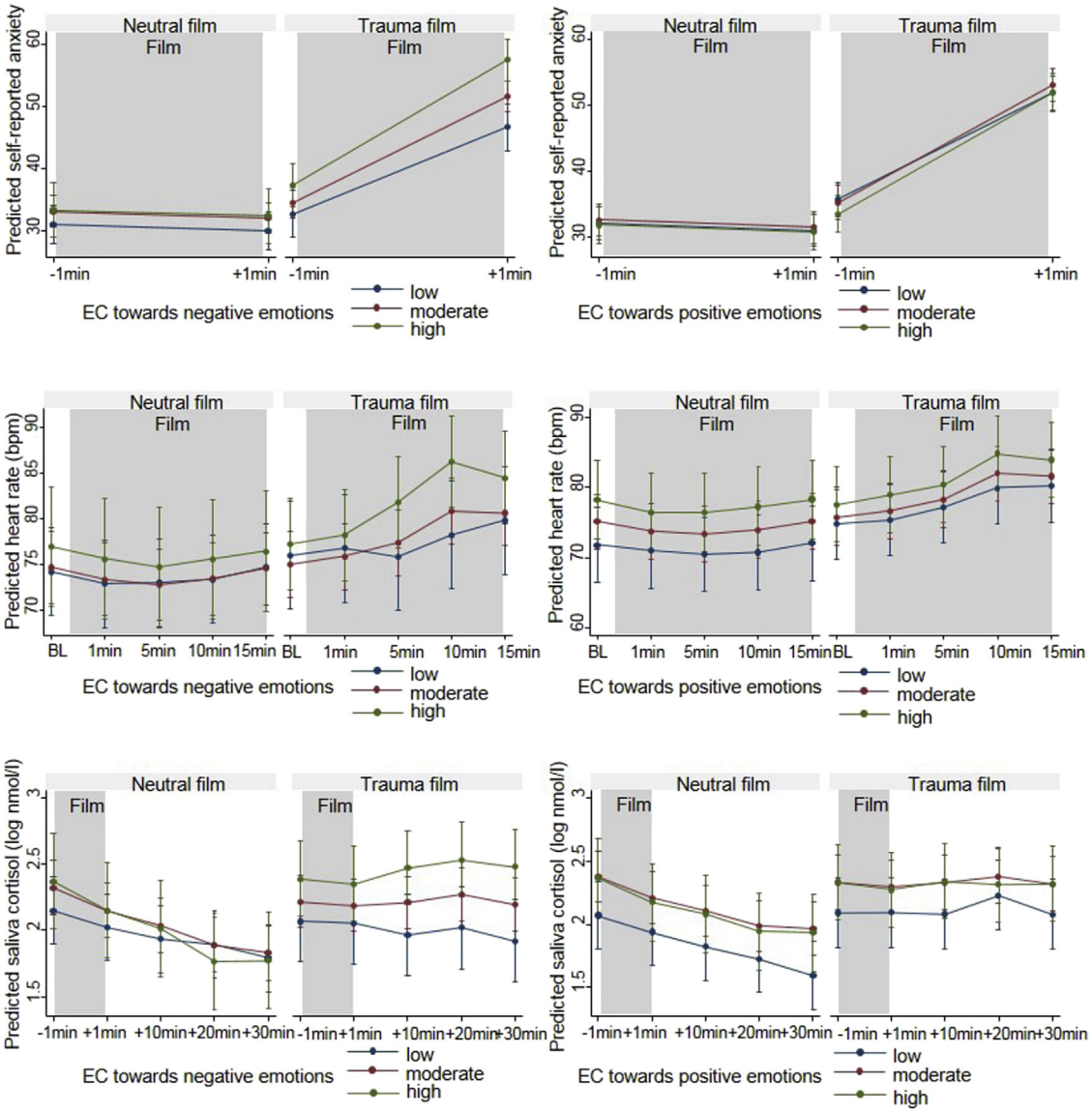

Fig. 3. Effects of the trauma film on self-reported anxiety, heart rate and saliva cortisol levels by levels of emotional contagion towards negative (left column) and positive (right column) emotions

Results from mixed effects regressions with first time point as reference adjusted for sex, age, history of traumatic events, trait anxiety and emotion dysregulation. In the trauma film condition, significant time x emotional contagion towards negative emotions were found for self-reported state anxiety (b = 6.4 [0.5–12.2] p = .034), for heart rate for measures 5 min (b = 4.7 [1.4–8.1] p = .006), 10 min (b = 6.8 [3.5–10.2] p < .001) and 15 min (b = 3.5 [0.2–6.8] p = .040) of the film, and for saliva cortisol levels 30 min after the film by trend (b = 0.2 [-0.02-0.5] p = .074)

For graphical illustration, levels of emotional contagion are shown in three categories (low, moderate, high)

BL = Baseline; Self-reported anxiety: state version of the Trait State Anxiety Inventory, Mean heart rates: dots represent the mean value of the interval to the preceding time point except for baseline which is the mean of a 3-min interval before the film.

trauma increased with higher values of EC towards negative emotions in those individuals witnessing the trauma film relative to individuals in the neutral film condition.

We could not find an association between EC towards positive emotions and any of the examined stress reactivity measures. This finding provides further evidence that EC is not a unidimensional construct (Lundqvist & Kevrekidis, 2008), and that only EC towards negative emotions could represent a valuable target for a vulnerability factor for adverse outcomes following exposure to potentially traumatic events. From a methodological point of view, these findings suggest that the total score of the ECS scale might not be a useful measure in the context of emotional and biological responsivity. It is further noteworthy that the perceived stressfulness of the film as well as all investigated measures of the stress response to the trauma film (state anxiety, heart rate, saliva cortisol) increased with higher levels of EC towards negative emotions except for post-film changes in cortisol for which only a trend for an association was observed. It should be noted that participants in the trauma film condition showed only a modest increase in cortisol levels after the film, which can be explained by a marked anticipatory anxiety causing a ceiling effect in the cortisol reactivity. This ceiling effect could have led to an underestimation of the moderating role of EC in the trauma film condition.

Although these findings were broadly in line with our hypothesis, the mechanisms underlying the found associations have still to be determined. One could argue that EC towards negative emotions just represents a general emotional lability, especially since it has been associated with harm avoidance (Lundqvist, 2008), emotional fragility (Coco et al., 2014), trait anxiety and neuroticism (Doherty, 1997).

However, we were able to show that the associations between EC towards negative emotions and stress reactivity remained stable after adjusting for trait anxiety and emotion dysregulation, which suggest that the associations are at least partly independent of the effects of other possible determinants of emotional reactivity. Since EC is also related to other forms of empathy (Luckhurst et al., 2017), it remains unclear whether the found associations are just a function of empathy rather than a specific effect of EC. Although this question remains open for future investigation, one could speculate that EC as an automatic process (Hatfield et al., 2011) might have a more direct effect on emotional reactivity than empathy which is likely to be modulated by self-other distinction (Klimecki & Singer, 2012). Instead of findings being attributable to empathy rather than EC, it seems more likely that EC and empathy could have additive or interactive effects on stress reactivity, which clearly warrants further investigation.

This study has several limitations. First, EC was not randomized or manipulated in this study, so associations may not be interpreted as causal inference. Second, the sample size did not allow for potentially relevant subgroup analyses (e.g. gender, familiarity with the suffering target (Langford et al., 2006)) or investigations of bimodal associations. Moreover, the limited sample size resulted in broad confidence intervals for the estimated effects, which is why point estimates of effect quantifications should be interpreted with caution. Third, we can only speculate about specific peri-traumatic processes involved (e.g. attentional processes) since the participants' behavior during the film was not closely monitored. Fourth, we excluded individuals with mental disorders and several somatic diseases, resulting in a healthy and resilient sample. Thus, the generalizability of the presented findings to the general population or at-risk samples might be limited.

4.1. Conclusions and future directions

Considering these limitations, our findings suggest EC towards negative emotions as a promising novel target for research on the development of adverse consequences after witnessing traumatic events. It could be a particularly relevant construct for analogue studies, which are often based on witnessing others being harmed, but also for research on collective witnessing events such terror attacks and natural catastrophes. It might also help to explain the phenomenon of "secondary traumatization" were close relatives of traumatized individuals exhibit emotional and behavioral problems (Yager, Gerszberg, & Dohrenwend, 2016). Future studies should directly investigate the association between EC and symptom development after witnessing trauma. This could be done by replicating this study including repeated measures of affect, arousal or intrusions in the aftermath of watching a trauma film, e.g. through diary or ecological momentary assessment (James et al., 2016; Kleim, Graham, Bryant, & Ehlers, 2013). It seems also warranted to investigate how EC relates to different forms of empathy and how these constructs affect reactions to distressing events. Future studies may consider top-down cognitive empathic processes, which could moderate the association between EC and stress reactivity (de Waal & Preston, 2017). Moreover, within-subject designs have advantages regarding confounding variables, which should be considered in future studies. Additional measures of trait emotionality as well as peri-traumatic processes such as attention or direct behavioral fear measures such as freezing (Hagenaars, Roelofs, & Stins, 2014; Laposa & Rector, 2012; Verwoerd, Wessel, & de Jong, 2012) could further facilitate a better understanding of mechanisms underlying the observed associations. Future studies might also benefit from the inclusion of film material with other valences (e.g. positive material) to provide a better control of arousal (Arnaudova & Hagenaars, 2017). Given the potentially limited external validity of analogue studies (Ehring, Kleim, & Ehlers, 2011; James et al., 2016), observational longitudinal studies should also investigate the relationships between EC, real potentially traumatic events and symptom development. Another question worth investigating is whether EC towards negative emotions is specifically related to the response to witnessing trauma or to potentially traumatic experiences in general as suggested by the association between EC and trait anxiety (as found in this study) and neuroticism (Doherty, 1997). Further knowledge on these aspects could clarify whether EC towards negative emotions constitutes a promising target for the development of interventions to prevent adverse consequences following trauma exposure. For now, our findings suggest that the susceptibility to negative emotions of others' is an important moderator of emotional and physical responses after witnessing an analogue trauma, with increased responses in those with higher susceptibility.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.brat.2018.09.001.

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