The Effect of Attachment Security Priming and Oxytocin on Physiological Responses to Trauma Films and Subsequent Intrusions

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Abstract

To further understand protective mechanisms to prevent post-traumatic stress disorder or assist recovery from psychological trauma, this study investigated whether pharmacological and psychological activation of a secure attachment representation elicits higher felt-security and a related response pattern of reduced physiological arousal and increased parasympathetic activation; and whether it protects individuals from developing intrusions and experiencing distress in the week following exposure to a trauma film. Using a double-blind, experimental mixed factorial design, 101 volunteers received either oxytocin or placebo and either secure attachment or neutral priming before watching a trauma film. We measured felt security as an indicator of the strength of activation of a secure attachment representation, skin conductance and heart rate as indicators of physiological arousal, and high frequency heart rate variability as an indicator of parasympathetic activation during the priming and the film. Participants then completed a seven-day intrusion diary. Secure attachment priming, but not oxytocin administration or the combination of both, was associated with reduced physiological arousal and increased parasympathetic activity during priming. Although secure attachment priming was not related to the absolute number of intrusions or to less perceived distress or physiological arousal during the trauma film, it was associated with lower intrusion-related distress in the 7-days post-testing. Our findings extend previous research that suggests the importance of interventions that address intrusion-related distress for recovery from trauma, and suggest a promising role for secure attachment priming in trauma-focused psychological therapies. We contribute to the growing literature that finds that higher subjective distress during a trauma is associated with higher intrusion-related distress. We discuss theoretical implications and possible mechanisms through which secure attachment priming may exert potential beneficial effects.

Keywords: oxytocin, attachment priming, trauma film paradigm, psychophysiology, intrusions

The Effect of Attachment Security Priming and Oxytocin on Physiological Responses to Trauma Films and Subsequent Intrusions

Psychological trauma, such as severe accidents, natural disasters, physical or sexual assaults, combat or political imprisonment, can lead to the development of post-traumatic stress disorder (PTSD), a condition characterized by intrusive recollections of the trauma, avoidance, heightened physiological arousal and an array of cognitive-affective alterations, such as negative cognitive appraisals of the self and world, emotional numbing, and feelings of detachment from others (AmericanPsychiatricAssociation, 2013). Recovery from trauma, prevention of PTSD, and improved treatment outcome for PTSD have been associated with high quality social bonds, including social support (Brewin et al., 2000) and secure attachment relationships (see (Mikulincer et al., 2015) for a review). The aim of the present research is to examine the potential causal role of secure attachment and intranasal oxytocin administration in coping with an analogue trauma using an established trauma film paradigm. We examined psychophysiological indicators of distress (skin conductance level, heart rate), safety and social affiliation (heart rate variability), as well as self-reported stress and intrusions.

Beneficial effects of Secure Social Bonds

Social bonds are important for wellbeing (Cacioppo & Cacioppo, 2014) and for recovery from psychological trauma and PTSD (Brewin et al., 2000). The ability to form and maintain secure social bonds is acquired via early experiences with caregivers (Ainsworth et al., 1978) that shape an individual's emotion-regulation strategies and their ability to cope with threat and stress through the development of internal working models about themselves and others (Bowlby, 1982).

If individuals experience their caregivers as consistently available, attentive and sensitive to their needs, they develop an internal working model of the self as lovable and others as trustworthy and reliable; in other words, the individual develops a secure attachment representation (Ainsworth et al., 1978). When distressed, securely attached individuals seek proximity to others or to an internalized secure base self-representation for comfort; this soothing down-regulates the

attachment system and allows the individual to turn to other pursuits (Ainsworth et al., 1978). Securely attached individuals are able to recover from distress quickly due to their abilities to 'self-soothe' and seek support (Mikulincer & Shaver, 2018). Physiologically, this capacity has been accompanied by higher baseline parasympathetic activity as indicated by beat-to-beat variation in heart rate (HR) known as heart rate variability (HRV) (Diamond & Hicks, 2005). Adaptive emotion regulation refers to the ability to influence what emotions we have, when we have them, and how we experience and express them (Gross, 2015). HRV has been linked to adaptive emotion regulation in threat contexts (Thayer & Lane, 2000), which might explain some of the observed health benefits of secure attachment (Pietromonaco & Powers, 2015). Of particular interest is the high frequency band (0.15-0.4 Hz) of heart rate variability as an indicator of parasympathetic activity (Berntson et al., 1997; Guidelines, 1996; Thayer et al., 2010). This has been associated with vagus nerve activation (Kuo et al., 2005) and recently it has also been associated with reduced activation of the locus coeruleus, a brain structure involved in sympathetic arousal (Mather et al., 2017).

In contrast, rejection and neglect are associated with an avoidant attachment pattern, based on internal working models in which other people are unavailable and unreliable. Avoidant attachment can lead to deactivating emotion regulation strategies, such as avoiding proximity to others, suppressing or not expressing negative emotions, and turning attention away from threat (Mikulincer & Shaver, 2007). This pattern is associated with elevated sympathetic arousal indicated by elevated skin conductance levels (SCL) during interpersonal situations (Roisman et al., 2004).

An anxious attachment pattern results from inconsistent, intrusive caregiving and is characterized by fear of abandonment and a negative model of the self (Brennan et al., 1998). Here, emotion regulation involves hyperactivating strategies with excessive proximity seeking, hypervigilance to threat, elevated emotional reactivity and dysregulation (Mikulincer & Shaver, 2007) accompanied by elevated HR responses to interpersonal conflict cues (Roisman et al., 2004) and lower resting HRV compared to securely attached individuals (Diamond & Hicks, 2005).

Attachment patterns influence relationship functioning throughout life and contribute to the individual's ability to regulate emotions in stressful situations such as psychological trauma (Mikulincer & Shaver, 2018). Secure attachment has been associated with lower post-traumatic symptom severity, whereas, attachment anxiety and avoidance have both been positively related to severity of post-traumatic symptoms and PTSD (e.g., (Arikan et al., 2016; Mikulincer et al., 1993)). In addition, attachment security is associated with better therapeutic outcome and symptom reduction (Forbes et al., 2010). This research suggests that secure attachment may be a protective factor for PTSD, but due to its correlational nature current research does not provide evidence for causal processes, nor does it explain how secure attachment exerts its protective effect.

Mental Representations of Secure Attachment can be Primed

One possible mechanism by which secure attachment exerts a protective effect is via the reduction of states of threats and distress and the activation of self-soothing (Gilbert et al., 2008). There is evidence that attachment representations can be temporarily malleable despite the dispositional nature of adult attachment styles (Baldwin & Meunier, 1999). Even brief activations of mental representations of a secure attachment figure; i.e., secure attachment priming, can lead to increased felt-security in laboratory (Carnelley & Rowe, 2007) and real-life contexts (Otway et al., 2014). This paradigm asks a person to mentally experience a situation in which a close other provided understanding and appropriate support, and allows us to test causal hypotheses (Mikulincer et al., 2001).

Beneficial effects of secure attachment priming include reduction of fearful facial expressions when children were presented with threatening animal images (Stupica et al., 2017), reductions in depressed and anxious mood in clinical and non-clinical samples (Carnelley et al., 2018; Otway et al., 2014), alleviation of the effects of experimentally induced pain (Rowe et al., 2012), enhanced positive self-views and relationship expectations (Rowe & Carnelley, 2003), and creative problem-solving (Mikulincer et al., 2011). There is also emerging evidence that activating mental representations of secure attachment figures reduces peripheral and central threat- and

stress-related physiological activations indicated by decreased noradrenergic activation (Bryant & Chan, 2015), SCL response (Stupica et al., 2017) and amygdala activation to threat (Norman et al., 2015). Activation of secure attachment also increases parasympathetic activity after a laboratory stressor, as indicated by higher HRV (Bryant & Hutanamon, 2018). Although previous research studied the effect of attachment priming on skin conductance synchronisation in therapists (Palmieri et al., 2018), there is however to date no research reporting individuals' peripheral physiological responses during the priming. Taken together, research suggests that a number of beneficial effects of secure attachment priming are potentially relevant for PTSD and recovery from trauma. An emerging body of research demonstrated that priming attachment security leads to a temporary reduction of both PTSD symptoms and attentional bias to threat in a sample of people with PTSD (Mikulincer et al., 2006; Mikulincer et al., 2014). We examine physiological responses during the priming and whether these effects can be facilitated by an additional pharmacological intervention.

Oxytocin and its Beneficial Effects

Intranasal administration of the neuropeptide oxytocin (OT), which crosses the blood-brain barrier (Born et al., 2002), could have a similar threat-reducing and social-affiliative effect (Carter, 1998) as security priming. OT is produced in the hypothalamus, released into the bloodstream and the brain (Landgraf & Neumann, 2004) and has an important role in reproductive functions. Earlier human studies, mainly conducted in male samples, suggested that OT exerts an anxiolytic effect via reduced amygdala activation to threat stimuli (Kirsch et al., 2005), improves emotion recognition (Domes et al., 2007) and increases interpersonal trust (Kosfeld et al., 2005) in healthy participants (Norman et al., 2011), but not in patients with mental health problems (J. Bartz et al., 2011). Intranasal oxytocin also increased resting HRV indicating its possible role in facilitating effective emotion regulation (Kemp et al., 2012), although it did not do so in patients with physical health problems (Tracy et al., 2018). When administered to recently traumatized individuals with high levels of acute stress, oxytocin was associated with fewer symptoms 1.5 months later (van Zuiden et

al., 2017). In PTSD patients before symptom provocation it was associated with lower PTSD and avoidance symptoms (Sack et al., 2017).

However, not all findings are consistent. Pitman and colleagues (Pitman et al., 1993) found either no or very small effects of OT in reducing physiological response to idiosyncratic trauma reminders, and Sack et al. (Sack et al., 2017) found that OT increases HR and reduces cardiac output. More importantly, Frijling et al. (Frijling et al., 2016) found that when OT is administered in recently traumatized individuals, it impairs successful trauma processing by disrupting the emotion regulation brain circuitry and increasing flashbacks. Investigations of the effects of OT on fear extinction in the laboratory (Acheson et al., 2013) and therapeutic settings (Acheson et al., 2015) have been mixed, suggesting researchers use caution and consider the context before administering OT. Rather than having unequivocally beneficial effects, OT may increase the salience of the external or internal environment, suggesting that it activates the affiliative system in a context-dependent way, with either beneficial or negative consequences (J. A. Bartz et al., 2011; Shamay-Tsoory & Abu-Akel, 2016). Therefore, if administered together with a stress-reducing psychological intervention, such as secure attachment priming, OT should facilitate the experience of felt-security. Support for our hypotheses comes from research by (Heinrichs et al., 2003) where OT increased the effects of social support on stress reduction; it reduced cortisol levels and anxiety during a social stress test when a significant other was present.

Studying the Role of Secure Attachment Priming and OT for Analogue PTSD Symptoms using the Trauma Film Paradigm

Previous research has looked at secure attachment priming and OT on trauma/stress-related processing in isolation. There is emerging evidence that pharmacological manipulations can facilitate the effects of psychological interventions (Keller et al., 2000). The effects of one-off secure attachment priming are temporary and combining it with intranasal OT administration could increase or extend the impact on felt security. For individuals with PTSD who struggle to learn safety (Milad et al., 2009), this combined intervention might increase the effect of the activation of

the secure attachment system which in turn could facilitate safety learning (Eckstein et al., 2019) and reduce PTSD symptoms. To support our reasoning, another drug that downregulates the biological stress response and activates the oxytocinergic system, 3,4-methylenedioxymethamphetamine (MDMA), has been shown to increase the effects of psychological therapy in PTSD predominantly via reducing the salience of negative memories and improving the therapeutic alliance (Mithoefer et al., 2013). Combined, secure attachment and OT are relevant for trauma recovery because they may reduce hypervigilance to threat, and levels of distress and physiological arousal, all of which have been associated with PTSD (Ehlers & Clark, 2000; Pole, 2007). In addition, the combination of secure attachment and OT could reduce the formation of stressful intrusive memories, i.e., vivid sensory and emotionally-charged fragmented recollections of the traumatic event (Brewin, 2001; Ehlers & Clark, 2000). One suggested mechanism through which intrusive memories develop is via stress-related neurotransmitter release (noradrenaline and glucocorticoids) that accompanies intense negative emotion and physiological arousal during peri- and posttraumatic information processing. The resulting ‘over-consolidation’ of the trauma memory (Pitman & Delahanty, 2005) makes it more easily accessible for subsequent triggering, which in turn strengthens the memory trace and facilitates its association with a wide-range of environmental stimuli.

In line with the social salience hypothesis, OT may increase the salience of the external or internal environment, suggesting that it activates the affiliative system in a context-dependent way (J. A. Bartz et al., 2011). Intranasal OT alters the activation of brain circuitries high in OT receptor density (D. Martins et al., 2020) including the amygdala, a region also implicated with reduced fear after OT administration (Kirsch et al., 2005) and secure attachment priming (Norman et al., 2015). In turn, attachment priming could activate the central release of oxytocin although to date no human studies have investigated this potential effect. Therefore, if administered together with a stress-reducing psychological intervention, such as secure attachment priming, OT could facilitate the experience of felt-security. Support for our hypotheses comes from research by (Heinrichs et al.,

2003) where OT increased the effects of social support on stress reduction; it reduced cortisol levels and anxiety during a social stress test when a significant other was present.

In order to study peri- and immediate posttraumatic processes contributing to mechanisms of intrusion development in a well-controlled way, Holmes and colleagues (Holmes et al., 2004; Holmes et al., 2009; Lau-Zhu et al., 2018) , based on earlier work (Brewin & Saunders, 2001; Horowitz, 1969; Lazarus, 1964), developed and validated the trauma film paradigm, a set of trauma-related video clips, and a 7-day intrusion diary that are administered to individuals not previously traumatized.

Using the trauma film paradigm or related approaches, a number of factors have been identified that contribute to intrusive memory formation and maintenance (Iyadurai et al., 2019; James et al., 2016): avoidance and suppression of negative emotions as maladaptive emotion regulation strategies and enhanced physiological arousal as indicated by increased SCL (Ripley et al., 2017), and increased salivary alpha amylase (a peripheral indicator of noradrenergic activation) and cortisol levels (an indicator of biological stress axis activation) during a stressor in the aftermath of encoding negative images (Nicholson et al., 2014). However, others have found either reduced physiological arousal (HR) to the trauma film (Chou et al., 2014), or no effects on physiological arousal (Holz et al., 2016). Factors that prevent intrusions have also been identified, such as the administration of specific cognitive tasks in the aftermath of trauma film exposure (Holmes et al., 2009). Whilst it is well-established that intrusions as developed in the week after exposure to the trauma film decline, no previous research has studied whether individual differences in the trajectory/slope of this is explained by peritraumatic processes. OT and secure attachment priming could speed up the intrusion decline.

Furthermore, other studies suggest that secure attachment priming beneficially altered recall of previously encoded negative information. In particular, it reduced intrusions when individuals were asked to recall previously encoded negative images (Bryant & Foord, 2016). Whereas this research points to a beneficial modulation of cognitive-affective processes we know contribute to

PTSD, it is uncertain whether a state of secure attachment could prevent or reduce the development of intrusive memories after a stressful event or trauma analogue. Furthermore, the possible role of the combination of secure priming and OT for intrusive memory formation has not previously been studied.

The Present Study

We hypothesised that a combination of secure attachment priming and oxytocin (OT+SEC) is superior in increasing a sense of secure attachment (felt security) from pre-to post-priming than either condition alone (i.e., OT+NEU and PL+SEC) and that either condition alone is superior to a combination of no OT and secure priming (PL+NEU) (Hypothesis 1). In other words, we expected that felt security increases as a function of experimental condition which would be shown by a significant linear trend. Second, similarly, we hypothesised that significant linear trends would also be identified for felt-security from pre-to post-trauma film exposure (Hypothesis 2) and film-related distress (Hypothesis 3). To better understand underlying mechanisms, we wanted to complement self-report measures with indicators of physiological reactivity (SCL, HR, and HRV) that have been implicated in threat processing or social safety and effective emotion regulation. We therefore hypothesised that OT and secure priming (main effects OT and Sec) and a combination of both (interaction effect OT+SEC) would reduce physiological arousal (HR, SCL) and increase parasympathetic activation (HRV) during the priming phase (Hypothesis 4) and during the trauma film presentation (Hypothesis 5) more than placebo and neutral priming. Additionally, we hypothesised that OT and secure priming (main effects OT and Sec) and a combination of both (interaction effect OT+SEC) would protect individuals more from developing intrusions (intrusion count, Hypothesis 6.1) and experiencing intrusion-related distress (Hypothesis 6.2) within a week after trauma film exposure than placebo and neutral priming (PL+NEU). Finally, we hypothesised that peritraumatic factors (film-related distress and physiological activation) would mediate the effect of OT and priming (main effects and interactions) on intrusions. In particular, we expected that the effect of OT and secure priming (main effects OT and Sec) and a combination of both

(interaction effect OT+SEC) would exert their effect on reduced intrusion count (Hypothesis 7.1) and distress (Hypothesis 7.2) via lower film-related distress and physiological arousal and higher parasympathetic activation (HRV). Our hypotheses align with the cognitive model of PTSD (Ehlers & Clark, 2000) in that we test whether activation of a secure attachment representation as a pre-trauma protective factor leads to lower distress during the analogue trauma and thus prevents intrusions. They are also in line with predictions derived from attachment theory and the tripartite model of emotion regulation in which felt security is related to a content calm state (secure priming), and this in turn has been associated with effective emotion regulation under stress (Gilbert et al., 2008; Mikulincer et al., 2006).

Method

Design

We employed a double-blind, placebo-controlled, mixed factorial design with self-report (felt-security, trauma film processing and intrusion distress and numbers in the 7-days after trauma) and physiological (SCL, HR and HRV during priming and film processing) dependent variables[1]. Participants were randomized into one of two drug conditions (OT, placebo (PL)) and into one of two priming conditions (secure attachment (SEC), neutral (NEU)) resulting in four possible combinations: OT and secure priming (OT+SEC), OT and neutral priming (OT+NEU); placebo and secure priming (PL+SEC), and placebo and neutral priming (PL+NEU).

Participants

Students from a British university (N=101) participated in exchange for course credits or a gift of £10. Target sample size was based on *a priori* power calculation. Participants were recruited via flyers around the university and were included if they were native speakers and aged 18 or over and excluded if they had health conditions that would preclude administering OT or completing the measurements (asthma, breast-feeding, severe skin allergies, pregnancy, hormonal or any other mental or physical health conditions) (Heinrichs & Domes, 2008). Participants who had experienced a severe traumatic event (as defined by DSM-IV) were excluded via a screening

questionnaire (see supplementary material for detailed questions). Female participants were checked for their menstrual cycle and invited to participate during their luteal phase. The rationale is that in the luteal phase the effects of oxytocin nasal administration might be more pronounced (Riem et al., 2011) due to low plasma oxytocin levels (Salonia et al, 2005). By mistake, one participant did not receive the prime, so was excluded from analysis. A detailed recruitment and randomization flow chart is shown in Figure 1. The study was approved by the Southampton South West Hampshire Research Ethics Committee.

Measures

Self-Report Questionnaires and State Measures

In order to account for baseline differences in trait attachment and anxiety we administered the Relationship Structures Questionnaire (RSQ) (Fraley et al., 2000) and the State and Trait Anxiety Inventory (STAI-T) (Spielberger et al., 1983). The RSQ assesses two attachment dimensions, anxiety and avoidance, in four different relational contexts (mother, father, romantic partner, and best friend) and provides composite indices of global attachment when the scores are averaged across these four contexts. The RSQ consists of 40 questions rated on a 7-point Likert scale (1 = *strongly disagree*; 7 = *strongly agree*) and has good psychometric properties (Fraley et al., 2006). Cronbach's alpha for attachment avoidance was $\alpha = .895$ and for attachment anxiety $\alpha = .826$. The STAI -T assesses stable individual differences regarding anxiety proneness. It consists of 20 items and each item is scored on a 4-point Likert scale (1 = *not at all*; 4 = *very much so*). The STAI shows good psychometric properties (Spielberger et al., 1983) and is widely used. Cronbach's alpha was $\alpha = .937$.

Felt-security. The Felt-security Scale (Luke et al., 2012) assesses state attachment security with 16 items ($\alpha = .94$) rated on a 6-point Likert scale (1 = *not at all*; 6 = *very much*). It has been used frequently in experimental research as a manipulation check for security priming (e.g., (Carnelley et al., 2018).

Trauma Film Ratings. Aspects of trauma-film processing were assessed by 4 items on Likert scales (Holmes et al., 2004). Participants indicated how much attention they paid to the films (0 = *not at all*; 10 = *total attention*), how distressing the movies were (0 = *not at all*; 10 = *extremely*), how personally relevant the movies were (0 = *not at all*; 10 = *extremely*), and from what perspective they were watching the movies (field vs. observer perspective) (-3 = *entirely looking out through my own eyes*, +3 = *entirely observing myself from an external point of view*).

Intrusion diary. The intrusion diary assessed intrusive recollections related to the movie clips during the morning, afternoon and evening (Holmes et al., 2004). Participants were asked to monitor images, thoughts, and image-thought combinations. For each intrusion, participants reported on the possible triggers and the related distress levels (*How distressed were you at the intrusion?*) on a Likert scale ranging from 0 (*not at all*) to 10 (*extremely*). For each day, we calculated the total number of intrusions (images and thoughts combined) and the mean intrusion-related distress-levels.

Experimental Tasks and Stimulus Material

Oxytocin vs. placebo administration. A single dose of 24IU oxytocin (Syntocinon-Spray, Novartis, Basel, Switzerland) or placebo was intra-nasally (3times in each nostril (cf., (Heinrichs et al., 2003) administered 40-minutes prior to the experiment.

Priming. In order to prime a mental representation of secure attachment, participants recalled and wrote for 8-minutes about an event in which they faced a problematic situation and received help from a significant other with whom they have a secure relationship (i.e., a person who is responsive and sensitive) (Carnelley & Rowe, 2007). Examples of individual transcripts are provided in the supplementary material. As a neutral control condition, individuals wrote about their experience when shopping at a supermarket (Mikulincer & Shaver, 2001).

Trauma film paradigm. We used an abbreviated trauma-film paradigm to induce transient trauma-analogue distress (Badawi et al., 2020; Holmes & Bourne, 2008; Holmes et al., 2009; Lau-Zhu et al., 2018). Three emotionally upsetting film-clips lasting approximately 4-minutes were

presented: a 2-minute section of the movie '*The Big Shave*' (1967) in which a man cuts his face many times, '*The Faster the Speed, The Bigger the Mess*' (2007), a road safety advert that shows a man speeding and crushing a boy while he was hugging his girlfriend, and '*Orthopaedic Management of Compound Wounds*' (2006) which shows a wound being cleaned and includes graphic images of skin and bone. The three most distressing film clips were chosen based on ratings by three students from 11 movies. The instruction followed Holmes et al. (2008) of a "no specific task" instructions and invited participants to "watch the following brief film clips as you would normally watch a movie in the cinema."

Psychophysiological Measures

Skin conductance. Skin conductance was recorded continuously from two Ag/AgCl surface electrodes of 8mm diameter from the hypothenar of the non-dominant hand using a Coulbourn isolated skin conductance coupler V71-23 (LabLinc) and custom-made software BioReader (Jones, 2008). The SCL signal was digitized at a sampling rate of 10 kHz using direct coupling for the measurement of basal tonic SCL.

Electrocardiogram (ECG). To determine HR and HRV, ECG was recorded continuously from two 2.5-cm electrodes from below the right collar bone and from below the left ribcage, with the ground electrode attached to the left collar bone using a Coulbourn Bioamplifier, V76-24 channel integrator, V75-04, (LabLinc) and BioReader. The ECG signal was digitized at a sampling rate of 10 kHz using a time constant 10s, gain 1000 and high frequency cut-off filter of 150Hz.

Procedure

Participants who met the inclusion criteria were randomly assigned to experimental condition. We used a double-blind method. Prior to testing, participants completed questionnaires and brought them to the lab (reported elsewhere in (Arikan et al., in preparation). Participants were instructed not to drink alcohol for 2-days before the experiment, not to smoke or drink coffee or tea on the day of the experiment and not to eat or drink anything (except water) for at least 2-hours before the experiment.

Figure 2 summarizes the procedure. Upon arrival in the lab, participants provided written informed consent, returned the questionnaires, and then received either OT or placebo. During the 40-minute waiting interval, the experimenter explained the procedure and attached electrodes used for continuous recording of ECG and SCL. Participants rated their current state felt-security, and mood and arousal (reported elsewhere (Arikan et al., in preparation). After a 1-minute baseline physiological recording, the priming was conducted for 8-minutes after which participants rated their felt-security and arousal again. After a second 1-minute baseline physiological recording, participants watched the trauma film. Next, participants answered the film-processing items and reported felt-security. Finally, the intrusion diary was given to participants to keep for a week and an appointment was made to collect the diary. On collection, £10 payment or 10 course credits were given and participants were debriefed and thanked.

Data analysis

Trauma Film Processing

The intrusion diary assessed intrusive recollections related to the movie clips during the morning, afternoon and evening (Holmes et al., 2004). Participants were asked to monitor images, thoughts, and image-thought combinations. For each intrusion, participants reported on the possible triggers and the related distress levels (How distressed were you at the intrusion?) on a Likert scale ranging from 0 (*not at all*) to 10 (*extremely*). For each day, we calculated the intrusion count as the total number of intrusions (images and thoughts combined) and intrusion-related distress as the mean intrusion-related distress-levels. For Hypothesis 7, we also calculated the reduction slope of intrusion count and intrusion-related distress across the 7 days post-trauma film exposure. Hence, we had two indicators of intrusion development for count and distress.

Physiological Data Preprocessing

Data preprocessing was conducted using AcqKnowledge (Version 4.1., BIOPAC Systems Inc., Goleta, CA) software.

Skin conductance level. Raw SCL was down-sampled to 1 kHz. Mean SCL, maximum SCL values and minimum SCL values were extracted for the same time windows and a range correction, as recommended by (Lykken et al., 1966), was applied to give a mean SCL corrected for individual differences formula: Corrected SCL = (SCL mean – SCL min) / (SCL max-SCL min)).

Heart rate. The HR determination in beats-per-minute was based on a semi-automatic R-wave detection algorithm after raw ECG data were down-sampled to 1 kHz and filtered applying a FIR bandpass filter between 0.5 and 35 Hz and 8000 coefficients. Artefact detection (i.e., noisy, missing or ectopic beats) and removal was performed using a template correlation and interpolation from the adjacent R-peaks based on established procedures (Berntson & Stowell, 1998). Interpolation was used for less than 5% of the ECG data. Mean HR in beats-per-minute were extracted from the R-waves for each data section.

Heart rate variability. High frequency HRV was determined from the artifact-free ECG by calculating a time series of the R-peaks and submitting it to a fast Fourier transformation that calculates the power spectrum of the R-R interval variation in a given time window (Berntson & Stowell, 1998). Of particular interest was the frequency range between 0.15 Hz and 0.4 Hz (high frequency, HF), as this is considered to be a marker of parasympathetic input. Mean HF HRV was extracted for each data section, transformed into ms^2 and log-transformed (ln).

For priming, mean scores were determined from 1 to 8 minutes post-priming in 1-minute segments. One minute prior to the priming was taken as baseline. For the films, scores were averaged for 1-minute prior to film start and measured for each film in 1-minute segments. Change in physiological activity from baseline was then determined for each minute.

Data Analysis Strategies

Data were inspected for assumptions (normality, outliers, multicollinearity, missing data). Where data did not fulfil these criteria, we used relevant non-parametric analyses. As a manipulation check, to ensure that drug administration had no effect on baseline (pre-prime) felt-

security and physiological measures, we conducted a series of t-tests by drug group (OT versus placebo condition) (see Supplementary material for more detail).

To investigate Hypotheses 1-3, we computed a priori planned contrasts comparing the effects of combined OT and SEC (OT+SEC) against all other conditions on felt security related to priming phase (Hypothesis 1) and film-related felt security (Hypothesis 2) and distress (Hypothesis 3) with either OT only (OT+NEU) and SEC only (PL+SEC) and with the combined neutral and placebo condition (PL+NEU). This allowed us to investigate if there were significant linear trends of the DV (felt security, film-related distress) as a function of experimental condition (dose response of activation of the oxytocinergic attachment system).

For Hypotheses 4, latent growth curve modelling (LGCM) using Mplus (Muthén & Muthén, 1998-2017) was used to determine if the experimental inductions were associated with different physiological response trajectories for SCL, HR and HRV throughout the tasks. We fitted a growth model in which repeated measures of a variable represent indicators of continuous latent variables, growth factors, the intercept (i.e., mean starting value) and the linear (i.e., rate of growth) and quadratic (i.e., levelling off, or coming down) slopes. To understand the role of the experimental conditions, we added dummy-coded drug and priming or combination thereof as covariates to our growth-curve model. In particular we examined interaction effects using dummy-coded variables OT+SEC, PL+SEC and OT+NEU and assuming PL+NEU as reference category and main effects using dummy-coded variables OT and secure priming. The resulting coefficients signify the contribution of each respective condition in the context of all other conditions; i.e., whether each condition differed significantly from the neutral condition (neutral or PL+Neu respectively) which was expected to reveal no significant change. We centered the intercept at minute 1 of the exercises but also ran alternative models with differing center-points from minutes 2 to 8 for priming and minutes 2 and 3 for film-processing to describe the influence of our conditions at different times during the exercises (Muthen & Muthen, 2000). Model fit was determined using the root mean square error of approximation (RMSEA), comparative fit index (CFI), the Tucker-Lewis index

(TLI), and the standardized root mean square residual (SRMR) (Schermelleh-Engel, Moosbrugger, & Müller, 2003). Comparisons between the different models within each outcome variable were made based on the sample size adjusted Bayesian Information Criterion (aBIC), the Akaike Information Criterion (AIC), whereby smaller values indicate better model fit. Missing data were treated as missing at random (MAR) (Arbuckle, 1996). To address multivariate non-normality, we applied the robust maximum likelihood estimation (MLR) (Muthén & Muthén, 1998-2017).

For Hypothesis 5 we computed three ANOVAs with mean SCL, HR, or HRV change across all trauma films as outcome and drug (OT, placebo) and prime (secure, neutral) as between-subjects factors.

For Hypothesis 6.1, we conducted count regressions for repeated measures to model the trajectories of the daily intrusion counts with dummy-coded variables. Because these data were bounded by zero, skewed and had a large proportion of zeros, they violated assumptions of the general linear model (e.g., normality of residuals). We therefore applied a two-part/hurdle (semicontinuous) growth approach (Olsen & Schafer, 2001) that uses a logit model to distinguish counts of zero from larger counts and then uses a truncated model (i.e., exclusion of zero) for the positive counts. The model creates one binary variable (i.e., intrusion occurs or not) and one continuous variable (i.e., where intrusion is reported, how frequently it is observed and what growth curve does it follow?). Intercept and linear slope were determined, and model fit indicated by AIC and aBIC. For hypothesis 6.2, to assess the distress levels in the 7-days post-testing, we used Mplus approaches for skewed data (Asparouhov & Muthen, 2016) to account for the data characteristics of these data (high number of zeros, skewed, daily mean values) where best model fit was obtained using the MLR procedure.

For Hypotheses 7.1 and 7.2, to test if peritraumatic factors (film-related distress and physiological activation) mediated the effects of OT and priming (main effects and interactions) on intrusions, we conducted path analyses in Mplus. First, in order to account for our sample size and the high numbers of variables, we performed backwards and forwards regressions (described in

supplementary material) with dummy-coded drug and priming variables, psychological (felt-security, film-related distress) and physiological response variables (HR, HRV, SCL) to film and prime as predictors. Variables that survived were permitted to path analyses to understand direct and indirect effects in explaining intrusion-related variables. For felt-security, we calculated residualized gain scores (RGS) (Mintz et al., 1979) in order to account for individual differences before administering experimental conditions.

Results

Overall, the sample had low levels of attachment anxiety and avoidance, a high level of baseline self-reported felt-security, and low-medium levels of trait anxiety (Table 1). There were no significant group differences in these measures (all *p*'s for ANOVAs > .05) suggesting randomization into experimental conditions was successful.

Manipulation Checks

Effect of Drug on Baseline Measures prior to Attachment Priming

To ensure that drug administration had no effect on baseline (pre-prime) felt-security and physiology, we conducted a series of t-tests by drug group (OT versus placebo condition). There were no significant differences in felt-security, HR, SCL and HRV prior to priming between individuals who received OT and those who received placebo (all *p*'s > .05). (See supplementary material for these detailed analyses).

Film Processing

Self-reported levels of attention paid to the film were high overall and participants reported moderate levels of distress (Table 1) suggesting successful film administration. However, there were low self-relevance ratings of the films overall and no clear leaning to either field or observer perspective.

Hypothesis 1

Hypothesis 1 addressed whether a combination of secure attachment priming and oxytocin (OT+SEC) is superior in increasing a sense of secure attachment (felt security) from pre-to post-

priming than either condition alone (i.e., OT+NEU and PL+SEC) and if either condition alone is superior to a combination of no OT and secure priming (PL+NEU). A priori planned contrasts to investigate this hypothesized linear trend of felt security increase as a function of experimental condition revealed a significant effect, $F(1, 97) = 6.42$, $p = .013$. We found proportionally higher residualized gain scores of felt-security from pre-to post-priming with increasing dose of active drug and experimental manipulation. Compared to the PL+NEU group, who received no active drug and completed the neutral-control condition, felt-security gain in the group receiving either OT (OT+NEU) or secure priming (PL+SEC) was a third of the standard deviation higher, Cohen's d = 0.37, 95% CI [-0.012, 0.863], and half of the standard deviation higher in the OT+SEC group, Cohen's d = 0.74, 95% CI [0.167, 1.314]. The latter group's felt-security gain was a third of the standard deviation higher, Cohen's d = 0.35, 95% CI [-0.158, 0.815], than the combined OT+Neu and PL+SEC group. Planned contrasts revealed that having received either OT, secure priming or both was accompanied by significantly higher felt-security gain compared to PL+NEU, $t(95) = 2.40$, $p = .019$, but the combination of OT and secure priming (OT+SEC) did not significantly increase felt-security further compared to the administration of just one active condition (OT+NEU or PL+SEC), $t(95) = 1.25$, $p = .215$. The Hypothesis 1 that the combination of OT and secure priming has an additive effect on felt-security after priming was therefore not confirmed.

Hypotheses 2 and 3

Hypotheses 2 and 3 investigated whether significant linear trends were also identified for felt-security from pre-to post-trauma film exposure (Hypothesis 2) and film-related distress (Hypothesis 3). There were no significant linear trends or contrast effects by active drug and priming on felt-security after the film processing nor were there significant linear trends or contrast effects for distress induced by the film. The Hypotheses 2 and 3 that the combination of OT and secure priming would have an additive effect on film-related distress and felt-security were therefore not confirmed. It is of note that there was a small significant OT effect for self-reported attention paid to films $F(1,99) = 5.02$, $p = .027$, partial $\eta^2 = .05$, 95% CI [<.001, .150]. Individuals

in the OT condition (M = 8.68, SD = 0.83) paid significantly less attention to the stressful films than those in the placebo condition (M = 9.14, SD = 0.83).

Hypothesis 4

Hypothesis 4 examined if OT and secure priming (main effects OT and SEC) and a combination of both (interaction effect OT+SEC) reduce physiological arousal (HR, SCL) and increase parasympathetic activation (HRV) during the priming phase.

Skin conductance level. Figure 3A shows the pattern of change in SCL for the different experimental conditions. The model with continuous latent variables of the intercept for minute 1, free slope of SCL change at 8 time points as outcome, and drug and prime as independent variables revealed an acceptable model fit, $\chi 2$ (39) = 57.92, p = .026; CFI = .951; TLI = .945; SRMR = .075; RMSEA = .072, 90% CI [.022, .109]; AIC = 103; aBIC = 116. It indicated that receiving OT (b = -0.107, SE = 0.051, p = .033) significantly explained the intercept at minute 1. This effect was qualified by a significant effect of OT+SEC on the intercept (b = -0.166, SE = 0.075, p = .028) suggesting that individuals in the OT+SEC condition had a significantly larger SCL reduction in the first minute of priming as compared to the other conditions. An acceptable model fit was revealed, $\chi 2$ (45) = 63.05, p = .039; CFI = .955; TLI = .948; SRMR = .071; RMSEA = .066, 90% CI [.016, .101]; AIC = 105; aBIC = 119, for this model. No significant effects were found for the slopes. Additional models that re-centered the intercept over minutes 2-8 revealed that being in the OT condition was significantly negatively associated with SCL response at minutes 1, 5, 6, 7 and 8. With the exception of minute 6, this was qualified by being in the OT+SEC condition.

Heart rate. Figure 3B shows the pattern of change in HR for the different experimental conditions. The model with continuous latent variables intercept, linear and quadratic slope of HR change at eight time-points as outcome and drug and prime as independent variables revealed an acceptable model fit with $\chi 2$ (37) = 52.20, p = .050; CFI = .965; TLI = .959; SRMR = .065; RMSEA = .064, 90% CI [.001, .102]; AIC = 3666; aBIC = 3653. It indicated that secure priming significantly explained the intercept at minute one (b = -1.82, SE = .52, p < .001). This suggests that

receiving secure priming was significantly associated with greater HR reduction at the start of priming. Additional models that re-centered the intercept over all 8-minutes revealed that this effect was maintained throughout the priming, with secure priming being negatively associated with HR response at all eight minutes. At minutes one (b = -2.03, SE = .75, p = .007) and two (b = -1.40, SE = .67, p = .036), the effect of secure priming is qualified by a significant effect of receiving PL+SEC on the intercept. For PL+SEC, there was also a significant effect on the quadratic slope (b = -0.12, SE = .05, p = .019), indicating a greater downturn over time in this condition. This model also revealed a good model fit with $\chi 2$ (42) = 61.12, p = .028; CFI = .958; TLI = .948; SRMR = .061; RMSEA = .068, 90% CI [.023, .103]; AIC = 3670; aBIC = 3656.

Heart rate variability. Figure 3C shows the pattern of change in HRV for the experimental conditions. The model with continuous latent variables intercept, linear and quadratic slope of HRV change at eight time-points as outcome, and drug and prime as independent variables revealed a good fit with $\chi 2$ (37) = 37.54, p = .444; CFI = .998; TLI = .998; SRMR = .060; RMSEA = 0.012, 90% CI [<.001, .072]; AIC = 1225; aBIC = 1212. It indicated that secure priming significantly explained the intercept at minute one (b = 0.44, SE = .11, p < .001), suggesting that receiving secure priming was significantly associated with higher HRV increase at the start of priming. Additional models that re-centered the intercept over all 8-minutes revealed that being in the secure condition was positively associated with HRV response at minutes 1,2,3,7 and 8. In addition, significant effects were found for receiving secure priming on the linear (b = -0.16, SE = .06, p = .009) and the quadratic slope (b = 0.02, SE = .01, p = .007). It appeared that the significant linear (b = -0.20, SE = .10, p = .033) and quadratic slope effects (b = 0.03, SE = .01, p = .025) were explained by the PL+SEC condition suggesting that in this condition, both HRV downturn and upturn were larger (see Figure 3C). Although somewhat lower, this also revealed a good model fit, $\chi 2$ (42) = 46.30, p = .299; CFI = .985; TLI = .981; SRMR = .060; RMSEA = 0.032, 90% CI [<.001, .078]; AIC = 1231; aBIC = 1216. At minutes 3 and 7 the effect on the intercept was qualified by being in the OT+SEC condition.

Hypothesis 5

Hypothesis 5 tested whether OT and secure priming (main effects OT and Sec) and a combination of both (interaction effect OT+SEC) reduced physiological arousal (HR, SCL) and increased parasympathetic activation (HRV) during the trauma film presentation more than placebo and neutral priming. Three ANOVAs with mean SCL, HR, or HRV change across all trauma films as outcome and drug and prime as between-subjects factors revealed no significant main effects of drug, prime or drug by prime interactions, all *p*-values > .05 (see supplementary material).

Hypothesis 6

Hypothesis 6 postulated that OT and secure priming (main effects OT and SEC) and a combination of both (interaction effect OT+SEC) would protect individuals more from developing intrusions (intrusion count, Hypothesis 6.1) and experiencing intrusion-related distress (Hypothesis 6.2) within a week after trauma film exposure than placebo and neutral priming (main effects) or a combination of both (interaction effect of PL+NEU).

Intrusion count (Hypothesis 6.1). LGCM for count data (two-part hurdle model) revealed that the number of participants who reported intrusions dropped significantly from 68.7% (n = 68) on day 1 of the intrusion diary to 13.1% (n = 13) on day 7 (*b* = -0.50, *SE* = 0.09, *p* < .001). The mean daily count dropped significantly from .43 (*SD* = .06) to .19 (*SD* = .10) (*b* = -0.06, *SE* = 0.02, *p* = 0.002). The model fit criteria were Loglikelihood (LL) = - 461.72, MLR correction factor = 1.18, AIC = 971, aBIC = 958. Neither drug nor priming condition significantly explained the drop in intrusions over time. The only variable that explained the number of intrusions was perceived distress immediately after the trauma film (*b* = 0.20, *SE* = 0.08, *p* = .017); higher levels of perceived distress after the film predicted that a person reported any intrusions at the start of the diary assessment, but there were no significant effects on the logit slope or the count intercept and slope. This model showed a slightly better fit with LL = - 453.69, MLR correction factor = 1.14, AIC = 963, aBIC = 947.

Intrusion-related distress levels (Hypothesis 6.2). LGCM using robust MLR for determining trajectory of perceived trauma-film-related distress during the 7-days post-testing with drug and prime as covariates revealed an acceptable model fit, $\chi 2$ (28) = 35.43, p = .158; CFI = .906; TLI = .883; SRMR = .078; RMSEA = .052, 90% CI [<.001, .098]; AIC = 2433; aBIC = 2421. Receiving secure priming was associated with lower distress levels at day three (b = -0.48, SE = 0.16, p = .003) all the way through to day seven (b = -0.36, SE = 0.15, p = .017). There was no effect of drug.

Hypothesis 7

Hypothesis 7 examined if the effect of OT and secure priming (main effects OT and SEC) and a combination of both (interaction effect OT+SEC) exert their effect on reduced intrusion number (Hypothesis 7.1) and distress (Hypothesis 7.2) via lower film-related distress and physiological arousal and higher parasympathetic activation (HRV). Prior to answering this hypothesis, we run backward and forward regression analyses to identify variables that significantly explain intrusion variables (see supplementary material).

Number of intrusions (Hypothesis 7.1).

No significant mediation model was identified for intrusion count and reduction slope.

Intrusion-related distress levels (Hypothesis 7.2).

Levels of intrusion-related distress (Hypothesis 7.2a). There were two pathways to explain total levels of distress (see Figure 4a) in an overall significant mediation model, R^2 = .202, 90% CI [.094, .324], p = .006, that explained 20% of the variance. The first is a direct negative association between receiving the secure prime and total distress levels (b = - .61, SE = .18, p = .001), indicating that secure priming leads to lower distress levels in the seven days after watching the trauma film. The second pathway is from being in the OT condition via perceived distress immediately after the trauma film (see Figure 4a): OT was significantly associated with lower levels of perceived distress after the film, which in turn was associated with higher stress levels in the

seven days after watching the trauma film (see Figure 4a). Assuming a linear association between film-related distress and total distress levels post-testing, the indirect effect was marginally significant (b = -0.15, SE = .08, p = .057) but when a quadratic association was added, indirect effects became significant (b = -0.22, SE = .09, p = .011).

Linear slope of distress reduction (Hypothesis 7.2a). Again, there were two pathways to explain the linear slope of distress reduction (see Figure 4b) in an overall significant mediation model, R^2 = .244, 90% CI [.127, .368], p = .001, that explained 24% of the variance. The first is a direct positive association between receiving the secure prime and distress reduction slope (b = .63, SE = .18, p = .001), indicating that secure priming leads to a higher linear slope of distress reduction in the seven days after watching the trauma film. The second pathway is from being in the OT condition via perceived distress immediately after the trauma film (see Figure 4b): OT was significantly associated with lower levels of perceived distress after the film, which in turn was associated with a smaller linear slope of distress reduction in the seven days after watching the trauma film (Figure 4b). Assuming a linear association between film-related distress and distress reduction slope post-testing, the indirect effect was marginally significant (b = 0.16, SE = .09, p = .055), but when a quadratic association was added, indirect effects become significant (b = 0.24, SE = .10, p = .013).

Discussion

This investigation aimed to determine if temporarily activating a secure attachment representation stimulates perceived felt-security and a related response pattern of reduced physiological arousal and increased parasympathetic activation, and whether it protects individuals from experiencing high trauma-film-related distress and from developing intrusions during the week following exposure to the trauma-film. In line with the salience hypothesis (Shamay-Tsoory & Abu-Akel, 2016), we expected that a combination of security priming and intranasal OT would increase this effect compared to each intervention in isolation.

Secure Attachment Priming but not OT Activated a State of Felt-Security, Parasympathetic Activation and Low Physiological Arousal

With the exception of SCL during the priming phase, where individuals who received OT and secure priming showed persistently reduced SCL, we did not find evidence for an additive effect of combining the behavioral and pharmacological interventions. There was also no main effect of OT, which is surprising given the literature on its propensity to promote positive social affiliation memories (Cardoso et al., 2014), increase sense of trust (Kosfeld et al., 2005) and to reduce threat bias (Kirsch et al., 2005), but this could potentially be explained by a number of inconsistencies in the emerging OT literature. First, most studies that find OT enhances prosocial effects were conducted in healthy male populations e.g. (Domes et al., 2007), whereas studies that failed to replicate OT effects and that were published after we had started testing, were conducted in predominantly female samples, similar to our sample e.g. (Domes et al., 2010). In addition, individual differences in the passage of OT across the blood-brain barrier and in timing of its peak effect (assumed to occur 40-60 minutes after administration) may result in individual differences in the way OT facilitated the experience of felt-security. Our study did not assess peripheral levels of OT, so we cannot confirm if this explains the lack of an additive effect.

Instead we found a main effect of secure attachment priming; in particular, it increased HRV and reduced HR at the beginning and end of the priming phase thus extending previous research (Bryant & Hutanamon, 2018) and suggesting both an increase in parasympathetic activation and a reduction in physiological arousal. This physiological state has been described earlier as a ‘hypometabolic’ (Benson & Beary, 1974) or low-arousal parasympathetic state. Psychologically, it has been associated with feeling relaxed (e.g., (Kanji et al., 2006)) and compassionate and connected with others (e.g., (Kirschner et al., 2019; Kok et al., 2013). It confers health benefits (Kanji et al., 2006) and has been accompanied by reduced cortisol levels (Rockliff et al., 2008) and improved immune functioning (Breines et al., 2014), which together point to its potentially beneficial role in countering chronic stress conditions such as PTSD. Intrusive memories of the

traumatic events are key factors in facilitating chronic stress (Baum, 1990; Baum et al., 1993). Thus, our finding of reduced intrusion-related distress in the seven days post analogue trauma in those who activated a mental representation of secure attachment is possibly an early/acute indicator that these individuals are potentially able to effectively activate this health-beneficial state.

Priming, Drug and Trauma Film-Processing

Absence of Priming and Drug Effects

We did not find significant effects of prime or drug on the subjective or physiological indices of film-processing with the exception of attention paid to the films which was lower in the OT condition, but still overall high in all conditions. We had hypothesized that the previously induced state of felt-security would enable individuals to experience lower distress and arousal when processing the film, shown a few minutes after the prime. There are a number of possible explanations for the absence of priming or drug effects on film processing.

First, the priming effect is only transient, and answering the mood ratings and sitting quietly for another minute of baseline prior to the film could have weakened the priming effect. Future studies could test if a booster stimulus immediately at the film start may have helped to retain or reinstate the secure priming effect such as found using text security-primes (Otway et al., 2014). Second, and related, the exact timing and duration of OT's effect is difficult to control. We administered OT so that the experimental manipulation occured in the recommended time window of 40-60 minutes later (Heinrichs & Domes, 2008). The trauma film was shortened from 10 to 4 minutes to account for transience of priming effects and to allow it to be presented in full in the second part of that time window. This could have been too short to identify drug and priming effects although it is of note that the effects during priming show early on.

Another possibility is that priming and OT effects on trauma film processing have 'cancelled each other out'. OT as compared to secure priming, appears to have reduced self-reported processing of the trauma film. The function of this is not entirely understood. Because higher attention to negative stimuli (hypervigilance) has been described as a cognitive bias that

maintains PTSD ((Ehlers & Clark, 2000), reducing attention to the trauma films could be protective. However, if OT has contributed to emotion dampening or suppression, one would expect it to be more detrimental for recovery from trauma (Amstadter & Vernon, 2006, 2008). (Frijling et al., 2016) found that OT interfered with trauma processing in newly traumatized individuals which we discuss below. Without directly assessing emotion suppression or a related tendency for negative appraisal (Wilksch & Nixon, 2010) results should be interpreted with caution.

Finally, there could have been a ceiling effect: individuals had overall low levels of attachment insecurity so that the secure priming alone could have been sufficient to elicit maximum increase in state attachment security. The role of attachment style on attachment priming has been debated in previous research. Whereas Bryant found high avoidant attachment prevented benefits from attachment priming (Bryant & Hutanamon, 2018), other research suggested no effects of attachment style (Rowe et al., 2020) or even beneficial effects of priming in individuals with high levels of anxious (Mikulincer et al., 2011) or avoidant attachment (Shaver et al., 2009).

Physiological Responses to the Trauma Film

Instead of significant drug and priming effects we found a general decrease across conditions in both HR and SCL in comparison to the pre-film baseline. This is surprising given that the film paradigm reliably induces experimental distress (Holmes & Bourne, 2008). Individuals in our study reported moderate distress levels. For ethical reasons the trauma film paradigm differs considerably from real-life traumatic events which are often personally life-threatening in nature. In the context of moderate distress levels, relatively high felt-security post-films and low self-relevance of the films, the overall reduction in HR, accompanied by reduced SCL, an indicator of sympathetic activation (Boucsein, 2012), could indicate that individuals have an orienting response (Sokolov, 1960); i.e., that they found the trauma films interesting and non-threatening. It would have been helpful to measure interest elicited by the films to test whether the physiological responses do indeed indicate orientation. The alternative explanation, put forward in previous trauma film research to explain their finding of decreased HR, that it indicates a state of fear

bradycardia or freezing (Campbell et al., 1997) is less likely in our study because of the moderate nature of the stressors and because of the sample characteristics described earlier. Fear bradycardia, part of a parasympathetic reflex designed to facilitate survival by saving resources in the context of uncontrollable stress, could however be important when understanding peri-traumatic risk factors for PTSD in those experiencing real-life trauma.

Interestingly, we found a positive correlation between HR increase during the film and reported post-film distress, which accords with extensive research on the association between stress and physiological arousal (Craig, 1968) and is relevant for the development of intrusions.

Pathways to Intrusions

Using an intrusion diary in the 7-days post-testing, allowed us to further investigate whether secure attachment priming and OT prevent or reduce the development of intrusions. Despite not having a significant effect on trauma film-processing, secure attachment priming was associated with greater reduction of intrusion-related distress over time, whereas there was no direct effect for OT. Contrary to our expectations, neither secure priming nor OT had an effect on the overall number of intrusions. Our results suggest that secure attachment priming may not prevent intrusions per se but could avert intrusions from being appraised as negative and stressful. If replicated, this is an important finding given that immediately after trauma, intrusions are common and usually reduce over time unless a process of stress sensitization leads to an increasing sense of current threat (Ehlers & Steil, 1995).

Beneficial effect of Secure Attachment Priming on Intrusion-Related Distress

Extending previous research, we identified two pathways from drug and priming to intrusion-related distress levels in the week after testing. First, we found a direct association between secure attachment priming and lower intrusion-related distress levels and faster recovery (i.e., slope for the reduction of the intrusion-related distress over the seven days). It extends previous research in support of a protective effect of security priming on trauma memory. Bryant and co-workers (Bryant & Chan, 2017; Bryant & Foord, 2016) found that when a mental

representation of a secure attachment figure is activated prior to recall of previously encoded negative images, fewer intrusions are reported in a recall session 2-days post-encoding. They found this effect only in individuals with low levels of avoidant attachment. Our study sample had overall low levels of attachment insecurity. It also differed in that it employed the trauma film paradigm and administered the priming prior to the stressor, thus enabling us to investigate if intrusions develop in the first place. Direct evidence for attachment priming's role in altering appraisals of negative memories comes from Selcuk et al. (Selcuk et al., 2012), who found reduced negative thinking after secure priming following the recall of an upsetting autobiographical memory for those with lower levels of avoidant attachment. Although we have not explicitly assessed negative appraisals in our study, we infer from stress models which posit that subjective distress occurs when a situation is appraised as psychosocial threat (Lazarus & Folkman, 1984). Our interpretation is also supported by evidence that both elevated psychobiological stress response to a psychosocial stressor prior to the trauma film (Schultebraucks et al., 2019) and negative appraisals facilitate intrusion development and maintenance (Schweizer et al., 2019) and are detrimental for recovery from trauma by helping to maintain PTSD re-experiencing symptoms (Ehlers & Steil, 1995). Secure attachment priming could exert its protective effect on intrusion development by reducing distress and thus altering negative appraisals of trauma memories, which is a promising avenue for future research and clinical approaches for PTSD.

Second, we found an indirect effect of OT on higher intrusion-related distress via lower distress levels immediately after film processing. The possibility that OT has reduced film-related distress, which in turn leads to higher intrusion-related distress and its slower reduction was unexpected and is consistent with our earlier argument that OT interfered maladaptively with trauma-film processing. Previous research has shown that OT does not always have beneficial effects. For example, when OT is administered in freshly traumatized individuals it impairs successful trauma-processing by disrupting the emotion regulation brain circuitry and by increasing flashbacks (Frijling et al., 2016). It has also been shown to interfere with the extinction of

conditioned fear or exposure therapy (Acheson et al., 2015). If OT and secure attachment affect physiological responses (HR) (Sack et al., 2017) and peri-traumatic information processing in diametrically opposite ways, then this cannot only explain the absence of an additive OT-priming effect discussed above, but also why there were no peri-traumatic physiological effects. Our findings and those of others therefore suggest caution in the administration of OT for prevention of intrusions/and other post-traumatic-like symptoms and indicate that more research is needed to identify for which sub-groups it may confer beneficial effects.

Role of Physiological Arousal for Intrusion-Related Distress

Whereas perceived distress after the trauma film was positively associated with intrusions in line with existing research (Holmes & Bourne, 2008), it was surprising that the physiological responses to priming and the trauma film were not associated with intrusion development. The role of peri-traumatic physiological arousal for intrusion development has been a focus of considerable debate. Whereas emergency assessment of HR in recently traumatized individuals revealed mixed results with some studies reporting elevated (Bryant et al., 2008) and some studies reporting reduced (Blanchard et al., 2002) HR levels being associated with higher prospective PTSD symptoms, response to analogue trauma films has pointed to reduced HR as a predictor for intrusions in the 7-days post-testing (Chou et al., 2014). The absence of any predictive effect of physiological response during trauma film processing on intrusions found here are in line with research in trauma survivors that showed no association between emergency vital signs and PTSD (Buckley et al., 2004). The inconsistency in findings could also imply that the association between peritraumatic HR response and intrusion is non-linear with decelerated HR as an indicator of parasympathetically mediated fear bradycardia/freezing (Campbell et al., 1997) and accelerated HR as an indicator of a sympathetically mediated defensive high arousal state (Graham, 1979) predicting intrusions, but we found no evidence for this, possibly because both extreme states were not experienced with the trauma film paradigm. SCL reduction during the film processing indicated the absence of a defensive psychological state (Mendolia et al., 2016).

Theoretical Implications

Our findings suggest a number of mechanisms through which secure attachment could confer benefits for recovery from trauma and for preventing PTSD. First, in partial support of a cognitive model of PTSD (Ehlers & Clark, 2000), in which a sense of current threat, physiological arousal and highly emotionally charged intrusive memories are maintained by negative appraisals about the trauma concerning the self (e.g. 'it happened because I am a bad person; I can't cope') and/or the world (others cannot be trusted), we found that priming secure attachment was associated with felt-security, reduced physiological arousal and increased parasympathetic activation prior to the trauma film and lower intrusion-related distress in the week after testing. In conclusion, secure priming could confer its beneficial effect for recovery from trauma by preventing such excessive levels of distress, sense of current threat and physiological arousal. In support of the argument of threat reduction, we have recently shown that secure attachment priming in healthy individuals reduces amygdala activation to threat stimuli (Norman et al., 2015). Related to this, secure priming may activate a more positive representation of the self as mastering stress in the context of a safe haven. We have previously suggested that attachment anxiety may exert its PTSD-facilitating effect via an increase in negative posttraumatic cognitions of the self (Arikan et al., 2016). There is also evidence that secure priming facilitates more positive self-referential processing (Carnelley & Rowe, 2007).

Second, the positive association between perceived distress during film processing and distress-levels of intrusions in the week after testing aligns with the trauma film literature (Holmes & Bourne, 2008) and supports Pitman and Delahanty's (Pitman & Delahanty, 2005) assumption that increased encoding of the trauma memory leads to more easily triggered and distressing intrusive recollections. Although the physiological film response was not associated with intrusions in the post-testing phase, HR response to the film was positively associated with perceived stress during the trauma film thus being in line with findings that elevated sympathetic arousal predict intrusions or PTSD (Bryant et al., 2013).

Third, secure attachment priming could directly prevent or reduce the formation of intrusive memories by altering the connectivity in brain circuitries responsible for emotional learning (Sripada et al., 2013) that is impaired in PTSD (Milad et al., 2009); in particular ,functional connectivity between the amygdala and the medial prefrontal cortex (mPFC), which is vital for extinction of learned fear. Although the trauma film paradigm is not equal to fear-conditioning paradigms, there is indirect evidence in support of this. Preclinical evidence indicates that the pharmacological activation of the attachment system via OT reduces fear-conditioning (Knobloch et al., 2012) and facilitates fear extinction (Toth et al., 2012). In addition, attachment priming altered activity or functional connectivity in brain circuitries implicated in emotional learning (Norman et al., 2015).

Finally, our findings of the facilitation of a psychophysiological state of felt-security by inviting individuals to activate a mental representation of a secure attachment figure is in line with attachment theory (Mikulincer & Shaver, 2007, 2018), which postulates that secure attachment is accompanied by adaptive levels , i.e. neither excessive nor dampened/suppressed of physiological arousal and stress regulation by balancing self-soothing and seeking proximity to a secure attachment figure when facing challenging situations which thus prevent mental health problems (Mikulincer & Shaver, 2012). In particular, the finding that security priming was associated with lower intrusion-related distress over the seven days after the trauma-analogue exposure supports this assumption. Taken together with previous findings (Bryant & Chan, 2017; Bryant & Chan, 2015; Bryant & Foord, 2016; Bryant & Hutanamon, 2018), our results contribute to evidence that the attachment system plays an important role in the recovery from analogue trauma with implication for the development and maintenance of PTSD and could explain the consistent positive effects of social support on recovery from trauma (Brewin et al., 2000).

Taken together, there are several important contributions of the paper. First, by investigating if the combination of a pharmacological and a psychological intervention found to increase social connectedness and reduce distress amplify each other’s effect and thus reduce peritraumatic distress

and intrusions we address a novel question. Rather than an overall additive effect of drug and priming (except for the SCL in the first minute of secure priming), we found that secure attachment priming but not OT lead to some of the hypothesised effects in felt security, HR reduction and HRV increase early during the priming and intrusion-related distress. Second, we contribute to the growing literature that higher subjective distress during the trauma is associated with higher intrusion-related distress. Third, we also found that the effect of secure priming on intrusion-related distress was not mediated by the peritraumatic physiological and psychological stress response.

Regarding the role of OT, the combined consideration of our results and recent research on its role in memory formation and reconsolidation suggest that the timing of its administration could have been critical. If OT facilitates survival-related emotional learning as posited in a new theoretical model (Quintana & Guastella, 2019), then we could potentially expect that it increases the formation of trauma memories (intrusions) if the timing of the OT administration is close to the analogue trauma. Eckstein et al. have shown that OT can enhance fear memories (Eckstein et al., 2016). Whereas OT in our study appears to have amplified the secure priming effect of sympathetic arousal reduction as seen in the early SCL response, OT still active whilst individuals watched the trauma film could have also amplified maladaptive trauma memory processing. Research has pointed out OT's potentially sympathomimetic effect (Sack et al., 2017) in specific contexts (although others have not found an effect of OT on heart rate (D. A. Martins et al., 2020)), which could facilitate emotional learning via noradrenergic activation (McGaugh, 2018). It has been shown that sympathetic activation facilitates the formation of trauma memories (Keyan & Bryant, 2017; Nicholson et al., 2014). OT in freshly traumatised individuals has also not always shown beneficial effects (Frijling et al., 2016). Interestingly, in our study OT was associated with higher intrusion-related distress, which was not a direct effect but mediated by film-related peri-traumatic distress. OT also reduced the attention paid to the film. This together could indicate a defence response (Bradley et al., 2001); however, we did not find a pattern of increased HR and SCL to corroborate that claim in our study. Our OT findings appear to be at odds with our hypothesis that

OT reduces intrusions because we have previously facilitated a state of felt security that makes the individual more resilient when experiencing an analogue trauma and thus preventing intrusions. Indeed, OT has been shown to promote positive social affiliation memories (Cardoso et al., 2012; Eckstein et al., 2019). However, our findings are not at odds with the social salience hypothesis (Shamay-Tsoory & Abu-Akel, 2016) that OT increases the salience of the context. In our study secure priming was experienced at the beginning followed by the trauma film shortly after, making this potentially an ambiguous or partially threatening context where participants knew that they were going to see a stressful film which could have increased anticipatory state anxiety and thus affected the effects. Therefore, a follow-up study could administer OT and secure priming in a completely non-threatening context first a few days before the trauma film paradigm and investigate if/how OT and security priming can act synergistically as has been highlighted to be important for additive effects between a drug and a psychological intervention (Browning et al., 2011). Our findings do not rule out that OT could have a positive effect for individuals who have developed PTSD. In line with OT's proposed role in facilitating context-relevant emotional learning (Quintana & Guastella, 2019), OT could facilitate reconsolidation and thus alter the appraisals of intrusions and other PTSD symptoms during trauma-focussed therapy that facilitates more positive appraisals and meaning of the traumatic memories. There has been emerging evidence that OT administration is beneficial in the context of chronic PTSD (van Zuiden et al., 2017) and Hou et al. (Hou et al., 2015) have shown how OT altered retrieved fear memories in the context of reconsolidation.

Clinical Implications

Our findings extend previous research by pointing to secure attachment priming as an approach to target intrusion-related distress after an analogue trauma. Our finding of reduced intrusion-related distress in those primed before the analogue trauma suggests that secure attachment priming could have potential benefits as part of professional training for those who are exposed to psychological trauma as part of their job such as emergency and fire department workers. Future research could also investigate if repeated secure attachment priming after analogue

trauma reduces negative and increases positive appraisals of the trauma film memory over time which if effective, could be a promising approach complementing in trauma-focused psychological therapies. Treatment approaches which target the 'meaning' of intrusive recollections, such as reappraisal training (Woud et al., 2012) and using new technologies (Iyadurai et al., 2019; McNally & Woud, 2019) are promising. We have previously shown that ecologically valid secure attachment priming via text messages can reduce daily experienced levels of anxiety and depression in depressive patients (Carnelley et al., 2018). Our findings are additionally relevant for embedding secure attachment priming approaches that target trauma memory reprocessing and reappraising such as imaginal exposure and imagery re-scripting approaches that focus particularly on the self (Cili et al., 2017).

Limitations and Strengths

The study has a number of limitations. First, to reduce testing time, no pre-drug baseline measures were taken, but after the intranasal drug administration, the 40-minute waiting time was used to attach electrodes, provide instructions and ask participants to complete mood measures.

Although our manipulation checks showed that there were no pre-priming differences in self-report and physiological baseline measures between OT and placebo, a within-subject comparison would have been optimal, also for the perceived levels of distress which we only assessed after the film. Related, although we found significantly greater reduction in skin conductance (i.e., reduced sympathetic arousal) for the first minute of secure priming in those with OT as compared to the placebo condition, without a priming only/no drug condition, we cannot rule out that the placebo also facilitated the priming. The placebo effect has gained increasing interest in mental health research (Kam-Hansen et al., 2014) and future studies could add a non-drug, priming only control condition to test for this possibility.

At the time of study planning, no research was published on the effects of OT on baseline physiological measures but it has since emerged that OT can potentially increase HR (Sack et al., 2017) and, interestingly, HRV (Kemp et al., 2012) whilst other studies failed to find effects (D. A.

Martins et al., 2020; Tracy et al., 2018). Although our study was based on *a priori* power calculation (see supplementary material) and allowed us to detect medium-to-large effect sizes, it did not allow us to detect small effects which could be relevant in understanding additive pharmacological and psychological interventions (our contrast analyses) and also our mediation analyses (Fritz & Mackinnon, 2007). Future research should attempt to replicate this with a larger sample.

Previous research has found interactions between experimental effects of attachment priming and individual differences in adult attachment style (Bryant & Hutanamon, 2018). The absence of some expected effects and significant, yet small, levels of explained variance in our mediation models suggest there is a possibility that attachment style moderated both self-report and physiological responses to OT and priming which we were unable to investigate systematically in light of sample size and statistical power constraints.

Lastly, we included a convenience sample of largely (70%) young female participants. Whilst this reflects the epidemiology of PTSD (Olff et al., 2007), a replication in a male or more balanced mixed gender sample is necessary to ascertain potential generalizability. This is especially important given that most early OT studies were conducted in male samples and more recent studies in females revealed partially contrary effects of OT on social cognition (Domes et al., 2007; Domes et al., 2010). There is also an emerging body of research focusing on the role of sex-related neuropeptides in the susceptibility to PTSD and trauma memory formation (Milad et al., 2009) highlighting the importance of accounting for gender in research. Whilst we were unable to systematically study gender effects, we reran our analyses with a female-only sample and retained the findings.

Our study has a number of strengths. It is the first to investigate the combined effect of OT and secure attachment priming, a pharmacological and a psychological intervention previously shown to reduce distress and facilitate safety. By manipulating state attachment security and complementing self-report with physiological assessments we extended previous research to

investigate underlying mechanisms important to reduce stressful intrusions following an analogue trauma. Our results are in line with attachment theory contributing to accumulating evidence of a promising role of secure attachment priming in activating a parasympathetic state and reduce stress-related physiological arousal, a state associated with improved emotion regulation under stress. Regarding the role of OT, the combined consideration of our results and recent research on its role in memory formation and reconsolidation (Quintana & Guastella, 2019) can explain some unexpected findings and inform future mechanisms research. Additionally, our results are also in line with the social salience hypothesis (J. A. Bartz et al., 2011; Shamay-Tsoory & Abu-Akel, 2016). Moreover, a double-blind, randomization design ensured methodological rigor. Finally, the use of growth curve modelling allowed us to study both the trajectory of psychophysiological responses and of intrusions and distress levels in the days after testing.

Conclusions

We found that secure attachment priming, but not oxytocin or the combination of both, was associated with reduced physiological arousal and increased parasympathetic activity during priming. Although secure attachment priming was not related to absolute count of intrusions or more adaptive trauma film processing, it was associated with lower intrusion-related distress in the 7-days post-testing. Our findings extend previous research that suggests the importance of interventions that alter stress appraisals of intrusions for recovery from trauma, and point to a promising role for secure attachment priming in trauma-focused psychological therapies.

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Footnotes

1 The present reported outcomes are part of a larger project, which assessed a larger set of outcomes, and will be published separately to reduce complexity.

Tables

Table 1

Means and standard deviations of psychological and physiological variables

Variables \ Conditions	OT+Sec n = 25		PL+Sec n = 25		OT+Neu n = 24		PL+Neu n = 25		Total N = 99	
	n	%	n	%	n	%	n	%	n	%
Female gender	18	25.7	16	22.9	17	24.3	19	27.1	70	70.7
	M	SD	M	SD	M	SD	M	SD	M	SD
Age	21.96	4.13	20.72	2.78	21.38	3.13	20.80	3.11	21.21	3.31
Trait Anxiety (STAI) (20-80)	37.24	9.93	36.63	9.28	40.92	9.40	39.96	7.79	38.68	9.17
Attachment anxiety (1-7)	1.82	0.74	1.73	0.58	2.11	0.88	1.87	0.69	1.88	0.73
Attachment avoidance (1-7)	2.48	0.71	2.74	0.99	2.74	0.65	2.66	0.71	2.66	0.77
FSS BL (1-6)	4.68	0.74	4.79	0.81	4.34	0.93	4.58	0.91	4.60	0.85
FSS Post Priming (1-6)	4.97	0.92	5.14	0.85	3.98	1.19	4.18	1.45	4.57	1.22
FSS Post Films (1-6)	3.71	1.20	3.79	0.94	3.19	1.27	3.70	1.40	3.60	1.22
Attention paid to film (0-10)	8.80	1.31	9.14	0.83	8.56	1.01	9.14	0.83	8.91	1.03
Relevance of film (0-10)	3.76	2.91	4.44	2.95	3.65	2.67	2.60	2.52	3.61	2.80
Perceived stress to film (0-10)	6.72	2.17	7.46	1.24	5.83	3.10	6.80	2.20	6.71	2.30
Perspective taking (-3 to +3)	-0.04	2.37	-1.08	1.87	-0.92	1.95	-1.24	1.71	-0.82	2.02
SCL Baseline (in µS)	0.59	0.29	0.42	0.28	0.51	0.27	0.52	0.25	0.51	0.27
HR Baseline (in bpm)	81.70	11.06	77.13	9.08	71.54	10.69	78.71	9.68	77.33	10.65
HRV Baseline (in ln(ms^2))	3.96	0.97	4.54	0.76	4.61	1.14	4.00	1.06	4.27	1.02
Mean ΔSCL Priming (in µS)	-0.29	0.30	-0.08	0.21	-0.14	0.22	-0.16	0.23	-0.16	0.24
Mean ΔHR Priming (in bpm)	-0.70	3.62	-0.86	2.65	1.39	1.92	0.62	1.98	0.10	2.76
Mean ΔHRV Priming (in ln(ms^2))	0.21	0.43	0.13	0.47	-0.03	0.33	-0.14	0.54	0.01	0.49
Mean ΔSCL Film (in µS)	-0.26	0.32	-0.07	0.21	-0.17	0.19	-0.17	0.29	-0.17	0.26
Mean ΔHR Film (in bpm)	-5.39	3.64	-5.83	4.29	-3.81	3.87	-5.21	3.44	-3.73	2.87
Mean ΔHRV Film (in ln(ms^2))	0.31	0.45	0.27	0.48	0.06	0.39	-0.08	0.56	0.25	0.45
Intrusion count $	4.00	3.50	3.00	4.50	3.00	4.75	4.00	4.50	3.00	4.00
Intrusion-related distress (0-10)	0.76	0.78	0.79	0.79	1.30	1.09	1.13	0.98	0.99	0.93
Linear slope of intrusion-related distress	-0.22	0.14	-0.22	0.13	-0.31	0.18	-0.28	0.15	-0.26	0.15

OT+Sec = Oxytocin and secure attachment priming, OT+NP = Oxytocin and neutral priming, Pl+Sec = Placebo and secure attachment priming, Pl+NP = Placebo and neutral priming, STAI = State Trait Anxiety Inventory, FSS = Felt Security Scale; SCL= Skin conductance level; HR = heart rate; HRV = heart rate variability. $ Median & Interquartile ranges

Figure Captions

Figure 1

Flow of Participants. OT+Sec = Oxytocin and secure attachment priming, OT+Neu = Oxytocin and neutral priming, Pl+Sec = Placebo and secure attachment priming, Pl+Neu = Placebo and neutral priming, SCL = Skin conductance level, HR heart rate, HRV heart rate variability, Intr = Intrusion, Intr Distress = intrusion-related distress.

Figure 2

Experimental Procedure. OT = Oxytocin, SCL = Skin conductance level, ECG = electrocardiogram.

Figure 3

Time Course of Psychophysiological Responses to Priming. (a) Skin conductance, (b) Heart rate, (c) Heart rate variability. OT+Sec = Oxytocin and secure attachment priming, OT+Neu = Oxytocin and neutral priming, Pl+Sec = Placebo and secure attachment priming, Pl+Neu = Placebo and neutral priming.

Figure 4

Time course for median daily (a) intrusion numbers and (b) intrusion-related distress in the week after testing. OT+Sec = Oxytocin and secure attachment priming, OT+Neu = Oxytocin and neutral priming, Pl+Sec = Placebo and secure attachment priming, Pl+Neu = Placebo and neutral priming.

Figure 5

Two different paths to trauma-film-related distress during seven days post-testing. (a) explaining total distress levels over seven days, (b) explaining the distress reduction slope over seven days. OT+Sec = Oxytocin and secure attachment priming, OT+Neu = Oxytocin and neutral priming, Pl+Sec = Placebo and secure attachment priming, Pl+Neu = Placebo and neutral priming.

Figures

Figure 1

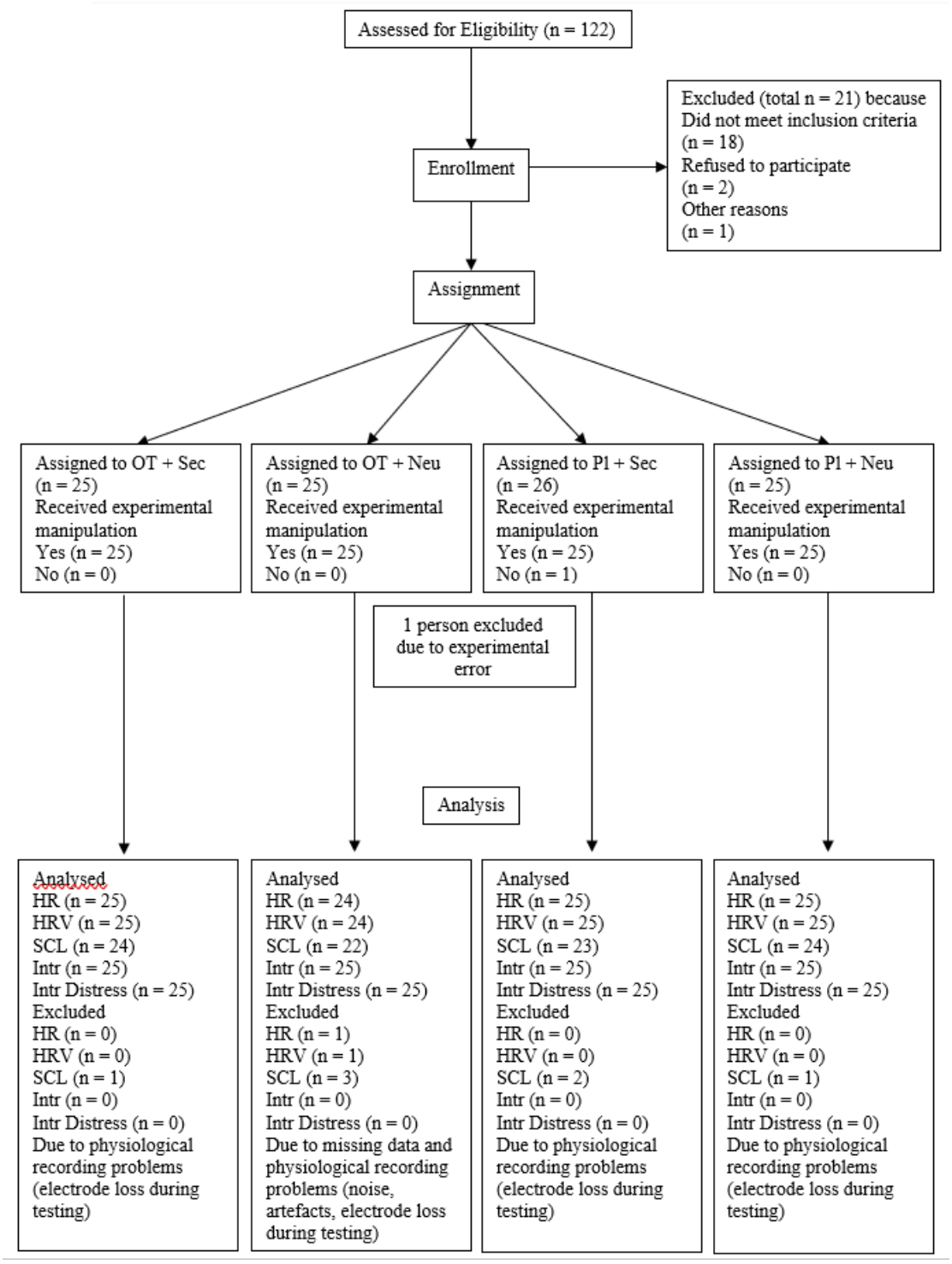


Figure 2

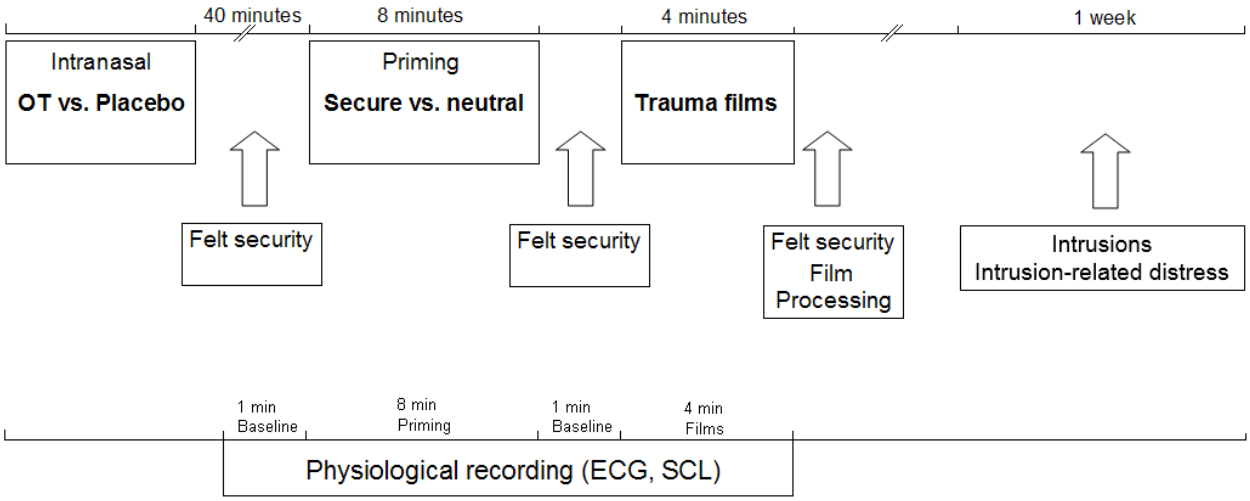

40 minutes
8 minutes
4 minutes
1 week
Intranasal
OT vs. Placebo
Priming
Secure vs. neutral
Trauma films
Felt security
Felt security
Felt security
Film
Processing
Intrusions
Intrusion-related distress
1 min
Baseline
8 min
Priming
1 min
Baseline
4 min
Films
Physiological recording (ECG, SCL)

Figure 3

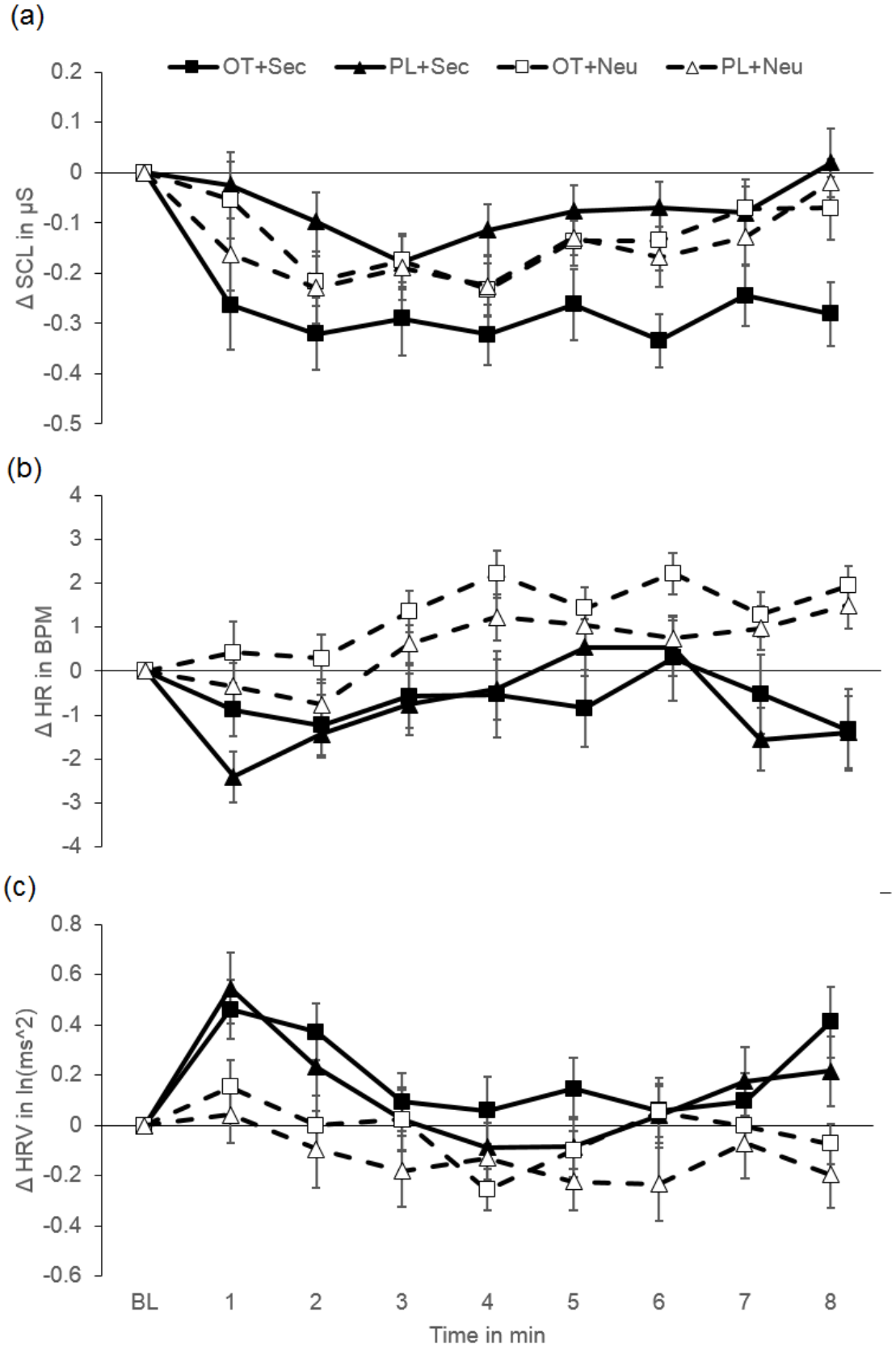

(a)
OT+Sec
PL+Sec
OT+Neu
PL+Neu
Δ SCL in µS
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
(b)
Δ HR in BPM
4
3
2
1
0
-1
-2
-3
-4
(c)
Δ HRV in ln(ms^2)
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
BL
1
2
3
4
5
6
7
8
Time in min

Figure 4

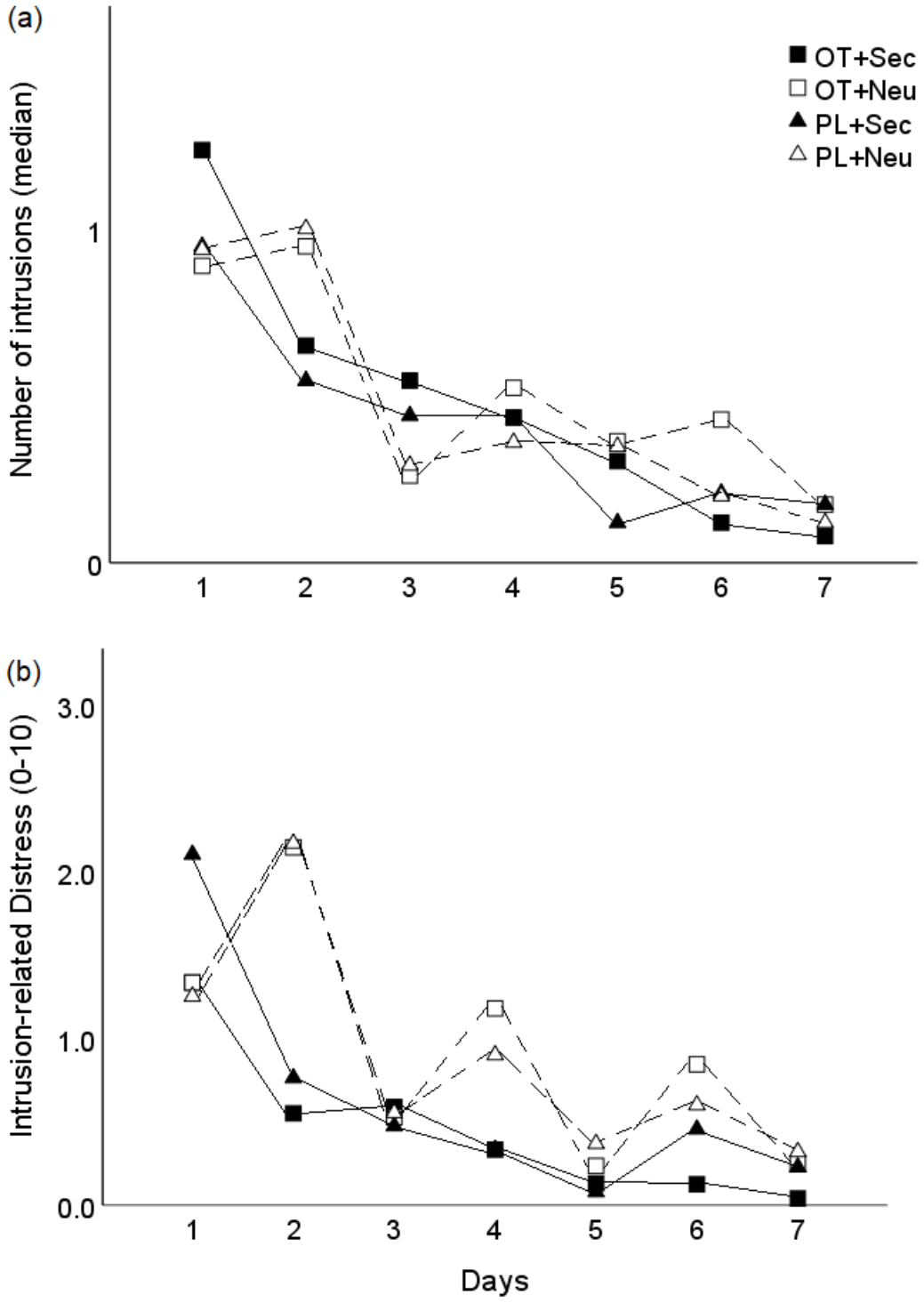
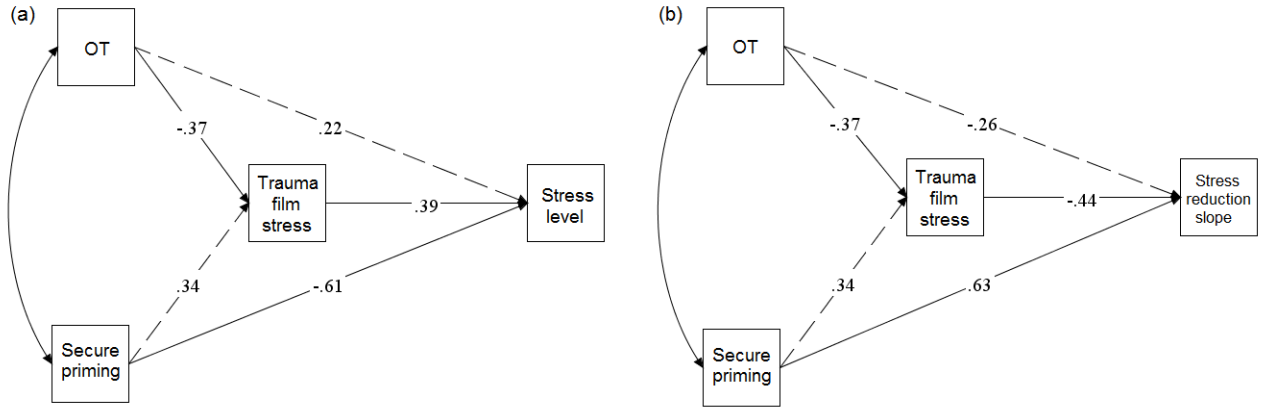

(a)
Number of intrusions (median)
1
0
OT+Sec
OT+Neu
PL+Sec
PL+Neu
1
2
3
4
5
6
7
(b)
Intrusion-related Distress (0-10)
3.0
2.0
1.0
0.0
1
2
3
4
5
6
7
Days

Figure 5


(a)
OT
-.37
.22
Trauma film stress
.39
Stress level
.34
-.61
Secure priming
(b)
OT
-.37
-.26
Trauma film stress
-.44
Stress reduction slope
.34
.63
Secure priming