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Biological responses to trauma and the development of intrusive memories: An analog study with the trauma film paradigm

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ABSTRACT

Evidence suggests that previous trauma reduces the cortisol response to subsequent stressors. We examined the relation of this response to intrusive memory, and the potential moderating roles of sympathetic reactions. Pre-existing trauma-related factors and the cardiac defense response were assessed before 58 healthy participants viewed a trauma film. Salivary cortisol and alpha-amylase (sAA) were collected pre-, peri- and post-film. Intrusive memories about the film were recorded for a week. Cortisol increased whereas sAA decreased after the film. Those with more recent traumatic experiences and greater subclinical PTSD symptoms had lower cortisol concentration post-film. Lower cortisol levels predicted greater vividness of intrusions. Positive correlations between cortisol and the frequency of intrusion were only present among individuals with more sympathetic activations. These findings suggest the contribution of insufficient cortisol secretion to over-consolidation of traumatic memory, and highlight the variation attributable to individual differences and different memory characteristics.

1. Biological responses to trauma and the development of intrusive memories

Cortisol is stress-reactive and influences brain regions involved in memory processing (Bowirrat et al., 2010). It has therefore been widely studied in the context of posttraumatic stress disorder (PTSD; APA, 1994). Findings regarding the influences of trauma and PTSD on resting cortisol levels have been inconsistent (Klaassens, Giltay, Cuijpers, van Veen, & Zitman, 2012). However, prior traumas have been shown to have attenuating effects on the cortisol response to a new traumatic stressor (Delahanty, Raimonde, Spoonster, & Cullado, 2003; Ehring, Ehlers, Cleare, & Glucksman, 2008; Resnick, Yehuda, Pitman, & Foy, 1995). In one study, low absolute cortisol levels after the new trauma mediated the association between prior traumatic history and later PTSD symptoms associated with the new trauma (Delahanty et al., 2003).

In terms of the effect of cortisol on memory, a meta-analysis suggested that while cortisol showed slightly positive effects on recall, studies adopting recognition tasks have reported adverse effects (Het, Ramlow, & Wolf, 2005). Echoing the latter, lower absolute cortisol levels immediately after accidents have been found among individuals who later develop PTSD and intrusive memories (Delahanty, Raimonde, & Spoonster, 2000; McFarlane, Atchison, & Yehuda, 1997). Consistent with this, insufficient cortisol secretion in the early aftermath of trauma and the related failure to down-regulate catecholamines have been hypothesized to cause over-consolidation of traumatic memories in PTSD and hence lead to intrusive memory symptoms (Yehuda & Harvey, 1997). However, inconsistent results have been reported (e.g., van Zuiden, Kavelaars, Geuze, Olff, & Heijnen, 2013).

Because in real-life situations there may be hard-to-measure complications such as the severity and nature of trauma, we adopted the trauma film paradigm (Holmes & Bourne, 2008; Lazarus, Opton, Nomikos, & Rankin, 1965) to examine the above-mentioned hypothesis and to clarify the correlations between prior trauma, cortisol level, and the development of intrusive memories. We investigated whether prior trauma would predict less cortisol secretion among healthy individuals in response to a traumatic film, and whether a lower absolute cortisol level would in turn predict the development of intrusive memories of the film. We also investigated the influence of pre-existing traits, such as dissociation, which have been linked with decreased physiological activation in response to traumatic stimuli (Lanius et al., 2010). Significant negative associations between previous traumas, preexisting trait dissociation, and cortisol concentration were predicted; in turn,

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a lower cortisol concentration was hypothesized to predict more frequent and vivid intrusive memories of the film.

Finally, we investigated potential moderators of the association between cortisol levels and intrusive memories. As sympathetic nervous system (SNS) activation has been suggested to moderate cortisol's effect on memory (Roozendaal, Okuda, de Quervain, & McGaugh, 2006; Roozendaal, Quirarte, & McGaugh, 2002), two factors related to the SNS activation were examined. First, salivary alpha-amylase (sAA) was used to index its possible effects (Rohleder, Nater, Wolf, Ehlert, & Kirschbaum, 2004). We predicted that cortisol and sAA would interact in a synergistic fashion to predict the number and vividness of intrusive memories.

The second moderator we investigated was the cardiac defense response (CDR; Eves & Gruzelier, 1984; Turpin & Siddle, 1978), which is a heart rate (HR) response to a sudden onset of loud noise. While almost everyone shows an increase of HR after the loud noise, a group of individuals (i.e., Accelerators) showing a secondary HR increase without any further external stimulus has been identified. The assessment of CDR has been established through careful examination of its measurement and reliability (Eves & Gruzelier, 1984; Vila, Fernández, & Godoy, 1992). Accelerators have been suggested to be more prone to adopt extreme coping strategies and to initiate a fight/flight response (Fernández & Vila, 1989). Moreover, they have been shown to have stronger anxiety traits, and greater vulnerability to anxiety disorders (Delgado et al., 2009; López, Poy, Pastor, Segarra, & Moltó, 2009; Richards & Eves, 1991; Robles Ortega, Marfil, & Reyes del Paso, 1995; Ruiz-Padial, Mata, Rodríguez, Fernández, & Vila, 2005). In assessing CDR, we expected greater vulnerability toward the development of intrusive memories among the Accelerators. Specifically, we predicted higher frequency and vividness of intrusive memory among Accelerators than Decelerators. Moreover, we expected a stronger inverse association between cortisol levels and intrusive memory among the Accelerators, compared to the Decelerators.

2. Methods

2.1. Participants

The current article reports the neuroendocrinological data from a larger study (Chou, La Marca, Steptoe, & Brewin, 2014). All procedures were approved by the Research Ethics Committee at University College London (UCL). Non-smoking native English speakers aged between 18 and 40, without any major physical or mental illnesses, and with a body mass index (BMI) range of 17.5–30 were recruited through a website recruiting UCL students and the general public in London to take part in psychological studies. Volunteers were sent a detailed information sheet about the study and screening questions via email after their first contact with the researcher. Individuals who reported having been diagnosed with or having received treatments for any mental disorders were excluded. Additionally, those who were taking medications or contraceptives, and those with cardiovascular or other significant physiological illnesses were not eligible for the study. Because the study contained graphic footages from car accidents, individuals who had experienced/witnessed, had close others seriously injured/died in road traffic accidents, or with a history of any mental disorders were also not eligible.

Volunteers who fulfilled the inclusion and exclusion criteria read through the information sheet again and asked questions before a consent form was signed at the beginning of the study. Eighty-seven completed the study. They were paid £15 as a reward for participation at the end. Only the 64 participants taking part in the afternoon (i.e., 1:30 p.m. to 6 p.m.) were included in this analysis in order to control for the circadian fluctuations of cortisol and sAA (Nater, Rohleder, Schlotz, Ehlert, & Kirschbaum, 2007). Among them, six were excluded due to procedural failures (e.g., contaminated the saliva samples, experienced actual traumatic or stressful events between the two experimental sessions), resulting in a final sample size of N = 58 (male = 32; ages between 18 and 37, $M = 24.16$, $SD = 4.22$).

2.2. Psychophysiological data acquisition

The Actiwave Cardio system (Camntech, Cambridge, UK) was used with two disposable electrodes (Blue Sensor SP; Ambu, Denmark) attached to the participants' chests to collect electrocardiography (ECG) signals. Signals were sampled continuously at 512 Hz, with resolution nine bits and no notch filter.

Salivary cortisol and sAA were collected by chewing salivettes (Sarstedt, Leicester, UK) for 2 min. Samples were stored at −20 °C before the biochemical analysis. After thawing, saliva was centrifuged at 3000 rpm for 5 min before free cortisol and sAA were analyzed using an immuno-assay with time-resolved fluorescence detection (Dressendörfer, Kirschbaum, Rohde, Stahl, & Strasburger, 1992). Inter- and intra-assay variance were both lower than 5% for cortisol, and both lower than 6% for sAA.

2.3. Psychophysiological reactivity test

A psychophysiological reactivity test (Eves & Gruzelier, 1984; López et al., 2009; Turpin & Siddle, 1978) was conducted to assess the CDR. Participants were told that the aim was to examine the effect of sound on relaxation and therefore an unexpected loud noise might be played, although the only thing they needed to do was try to relax. A 6-min resting period was given with a white noise (500 ms, 110 dB and instantaneous risetime) presented through headphones at the end followed by an 80-s ECG recording.

2.4. Trauma film viewing and intrusion diary

A 13 min–40 s trauma film (Holmes, Brewin, & Hennessy, 2004) was presented on a 28.5 cm × 40 cm computer monitor with the sound played through headphones. The film consists of five scenes of different real-life car accidents containing horrific images of emergency service personnel extracting trapped victims and dead bodies, injured individuals screaming, and body parts among vehicle wreckage. Before each scene, a brief narration (voiceover without images) introducing the context of the accident and background of the victims was played. Participants were asked to watch the film closely and imagine themselves being present and witnessing the occurrences first-hand. The researcher was present during the film viewing to ensure that all participants watched the film in full. In rare cases when participants looked away, reminders were given to return their attention to the film.

An intrusion diary was used to record the intrusions for 7 days after the film. Intrusion was defined as 'unintended and spontaneous, rather than deliberate, memories/thoughts/images about the film that easily capture attention and may interfere with ongoing activities'. Participants were asked to note the timing, give a brief description of every intrusion, and specify whether it took the form of images, thoughts, or a mixture of both. They were advised to carry the diary with them to record each occurrence as soon as possible, and to avoid retrospective completion. A text message was sent at 9 p.m. each day as a reminder to complete the diary. Participants reviewed their diary with the researcher when they returned to the laboratory on the 8th day. A self-rating of compliance (0 = very unreliable, 10 = very reliable) was then performed. The frequency of intrusive images was determined by summing up the numbers of pure imagery and mixed intrusions over the week, excluding any pure intrusive thoughts. Participants rated each intrusive image for vividness (0 = not at all, 10 = extremely) and these ratings were averaged.

2.5. Subclinical symptom, psychological trait, and state measures

2.5.1. Post-traumatic Stress Diagnostic Scale (PDS)

The PDS (Foa, 1995) is a 49-item questionnaire of traumatic experiences and PTSD symptoms. We used this scale to assess subclinical PTSD symptoms. The first section presents a checklist of different types of trauma. The second section identifies the one, among the selected events in the first section, which is the most troublesome and then asks about the elapsed time and questions for Criterion A for PTSD in DSM-IV (APA, 1994) based on the specified event. In the third and fourth sections, Criteria B, C, D, and E for PTSD are rated also based on the specified event. PTSD symptom severity is indicated by the sum of the items for Criteria B, C, and D. The scores range between 0 and 51, with 0–10 indicating mild distress, 11–20 indicating moderate distress, 21–35 indicating moderate to severe distress, and 36–51 indicating severe distress. The validity of the PDS (Foa, Cashman, Jaycox, & Perry, 1997) has been supported by good diagnostic agreement with the Structured Clinical Interview for DSM-III-R (Spitzer, Williams, Gibbon, & First, 1990).

2.5.2. State Trait Anxiety Inventory (STAI)

The STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a self-report scale of which the first subscale measures state and the second measures trait anxiety. They each have 20 items, and anxiety levels are indicated by the sum of all items. The scores range between 20 and 80, with higher scores indicating greater anxiety. The validity of the STAI has been supported by its ability to discriminate high vs. low stress situations and by agreement with other anxiety assessment tools (Metzger, 1976; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1989). Satisfactory reliability was found in the current sample (Cronbach's α ranged between .94 and .96).

2.5.3. Dissociative Experiences Scale (DES-II)

The DES-II (Carlson & Putnam, 1993) is a 28-item questionnaire designed to examine trait-like dissociation. It is composed of three aspects: Amnesia (e.g., finding oneself in a place with no idea how one got there), depersonalization-derealization (e.g., feeling one's body does not seem to belong to one's self), and absorption (e.g., finding oneself so involved in a fantasy or daydream that it feels as though it were really happening). The percentage of time (0–100%) that one is engaged in each experience in daily life is rated. Trait dissociation was indicated by