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Structural brain correlates of resilience to traumatic stress in Dutch police officers

Steven J.A. van der Werff[a,b,*], Bernet M. Elzinga[b,c], Annika S. Smit[d], Nic J.A. van der Wee[a,b]

[a] Department of Psychiatry, Leiden University Medical Center, Leiden, The Netherlands
[b] Leiden Institute for Brain and Cognition, Leiden, The Netherlands
[c] Clinical, Health and Neuropsychology Unit, Institute of Psychology, Leiden, The Netherlands
[d] Dutch Police Academy, Apeldoorn, The Netherlands

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ABSTRACT

Objective: Neurobiological research has traditionally focused on vulnerability rather than on resilience to severe stress. So far, only a few neuroimaging studies examining resilience have used designs that allow disentangling of the neural correlates of resilience from those related to psychopathology or trauma-exposure. The aim of this study was to identify structural brain correlates of resilience, and their correlations with behavioral measures.
Method: MRI scanning was performed in three groups of police officers: (1) a resilient group (N = 29; trauma-exposed, no psychopathology), (2) a vulnerable group (N = 33; trauma-exposed, psychopathology), and (3) a control group (N = 19; no trauma, no psychopathology). Using whole brain and region-of-interest approaches, we examined gray matter volume and shapes, and white matter integrity using software tools from the FSL-library.
Results: We did not find patterns of gray matter volumes or shape specific for the resilient group. In resilient police officers, we found an increase in structural connectivity in the corticopontine tract. White matter integrity in this location correlated with a coping style of positive reappraisal.
Conclusions: Resilient police officers show a specific pattern of increased structural connectivity, which is associated to the use of higher order emotion regulation strategies. Given this finding in an area that has not been implicated in stress-related disorders before, as well as the null findings in areas repeatedly shown to be involved in stress-related disorders, the current study indicates that resilience is not simply the opposite of having psychiatric symptoms, but rather an independent construct.

1. Introduction

By virtue of their profession, police officers have a higher chance of experiencing traumatic events compared to the general population. Stringent selection criteria for admission to police academies, including an extensive psychological assessment, exist to safeguard an elevated level of resilience in police officers. Moreover, training methods have been applied to further increase resilience to stress in police forces. Although in some cases experiencing traumatic events may lead to the development of trauma-related disorders like posttraumatic stress disorder (PTSD), major depressive disorders (MDD) and anxiety disorders (Berg et al., 2006, Carlier et al., 1997, Maguen et al., 2009), there is no evidence that police officers suffer from more psychiatric symptomatology compared to individuals without high-risk occupations (van der Velden et al., 2013). This makes the police force an interesting group to study in light of resilience (Marmar et al., 2006).

Despite progress in neuroscience methods, research into the neurobiology of resilience to traumatic stress is still very limited. Information we do have is often based on studies that examine PTSD patients compared to trauma-exposed non-PTSD individuals; for a review see: (van der Werff et al., 2013). With this comparison, however, it remains unclear whether differences found between these two groups are to be attributed to trauma-related symptomatology in the patient group, or to the resilience in the control group. To identify alterations in brain networks associated with resilience, a third group of individuals without traumatic experiences and without psychopathologies should be added to the design. As only a comparison of these three groups can elucidate the specific characteristics of the resilient individuals compared to the other two groups and thus which of the effects are specifically related to resilience.

Structural neuroimaging studies using magnetic resonance imaging (MRI) to study gray matter in trauma-exposed twins and non-trauma-

* Corresponding author at: Department of Psychiatry Leiden University Medical Center, Albinusdreef 2, 2333 ZA, Leiden, The Netherlands.
E-mail address: s.j.a.van_der_werff@lumc.nl (S.J.A. van der Werff).

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exposed co-twins suggest that an increased size of the hippocampus is related to resilience (Gilbertson et al., 2002, Kasai et al., 2008). In addition, neuroimaging studies consistently show reductions in hippocampal volume in stress-related disorders like PTSD and MDD (Bremner et al., 2003, Campbell et al., 2004, Gurvits et al., 1996, Kitayama et al., 2005, O'Doherty et al., 2015, Cardenas et al., 2011), and as a result of hypercortisolism (Starkman et al., 1992, Starkman et al., 1999).

The role of white matter structural connectivity has not yet been studied in the context of resilience. In stress-related disorders, decreases of white matter integrity of the uncinate fasciculus (Cullen et al., 2010, Eluvathingal et al., 2006) and the cingulum bundle (Daniels et al., 2013, Fani et al., 2012) have often been found using diffusion tensor imaging (DTI). The uncinate fasciculus connects parts of the limbic system with the medial prefrontal cortex (mPFC). The mPFC inhibits fear responses and emotional responsiveness mediated by the amygdala (Sotres-Bayon et al., 2004), a process that has been found to be disturbed in stress-related psychiatric disorders, including PTSD (Elzinga and Bremner 2002). However, it remains unclear whether these decreases in white matter integrity are purely associated the PTSD symptomatology or whether an increase of white matter integrity might also be indicative of resilience.

This study examines the gray matter volume and white matter integrity correlates of resilience to traumatic stress in a design with a resilient group, a vulnerable group and a healthy control group. Given the lack of existing data on neurobiological characteristics of resilience we based our hypotheses on the existing literature on stress-related disorders. We hypothesized to find an increase in gray matter volume of the hippocampus in trauma-exposed police officers without a history of psychopathology (the resilient group) compared to both trauma-exposed police officers with a history of psychopathology (the vulnerable group) and trauma non-exposed recruits from the police academy without a history of psychopathology (the control group). We also hypothesized to find an increase in white matter integrity of the uncinate fasciculus and the cingulum, specific for resilient officers. In addition to analyses in these regions-of-interest (ROI), we performed an explorative whole brain analysis to detect structural correlates of resilience outside these a priori defined ROI's. For a better understanding of the results, we will associate these measures of brain structure and structural connectivity with resilience-related behavioral measurements.

2. Material and methods

2.1. Subjects

Trauma-exposed executive personnel of the Dutch police were recruited through advertisements on the intranet of the Dutch police force. For optimal homogeneity across groups the non-exposed healthy control group, was recruited from the Dutch police academy. A total of 149 subjects signed up and were screened for eligibility. Exclusion criteria for all subjects were: MRI contraindications such as metal implants, heart arrhythmia, claustrophobia and possible pregnancy, a history of neurological or other medical illness with central nervous system sequelae, the use of psychotropic medications other than stable use of SSRI's or infrequent benzodiazepine use (i.e., equivalent to 2 doses of 10 mg of oxazepam 3 times per week as a maximum and refrain from use 48 h before scanning), a history of childhood maltreatment (i.e. < 18 years), a history of psychopathology with onset before work related traumatic events, left-handedness, insufficient knowledge of the Dutch language, and smoking > 5 cigarettes a day on average. 86 subjects were invited to participate in the study. Five subjects were excluded from the study after quality checking the MRI data, due to imaging artifacts in their respective MRI scans. The resulting 81 subjects were divided into three groups based on clinical assessment. The resilient group (N = 29) consisted of individuals who report having experienced traumatic events, and did not fulfill the criteria for any DSM-IV diagnoses, either current or past. The vulnerable group (N = 33) consisted of individuals who report having experienced traumatic events and fulfilled the criteria for one or more DSM-IV diagnoses, either current or past. Individuals in this group met the criteria for the following diagnoses at least once in their lives, after graduating from the Police Academy: major depressive disorder (n = 27), panic disorder (n = 3), agoraphobia (n = 7), specific phobia (n = 1), social phobia (n = 2), generalized anxiety disorder (n = 2), posttraumatic stress disorder (n = 14), substance abuse (n = 8). The control group (N = 19) consisted of trainees recruited from the police academy who reported no exposure to traumatic experiences and did not meet the criteria for any DSM-IV diagnosis in the present or past. As participants in this group were still in training and the participants in the other groups had already completed their training in the past it was expected that there would be an age difference between the groups, with the control group being younger compared to the other groups. Written informed consent was obtained from all participants before the clinical assessment. The medical ethical committee of the Leiden University Medical Center approved the study protocol.

2.2. Behavioral assessment

Past and current DSM-IV axis-1 psychiatric disorders were assessed using the mini-international neuropsychiatric interview (MINI); (van Vliet and de Beurs, 2007).

Severity of depressive symptoms were evaluated using the Montgomery-Asberg Depression Rating Scale (MADRS); (Montgomery and Asberg 1979), and the Inventory of Depression Symptomatology (IDS); (Rush et al., 1996). Severity of anxiety symptoms was assessed using Becks Anxiety Inventory (BAI); (Beck et al., 1988). The Harvard Trauma Questionnaire (HTQ) was used to inquire trauma-related symptom severity (Mollica et al., 1992). The Connor-Davidson Resilience Scale (CD-RISC) was used to assess self-report resilience (Connor and Davidson 2003). The Police Life Events Schedule (PLES) was used to assess the amount of exposure to work-related life events (Carlier et al., 1997). The Cognitive Emotion Regulation Questionnaire (CERQ) was used to assess cognitive coping strategies. This questionnaire consisted of nine subscales which all measure a different coping strategy (Garnefski et al., 2001). Higher scores on these subscales indicate that it is more likely an individual will use that specific cognitive coping strategy in challenging situations. The nine subscales of the CERQ are: (1) Self-blame: referring to thoughts of blaming yourself for what you have experienced; (2) Blaming others: referring to thoughts of putting the blame of what you have experienced on others; (3) Acceptance: referring to thoughts of accepting what you have experienced and resigning yourself to what has happened; (4) Refocus on planning: referring to thinking about what steps to take and how to handle the negative event; (5) Positive refocusing: referring to thinking about joyful and pleasant issues instead of thinking about the actual event; (6) Rumination: referring to thinking about the feelings and thoughts associated with the negative event; (7) Positive reappraisal: referring to thoughts of attaching a positive meaning to the event in terms of personal growth; (8) Putting into perspective: referring to thoughts of playing down the seriousness of the event or emphasizing its relativity when compared to other events; (9) Catastrophizing: referring to thoughts of explicitly emphasizing the terror of an experience (Garnefski et al., 2001).

2.3. MRI data acquisition

Images were acquired on a Philips 3T MRI system (Philips Healthcare, Best, The Netherlands; software version 3.2.1). A SENSE-32 channel head coil was used for radio frequency transmission and reception.

For each subject both a high resolution anatomical scan and a DTI scan were acquired. The high resolution anatomical scan was obtained