



# Psychosocial stress exposure impairs memory retrieval in children

A.A. Quesada<sup>a,b,c</sup>, U.S. Wiemers<sup>a,b</sup>, D. Schoofs<sup>a</sup>, O.T. Wolf<sup>a,b,\*</sup>

<sup>a</sup> Department of Cognitive Psychology, Ruhr-University Bochum, Germany

<sup>b</sup> International Graduate School of Neuroscience (IGSN), Ruhr-University Bochum, Germany

<sup>c</sup> School of Medicine, University of Brasilia, Brazil

Received 16 February 2011; received in revised form 19 May 2011; accepted 23 May 2011

## KEYWORDS

Acute stress;  
Cortisol;  
Alpha-amylase;  
Memory;  
Valence;  
Children;  
Development

**Summary** Negative consequences of stress on working memory and delayed memory retrieval have been observed in adult humans. Little is known about the occurrence of similar effects in children. Forty-four German full-term children, aged 8–10 years, were randomly assigned to a stressful (Trier Social Stress Test for Children – TSST-C) or to a non-stressful control condition. Afterwards, delayed memory retrieval was tested using a computerized version of the well-known card game “Memory”. It contained positive, neutral and negative stimuli. In addition, working memory of verbal and non-verbal material was assessed. The stressed children showed pronounced cortisol increases accompanied by a decrease in mood. Children exposed to the stressor performed poorer in the delayed memory retrieval test (memory card game). They committed more errors. No differences were found for working memory. The stress-induced memory retrieval impairment mirrors findings in adults. In contrast, the missing working memory effects could suggest developmental differences in stress sensitivity.

© 2011 Elsevier Ltd. All rights reserved.

## 1. Introduction

How do stress and related neuroendocrine responses influence the memory of our children? During their education, they constantly have to manipulate and learn new information as well as retrieve memories in arousing or stressful environments. They have to face presentations, oral or written exams, and a strong pressure imposed by teachers,

parents and society. Children are often required to perform well under pressure. In these contexts, some of them fail to retrieve previously learned information. However, few experimental studies exist on this topic compared to the large body of research in adults (reviews in [de Quervain et al., 2009](#); [Wolf, 2009](#)) and animals (reviews in [Roosendaal, 2002](#); [Joëls, 2006](#); [Cazakoff et al., 2010](#)). One potential reason for the scarcity of studies in children could lie in the observation that the induction of stress in the lab appears to be more difficult in children than in adults (reviewed in [Gunnar et al., 2009a](#)).

Stressful events trigger two systems: the sympathetic nervous system (SNS), resulting in the release of catecholamines (noradrenalin and adrenaline), and the hypothalamic–pituitary–adrenal (HPA) axis, resulting in the release of

\* Corresponding author at: Department of Cognitive Psychology, Ruhr-University Bochum, Universitätsstr. 150, D-44780 Bochum, Germany. Tel.: +49 (0) 234 32 22670; fax: +49 (0) 234 32 14308.

E-mail address: [oliver.t.wolf@rub.de](mailto:oliver.t.wolf@rub.de) (O.T. Wolf).

glucocorticoids (reviewed in [de Kloet, 2003](#)). As in adults, SNS activity in children can be measured using salivary alpha-amylase as an indirect marker ([Rohleder and Nater, 2009](#)). However, the few studies reporting sAA concentrations in children after stress exposure yield conflicting results ([Strahler et al., 2010](#); [Yim et al., 2010a](#)). Salivary cortisol can be used as a non-invasive marker of HPA axis activity ([Kirschbaum and Hellhammer, 1994](#)). Nonetheless, a sizable number of studies have failed to induce a cortisol response in children in the laboratory (reviewed in [Gunnar et al., 2009a](#)).

Studies in adults have shown that glucocorticoids can affect memory in a multifaceted way (reviewed in [Roosendaal et al., 2006](#)). While consolidation is enhanced ([Buchanan and Lovallo, 2001](#); [Cahill et al., 2003](#)), memory retrieval is compromised by elevated glucocorticoid levels ([de Quervain et al., 2000](#), reviewed in [Wolf, 2009](#)). These consequences are often more pronounced for emotional material. This idea is supported by rodent data ([Okuda et al., 2004](#); [Roosendaal et al., 2004a](#)) as well as by adult human data from pharmacological ([Kuhlmann et al., 2005a](#)) or behavioral studies ([Buchanan and Tranel, 2008](#); [Smeets et al., 2008](#)). The apparently opposing impact on consolidation and retrieval seems to depend on noradrenergic activity in the basolateral complex of the amygdala (BLA) and its interaction with other brain regions (reviewed in [Roosendaal et al., 2009](#)).

With respect to stress effects on working memory (WM), the findings are more controversial. Detrimental effects of stress which appear to be mediated via dopamine, noradrenalin and cortisol have repeatedly been observed in rodents and monkeys (reviewed in [Arnsten, 2009](#)). However, results have been less consistent in humans. Some studies using laboratory stressors such as the Trier Social Stress Test (TSST) or the cold pressor stress test (CPS) have shown adverse consequences of stress on WM ([Elzinga and Roelofs, 2005](#); [Oei et al., 2006](#); [Schoofs et al., 2008, 2009](#)). Similar findings have been obtained using pharmacological administration of cortisol ([Wolf et al., 2001](#); [Terfehr et al., 2011](#)). In contrast, others have failed to replicate these results ([Kuhlmann et al., 2005b](#); [Smeets et al., 2006](#)). As in memory retrieval, the modulation of WM also seems to depend on co-activation of the HPA axis and the SNS ([Roosendaal et al., 2004b](#); [Elzinga and Roelofs, 2005](#)).

In this context, it might be important to differentiate between distinct components of WM. In typical span tasks attention and storage (as assessed by the forward condition) can be contrasted with manipulation (backward condition). We recently observed that stress selectively impaired performance in the digit span backward task ([Schoofs et al., 2009](#)). Here, we suggested that stress might only impair WM tasks with a high demand on executive functions. Other groups, however, have observed the reversed pattern of results (i.e. impaired forward but unimpaired backward performance; [Elzinga and Roelofs, 2005](#)). Moreover, WM for verbal and non-verbal material is thought to rely on different brain regions ([Owen et al., 2005](#)) as well as on different cognitive processes (reviewed in [Baddeley, 2003](#)). Most of the previous studies in the field of stress research have investigated one domain only (verbal or non-verbal) by using the digit span test, the Sternberg task or the n-back task. Recently, however, [Li et al. \(2010\)](#) reported evidence that negative emotions had a stronger impact on the retention of spatial compared to verbal material in WM.

It is unclear whether similar impairing effects of stress on memory retrieval and WM are evident among children. There is evidence for developmental variations in the sensitivity to stress ([Gunnar and Quevedo, 2007](#); [Lupien et al., 2009](#); [Sumter et al., 2010](#)). However, the issue of changes in 'cognitive' sensitivity to stress has received little attention. The majority of developmental studies have focused on the physiological response to an acute stressor without addressing its impact on memory.

We currently have knowledge of only two studies investigating the effects of stress-induced cortisol response on memory in children. [Quas et al. \(2004\)](#) reported associations between memory and cortisol response induced by a fire alarm incident, which were further modulated by social support. It was recently reported that a larger cortisol response to a laboratory stressor in children was associated more strongly with accurate memory of this event (tested two weeks later) compared to adults ([Quas et al., 2011](#)).

Although several studies indicate no apparent differences in neuroendocrine responses between boys and girls ([Khilnani et al., 1993](#); [Yim et al., 2010b](#)), there are examples for sex-differentiated HPA axis responses to stress throughout the human life cycle (reviews in [Kajantie and Phillips, 2006](#); [Dedovic et al., 2009](#)). In the Trier Social Stress Test (TSST), adult men typically show a more pronounced response than women (reviewed in [Kudielka and Kirschbaum, 2005](#); [Cornelisse et al., 2011](#)). Conversely, higher cortisol in response to TSST-C has been observed in 13-year-old girls ([Gunnar et al., 2009b](#)) as well as in 8-year-old-girls ([Räikkönen et al., 2010](#)) compared to boys. In line with these findings, a recent study ([Strahler et al., 2010](#)) suggested that there is an increase in cortisol response with age in males but not in females. In conclusion, while findings suggest that sex makes a difference in adults, this issue is not clear yet regarding children.

As the memory impact of acute stress in children is still poorly understood, we aimed at investigating whether acute stress and its related hormonal responses affect WM of verbal and non-verbal material, delayed memory retrieval, and immediate recall. We further tested whether stress differentially affects temporary storage (forward) and manipulation processes (backward) of WM. Since it is conceivable that gender could have an impact on the neuroendocrine stress response and its cognitive consequences, we studied this variable in an exploratory fashion. Based on previous findings in adults, we hypothesized that delayed memory retrieval and WM would be negatively influenced by stress in children.

## 2. Methods

### 2.1. Participants

Forty-four German full-term children, aged 8 to 10 years, participated in this study and were randomly assigned to a stressful ( $n = 22$ ) or to a non-stressful control condition ( $n = 22$ ). The exclusion criteria included somatic disorders, diabetes, hypertension, cardiovascular diseases, allergy, asthma, neurodermatitis/psoriasis, hepatitis, tuberculosis (TB) as well as sensorial disorders, intellectual disability, dyscalculia, dyslexia, and children taking medication or immunization for at least 3 months prior to the study. Three

متن کامل مقاله

دریافت فوری ←

**ISI**Articles

مرجع مقالات تخصصی ایران

- ✓ امکان دانلود نسخه تمام متن مقالات انگلیسی
- ✓ امکان دانلود نسخه ترجمه شده مقالات
- ✓ پذیرش سفارش ترجمه تخصصی
- ✓ امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
- ✓ امکان دانلود رایگان ۲ صفحه اول هر مقاله
- ✓ امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
- ✓ دانلود فوری مقاله پس از پرداخت آنلاین
- ✓ پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات