



The impact of psychosocial stress on conceptual knowledge retrieval



Christian J. Merz^{a,b,*}, Florian Dietsch^{a,c}, Michael Schneider^c

^a Department of Biological and Clinical Psychology, University of Trier, Johanniterufer 15, 54290 Trier, Germany

^b Institute of Cognitive Neuroscience, Department of Cognitive Psychology, Ruhr-University Bochum, Universitätsstr. 150, 44780 Bochum, Germany

^c Department of Educational Psychology, University of Trier, Universitätsring 15, 54286 Trier, Germany

ARTICLE INFO

Article history:

Received 13 May 2016

Revised 21 July 2016

Accepted 28 August 2016

Available online 30 August 2016

Keywords:

Cortisol

Glucocorticoids

SECPT

Naïve theory

Scientific theory

Stress hormones

ABSTRACT

The acquisition of conceptual knowledge in scientific domains is among the central aims of school instruction because this semantic declarative knowledge helps individuals make inferences and explain complex phenomena. Recent research shows that naïve concepts acquired during childhood persist in long-term memory long after learning the scientifically correct concepts in school. In this study, we investigated the effects of stress on the retrieval of these conceptual representations. To this end, 40 healthy men were randomly assigned to either psychosocial stress or a control condition and evaluated, as quickly and accurately as possible, statements that were compatible with scientific concepts or incompatible with those concepts. Some of these statements were true and some were false. Incompatible statements in this case are statements which are in line with adults' scientific concepts, but not with children's naïve theories. In contrast, compatible statements are in line with both. Stress induction was successful as evidenced by increases in blood pressure and cortisol concentrations in the stress group compared to the control group. Responses were delayed and less accurate for incompatible compared to compatible statements. Psychosocial stress had no main effect on retrieval, but abolished reaction time differences on false- vs. true-incompatible statements. This effect was mirrored in correlations between individuals' cortisol increases and reaction times. These results suggest that stress, as embodied by increases in cortisol concentrations, interferes with the retrieval of conceptual knowledge. They help to better understand conceptual knowledge retrieval in real-life situations such as examinations or problem solving in the workplace.

© 2016 Elsevier Inc. All rights reserved.

1. Introduction

A student completing an important exam, a pilot trying to fix a problem with the airplane mid-air, and a scientist interpreting data from an experiment under time pressure all have one thing in common: they need to retrieve conceptual knowledge, that is, semantic declarative memories about scientific concepts and the world, from their long-term memory while at the same time experiencing stress. Despite the general importance of the topic, little is known about the effects of stress on the retrieval of conceptual knowledge from memory.

It is widely acknowledged that stress influences memory retrieval processes in general through the release of stress mediators such as (nor)epinephrine after activation of the sympathetic ner-

vous system (SNS) and glucocorticoids (GCs; cortisol in humans) resulting from stimulation of the hypothalamic-pituitary-adrenal (HPA) axis (Schwabe, Joëls, Roozendaal, Wolf, & Oitzl, 2012; Wolf, 2009). GCs can cross the blood-brain-barrier and bind to mineralocorticoid receptors and glucocorticoid receptors (GRs), both located in limbic regions such as the hippocampus, although GRs are also and predominantly expressed in prefrontal areas (Perlman, Webster, Herman, Kleinman, & Weickert, 2007). Both receptor types play a crucial role in memory functions in that stress can exert beneficial or impairing effects depending on the timing of stress onset (Het, Ramlow, & Wolf, 2005; Schwabe & Wolf, 2013; Schwabe, Wolf, & Oitzl, 2010). After exposure to stress or after GC administration, impairments can be observed in working memory (Oei, Everaerd, Elzinga, van Well, & Bermond, 2006; Schoofs, Preuß, & Wolf, 2008; Schoofs, Wolf, & Smeets, 2009) as well as in the retrieval of declarative (De Quervain, Roozendaal, Nitsch, McGaugh, & Hock, 2000; Kuhlmann, Piel, & Wolf, 2005), social (Merz, Wolf, & Hennig, 2010; Takahashi et al., 2004) and autobiographical memories (Buss, Wolf, Witt, & Hellhammer, 2004; Schlosser et al., 2010). Neuroimaging studies have revealed

* Corresponding author at: Institute of Cognitive Neuroscience, Department of Cognitive Psychology, Ruhr-University Bochum, Universitätsstr. 150, 44780 Bochum, Germany.

E-mail addresses: Christian.J.Merz@rub.de (C.J. Merz), s1fldiet@uni-trier.de (F. Dietsch), mschneid@uni-trier.de (M. Schneider).

that the hippocampus and the prefrontal cortex are involved in these stress effects on memory retrieval (Oei et al., 2007; Schwabe & Wolf, 2013).

Conceptual knowledge consists of general knowledge about everyday or scientific concepts and their interrelations (Carey, 2009), encoded in semantic declarative memory (Yee, Chrysikou, & Thompson-Schill, 2013). Individuals can use conceptual knowledge to categorize objects, to understand principles, to generalize, and to make predictions (Machery, 2010). Conceptual knowledge is used on a task-specific basis as a cognitive tool to construct mental models in working memory (Schnitz & Preuß, 1997; Vosniadou & Brewer, 1992).

In many domains, children first acquire so-called naïve concepts in everyday life (e.g., the sun orbits the earth) and only later learn the scientifically correct concepts in school (cf. Carey, 1992). Several theories of conceptual change imply that newly learned scientific concepts overwrite and thus replace earlier naïve concepts (e.g. Carey, 2009; Vosniadou, 1994). Contrary to this classical view, recent empirical studies found that naïve concepts and scientific concepts coexisted in learners' long-term memory even after school instruction (Alibali & Sidney, 2015; Kelemen, Rottman, & Seston, 2013; Schneider & Hardy, 2013). The concepts are activated depending on the situational context, so that learners are not necessarily aware of the inconsistencies in their knowledge base (diSessa, Gillepsie, & Esterly, 2004).

Recent reaction time studies demonstrate that naïve and scientific concepts do not only coexist in memory but actually interfere with each other during retrieval under time pressure (Babai, Sekal, & Stavy, 2010; Kelemen et al., 2013; Potvin, Masson, Lafortune, & Cyr, 2015; Shtulman & Harrington, 2016). Whereas most of these studies tested for knowledge in a single content domain only, Shtulman and Valcarcel (2012) provided consistent evidence from 50 concepts in ten scientific content domains (astronomy, evolution, fractions, genetics, germs, matter, mechanics, physiology, thermodynamics and waves). For each concept, they constructed four statements. One item conflicted with the naïve concept as well as with the scientific concept (compatible-false, e.g. "rain produces heat"); one item was in line with the naïve concept as well as with the scientific concept (compatible-true, e.g. "ovens produce heat"); one item was in line with the naïve concept but conflicted with the scientific concept (incompatible-false, e.g. "coats produce heat"); and one item conflicted with the naïve concept but was in line with the scientific concept (incompatible-true, e.g. "pressure produces heat"). The participants evaluated the truth value of each statement as quickly and accurately as possible by pressing one of two buttons. In all ten domains, participants consistently showed less accurate and slower responses when verifying incompatible compared to compatible statements. This is explained by the fact that interferences between naïve and scientific concepts need to be resolved in working memory for incompatible but not for compatible statements.

Shtulman and Valcarcel (2012) also found reaction time differences between scientifically true and scientifically false statements. This is a typical finding in sentence verification tasks (Neubauer & Freudenthaler, 1994). Recent brain imaging data (Marques, Canessa, & Cappa, 2009) suggest that the verification of true statements activates the left inferior parietal cortex and the caudate nucleus which are both involved in matching processes. In contrast, the verification of false statements involves the frontopolar cortex and might involve the evaluation of contradictions.

Taken together, research shows that naïve concepts persist after formal instruction on a topic and can interfere with later acquired scientific concepts, suggesting that scientific knowledge inhibits rather than replaces naïve knowledge. Since these complex causal thinking tasks involve increased activation of prefrontal regions

(Brault Foisy, Potvin, Riopel, & Masson, 2015), stress might impair conceptual knowledge retrieval via its impact on prefrontal functioning (Oei et al., 2007; Schwabe & Wolf, 2013). The strengths of these effects might differ between the evaluations of compatible versus incompatible statements (Shtulman & Valcarcel, 2012) and true versus false statements (Marques et al., 2009) because these processes rely on partly different brain regions and cognitive resources.

The objective of this study was to examine the consequences of acute psychosocial stress and the associated endocrine response of the SNS and the HPA axis on conceptual knowledge retrieval. We hypothesized that stress would reduce conceptual knowledge retrieval in terms of a slower reaction time and a lower accuracy of responses, especially for false-incompatible statements. These false-incompatible statements require more conflict monitoring and interference resolution than the other three types of statements involving the recruitment of prefrontal areas (Marques et al., 2009), which are especially prone to stress effects due to the predominant expression of GRs in these areas (Perlman et al., 2007).

2. Material and methods

2.1. Participants

Participants were recruited through email announcements at the University of Trier, Germany, or by personally addressing them. Inclusion criteria comprised an age between 18 and 35 years and a body-mass-index between 18 and 27 kg/m². Due to known sex differences in cortisol responses to stress and in stress-mediated memory effects (Kudielka, Hellhammer, & Wüst, 2009; Merz & Wolf, 2015) only men were included in the present sample. Exclusion criteria were regular medication intake, any history of psychiatric treatment or a current psychiatric (e.g., depression or anxiety disorder) and/or somatic disease (e.g., high blood pressure, Raynaud's disease or allergies), especially endocrine diseases known to influence endogenous hormone levels (e.g., hyper-/hypothyroidism), and smoking. The study was approved by the local ethics committee of the University of Trier. Written informed consent was provided prior to participation in the study.

2.2. Procedure

Experimental sessions were run between 1 and 6 p.m. and participants had to have been awake for at least 3 h before testing in order to control for circadian fluctuations in salivary cortisol (Kudielka et al., 2009). They were instructed to refrain from intense physical exercise, eating and drinking anything but water for at least 90 min before the experiment.

On arrival, participants were randomly assigned to one of two groups comprising 20 persons each (socially evaluated cold-pressor test (SECPT) vs. warm water control condition; Schwabe, Haddad, & Schächinger, 2008). In both conditions, participants had to immerse their dominant hand up to the elbow into water, with a temperature between 0 and 3 °C in the SECPT and between 36 and 37 °C in the control condition. A neutral female experimenter only present for the duration of the SECPT videotaped and observed participants during the SECPT, while the experimenter executing the rest of the study stayed in the background. In the warm water control condition, neither videotaping nor observation took place. In both conditions, participants were instructed to remove their arm from the water after 3 min. If they did not manage to keep their arms in the ice water in the SECPT for this duration, they were instructed to hold their hands above the

Download English Version:

<https://daneshyari.com/en/article/5043282>

Download Persian Version:

<https://daneshyari.com/article/5043282>

[Daneshyari.com](https://daneshyari.com)