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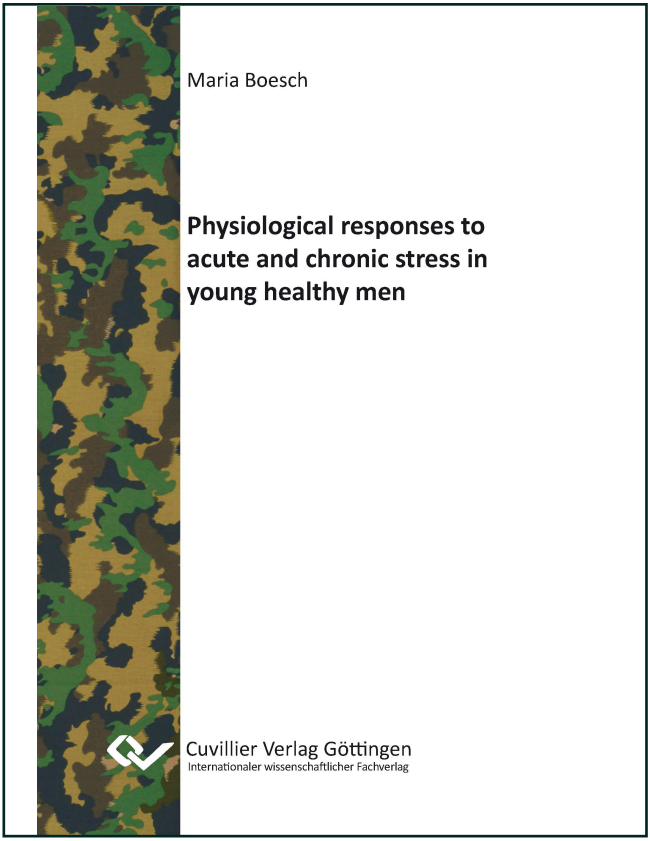
Physiological responses to acute and chronic stress in young healthy men



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1 Introduction

Everyone is familiar with it, everyone talks about it, no one wants it and yet sometimes people are proud to have it, and everyone has a different understanding of it: *stress*. It is therefore no great surprise that *stress* found its way into the 100 words thought to be most significant in the 20th century (Schneider, 1999).

The Swiss State Secretariat for Economic Affairs (SECO) has been keeping an eye on this phenomenon for years. In 2000, 26.6% of all of Swiss employees surveyed felt stressed at work frequently or even very often (Ramaciotti & Perriard, 2000). This number increased within ten years, with 34.4% stating that they were stressed in 2010 (Grebner, Berlowitz, Alvarado, & Cassina, 2011). This means that compared to the year 2000 around 30% of the employees are frequently stressed. Needless to say, Swiss employers are not protected from the negative effects of stress perception and the resulting costs of at least 4 billion Swiss Francs (Grebner et al., 2011).

Although stress can have advantages such as an increase in performance and promoting motivation, it can also have negative effects on the human organism, to which full attention is given in this thesis. Stress can influence the organism acutely or chronically. Acute stress can be the trigger for various diseases, such as eczema, asthma, indigestion, migraines, panic attacks, or psychotic episodes (Chrousos, 2009). Diseases, which are caused by chronic stress include hypertension, obesity, osteoporosis, anxiety, insomnia, depression, and burnout (Chrousos, 2009).

Because humans differ in their perception of stress, the exact effects on the body and the long-term consequences are difficult to assess. Since stress reactions can be of physical or psychological nature, valid and reliable measurement methods for psychobiological stress research and for the assessment of the effects of experimental stress induction are indispensable. By using established methods of measurement, researchers can determine the onset of a stress response, its duration, and its strength.

The present thesis focuses on two empirical studies. The first study is used to assess the physiological response to acute stress and the second study investigates the physiological response to chronic stress. A sample of young, healthy men who completed their basic military training (BMT) in the Swiss army during the second half of 2011 participated in both studies.

In the first study, acute stress was induced using a standardised stress test for groups, the Trier Social Stress Test for Groups (TSST-G; von Dawans, Kirschbaum, & Heinrichs, 2011). The novelty of our study was the investigation of the repeatability of the TSST-G and to examine two additional physiological parameters of the participants' reactions to the TSST-G. To our knowledge, the TSST-G has only been utilised in a one-time process based on heart rate (HR) and salivary cortisol measurements. The second study investigated whether the recruits perceive the basic military training as chronically stressful. A questionnaire that the participants filled in was used to determine their subjective perception of stress due to the training. Additionally, hair samples were taken to measure and identify the subject's aggregated physiological stress reaction using a novel measurement method that tracks the hair cortisol concentration (HCC).

As the starting point of the following chapters, the term *stress* is defined in order to clarify the theoretical framework of the two studies and also to dissociate it from the concept of psychological stress. Subsequently, the concepts of acute and chronic stress are compared to illustrate the reaction of an organism to psychological stress. Then this psychological stress response is discussed, in conjunction with the physiological systems and indicators that are important for this these. These are the sympathetic nervous system and its indicator the salivary alpha-amylase (sAA) as well as the parasympathetic nervous system (PSNS) with the heart rate variability (HRV) as its indicator. The focus is then shifted to another important system for stress reactions, the hypothalamus-pituitary-adrenal (HPA) axis with cortisol as one of its indicators. This axis' anatomy and physiology is described followed by cortisol

secretion under acute stress conditions and the assessment of long-term parameters for cortisol secretion. This serves as the basis for an integration of the various indicators to understand the methods of stress induction in the current state of research. After this, the focus shifts to the reaction of a human being to different stressors, concentrating primarily on healthy and unhealthy reactions of the organism. Then normal, healthy stress reactions as well as the more and more widespread unhealthy reactions resulting in mental disorders like depression are described. There follows a specification of the various methods of stress induction after which stress induction in a laboratory setting is introduced. The emphasis is on the group application of the Trier Social Stress Test (TSST), the TSST-G, which was used in one of our studies. The BMT as a possible real-life stressor is introduced in thorough detail, and finally the two studies with their results are presented. No detailed descriptions about the exact method of analysis are given, since they are apparent in the original papers. The findings of each study, as well as their strengths and weaknesses are discussed. After a final conclusion suggestions for possible directions of future studies are given.

2 Theoretical Background

In this chapter, relevant definitions of stress are presented. Then, the psychological stress response is explained in greater detail to provide the theoretical background for the experimental investigations described in this thesis. Next, the systems involved in the psychological stress response as well as their indicators are illustrated. Finally, the different methods of stress induction, which were important for the conducted studies, are presented.

2.1 Stress

This thesis uses the term *stress* to describe the organism's reaction in a certain psychobiological meaning (stress response) following a psychological or physiological trigger (stressor). First, there is an introduction to the definition of stress and then a comparison of acute stress versus chronic stress.

2.1.1 Psychological Definitions of Stress

In 1936, Selye introduced the term *stress* into the psychobiological linguistic repertoire. *Stress* originates from physics and means *pressure* or *tension* in reference to a material or an object in which a temporary or permanent change is caused. Selye's concept of general adaptation-syndrome (GAS) divides the physical reaction during a stress situation into three phases: (1) the *alarm phase* which starts immediately, (2) the *resistance phase*, which is reached as soon as the stressor persists for some time, and finally (3) the *exhaustion phase*, which occurs when the organism has used up its resources (Selye, 1950; 1998). This concept predicts harmful consequences on health when a stress reaction persists for a long time (Rief & Nanke, 2003). His definition determines that *stress* is the body's unspecific reaction to any adaptation to change (Selye, 1936). Since research indicates that the body can definitely counter similar stimuli with specific reactions (Gaab et al., 2003; Henry & Grimm, 1990), Selye's definition must be called into question.

Based on the discovery that a biological organism can regulate itself (Bernard, 1865), Cannon (1929) defined the term *homeostasis* as *maintaining various physiological parameters within acceptable limits*. He assumes that an external threat to *homeostasis* (for example a decrease in the body temperature or a cut) is detected by physiological *sensors*, resulting in a certain physiological reaction (Cannon, 1934; Knoll, Scholz, & Rieckmann, 2011; Rief & Nanke, 2003). This reaction aims to decrease the discrepancy between the values detected (actual values) and the acceptable values (nominal values). In order to maintain homeostasis under external as well as internal pressure, both physiological and psychological regulation mechanisms in the body are activated (Chrousos, 1992; 2009). In 1988, Sterling and Eyer expressed the hypothesis that for any physiological parameter there is not just one specific nominal value which should be maintained, but rather that these nominal values are dependent on the current status of the organism. According to McEwen (1998) the basic principle of stress research as well as the so-called allostatic regulation are based on *stability by means of change.* To describe the stress reaction he used the term *allostasis,* which means the suitable psychobiological reaction to a stressor. Accordingly, the stressed organism will react by changing certain physiological mediators to obtain homeostasis. Such mediators, among others, are the autonomic nervous system (ANS) and the HPA axis. To deal with daily stressors a moderate allostasis is helpful to keep the organism healthy (McEwen, 1998; 2005). A long-term allostatic load is the consequence of a chronic hyperactivation of the allostatic systems and the involved mediators. Allostatic systems are not able, unlike homeostatic systems, to rebound immediately after a stressor has disappeared. In the long term there can be a negative influence on the stress sensitive systems (like the ANS or the HPA axis); as a consequence these systems stay unbalanced. McEwen describes three types of such allostatic loads: (1) the inability to adapt to continuously repeated stress, (2) the inability to recover from a stress reaction, or (3) an inadequate physiological reaction (McEwen, 1998, pp. 38-39).