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Salivary cortisol concentrations after awakening, stress-induced psychophysiological reactions to an academic examination, and test performance

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1999

to my parents

Acknowledgments

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Summary

The present longitudinal psychophysiological study examines the activity of the hypo-thalamic-pituitary-adrenocortical (HPA) axis as well as adrenocortical activation in 148 students in the context of a written examination. The goal was to detect possible associations between the salivary cortisol response to awakening, psychophysiological indicators of examination stress, and academic performance.

A first part of the study elucidates individual differences in awakening-mediated salivary cortisol concentrations as well as their intraindividual stability. It investigates the question of what psychophysiological factors mediate early morning cortisol concentrations. One aim was to define a reliable, intraindividually stable marker of awakening-mediated adrenocortical activity.

Possible associations between these awakening-mediated cortisol markers and examination-related cortisol increases are assessed in a second part of the study. The circadian rhythm of the adrenocortical activity was investigated in the context of an acute and realistic stressor – an actual academic examination. It was hypothesized that the announced written examination provokes a stress reaction that is expressed by an anticipatory cortisol increase. Models containing psychosocial and adrenocortical variables are constructed to explain a maximal part of the variance of these stressor-induced elevations of cortisol.

The third part of the study concentrates on possible effects of the anticipatory cortisol increase on examination performance. The question was whether persons showing a pronounced examination-induced cortisol reaction perform worse on the test than examinees without strong adrenocortical activity. The observed variance of the academic performance is explained by selected physiological and psychosocial variables.

The 148 student volunteers (99 men and 49 women) participated in a week-long, live-in seminar as part of their course of studies leading to a Master's Degree in Science Education at the Swiss Federal Institute of Technology Zurich. Four months prior to the seminar, the students took part in an initial, basis investigation day. Three further observation days were conducted under the semi-experimental, live-in conditions during the seminar held at a boarding school. On each of the observation days, an academic event was held at five o'clock in the afternoon: a lecture on the first and third days, a written examination on the second day, and an intelligence test on the fourth observation day. The hour-long written examination was announced in advance and counted 20% towards the final post-graduate grade.

Saliva cortisol was collected on each observation day at individual awakening times, 30 minutes thereafter, and prior to the academic tasks at 5 p.m. During the seminar week, additional samples were taken after the academic tasks (at 6 p.m.) as well as at 6:30 p.m. Together with each saliva sample, potential moderating variables were assessed by means of a protocol. Following observation day one, a baseline package of validated questionnaires assessed health aspects, psychosocial data, selected personality characteristics as well as different controlling variables. Students filled out additional self-rating instruments assessing current emotional states just prior to the academic test situations on observation days two and four. Awakening was operationalized as the individual student's time of waking up just before getting up. The awakening response was defined as the salivary cortisol concentration 30 minutes post-awakening minus the concentration at awakening.

The process of awakening induced a cortisol increase in 78.6% (n = 419) of all cases (n = 533, provided by 148 subjects). A consistent pattern of increases, i.e. increases on all observation days, was observed in 46% of all students. Increases and individually consistent patterns of increases were more common in women than in men. Intrapersonal stability was maximal when the individual morning peak value, i.e. the higher of the two early morning saliva samples, was entered into the analysis ($0.40 < r < 0.62$). As hypothesized, the stability of cortisol levels declined with an increasing interval between sampling days. Interestingly however, even an interval of four months associated with a change in environment still showed moderate stability ($r = 0.40$, morning peak value). The post-awakening cortisol concentrations related to the subject's gender, body mass index (BMI), the personality trait of neuroticism, and use of oral contraception by women. In contrast, cortisol levels at awakening time as well as the intraindividual stability of the early morning cortisol concentrations remained uninfluenced by all investigated covariables.

Cortisol levels prior to the academic tasks at 5 p.m. were higher in males than in females (mean of all observation days = 9.2 nmol/l versus 6.0 nmol/l, $F = 53.1$, $df = 1/146$, $p < 0.001$). The academic examination induced an anticipatory relative cortisol increase of 85.6% (cortisol concentration immediately before the examination divided by the mean of the corresponding concentrations of the other observation days). Every second student displayed a pre-examination increase of more than 50%. Psychosocial data explained 16.1% of the variance of this relative increase. The explained variance of the increase was only marginally improved by the inclusion of non-stimulated circadian cortisol markers into the model. While the examination-related relative cortisol increase was independent of gender, men showed a higher absolute cortisol increase than women (5.2 versus 2.8 nmol/l; cortisol concentration immediately before the examination minus the mean of the corresponding concentrations of the other observation days). Gender as well as psychosocial variables explained 17.6% of the variance of this absolute cortisol increase. When including individual markers of circadian cortisol activity, the explained variance amounted to 29.7%.

No significant associations were detected between performance on the actual criterion-reference test and individual markers of adrenocortical (re)activity. Neither the examination-related anticipatory cortisol increase, nor non-stimulated circadian cortisol levels, nor indices of individual former cognitive performance explained a relevant part of the observed variation in examination results. The best model predicting test performance contained psychological variables as well as gender and explained 12% of the observed variance. Markers of adrenocortical (re)activity and indicators of former performance did not improve this predicting model. Evidently, the observed anticipatory cortisol reactions had no impact on the higher order cognitive performance in the investigated criterion-reference test.

Future assessment of the awakening-mediated cortisol reaction should define the individual awakening time as the first stage of the awakening process and clearly distinguish it from possible later phases of the awakening process preceding the subject's getting up. The higher of the two cortisol concentrations collected within 30 minutes after awakening should be entered into the analysis of the individual stability of the hypothalamic-pituitary-adrenocortical (HPA) axis. Further, absolute and relative cortisol changes related to examinations must be analyzed separately.

Zusammenfassung

Die vorliegende psychophysiologische Längsschnittstudie untersucht die Aktivität der Hypothalamus-Hypophysen-Nebennieren-(HHN)-Achse sowie die adrenokortikale Aktivierung im Kontext einer schriftlichen Prüfung bei 148 Studierenden. Das Ziel war, mögliche Assoziationen zwischen der Saliva-Kortisolreaktion auf das morgendliche Aufwachen, psychophysiologischen Indikatoren von Prüfungsstress und akademischer Leistung aufzudecken.

Ein erster Studienteil widmet sich individuellen Unterschieden der Saliva-Kortisolkonzentrationen im Zusammenhang mit dem Aufwachen sowie deren intrapersonellen Stabilität. Es wird untersucht, welche psychophysiologischen Faktoren eine Mediatorfunktion auf die frühmorgendlichen Saliva-Kortisolspiegel ausüben. Ein Ziel war, einen zuverlässigen, intraindividuell stabilen Marker der frühmorgendlichen adrenokortikalen Aktivität zu definieren.

Mögliche Zusammenhänge zwischen diesen frühmorgendlichen Kortisolmarkern und prüfungsbedingten Kortisolanstiegen werden in einem zweiten Studienteil erforscht. Die zirkadiane Rhythmik der adrenokortikalen Aktivität wird in Verbindung gebracht mit einem akuten natürlichen Stressor – einer realen akademischen Prüfung. Es wurde vermutet, dass die angekündigte schriftliche Prüfung eine Stressreaktion auslöst, welche sich in einem antizipatorischen Kortisolanstieg äussert. Modelle mit psychosozialen sowie adrenokortikalen Variablen werden aufgestellt, um die Varianz der stressinduzierten Kortisolanstiege bestmöglich zu erklären.

Der dritte Studienteil konzentriert sich auf mögliche Wirkungen des antizipatorischen Kortisolanstiegs auf die Prüfungsleistung. Die Fragestellung lautet, ob Personen mit ausgeprägter prüfungsbedingter Kortisolreaktion geringere Leistungen erbringen als Kandidaten ohne starke adrenokortikale Aktiviertheit. Die beobachtete Varianz der akademischen Leistung wird mit ausgewählten physiologischen und psychosozialen Variablen erklärt.

Die 148 freiwillig teilnehmenden Studierenden (99 Männer, 49 Frauen) absolvierten im Rahmen der Ausbildung für das Höhere Lehramt der Eidgenössischen Technischen Hochschule Zürich (ETH) ein einwöchiges Seminar. Ein erster Basis-Untersuchungstag fand vier Monate vor diesem Seminar statt. Drei weitere Untersuchungstage folgten unter semi-experimentellen, internatsmässigen Bedingungen während des Seminars. An jedem Untersuchungstag wurde um 17.00 Uhr eine akademische Veranstaltung durchgeführt – eine Vorlesung am ersten und dritten Untersuchungstag, eine schriftliche Prüfung am zweiten Untersuchungstag und ein Intelligenztest am vierten Untersuchungstag. Die einstündige schriftliche Prüfung war zuvor angekündigt worden und zählte 20% für die Schlussnote. Saliva-Kortisolproben wurden an allen vier Untersuchungstagen beim individuellen Aufwachen, 30 Minuten danach sowie vor den akademischen Veranstaltungen um 17.00 Uhr entnommen. An den Seminartagen erfolgten zusätzliche Probenahmen unmittelbar nach diesen Veranstaltungen (um 18.00 Uhr) sowie um 18.30 Uhr. Bei jeder Probenahme wurden potentielle Moderatorvariablen mittels eines Protokolls erfasst. Ein Basispaket mit validierten Fragebogen zum Gesundheitsverhalten, psychosozialen Aspekten, ausgewählten Persönlichkeitszügen sowie verschiedenen Kontrollvariablen wurde anschliessend an den ersten Untersuchungstag eingesetzt. Weitere Selbsteinschätzungsinstrumente zum momentanen emotionalen Befinden füllten die Teilnehmer

unmittelbar vor den akademischen Testsituationen am zweiten und vierten Untersuchungstag aus. Unter dem Aufwachen wurde der individuelle Zeitpunkt verstanden, der dem morgendlichen Aufstehen unmittelbar vorherging. Die Kortisol-Aufwachreaktion wurde als die Saliva-Kortisolkonzentration 30 Minuten nach dem Aufwachen minus die Konzentration beim Aufwachen definiert.

Ein derartiger frühmorgendlicher Kortisolanstieg wurde in 78.6% (n = 419) aller Fälle (n = 533, 148 Studierende) registriert. Konsistente Anstiege an allen vier Untersuchungstagen wurden bei 46% aller Studierenden beobachtet. Anstiege sowie individuell konsistente Muster von Anstiegen waren häufiger bei Frauen als bei Männern. Der Einschluss des individuell höheren der beiden frühmorgendlichen Kortisolwerte resultierte in maximaler intrapersoneller Stabilität (0.40 < r < 0.62). Wie vermutet, sank die Stabilität der frühmorgendlichen Kortisolwerte mit zunehmendem Zeitintervall zwischen den Untersuchungstagen. Erstaunlicherweise aber zeigte auch ein viermonatiger Abstand, verbunden mit einem Umgebungswechsel, noch moderate Stabilität (r = 0.40, höherer der beiden Morgenwerte). Die Kortisolkonzentrationen 30 Minuten nach dem Aufwachen korrelierten mit dem Geschlecht, dem Body Mass Index (BMI), dem Persönlichkeitszug Neurotizismus und dem Gebrauch oraler Kontrazeptiva bei Frauen. Die Kortisolspiegel beim Aufwachen als auch die intraindividuelle Stabilität der frühmorgendlichen Kortisolwerte erwiesen sich hingegen als unabhängig von allen untersuchten Kovariablen.

Die Männer zeigten vor den akademischen Aufgaben um 17.00 Uhr höhere Kortisolspiegel als die Frauen (Mittelwerte aller Untersuchungstage: 9.2 nmol/l versus 6.0 nmol/l, F = 53.1, df = 1/146, p < 0.001). Die schriftliche Prüfung induzierte einen antizipatorischen relativen Kortisolanstieg von 85.6% (Kortisol-Konzentration unmittelbar vor der Prüfung dividiert durch den Mittelwert der tageszeitgleichen Kortisol-Konzentrationen an den anderen Untersuchungstagen). Jeder zweite Studierende wies einen antizipativen Anstieg von mehr als 50% auf. Psychosoziale Daten erklärten 16.1% der Varianz dieses relativen Anstiegs. Die Berücksichtigung unstimulierter zirkadianer Kortisolmarker erhöhte die Vorhersagekraft dieses Modells nicht wesentlich. Währenddem der relative prüfungsbedingte Kortisol-Anstieg geschlechtsunabhängig war, zeigten Männer einen höheren absoluten Anstieg als Frauen (5.2 versus 2.8 nmol/l; Kortisol-Konzentration unmittelbar vor der Prüfung minus Mittelwert der tageszeitgleichen Kortisol-Konzentrationen an den anderen Untersuchungstagen). Das Geschlecht sowie psychosoziale Variablen erklärten 17.6% der Varianz dieses absoluten Anstiegs. Der Einschluss individueller Marker der zirkadianen Kortisolaktivität erhöhte die erklärte Varianz auf 29.7%.

Es ergaben sich keine bedeutsamen Assoziationen zwischen der Leistung in der untersuchten kriteriumsorientierten Prüfung und individuellen Markern der adrenokortikalen (Re)aktiviät. Weder der prüfungsbedingte antizipatorische Kortisolanstieg noch unstimulierte zirkadiane Kortisolspiegel oder Indikatoren individueller früherer kognitiver Leistungen erklärten einen bedeutsamen Anteil der Varianz der Prüfungsleistung. Das beste Vorhersagemodell für das Prüfungsresultat enthielt psychologische Variablen sowie das Geschlecht und erklärte 12% der beobachteten Varianz. Marker der adrenokortikalen Reaktivität und Indikatoren früherer Leistungen vermochten dieses Vorhersagemodell für die Prüfungsleistung nicht zu verbessern. Offensichtlich wirkte sich die beobachtete antizipatorische Kortisolreaktion nicht auf die erbrachte höher-kognitive Leistung in der kritieriumsorientierten Prüfung aus.

Bei zukünftigen Untersuchungen der frühmorgendlichen Kortisolreaktion sollte der Zeitpunkt des individuellen Aufwachens als erstes Stadium des Aufwachprozesses definiert und klar von eventuellen späteren Aufwach- und Aufstehphasen unterschieden werden. Die höhere der beiden Kortisolkonzentrationen innerhalb der ersten halben Stunde nach dem Aufwachen sollte in die Analyse der individuellen Stabilität der Hypothalamus-Hypophysen-Nebennieren-(HHN)-Achse einbezogen werden. Prüfungsbedingte absolute und relative Kortisolreaktionen müssen separat analysiert werden.

Chapter 1: Introduction

Little is so far known about possible effects of examination-related stress responses in students at the Swiss Federal Institute of Technology (Abd-el-Razik 1991, Wyss 1987). This study furnishes descriptive and comprehensive empirical data on physiological as well as psychological aspects. It investigates possible impacts of an academic examination on the psychophysiological well-being and performance of 148 post-graduate students at the Swiss Federal Institute of Technology. The study focuses upon associations between salivary cortisol changes after awakening and in anticipation of the academic examination, personality characteristics, and test performance.

However, what is *stress*? Although in common use, the term defies precise definition. While "stress" describes the response or a set of responses to a strenuous situation, "stressor" is the stimulus that elicits such stress responses (Cacioppo and Tassinary 1990). In this study, stress characterizes the individual perception of situations threatening or disturbing physiological and psychological well-being as well as the uncertainty as to whether and how these threats can be overcome (Zeier 1992).

The term stress was first defined by Hans Selye. Based on extensive experimental research with rats, he described a cluster of symptoms induced by a noxious stimulus as the "general adaptation syndrome" (GAS), or the biological stress syndrome (Selye 1936, Selye 1973, Selye 1982). He defined stress as "the nonspecific result of any demand upon the body" (Selye 1982). The psychological perspective was incorporated into stress research by the endocrinologist John W. Mason. Mason demonstrated in experiments with monkeys that an organism only shows stress reactions in different endocrine systems if it perceives a certain stimulus as threatening or aversive, i.e. if the stimulus provokes a stress emotion (Mason 1968). Different physiological systems were postulated to react in a specific way to distinct psychological challenges (Mason 1968, Mason et al. 1976).

Largely through the work of Richard S. Lazarus and associates, research focused on the individual appraisal of a forthcoming stressor as well as the perceived capacity to deal with the stressor in order to explain interpersonal differences in stress responses (Lazarus 1991, Lazarus and Folkman 1984, Lazarus and Launier 1978, Lazarus and Launier 1981). Stress is thus viewed as a particular reciprocal relation between an individual and the environment. This interaction process is set in motion when a person appraises a situation as taxing or exceeding his or her resources and endangering his or her well-being (Lazarus 1966, Lazarus and Folkman 1984, Lazarus and Launier 1981). The subjective cognitive estimation of a situation as challenge, threat, harm, or loss ("primary appraisal" or "demand appraisal") mediates between the stressor and the individual's stress reaction. In addition to the perception of environmental demands, personality characteristics and individual prior experiences as well as the subjective evaluation of the person's available resources ("secondary appraisal" or "resource appraisal") influence how an individual copes with a certain stressor (Lazarus and Folkman 1984, Vollrath et al. 1995).

The term *coping* characterizes "the cognitive, emotional and behavioral efforts of an individual to manage specific external or internal demands which are appraised as taxing or exceeding the resources of the person" (Lazarus and Folkman 1984), 141. Coping behaviors are conscious strategies used by the individual when confronted with particu-

lar stressful events. "Problem-focused" coping (task-oriented or instrumental coping, i.e. strategies to deal with the source of stress) is distinguished from "emotion-focused" coping (person-oriented, palliative, i.e. strategies to regulate emotions and affects). Which way of coping is most effective and adaptive depends on situational as well as personal characteristics. No general strategy, but rather a flexible way of coping seems to be most favorable for an individual (Krumpholz 1993). It has been argued that individuals show trait-like predisposed coping styles or strategies. However, according to the stress concept of Lazarus, the interaction between a person and his or her environment is dynamic, mutually reciprocal, and bi-directional (Lazarus and Folkman 1984). This concept integrates stressors, individual stress reactions and coping strategies as well as resulting interdependencies into continually changing person-situation transactions ("transactional process").

Based on this concept, a dynamic interactional model of stress, anxiety, and coping was proposed by Norman S. Endler and James D.A. Parker (Endler and Parker 1990a, Endler and Parker 1990b), (Vollrath 1997). According to these authors, stress and anxiety are overlapping, multidimensional concepts. If a situation is appraised as threatening, anxiety is provoked as a momentary or transient emotion. Resulting coping processes may not only be task-oriented or emotion-oriented, but also avoidant (Endler and Parker 1990a, Endler and Parker 1990b). With respect to this conceptual framework, it is obvious that psychological factors and personality characteristics should not be excluded from human stress research because they act as prominent mediating factors in different stages of the coping process (Schwarzer 1996, Vollrath 1997), (Jäger et al. 1989). Dispositional personality traits were found to be significant short-term and long-term predictors of coping (Vollrath 1997, Vollrath et al. 1995).

What situations may be regarded as "stressors"? Stressors range from severe "life events" (situations involving life or death, as for example the sudden death of a life companion) to so-called "minor life events" or "daily hassles" (everyday life events, as for example computer problems or missing a train). Factors of the psychosocial environment can be separated from intrapsychical challenges (Schandry 1996). Regarding formal properties, situational demands which are appraised as difficult, novel, ambiguous, unannounced, and uncontrollable are more likely to induce threat perceptions and somatic stress reactions than easy tasks that can be handled under feasible conditions (Lazarus 1991). However, up to now there have been no general, theoretically founded taxonomies which allow ratings of the stress potential of diverse situations or events (Vollrath 1997), (Perrez 1992). The stress concept presented above implies that the dimensions of mental or psychical strain versus physical strain are not mutually exclusive (Müller et al. 1992). Chronic stressors are distinguished from acute or short-term stressors. An acute psychological stressor lasts typically about 30 to 60 minutes and induces an immediate reaction in a person (Benschop and Schedlowski 1996). However, there is no consensus about the criteria that distinguish "acute" from "chronic" stressors, i.e. about the duration of the stressor and the period of the provoked stress reaction (Cook et al. 1992), (Ockenfels et al. 1995).

The phenomenon stress, i.e. the *stress reaction*, depicts a set of complex internal physiological and behavioral reactions in humans. Instead of a "nonspecific" reaction according to Selye's first concept, individuals demonstrate reactions which involve stressor-specific and individual-specific aspects (Schandry 1996). Symptoms of stress

can be found at the level of the body, behavior, and at emotional and cognitive levels as well (Cacioppo and Tassinary 1990, Zeier 1992). Stressors affect the sensory organs. They induce changes by transmitting sensory information over afferent neuronal pathways to the central nervous system. While the conscious analysis of this information is performed in the association cortex, emotional aspects are evaluated by the limbic system. In stressful situations, this system elicits physiological stress reactions (Zeier 1997). The so-called "effector systems" become activated, i.e. the sympathetic nervous system, the "hypothalamic-pituitary-adrenocortical" (HPA) axis, and the somatomotoric system. These systems in turn induce periphery-physiological, immunological, and metabolic processes in the so-called "end organs" (final organs, or "output" systems). Over 1,400 physicochemical changes can be associated with a certain stress reaction (Johnson and Anderson 1990). These symptoms vary with time, intensity, and nature of a stressor. Such possible effects, complicated functional interactions, and interrelations are investigated by the fast developing research field of "psychophysiology" or "psychoneuroendocrinoimmunology" (Schandry 1996, Schedlowski and Tewes 1996). Stressful situations are assessed by different "objective" physiological measures on the one hand and by "subjective" psychological aspects on the other hand, reflecting a person's appraisal of and coping with a certain stressor.

The present study investigates stress reactions and coping processes provoked by the acute real-life stressor of an academic examination. Possible stressor-induced changes or reactions are examined on the physiological side by measuring salivary cortisol levels and on the psychological side by wide-range indicators (self-report questionnaires). Moreover, objective performance data are collected. The theoretical and empirical framework of the psychophysiological variables is presented in the following part of this chapter.

1.1 Physiological background: the HPA axis and cortisol

The hypothalamic-pituitary-adrenocortical (HPA) axis is an effector system. Its stimulation by an afferent stimulus induces an activation process on the three different levels of the hypothalamus, the pituitary gland, and the adrenal cortex. The hypothalamus secretes corticotropin-releasing hormone (CRH) which stimulates the anterior pituitary to release adrenocorticotropic hormone (ACTH or corticotropin) into the blood circulation. ACTH in turn stimulates the adrenal cortex to excrete glucocorticoids into the circulation (Delbende et al. 1992). These steroid hormones act predominantly upon glucose and protein metabolism. In humans, the most prominent glucocorticoid is cortisol, a C21-steroid molecule. In the circulation, cortisol is mostly bound to the specific transport protein corticosteroid binding globulin (CBG). A minor part is bound to albumins. This bound part of cortisol is physiologically inactive and functions as a circulating hormone reservoir. Only about 5% to 10% of the total cortisol in the circulation is unbound. These "free" cortisol molecules are biologically active. Reaching their target cells, they attach themselves to glucocorticoid receptors and promote the transcription of certain segments of DNA. This induces the synthesis of specific enzymes. This mechanism is responsible for the numerous physiological effects of cortisol.

Cortisol is involved in numerous vital functions and is, therefore, necessary for normal physical activity. Small amounts of cortisol must be present for a number of metabolic reactions not produced by the hormone itself. Cortisol acts in such a "permissive" way

on the two catecholamines noradrenaline and adrenaline, allowing these hormones to exert their calorigenic, lipolytic and pressor responses as well as bronchodilation (Ganong 1995). The actions of cortisol on the intermediary metabolism of carbohydrates, proteins, and fat are complex. They include increased protein catabolism as well as increased hepatic glycogenesis and gluconeogenesis (Munck et al. 1984). As a consequence of this "anti-insulin action", the plasma glucose level rises. In addition, cortisol exerts effects on water metabolism and demonstrates anti-inflammatory as well as anti-allergic capabilities. It impairs different humoral and cellular immune functions.

Transient increases of circulating cortisol levels are essential for survival, i.e. for resisting potentially noxious situations. At first glance, there seems to be a contradiction: Why should cortisol be essential for survival if it inhibits inflammatory processes and the healing of wounds and if it suppresses the immune system, i.e. the corporal defense system? The life-saving effects of cortisol might be due to its permissive properties. A second theory holds that cortisol prevents other stress-induced changes from "over-shooting", i.e. from becoming excessive, thus helping the organism to re-establish homeostasis (Ganong 1995, Munck et al. 1984). While such brief increases in cortisol may therefore be life-saving, chronically increased levels are mostly regarded as harmful and disruptive (Schandry 1996, Selye 1936). In the past few years, researchers have disputed the possible harm of chronically increased cortisol levels (Raber 1998, Sapolsky 1996).

Furthermore, cortisol exerts different effects on the nervous system which are as yet not well understood (Müller et al. 1992). Recent data from experimental studies in animals suggest that stress-related acute elevations of glucocorticoid levels may impair various memory functions (De Quervain et al. 1998, Ohl and Fuchs 1998).

In men, glucocorticoids can act on the hippocampus, a region of the brain which is essential for a specific kind of memory, the so called declarative (explicit and relational) memory (Squire 1992). Clinical studies with traumatized human populations (Bremner 1999, Bremner and Narayan 1998) and in aging men (Kalmijn et al. 1998, Lupien et al. 1994, Lupien et al. 1997) have replicated studies in animals, showing associations between cortisol levels and declarative memory impairment. Correlations between memory and cortisol levels were also reported in certain disease conditions which share hyperactivity of the hypothalamic-pituitary-adrenal axis as well as symptoms of cognitive decline, namely in patients with chronic hypercortisolemia due to Cushing syndrome, Major depression, schizophrenia, and Alzheimer disease (Martignoni et al. 1992, Newcomer et al. 1998, Newcomer et al. 1991, Starkman et al. 1992, Starkman et al. 1981). Experimental studies with healthy men show that increased glucocorticoid levels are associated with reduced cognitive performance. Certain recalling capabilities managed by the hippocampus might be hampered (Drain et al. 1991, Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999). Very pronounced cortisol increases impede the recall of memory contents and may even totally block the memory function ("blackout"). However, a certain level of arousal, i.e. slightly increased cortisol levels, enhances the attentiveness of a concentrating person and facilitates the entrance of memory contents into the long-time memory of the brain (De Kloet 1995, De Kloet et al. 1999, De Kloet et al. 1998).

There is a two-fold negative feedback loop regulating cortisol secretion: cortisol inhibits the secretion of ACTH by the anterior pituitary as well as CRH secretion by the hypothalamus. The biological half-life of cortisol in the circulation amounts to about 60 to 90 minutes. This molecule is metabolized mostly in the liver. After its conversion to an inactive derivative, it is excreted in the urine and in part by tubular secretion.

1.1.1 Salivary cortisol – a suitable tool for assessing individual HPA activity

Measuring cortisol in saliva is a reliable, non-invasive method to assess individual cortisol activity and endocrine stress reactions in humans (Kirschbaum and Hellhammer 1989, Kirschbaum and Hellhammer 1994, Kirschbaum et al. 1993a). Only the unbound cortisol molecules may diffuse through the cells of the salivary glands into saliva (Vining et al. 1983). Therefore, the concentration of salivary cortisol reflects the unbound portion of cortisol in the blood. It represents a valid index of free, biologically active circulatory levels (Kirschbaum and Hellhammer 1991). The transfer from the blood stream to saliva is a process that takes about two minutes. Hence, a rise in cortisol levels in circulation is rapidly registered in saliva. Whereas in former studies cortisol was usually assessed in urine or in plasma by radioimmunoassays (RIA), measuring salivary cortisol by newly developed time-resolved immunoassays with fluorescence detection are now predominantly used (Dressendörfer et al. 1992).

1.1.2 Ultracircadian and circadian rhythm of cortisol

In unstimulated individuals, cortisol is secreted episodically. About 7 to 15 cortisol impulses can be typically registered within 24 hours (Kirschbaum 1991, Kirschbaum and Hellhammer 1989). An additional circadian rhythm is superimposed on this ultracircadian cycle. In humans, cortisol concentrations show a characteristic 24-hour rhythm. They are highest in the early morning at awakening (Prüssner et al. 1997b). This early morning acrophase is followed by a decline. After a stable base level in the afternoon, cortisol levels reach a nadir around midnight (Knutsson et al. 1997, Shimada et al. 1995).

1.1.3 Changes of cortisol levels associated with stressful situations

Stressor-induced cortisol peaks are superimposed on the non-stimulated circadian activity because the HPA system is sensitive to stressful situations. Numerous internal and external stimuli enhance adrenocortical activity, i.e. the frequency and the amount of the excreted cortisol (Kirschbaum 1991). Psychologically stressful situations may stimulate adrenocortical activity. Particularly situations which individuals appraise as new, unpredictable or uncontrollable may elicit remarkable cortisol increases (Kirschbaum and Hellhammer 1989, Kirschbaum and Hellhammer 1994, Müller et al. 1992, Müller and Netter 1992). Persons with a high need for achievement or a high desire for control seem to be more susceptible to uncontrollable situations and show larger stressor-induced cortisol reactions (Müller et al. 1992). As the HPA system is a part of the neuronal system that is functionally coupled with the immune system (Besedovsky and Rey 1996, Weihe and et al. 1996), cortisol represents a crucial mediator between the physiological stress response and corporal diseases (Schandry 1996).

Stressor-induced increases in circulating cortisol concentrations are transient. Their amplitude and exact timing depend on stressor-specific, i.e. situational aspects, as well as on personal characteristics. Usually salivary cortisol increases follow a stressor within 20 to 45 minutes, depending on the quality and the intensity of the stimulus. For psychological stressors, this latency amounts to 20 to 30 minutes (Kirschbaum and Hellhammer 1989). However, stressor-induced cortisol peaks may occur prior to the expected moment. Such anticipatory effects are due to individual appraisal processes. No matter whether the expected stressor has actually happened or not, studies report measurable cortisol increases in persons undergoing competitive tests or their first parachute jumping and in physicians called to emergency operations (Fischer et al. 1997, Kirschbaum et al. 1992b).

1.1.4 Changes of cortisol levels associated with examinations as distinct acute stressors

Examinations and test-like situations are widely used as distinct acute stressors in psychoendocrinological research. However, findings from laboratory tests have limited explanatory value for complex real-life examinations under field study conditions. Academic examinations are predictable, standardizable, and discrete examples of real-life stressors with good validity (Vassend et al. 1987). They contain mentally as well as emotionally challenging aspects. Examination stress has been reported to be one of those perceived as major stressors by students (Halamandaris and Power, under review b, quoted in (Halamandaris and Power 1999) p 668. Numerous researchers have investigated the physiological reactions of students undergoing examinations, and many of them assessed cortisol as a reliable endocrinological indicator. In the eighties and nineties, various authors investigating the effects of examinations observed increased plasma cortisol levels (Armario et al. 1996, Herbert et al. 1986, Hudgens et al. 1989, Johansson et al. 1989, Meyerhoff et al. 1988). Current research has examined possible examination-induced cortisol changes in saliva. Depending upon the difficulty and the practical significance of the tests, examinees showed a wide range of cortisol reactions. Mostly, pre-examination cortisol increases were reported, reaching up to 200% of the basal concentration in one third of the examinees (Cook et al. 1992, Hellhammer et al. 1985, Kahn et al. 1992, Nicolson et al. 1992). The timing of these cortisol peaks underlines the anticipatory effects due to individual primary appraisal of such examinations as a potentially harmful event. However, other authors registered cortisol levels that varied insignificantly (Dobbin et al. 1991, Glaser et al. 1994) or even levels that were higher after the examination than before (Huwe et al. 1998, Spangler 1997).

Different study designs and examination settings (formal properties, i.e. oral versus written examinations, laboratory testing versus real examinations, transparency, predictability and controllability, examination and rating procedures, practical relevance and impact of the test for the examinees, varying duration, and different participants) influence the exact timing and height of such cortisol reactions (Kirschbaum and Hellhammer 1989). Experimental findings based on laboratory test conditions show a limited ecological value (Hembree 1988, Schnabel 1998, Seipp 1991). Moreover, "cortisol reactions" are operationalized and assessed in different ways. Therefore, such findings are comparable only with caution.

Mostly, a large interindividual variability in both anticipatory and reactive cortisol increases is reported (Armario et al. 1996, Huwe et al. 1998, Jones et al. 1986, Kahn et al. 1992, Völs and Scheuch 1988). Therefore, the following question arises: What factors are involved in the variability of possible adrenocortical reactions? Usually, associations between cortisol stress responses and personality factors as well as psychological characteristics were investigated. However, studies of monozygotic and dizygotic twins showed that heredity plays a minor role in cortisol reactions to psychological stressors (Kirschbaum et al. 1992a). Further, possible confounding factors such as gender, psychological characteristics, or subjective stress perception explained only a relatively small part of the observed variability (Armario et al. 1996, Jones et al. 1986, Kahn et al. 1992, Malarkey et al. 1995, Spangler 1997). The self-reported appraisal of examinations and the anticipatory cortisol response seem to be differently regulated (LeDoux 1992, LeDoux 1998, Weinberger 1990).

Cognitive processes, motivational, emotional, and psychophysiological arousal processes influence test performance in examination situations (Schandry 1996). These complex interactions have been investigated under field conditions as well as in laboratory test situations. Empirical findings on test anxiety, examination-related stress responses, and test performance are, however, controversial and allow no general conclusions (Frierson H. T. and D. 1987, Frierson H. T. and D. 1992, Hunsley 1987, Krumpholz 1993).

1.1.5 Awakening-mediated cortisol activity and cortisol reactions to real-life stressors

Awakening is an important mediator synchronizing circadian HPA activity (Prüssner et al. 1997b). The process of awakening is associated with adrenocortical activation and characterized by increases in salivary cortisol. This aspect of the diurnal cortisol rhythm is a topic that has only recently been discussed in psychoneuroendocrinology. The latest studies have shown that cortisol levels increase 50% to 150% within the first 30 minutes after waking up in the morning (Hucklebridge et al. 1998a, Hucklebridge et al. 1998b, Hucklebridge et al. 1999, Prüssner et al. 1997b, Schmidt-Reinwald et al. 1999).

Ongoing research discusses intensively the following questions:

- Is the awakening process the first stressor of the day (Prüssner et al. 1995)?

- Are there any associations between this non-stimulated awakening-mediated cortisol activity and cortisol responses to stressful events (Ockenfels 1995, Prüssner et al. 1999)?

Different hypotheses regarding the biological significance or cause of this awakening cortisol response have been formed. Awakening cortisol reactivity might be genetically determined, since these markers seem to be only marginally influenced by situational impacts (Kirschbaum 1991, Kirschbaum et al. 1990). This early morning peak represents no "wake-up stimulus" or simple orthostatic effect for the individual, since it makes no difference whether awakening is induced by an alarm clock or subjects awake naturally. It also does not matter whether subjects get up immediately or remain in a supine position after awakening (Prüssner et al. 1997b). The awakening response might provide the organism with sufficient energy to shift from a resting to an active phase and

prepare the body for the metabolic demands of the day. However, a recent study that investigated possible interactions of the awakening response with energetic aspects did not support this teleological speculation. The magnitude of the cortisol increase proved to be independent of awakening blood glucose levels (Hucklebridge et al. 1999). Neither does the awakening response seem to be determined by the oxidizable substrate availability for energy metabolism, i.e. of blood glucose concentrations. It might be associated with an immune shift rather than with metabolic demands (Hucklebridge et al. 1999).

The cortisol response to awakening seems to be rather robust over weeks and months. It shows moderate to high intraindividual stability across days and weeks, with test-retest correlations typically ranging between $r = 0.39$ to $r = 0.67$ (Prüssner et al. 1997b), (Kirschbaum 1991). Therefore, the awakening response represents an interesting tool for assessing individual differences in adrenocortical activity, providing important information on the basal capacity and sensitivity of the HPA axis and reflecting subtle changes of the HPA reactivity associated with psychosocial stress (Prüssner et al. 1997a, Schmidt-Reinwald et al. 1999). However, early morning cortisol measurement must refer strictly to the individual time of awakening rather than to fixed times of the day (Prüssner et al. 1997b). Moreover, several potentially confounding factors such as gender, the consumption of oral contraceptives by women, sleep duration and sleep quality, alcohol consumption on the previous day, and personality measures should be controlled (Hucklebridge et al. 1998a, Hucklebridge et al. 1998b, Prüssner et al. 1997b).

Although such repeated measurement of early morning cortisol levels supplies researchers with interesting adrenocortical markers, few studies investigate possible associations between the diurnal cortisol rhythm and the endocrine response to psychosocial factors or real-life stressors (Smyth et al. 1997). The early morning cortisol increase seems to be altered by chronic stress and burnout. Chronic stress due to unemployment is accompanied by increased awakening-mediated cortisol activity (Ockenfels et al. 1995). Enhanced awakening cortisol responses were also reported in students suffering from chronic work overload (Schulz et al. 1998). These findings suggest that a prospective orientation to demanding tasks can be associated with elevated early morning cortisol levels (Schulz et al. 1998). However, teachers scoring high in burnout showed blunted cortisol levels after awakening (Prüssner et al. 1999). According to this recent study, chronic stress and burnout experienced by teachers exert differential, cumulative effects on HPA axis regulation.

Possible associations of awakening-mediated cortisol activity with the cortisol response to acute real-life stressors have not been investigated as yet. Possible interrelations between individual characteristics in the circadian cortisol rhythm and the stress response to academic examinations as acute real-life stressors remain to be explored.

1.1.6 Moderating variables of salivary cortisol

Salivary cortisol is highly sensitive and reactive to a great variety of psychophysiological factors. The effects of such moderating factors are superimposed on the internal circadian rhythm of cortisol and to external stressor-induced changes. Therefore, the following potentially confounding variables should be thoroughly controlled:

- gender (Kirschbaum and Hellhammer 1991, Kirschbaum et al. 1995a, Kirschbaum et al. 1999, Kirschbaum et al. 1992b),

- age (Gotthardt et al. 1995, Kirschbaum and Hellhammer 1991),

- weight (Biesalsky and et. al. 1995, Kirschbaum et al. 1995c),

- actual as well as chronic nicotine consumption (Kirschbaum and Hellhammer 1991, Kirschbaum et al. 1993b, Kirschbaum et al. 1992c),

- eating and drinking (Gibson et al. 1999, Kirschbaum 1991, Kirschbaum et al. 1992b)

- the use of medications (Kirschbaum and Hellhammer 1989, Kirschbaum and Hellhammer 1991),

- pregnancy (Kirschbaum and Hellhammer 1989),

- women's use of oral contraceptives (Kirschbaum et al. 1999, Kirschbaum et al. 1995b, Prüssner et al. 1997a, Reinberg et al. 1996),

- women's menstrual cycle phase (Kirschbaum et al. 1999),

- strenuous physical activities (Kirschbaum and Hellhammer 1991).

Further potential confounding factors, especially psychological characteristics, are presented in the following section.

1.2 Theoretical framework and psychological concepts

In this study, the focus is on the interaction between the examinees and their environment, according to the transactional stress concept of Lazarus (Lazarus 1966, Lazarus and Folkman 1984) and its enlargement to an interactional concept by Endler and Parker (Endler and Parker 1990a, Endler and Parker 1990b). In selected sub-areas of this complex theoretical system and heuristic framework, specific hypotheses were formulated and tested (Schwarzer 1998).

Such interactional research involves exact description of situational characteristics – on the objective as well as on the subjective level – as well as the assessment of personality characteristics (Vollrath 1997). While stress-inducing stimuli and physiological stress reactions can be observed, intervening psychological processes can only be assessed indirectly by questioning the subjects exposed to stress (Zeier 1997). In order to investigate possible interrelations between situational aspects and personality characteristics, various psychological self-rating instruments were applied. These inventories yielded self-reported information about the individual's conceptualization and subjective estimation of a potential stressor ("primary appraisal") as well as statements about the perceptions of self and personal well-being. The instruments also tapped specific

personal coping options ("secondary appraisal") that might have modulated the stress reaction.

Trait variables assessed consistent individual differences in personality. These personal dispositions were assumed to be stable in the individual during the observation period of the study. State variables provided information on momentary emotional conditions of the participants that were likely to vary on the different observation days. In academic situations, task-specific competencies and the perceived prerequisite knowledge to cope with the task are of primary importance (Schwarzer 1998). Therefore, general question-naires were complemented by highly specific instruments, tailored to the present study setting and academic examination. The following section presents an overview of the self-assessing instruments implemented. These questionnaires are discussed further in chapters 2 to 4. They are all itemized in the appendix.

1.2.1 Trait variables

The following baseline information and psychological traits were assessed within a three-week period following observation day one.

- A standard *sociodemographic questionnaire* containing items on age, gender, body mass index, employment status, and present occupation.

- A *health questionnaire* providing information on aspects of physical well-being, assessing, for example, habitual consumption of coffee, alcohol, and drugs, the use of medications, habitual smoking, and the presence of any hormonal disregulation. Women were additionally asked about pregnancy, use of oral contraceptives, and menstrual cycle phase.

- *Examination-related anxiety* was assessed by a 30-item German version of the "Test Anxiety Inventory" (TAI-G, form XU) with the four subscales "worry", "emotion-ality", "cognitive interference", and "lack of confidence" (Hodapp 1991, Hodapp et al. 1995). While "worry" characterizes self-depreciatory thoughts as well as cogni-tions of failure and its possible consequences, "emotionality" describes subjective feelings of affective and physiological arousal (Hodapp et al. 1995), (Hodapp 1996), (Deffenbacher 1986, Hodapp 1991). "Cognitive interference" comprises examina-tion-irrelevant thoughts disturbing or even blocking goal and task-oriented activity (Hodapp 1991, Hodapp et al. 1995). The forth subscale "lack of confidence" item-izes doubts about one's own efficiency, uncertainty about one's own capability to control behavior, and uncertainty about being accepted by the social environment.

- *"General self-efficacy"* was assessed by a 10-item scale (Schwarzer 1993). According to Bandura's social-cognitive theory (Bandura 1977, Bandura 1997), this construct characterizes the perceived available competencies to cope successfully with a challenging situation. It refers to "beliefs in one's capabilities to organize and execute the courses of action required to produce given attainments" (Bandura 1997). This confidence in being able to master demands by means of adaptive actions, or "can-do"cognitions, represents a crucial personal resource that influences stress and cop-ing processes at different stages of the coping process (Schwarzer 1992, Schwarzer 1996, Schwarzer 1997). Self-efficacy makes a difference in how people think, feel, and act. It facilitates cognitive processes and test performance (Schwarzer 1998).

- As self-efficacy beliefs may be different in various life domains, a special inventory assessing *examination-related self-efficacy* was developed (Schwarzer, Haldemann, unpublished data). This 7-item scale assesses how optimistically students view their own capabilities to deal with examination-related demands.

- Items assessing examination-related self-efficacy were combined in alternating fashion with *examination-related procrastination* (eight items; Schwarzer, Haldemann, unpublished data). This questionnaire assesses the tendency to delay learning activities associated with examinations (Ellis and Knaus 1977, Ferrari et al. 1995). Procrastination appears to be a personality trait generated by a broad, partly inherited dispositional factor. In academic settings, trait procrastination produces delays in completing academic tasks. Academic procrastination may serve as an important predictor in studies of educational outcome (Ferrari et al. 1995). Experimental studies reveal that chronic procrastinators engage in exaggerated self-handicapping of their task performance (Ferrari et al. 1995).

- *Positive attitude towards life* was estimated by means of an eight-item scale derived from the Well-Being Scale of Grob and associates (Grob et al. 1991, Grob et al. 1989).

- *Dispositional coping strategies* were assessed by a 24-item German version of the coping inventory "CISS", containing the three subscales "task-oriented coping", "emotion-oriented coping", and "avoiding coping" (Endler and Parker 1990a, Semmer et al. 1991).

- Participants completed an eighteen-item short version of the SOZU-K22 questionnaire assessing *perceived social support*. This scale encompasses the four subscales "emotional support", "social integration", "person of confidence", and "satisfaction with social support". Four items assessing practical support were omitted (Sommer and Fydrich 1991). Social support characterizes the result of social interactions and their appraisal by an individual (Sommer and Fydrich 1988).

- The two personality domains of *"neuroticism"* and *"extraversion"* were assessed by the corresponding subscales of the German short version of the personality inventory "NEO-FFI", with twelve items for each (Borkenau and Ostendorf 1993, Costa and McCrae 1992, McCrae et al. 1996). Persons scoring high in neuroticism tend to be nervous, anxious, sad, uncertain or embarrassed, and to worry about their health (Borkenau and Ostendorf 1993). They are likely to react non-adaptively to stressful situations. Moreover, neurotic traits may foster potentially dysfunctional avoidant coping styles. For these reasons, they constitute a risk factor rather than a resource in stress and coping processes (Vollrath et al. 1995). Persons scoring high in extraversion are rather sociable, communicative, active, optimistic, and cordial. Such individuals seem to cope well with various stressors.

1.2.2   State variables

The following state aspects were investigated in this study:

- By means of a state version of the coping inventory CISS, *situation-specific anticipatory coping* was assessed (Endler and Parker 1990a, Semmer et al. 1991). The subject's appraisal of the two specific forthcoming examinations and their own perceived personal resources for dealing with them was investigated by 24 items.

- *Pre-examination test anxiety* was assessed by a state version of the Test Anxiety Inventory TAI-G (Hodapp 1991, Hodapp et al. 1995). The instructions were adapted from trait to state conditions (30 items).

- *Examination-related self-efficacy* was assessed by a single specific item (Schwarzer, Haldemann, unpublished data).

- The *subjective appraisal of the two forthcoming tests* was assessed by an examination-specific self-rating scale (Perrez, Haldemann, unpublished data), portraying the "primary appraisal" of the transactional stress model. Seven items informed about the perceived non-transparency of the tests and about how challenging, threatening, or demanding, and how flexible the expected tests were judged to be (Perrez and Reicherts 1992).

- The *student's preparation for the announced examination* on observation day two was assessed by 20 items of the WLI scale by Metzger (Metzger et al. 1995). It contained the four examination-specific subscales "time planning" (nine items), "achievement motivation" (four items), "concentration" (four items), and "perceived control of oneself" (four items). While "time planning" assesses how a person deals with the time available to learn, "achievement motivation" contains questions about the willingness to learn seriously, diligently, and with effort. "Concentration" assesses a person's perceived capacity to fully concentrate on learning. "Perceived control of oneself" contains statements about how a person evaluates his or her learning progress and checks how well the material studied is understood.

- Moreover, the participants rated their *momentary subjective perception of "stress"* on a ten-graded visual analogue scale immediately before each saliva sample was taken.

1.3   Experimental design and methods

Material and methods as well as statistical analyses are described in detail in chapters 2 to 4. Wherever possible, standard methods were used. This procedure minimized methodological influences and problems and allowed a better comparison of the present results with the findings of other studies.

The participants were 148 post-graduate students (49 women, 99 men) applying for a Master's Degree in Science Education at the Swiss Federal Institute of Technology Zurich. They all attended a one-week training seminar at a secluded boarding school. This naturalistic setting subjected the participants to a largely common schedule of daily activities (awakening time, meals, academic tasks). The mean age of the students was 27.1

years (range 22 to 48 years). All students gave written informed consent to participating in the study. No financial incentives were offered.

The study comprised four observation days: a first observation day was realized four months prior to the training seminar (April 1997, in Zurich, altitude 450 m). Three additional observation days followed during the seminar (second, third and fifth day of the seminar, last week of July 1997, in Zuoz, altitude 1600m).

On each observation day at 5 p.m., a one-hour academic task had to be completed: an academic lecture on observation days one and three, a written examination on observation day two and a Raven intelligence test (Raven 1979) on observation day four. The written examination on observation day two was clearly announced beforehand and demanded about one week of study preparation. Test performance on this examination was evaluated in a criterium-oriented way (criterion-reference test) by comparing the actual results of each examinee with model solutions previously defined (Jäger 1988, Jäger et al. 1989, Klauer 1987). From the attained raw points (maximal 17 raw points), a mark of either 0, 1 or 2 points was derived, counting 20% towards the final postgraduate grade. While the criterium-oriented design of this examination aimed to provide maximal transparency, students were not informed about the Raven intelligence test beforehand.

The physiological response to the process of awakening and to the different academic tasks was assessed by measuring salivary cortisol concentrations. Cortisol was analyzed in duplicate by a time-resolved immunoassay with fluorescence detection, using a stable cortisol-biotin conjugate in combination with rabbit cortisol antibodies (Dressendörfer et al. 1992). On each observation day, participants collected samples immediately after awakening and 30 minutes thereafter. Awakening was defined as the final awakening prior to the subject's getting up. Additional saliva sampling was performed in the late afternoon before the academic tasks at 5 p.m. (on all observation days) as well as after the tasks at 6 p.m. and 6:30 p.m. (on observation days two through four). Two different observation days without examinations served as baselines (observation days one and three). Thanks to this longitudinal design, intraindividual differences in adrenocortical (re)activity could be assessed. The best time of the day for testing remains controversial and depends on the context of the assessed stressful situation (Tout et al. 1998). In order to avoid possible confusion with cortisol increases due to awakening or to eating and drinking, the academic tasks were scheduled in the late afternoon when non-stimulated cortisol levels are basal.

Clear instructions how to collect saliva samples as well as distinct restrictions should prevent potential moderating effects on salivary cortisol levels. The students were requested to refrain from eating, smoking, and brushing their teeth, and asked to take nothing by mouth except plain water for the 60 minutes prior to saliva sample collection in the afternoon. For the first two samples in the early morning, participants were asked to complete sampling before breakfast and before brushing their teeth. They recorded the exact times of awakening and of the saliva sampling. Additionally, they indicated the total hours slept during the preceding night and the relative quality of sleep. In order to check confounding factors due to possible ignoring of these restrictions, the students answered some additional questions prior to each saliva sample, stating any physical activities, taking of food, coffee or beverages other than plain water, smoking, and medications. These questionnaires are presented in the appendix.

Psychologically, responses to the academic tests were assessed by a selection of evaluated standardized self-rating scales. Baseline information and psychological traits were assessed within a three-week period following observation day one. Additionally, participants completed a set of questionnaires containing different state aspects immediately before the written examination on observation day two and the Raven intelligence test on observation day four. These instruments are all itemized in the appendix. They were presented above and will be discussed in chapters 2 to 4.

The following four chapters address a number of related issues.

Chapter 2 investigates the issue of how individual awakening-mediated adrenocortical activity can be reliably assessed with minimal effort under real-life conditions. The aim was to clearly define a simple but intraindividually stable marker of awakening-mediated adrenocortical activity that is not confounded by moderating health variables or personality characteristics. Furthermore, the impact of short-term and long-term sampling-day intervals on the individual stability and reliability of different early morning cortisol markers is clarified.

Chapter 3 examines the extent to which examination-related cortisol increases can be explained by gender, baseline and psychosocial characteristics, and non-stimulated circadian cortisol dynamics. For 148 post-graduate students, salivary cortisol activity associated with a specific written examination is described. The exact timing and height of cortisol impulses as well as stressor-specific and individual-specific aspects of these stress reactions are assessed. The following questions are investigated: Is the adrenocortical stress response related to individual differences in personality traits or momentary emotional states of the students? Is the variance of the examination-related cortisol increases explained by a model containing psychological data only improved by including individual measures of the non-stimulated circadian cortisol activity?

Chapter 4 investigates possible associations between test performance on the pre-announced academic examination and psychophysiological characteristics of the examinees. The focus is on the following questions: What factors distinguish high and low test performers? Are there any relations among cortisol (re)activity, personality characteristics, and test performance? As clinical studies have observed glucocorticoid- and stress-induced decreases in human declarative memory function (Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999), such effects of cortisol-hypersecretion could probably also be detected in the context of a previously announced, one-hour written examination that had practical relevance for the students. Accordingly, high examination-related cortisol responses would be associated with impaired performance, i.e. low test results. Potential risk factors for low test performance such as high levels of test-anxiety, a lack of examination-specific self-efficacy, subjective appraisal of the examination as a non-transparent and threatening event, low performance in former test situations, and very pronounced cortisol awakening-responses or pre-examination increases are entered into the analysis of test performance.

Finally, a discussion is presented in **chapter 5**.

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Chapter 2: Response of the hypothalamic-pituitary-adrenal (HPA) axis associated with awakening: a suitable tool for assessing individual HPA activity

2.1 Abstract

2.1.1 Objective

We aimed to provide a simple and stable measure for assessing individual HPA activity using the awakening response of the HPA system.

2.1.2 Methods

148 post-graduate students (49 women, 99 men) who attended a one-week training seminar participated. Saliva samples were collected on 4 days: 4 months prior to the training seminar, and on the second, third and fifth day of the seminar. Participants collected samples immediately after awakening and 30 minutes thereafter. The setting of the seminar subjected all participants to the same daily rhythm.

2.1.3 Results

The mean cortisol concentration at awakening was 18.1 nmol/l ($\pm$ 8.9) and 25.6 nmol/l (±10.5) 30 minutes later. A post-awakening decrease occurred in 21.4% of all cases and was associated with higher awakening concentrations (24.7 ± 10.6 nmol/l) than in cases with increases (16.3 ± 7.5 nmol/l, $p < 0.004$). Post-awakening concentrations were higher in subjects scoring above the median in neuroticism ($F = 4.94$, $df = 1/99$; $p = 0.03$) and in non-users of oral contraceptives ($F = 3.21$, $df = 1/30$; $p = 0.08$). The intraindividual stability was highest ($0.40 \leq r \leq 0.62$) when using the higher of the two samples (awakening / post-awakening). An increase in the interval between sampling days was associated with a decrease in stability. Stability was independent of the covariables investigated (e.g. gender, body mass index).

2.1.4 Conclusion

Our findings support the usefulness of the awakening response for assessing individual HPA activity. For future studies, we propose that samples are collected at awakening and 30 minutes thereafter and that the higher of the two samples is included in the analysis.

2.2 Introduction

In common with many other biological systems, the activity of the hypothalamic-pituitary-adrenal (HPA) system follows a circadian rhythm that is reflected in the change of gluco-corticoid concentrations (cortisol in humans) over a 24-hour period. In humans, cortisol concentrations are highest in the morning around awakening and reach a nadir around mid-night (Knutsson et al. 1997, Shimada et al. 1995). This rhythm is established in infancy (Mantagos et al. 1998, Price et al. 1983). In the last few years, it has been demonstrated that the process of awakening is an important mediator of the circadian activity of the HPA system. A burst of activation can be observed immediately after awakening with peak corti-sol levels occurring approximately 30 minutes after awakening (Hucklebridge et al. 1998a, Hucklebridge et al. 1998b, Prüssner et al. 1997, Spath-Schwalbe et al. 1992).

The HPA system is sensitive to stressful situations and responds with an increase in cortisol concentration that is superimposed on the circadian activity. Thus, measuring levels of cor-tisol became a popular method of assessing short-term and chronic stress in humans. How-ever, the circadian activity acts as a confounding factor in stress assessment. The best time of day for testing is still controversial and may depend on the context (Tout et al. 1998). Recently, the reliability of the awakening response for the assessment of individual HPA activity was discussed (Prüssner et al. 1997). The authors reported higher individual stabil-ity of cortisol concentrations during a 30 minutes post-awakening phase compared to sam-ples collected at a given time in the early morning but without reference to the individual awakening time. Furthermore, the activation of the HPA axis associated with awakening appears to be independent of sleep duration, time of awakening, alcohol consumption on the previous day, smoking, weight, or age (Prüssner et al. 1997). However, in the previ-ously described study, saliva samples were collected four times an hour, a method with lim-ited practical applicability.

In this study, we investigated the individual stability of cortisol measurements obtained during the 30 minutes post-awakening phase with respect to the sampling-day interval (short-term, long-term). Furthermore, the impact of individual characteristics and habits as well as personality traits on those measurements was explored. We aimed to provide a cor-tisol measure that is characterized by high intraindividual stability, that is not affected by individual characteristics, and that can be obtained with minimal effort.

2.3 Methods

2.3.1 Subjects

Subjects were recruited from students participating in a post-graduate course leading to a Master's Degree in Science Education at the Swiss Federal Institute of Technology Zurich. All students planning to participate in a one-week training seminar at a Swiss boarding school were eligible (n = 160). Seven students withdrew from attending the seminar, and one student chose not to participate in the study. Thus, 95% (n = 152) of the eligible students agreed to participate and gave written informed consent. From this sample, we had to exclude two male students who failed to comply with sampling instructions and two pregnant females. The final sample (n = 148) consisted of 49 females and 99 males with an average age of 27.1 years (range 22 – 48 years). All subjects were in good health. No financial incentive was offered.

2.3.2 Study design

The subjects collected saliva samples on four different sampling days. The first sampling day was scheduled in April 1997 at an altitude of 450 m and four months prior to the training seminar. The remaining three sampling days were the second, third and fifth day of the seminar that was held in July at an altitude of 1600 m. The setting of the seminar subjected all participants to the same daily rhythm with approximately similar awakening times, scheduled meals and activities. On each sampling day, the first sample was collected immediately after awakening, a second sample 30 minutes later. Awakening was defined as the wake up that preceded the subject's getting up. This might have been the final stage of a transitory awakening process, where the subject went through repetitive cycles of awakening – falling asleep – awakening. Within a three-week period after sampling day 1, subjects completed a set of items on baseline information and a questionnaire assessing the personality domains of neuroticism and extraversion (for details, see below).

2.3.3 Samples

Each subject was given sampling kits including the collection material and written instructions on the sampling procedure (see appendix 2, p. 108-109). Subjects were requested to refrain from eating, smoking, brushing their teeth, and to take nothing by mouth except plain water prior to any sampling (see appendix 1, p. 102-103). Saliva samples were collected using purpose-designed tubes (Polyester swab, Salivette, Sarstedt, Chur, Switzerland). The participants first rinsed their mouths with plain water and then mouthed the salivette Polyester swab for two minutes. The swabs, soaked with saliva, were returned to the vial and frozen within 2 hours at -25°. Subjects recorded the exact time of awakening and the time when each sample was collected. The frozen samples were shipped on dry ice for assay. Cortisol levels were determined in duplicate by a time-resolved immunoassay described elsewhere (Dressendörfer et al. 1992). For the present study, the intra-assay coefficient of variation was 8.6% and the inter-assay coefficient of variation was 10.5%. Thus,

results from two samples differing by more than 1 nmol/l were regarded as indicative of a true difference.

The median awakening time on sampling day 1 was slightly later than on sampling day 2 through 4: day 1 at 6:50 a.m. with a range of 5:15 – 11:50 a.m., day 2 through 4 at 6:30 a.m. with a range of 5:05 – 7:10 a.m. On average, the participants collected the awakening sample 8.3 minutes after awakening (STD 2.6 minutes).

2.3.4 Baseline information and psychological assessment

Subjects reported on baseline information such as gender, age, body mass index, use of medications, use of oral contraceptives by women, pregnancy, smoking, alcohol and coffee consumption, and specific disorders concerning the endocrine system (see appendix 1, p. 89-90). On each sampling day, they provided additional information on absolute and relative sleep duration and the quality of sleep (two categories: "as usual or better" / "worse than usual"; see appendix 1, p. 102-103). The personality traits of neuroticism and extraversion were assessed by means of the German version of the NEO Five-Factor Inventory (NEO-FFI) from Costa and McCrae (Borkenau and Ostendorf 1993, Costa and McCrae 1992, McCrae et al. 1996). For this purpose, we extracted the 24 items (12 each) concerning neuroticism and extraversion from the original version (see appendix 1, p. 96).

2.3.5 Statistical analysis

All subjects who failed to collect a saliva sample within 15 minutes of awakening were excluded from all analyses which included that particular sampling day (Figure 1). These amounted to 29, 11, 11, and 7 subjects on sampling days 1, 2, 3 and 4 respectively. Therefore, the analyses differ as to the number of subjects that were included. To test for normal distribution, we examined cortisol data for skewness and kurtosis. We printed normal probability plots and discovered that the raw data, without any transformation, best approximated normal distribution. Descriptive statistic was performed on partially dependent data, whereas statistical analyses included only independent data. We analyzed cortisol concentrations collected immediately after awakening and 30 minutes post-awakening, as well as the difference between the two values (post-awakening change: post-awakening value minus awakening value). A positive result for this difference describes an increase in cortisol concentration, a negative value reflects a decrease.

On sampling day 1, we investigated the relation between awakening time and cortisol concentration by means of one-way ANOVA. The awakening times were grouped into 4 categories: 5 – 6 a.m., 6 – 7 a.m., 7 – 8 a.m. and > 8 a.m. and served as the independent variable. The association between cortisol concentrations and the duration of sleep on each sampling day was analyzed using simple correlation. The relation between sleep quality and cortisol levels was assessed by t-tests, based on the two categories "as usual or better" and "worse than usual". Differences in cortisol concentrations between sampling days were calculated using a one-way analysis of variance with repeated measures. Cortisol levels served as the dependent variable, sampling days as the within-subject factor.

To examine the effects of covariables, such as gender, body mass index, use of oral contraceptives by women, smoking, or the personality traits of neuroticism and extraversion on cortisol concentrations, we employed a two-way analysis of variance with repeated measures. Sampling days were used as the within-subject factor, the covariables as the between-subject factor. Continuous variables were grouped into the categories "above the median" and "below the median". Where appropriate, comparisons were made using the Bonferroni correction for multiple comparisons.

The individual stability of cortisol concentrations between sampling days was first calculated by simple linear correlation. Additionally, partial correlation was carried out to control for covariables.

Analyses were performed using the statistical software package SPSS (version 8, SPSS Inc.).

Fig. 1: *Scatter plot of cortisol concentrations collected at different times after awakening. Samples collected within 15 minutes of awakening were included in the analyses as awakening concentrations, samples collected after 15 minutes were excluded.*
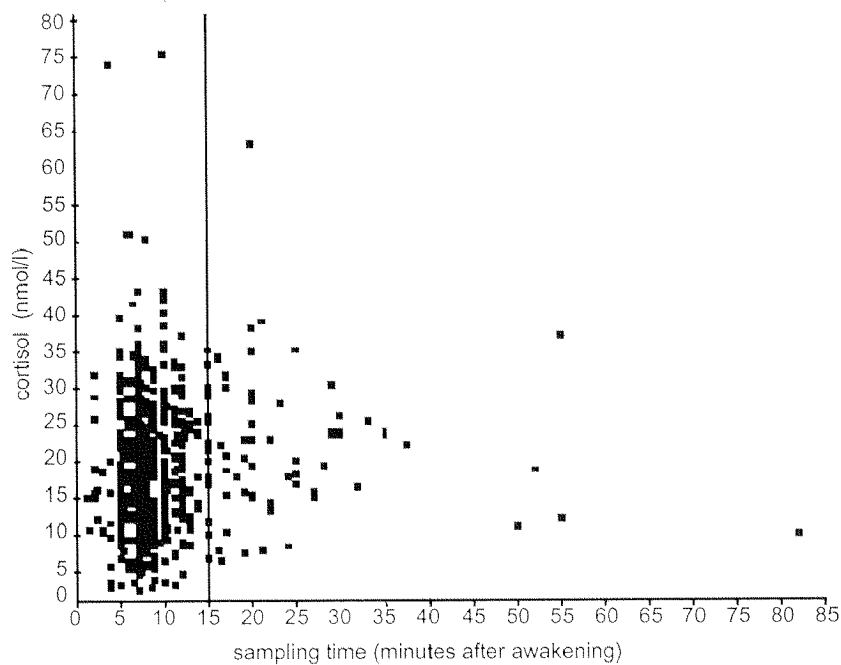
2.4 Results

2.4.1 Post-awakening change

The expected cortisol increase 30 minutes post-awakening was detected in 78.6% (n = 419) of all cases (n = 533, provided by 148 subjects). Forty-six percent of the subjects showed a consistent pattern with cortisol increases on each sampling day. Decreases only were observed in 2.7% of all subjects, while the remaining 51.3% showed a mixed pattern with increases and decreases. Increases were more common in women (86.5%) than in men (74.6%), as were consistent patterns of cortisol increases (women: 55.1%, men: 41.1%). The occurrence of decreases differed between sampling days and varied between 13.9 to 29.4%. Table 1 provides a summary of mean cortisol concentrations when all cases, increases only, and decreases only were included. Excluding decreases when calculating mean cortisol concentrations did not considerably change the results. On all sampling days, the cortisol level at awakening was significantly higher in subjects who showed a cortisol decrease than in subjects with a cortisol increase (t-test, p ≤ 0.004). In contrast, concentrations 30 minutes post-awakening were lower in cases of decreases than in those of increases (t-test, p ≤ 0.001).

Table I: *Summary of mean cortisol concentrations (nmol/l, ± standard deviation) at awakening and 30 minutes post-awakening, as well as the mean differences between the two samples. Values were calculated separately for all cases (decreases and increases), increases only, and decreases only.*

	all cases (N = 533)	increases only (N = 419)	decreases only (N = 114)
awakening	18.1 (± 8.9)	16.3 (± 7.5)	24.7 (± 10.6)
post-awakening	25.6 (± 10.5)	27.4 (± 10.4)	19.5 (± 10.3)
difference	7.5 (± 10.5)	11.1 (± 10.7)	-5.3 (± 5.1)

The time of awakening varied considerably between subjects on sampling day 1. However, we found no association between the time of awakening and the cortisol concentrations at awakening (F = 1.36, df = 3/115, p = 0.26), 30 minutes later (F = 0.62, df = 3/115, p = 0.61), or the magnitude of the post-awakening change (F = 0.35, df = 3/115, p = 0.79). On all sampling days, cortisol concentrations were also independent of sleep duration (-0.04 < r ≤ 0.10) and, with one exception (day 1, awakening concentration, t-test, p = 0.03), of sleep quality.

When controlled for the unequal occurrence of decreases in women and men, we observed no gender difference on any sampling day with respect to the cortisol concentration at awakening, 30 minutes post-awakening or the post-awakening change (p ≥ 0.06).

2.4.2 Differences between sampling days

The repeated measures analysis revealed a trend towards an increase in awakening cortisol concentrations from sampling day 1 to sampling day 4 (day 1: 16.8 nmol/l, day 4: 19.2 nmol/l, F = 2.40, df = 3/98, p = 0.07; table II). Additionally, a highly significant difference between sampling days was observed for samples collected 30 minutes post-awakening (F = 12.69, df = 3/98, p ≤ 0.001; table II). Comparisons indicated that these post-awakening concentrations were lower on sampling day 1 than on sampling day 2 through 4 (day 1: 21.7 nmol/l, day 2 – 4: ≥ 25.4 nmol/l, p < 0.001). Likewise, the post-awakening change was significantly higher on sampling days 2 through 4 than on sampling day 1 (day 1: 4.9 nmol/l, day 2 – 4: > 7.6 nmol/l, F = 4.56, df = 3/98, p < 0.005). When increases only were included to control for the unequal occurrence of decreases, the difference was still present between sampling day 1 and sampling day 3 through 4 (t-test [Bonferroni correction α = 0.02]: p ≤ 0.01).

The analyses were then repeated including gender, body mass index, smoking, use of oral contraceptives by women, or neuroticism and extraversion as between-subject factors (Table II). Cortisol concentrations at awakening remained uninfluenced by all investigated covariables. In contrast, cortisol concentrations measured 30 minutes post-awakening related to the subject's gender, body mass index, use of oral contraceptives, and level of neuroticism. Thirty minutes after awakening, cortisol concentrations were higher in women than in men, in subjects with a body mass index below the median, in subjects scoring above the median in neuroticism, and in women using no oral contraceptives when compared to users (Table II). However, the relation between body mass index and cortisol was no longer evident after controlling for gender (F = 2.41, df = 1/98, p = 0.12). Similar, controlling for gender reduced the degree of association between neuroticism and levels of cortisol (F = 4.10, df = 1/98, p = 0.05).

Table II: *Changes in cortisol concentrations at awakening and 30 minutes post-awakening with respect to sampling day, gender, body mass index (BMI), smoking, neuroticism, extraversion, and use of oral contraceptives (OC) by women (two-way analysis of variance with repeated measures).*

Factor/ covariable	awakening			30 minutes post-awakening		
all subjects	F-value	df	p-value	F-value	df	p-value
day	2.40	3/98	0.07	12.69	3/98	<0.001
day	1.89	3/97	0.14	10.47	3/97	<0.001
gender	0.06	1/99	0.81	5.90	1/99	0.02
interaction	0.08	3/97	0.97	0.34	3/97	0.79
day	2.59	3/97	0.06	12.94	3/97	<0.001
BMI	0.02	1/99	0.90	4.62	1/98	0.03
interaction	0.79	3/97	0.49	1.17	3/97	0.32
day	1.05	3/97	0.37	9.41	3/97	<0.001
smoking	2.52	1/99	0.12	0.03	1/99	0.87
interaction	3.39	3/97	0.02	0.73	3/97	0.53
day	2.38	3/97	0.08	12.57	3/97	<0.001
neuroticism	0.57	1/99	0.45	4.94	1/99	0.03
interaction	0.88	3/97	0.45	1.10	3/97	0.35
day	2.31	3/97	0.08	12.86	3/97	<0.001
extraversion	0.33	1/99	0.57	0.18	1/99	0.74
interaction	0.06	3/97	0.98	0.38	3/97	0.77
women only						
day	0.54	3/30	0.66	3.29	3/30	0.03
day	0.52	3/28	0.67	2.95	3/28	0.05
OC	0.19	1/30	0.97	3.21	1/30	0.08
interaction	2.39	3/28	0.09	0.45	3/28	0.72

df = degrees of freedom.

day = factor; gender, BMI, smoking, neuroticism, extraversion and OC = covariables.

2.4.3 Intraindividual stability

The intraindividual stability of cortisol levels was determined by the time of sampling and the interval length between sampling days (Table III). Stability was higher in samples collected 30 minutes after awakening than in samples collected immediately after awakening. Furthermore, stability increased steadily with shorter intervals between sampling days. Only a relatively weak correlation was observed between the post-awakening changes in cortisol concentrations obtained on different days ($r \leq 0.31$, $p = 0.02$). When our calculations included the higher of the two values, we obtained slightly better stability than from any other measure. Including gender, body mass index, smoking, neuroticism, extraversion, and use of oral contraceptives as covariables did not further improve intraindividual stability.

Table III: *Intraindividual stability of cortisol levels between sampling days (simple linear correlation). Values represent correlation coefficients of awakening samples, 30 minutes post-awakening samples, and maximum values.*

Cortisol levels	Sampling interval			
	day 1 – day 2 (4 months)	day 2 – day 4 (2 days)	day 3 – day 4 (1 day)	day 2 – day 3 (consecutive days)
Awakening	0.22	0.19	0.42	0.47
30 min. post-awakening	0.42	0.53	0.57	0.59
Maximum values	0.40	0.54	0.60	0.62
Maximum values, women only	0.40	0.44	0.67	0.72

All correlations were significant below the $p < 0.05$ level.

2.5 Discussion

In this study, we investigated the response of the HPA axis associated with awakening and explored the intraindividual stability of different measures obtained during a 30 minutes post-awakening period across days and months. A characteristic of the HPA system is a cortisol increase during the first 30 minutes after awakening (Hucklebridge et al. 1998a, Hucklebridge et al. 1998b, Prüssner et al. 1997, Spath-Schwalbe et al. 1992). However, we observed cortisol decreases in about 20% of all cases. The awakening concentrations in subjects with decreases were higher than the awakening concentrations observed when subjects showed increases. In contrast, post-awakening concentrations were lower in cases of decreases than in cases with increases. All together, this suggests that in the case of decreases, the morning activation of the HPA system occurred prior to the recorded time of awakening. This finding may be simply explained by our definition of awakening. Subjects recorded the time of their "final" awakening, but this might represent the endpoint of a transitional awakening process. If this holds true, the awakening response of the HPA system was already elicited at an earlier stage of the awakening process and the measured "awakening concentrations" actually represent a post-awakening level. This problem does not appear to be exclusive to our experimental design (Prüssner et al. 1997). Nevertheless, we cannot rule out that some subjects may occasionally lack this awakening-mediated activity of the HPA axis nor that the observed burst of HPA activity may be triggered prior to and independent of the process of awakening.

The sampling time and sampling interval determined the intraindividual stability of cortisol concentrations measured during the 30 minutes post-awakening phase of the HPA system. Considerably higher stability was observed between post-awakening concentrations than between awakening samples. Furthermore, the stability increased with a decline in interval length between sampling days. When accounting for the occurrence of cortisol decreases in some subjects by using the higher concentrations of the two samples collected, the stability increased marginally over the stability of post-awakening samples. In summary, the maximal cortisol concentrations obtained during a 30 minutes post-awakening period provided good stability in connection with short sampling intervals. It compared well to the stability reported by Prüssner and coworkers (Prüssner et al. 1997) who used a more sophisticated measure. Interestingly, even a long-term interval between sampling days, associated with a change in environment, showed moderate stability. One limitation of our study is that the long-term interval was accompanied by a change of altitude, season, and setting. The stability over months might have been higher when both samples were collected in the same environment. These changes may also account for the observed difference in cortisol concentrations between the first sampling day and the remaining three sampling days.

The HPA activity can be confounded by individual characteristics (Kirschbaum 1991). There is controversial evidence from the current literature about gender differences with respect to the awakening response of the HPA axis (Bonen et al. 1991, Hucklebridge et al. 1998b, Prüssner et al. 1997). In concordance with Prüssner and coworkers (Prüssner et al. 1997), the extent of the awakening response depended on the subject's gender. However,

when controlled for the unequal occurrence of post-awakening decreases between women and men, this difference was no longer evident. Concentrations measured 30 minutes post-awakening, but not at awakening, were lower in women using oral contraceptives when compared to non-users. This is in line with the findings of Prüssner and coworkers (Prüssner et al. 1997). A potential explanation is offered by the different kinetics of cortisol responses in women using oral contraceptives (Bonen et al. 1991, Kirschbaum et al. 1999, Kirschbaum et al. 1995, Reinberg et al. 1996).

The observed associations between cortisol concentrations and covariables were in general weak and should be considered as trends. Of importance is, however, that the individual stability in cortisol concentrations was not affected by the investigated covariables.

In conclusion, our data support the hypothesis that the awakening response of the HPA system is a suitable tool for assessing individual HPA activity. Our aim was to provide a measure that is characterized by high intraindividual stability, that is insignificantly affected by individual characteristics, and that can be obtained with minimal effort. Therefore, we propose that for future studies, saliva samples are collected immediately after awakening and 30 minutes post-awakening and that the higher of the two concentrations are included in the analysis. This procedure takes into account that some subjects will demonstrate a cortisol decrease, rather than an increase, which might be related to a transitory awakening process which has an impact on the recording of awakening time.

2.6 References

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Chapter 3: Impact of the circadian cortisol rhythm on endocrine responses to examination-related stress

3.1 Abstract

3.1.1 Objective

Unpredictable situations, such as university exams, can elicit transient increases of circulating cortisol. Little is known about the association between the magnitude of the endocrine response to such acute stressors and the circadian cortisol amplitude. We conducted an observational cohort study to elucidate this relation.

3.1.2 Methods

Participants (148 post-graduate students, 67% males) attended a one-week training seminar. Saliva cortisol levels were measured during 4 observation days: 4 months prior to the seminar, and on the second, third and fifth day of the seminar. Samples were collected at awakening, 30 minutes thereafter, prior to different one-hour academic tasks at 5 p.m. and after the tasks (6 p.m. and 6:30 p.m.). On observation day 2, subjects completed a relevant written examination.

3.1.3 Results

Cortisol levels at 5 p.m. were higher in males than in females (mean of all observation days = 9.2 nmol/l versus 6.0 nmol/l, F = 53.1, df = 1/146, p < 0.001). The pre-examination cortisol level (day 2) showed a larger absolute increase over the corresponding 5 p.m. levels on days 1, 3 and 4 in males as compared to females (F = 43.4, df = 1/146, p < 0.001). The best model containing psychological, baseline variables and cortisol measures related to the circadian amplitude or its variability explained 29.7% of the observed variance in absolute cortisol increases. Within this model, gender, extraversion, positive attitude towards life, and subjective stress perception prior to the examination accounted for 16.0% of the variance. The mean relative examination-related increase amounted to 85.6%. There was no gender difference (p = 0.64). Psychological variables explained 16.1% of the variance. Non-stimulated cortisol measures did not further improve the model (explained variance 17.9%).

3.1.4 Conclusions

The absolute examination-related increase in salivary cortisol is dependent on the individual's circadian cortisol amplitude. The relative examination-related change to baseline provides a measure which is independent of the circadian rhythm.

3.2 Introduction

Neuroendocrine arousal in response to psychologically stressful events, such as academic examinations, is a well-documented phenomenon (Kirschbaum and Hellhammer 1989, Kirschbaum and Hellhammer 1994). The neuroendocrine arousal, which involves the activation of the hypothalamic-pituitary-adrenal axis, can be conveniently quantified by determination of salivary cortisol levels (Kirschbaum and Hellhammer 1994). The majority of studies which investigated endocrine reactivity in response to academic examinations reported a large interindividual variability both in anticipatory and reactive cortisol increases (Huwe et al. 1998, Jones et al. 1986, Kahn et al. 1992). The observed variability was only partially explained by psychological variables, subjective stress perception, or gender (Jones et al. 1986, Nicolson et al. 1992, Spangler 1997).

More recently, research into the interindividual variation of salivary cortisol levels showed reasonable stability of the individual awakening cortisol levels and the post-awakening increase (Prüssner et al. 1995, Prüssner et al. 1997), suggesting a genetic determination of awakening cortisol reactivity. On the other hand, studies in monozygotic and dizygotic twins found limited influence of heredity on cortisol responses to physical exercise or psychological stress (Kirschbaum et al. 1992). However, there is a paucity of data regarding the association between the endocrine responses to real-life stressors and the individual non-stressed circadian cortisol reactivity (Ockenfels et al. 1995, Prüssner et al. 1999, Samuel et al. 1999, Schulz et al. 1998). We therefore designed the present study to ascertain whether measures indicating the individual circadian cortisol amplitude or its variation explain some of the observed variance in examination-related cortisol responses, after controlling for psychological variables and other confounders.

3.3 Methods

3.3.1 Subjects

Subjects were recruited from students participating in a post-graduate course leading to a Master's Degree in Science Education. Eligible were students (n = 160) who planned to attend a one-week-training seminar at a secluded Swiss boarding school located at an altitude of 1600 m. This semi-experimental setting subjected participants to the same awakening time and the same schedule of activities during the day, such as meals and academic tasks. Seven students withdrew from attending the seminar, one student chose not to participate in the study. The remaining 152 students gave written informed consent. No financial incentive was offered. Subjects were in good health.

3.3.2 Study design

Participants collected saliva samples on four observation days and completed questionnaires assessing psychological variables. The first observation day was a midweek day at the beginning of the summer term (April 1997, location Zurich, altitude 450 m), the remaining three observation days were the second, third and fifth day of a one-week training seminar at a boarding school (last week of July 1997, location Zuoz, altitude 1600 m). Samples were collected immediately after awakening, 30 minutes thereafter, at 5 p.m. and, for observation days 2 through 4, additionally at 6 p.m. and at 6:30 p.m. Awakening was defined as the awakening immediately prior to leaving the bed. Transitory sleep disruption, for example when subjects awoke to an external stimulus (e.g. alarm clock) but fell asleep again, was not regarded as awakening.

On every observation day, an academic task of one-hour duration was scheduled at 5 p.m. This academic task was a lecture on day 1, a written examination that counted 20% towards the final post-graduate grade on day 2, a lecture on day 3, and the Raven intelligence test on day 4. While the examination was announced and required approximately one week of preparation, students were not informed about the intelligence test until after the 5 p.m. sample had been collected. Subjects received no feedback on the examination performance until after the end of the study.

3.3.3 Samples

Each subject was given written instructions together with a set of salivettes (see appendix 2, p. 108-109). The instructions required participants to refrain from physical exercise, eating, smoking, brushing their teeth and to take nothing by mouth except plain water during the 60 minutes preceding any salivary sampling. Participants recorded the exact time of awakening and sampling, prior physical activities, meals, coffee, alcohol and nicotin consumption (see appendix 1, p. 102-107). Before each sample was taken, participants rinsed their mouths with plain water. Saliva collection followed a standardized procedure with purpose-designed tubes (Polyester swab, Salivette, Sarstedt, Chur, Switzerland). Subjects introduced the salivette Polyester swab into the oral cavity for a two-minute collection period. Swabs were then returned to the salivette tube. Samples were frozen within two hours of collection at –25° C. Frozen samples were shipped on dry ice for assay. Salivary cortisol levels were determined in duplicate by a

time-resolved immunoassay with fluorescence detection (Dressendörfer et al. 1992). For the present study, the intra-assay coefficient of variation amounted to 8.6%, the inter-assay coefficient of variation was 10.5%. Thus, results from two samples differing by more than 1 nmol/l were regarded as indicative of a true difference.

3.3.4 Sociodemographic variables

Baseline data included: age, gender, body mass index, employment status, present occupation, habitual smoking, alcohol consumption, and regular intake of medications. Women were asked about the current phase of the menstrual cycle, whether they used oral contraceptives and whether they were pregnant. Further questions assessed the presence of any health disorder (see appendix 1, p. 89-90).

3.3.5 Psychological variables

Trait variables were assessed following observation day 1 (see appendix 1, p. 91-96). This baseline assessment comprised a 30-item questionnaire assessing examination-related trait anxiety (Hodapp 1991, Hodapp et al. 1995), a 10-item questionnaire assessing general self-efficacy (Schwarzer 1993) as well as a 15-item questionnaire evaluating examination-specific self-efficacy (7 items) and examination-specific procrastination (8 items; Schwarzer, Haldemann, unpublished data). We assessed personality traits using the scales for neuroticism and extraversion (12 items each) from the German short form of the NEO-FFI personality inventory (Borkenau and Ostendorf 1993, Costa and McCrae 1992, McCrae et al. 1996). Dispositional coping strategies were assessed by a 24-item German version of the coping inventory "CISS" (Endler and Parker 1990, Semmer et al. 1991). Perceived social support was estimated by an 18-item short version of the SOZU-K22 questionnaire from which the four items for practical support were omitted (Sommer and Fydrich 1991). Finally, positive attitude towards life was estimated by the 8-item Well-Being Scale (Grob et al. 1991).

State variables were obtained on observation days 2 and 4 by completion of a 30-item questionnaire assessing situation-specific examination-related state anxiety (Hodapp 1991, Hodapp et al. 1995) as well as a 24-item questionnaire assessing actual coping behavior (Endler and Parker 1990, Semmer et al. 1991) immediately prior to the academic task and before the 5 p.m. sample (see appendix 1, p. 97-100). For all samples (including awakening), subjects recorded their momentary subjective stress perception on a visual analog scale graded from 0 to 10 (see appendix 1, p. 101).

3.3.6 Statistical analysis

We defined the higher of the two cortisol measurements from the samples after awakening and 30 minutes post-awakening as the peak morning level. The absolute post-awakening change was derived by subtracting the cortisol concentration measured in the second sample from the result of the first sample. For observation days 2 through 4, we calculated the circadian amplitude as the difference between the peak morning cortisol level and the lowest afternoon saliva cortisol concentration. In order to estimate the individual variability we calculated the standard deviations of the subject's peak morning level, the absolute post-awakening change and the circadian amplitude.

To compare changes in the pre-examination levels at 5 p.m., we calculated two measures. The absolute examination-related increase was defined as the pre-examination cortisol level at 5 p.m. minus the mean 5 p.m. cortisol levels of the other observation days. The relative examination-related increase was defined as the pre-examination cortisol level at 5 p.m. divided by the mean of the 5 p.m. cortisol levels of the other observation days. Normal distribution was examined visually from Q-Q-normal probability plots and by the Wilk-Shapiro test. All of the raw cortisol measures were transformed where appropriate to approximate normal distribution.

In a first analysis, we checked the cortisol levels at each sampling point (awakening, 30 minutes post-awakening, 5 p.m., 6 p.m., and 6:30 p.m.) for differences between observation days by means of a two-way analysis of variance with repeated measures, with observation days and gender as the two variables. Next, we examined the association of psychological variables with the absolute and relative cortisol increases at 5 p.m. on the examination day. Variables were examination-related trait and state anxiety, general self-efficacy, examination-specific self-efficacy, examination-specific procrastination, extraversion, neuroticism, trait and state coping behavior, perceived social support, positive attitude towards life and subjective stress perception prior to the examination. We calculated two-way analyses of variance, entering absolute or relative pre-examination cortisol increases as dependent variables and gender plus the psychological parameters as independent variables. Psychological variables were entered in a stepwise fashion by forward and backward selection (entry and removal criterion $p < 0.15$), in order to achieve a model that best explained the observed variance and that was parsimonious.

In the final step of the analysis, we checked whether including mean peak morning cortisol levels, mean post-awakening change, mean circadian amplitude or measures of cortisol variability further improved the explanatory performance of the model that included only psychological variables and gender.

Where appropriate, we used the Student-Newman-Keuls Test for post hoc comparisons and the Greenhouse-Geisser approximation to control for nonhomogeneity. In repeated measures analyses, we specified contrasts a priori and corrected for multiple testing by a Bonferroni correction. Otherwise a probability of the type I error of less than 0.05 indicated statistical significance. Calculations were performed using the SAS system (version 6.12, SAS Inc., Cary, NC, USA).

3.4 Results

3.4.1 Population

One hundred and fifty two of 160 potentially eligible students (95%) participated. Two pregnant females and two males who violated the sampling instructions were excluded. The study population finally comprised 148 students (99 males and 49 females). The mean age was 27.1 years (range 22 – 48 years). Further characteristics of the population are presented in Table 1.

Table 1: *Study population*

	Males	Females	Total
No. participants	99	49	148
Mean age (SD)	27.2 (5.2)	26.9 (4.3)	27.1 (4.9)
Body mass index (SD)	22.6 (2.2)	20.9 (2.0)	22.0 (2.25)
employment status			
No. of students (percent)	59 (60%)	30 (61%)	89 (60%)
No. of unemployed (percent)	5 (5%)	5 (10%)	10 (6.8%)
No. of habitual smokers (percent)	17 (17%)	4 (8%)	21 (14.1%)
No. of women taking oral contraceptives	–	20 (41%)	20 (13.5%)
No. of regular coffee drinkers (percent)	80 (81%)	40 (82%)	120 (81%)
Examination-related			
Anxiety trait score[a] (SD)	68.8 (13.0)	66.9 (13.1)	68.2 (13.0)
Anxiety state score[b] (SD)	64.3 (13.9)	63.7 (14.1)	64.1 (14.0)
Self-efficacy score (SD)	19.7 (3.1)	19.0 (3.9)	19.5 (3.4)
Extraversion score (SD)	27.9 (6.3)	30.2 (6.7)	28.6 (6.5)
Neuroticism score (SD)	17.6 (6.9)	19.5 (6.8)	18.2 (6.9)
Positive attitude towards life score (SD)	35.5 (6.0)	37.0 (5.2)	36.0 (5.8)
General self-efficacy score (SD)	28.9 (3.5)	27.9 (3.9)	28.6 (3.7)
Perceived social support score (SD)	76.6 (10.9)	78.8 (7.0)	74.7 (10.1)

[a]   Higher scores on psychometrical scales indicate stronger expression of the tested factor.

[b]   State score: prior to the written examination on observation day 2.

SD   Standard deviation

3.4.2 Mean cortisol levels prior to the academic tasks

The mean pre-academic task values obtained at 5 p.m. differed significantly between the four observation days (F = 31.4, df = 3/144, p < 0.001). Males had a higher average cortisol level at 5 p.m. than females (mean of day 1 through day 4: 9.2 nmol/l versus 6.0 nmol/l, F = 53.1, df = 1/146, p < 0.001). The highest levels were observed prior to the examination (Figure 1). Males showed a higher absolute examination-related increase than females (observation day 2 minus mean of days 1, 3 and 4: 5.2 nmol/l versus 2.8 nmol/l, p < 0.001). The strongest correlation for 5 p.m. levels was observed between observation days 3 and 4 (seminar, prior to lecture and Raven intelligence test, Pearson's r = 0.54). The correlation between observation days 1 and 3 (prior to lectures, sampling four months apart) was weaker (Pearson's r = 0.37, p < 0.001). The 5 p.m. cortisol levels, separated by day and gender, are presented in Figure 1.

Figure 1: *Mean salivary cortisol levels at 5 p.m. in post-graduate students, separated by gender, prior to academic tasks (females n = 49, males n = 99). The task consisted of a lecture on day 1 and day 3, a written examination counting towards the final post-graduate grade on day 2 and the Raven intelligence test on day 4. Error bars indicate the standard error of the mean.*
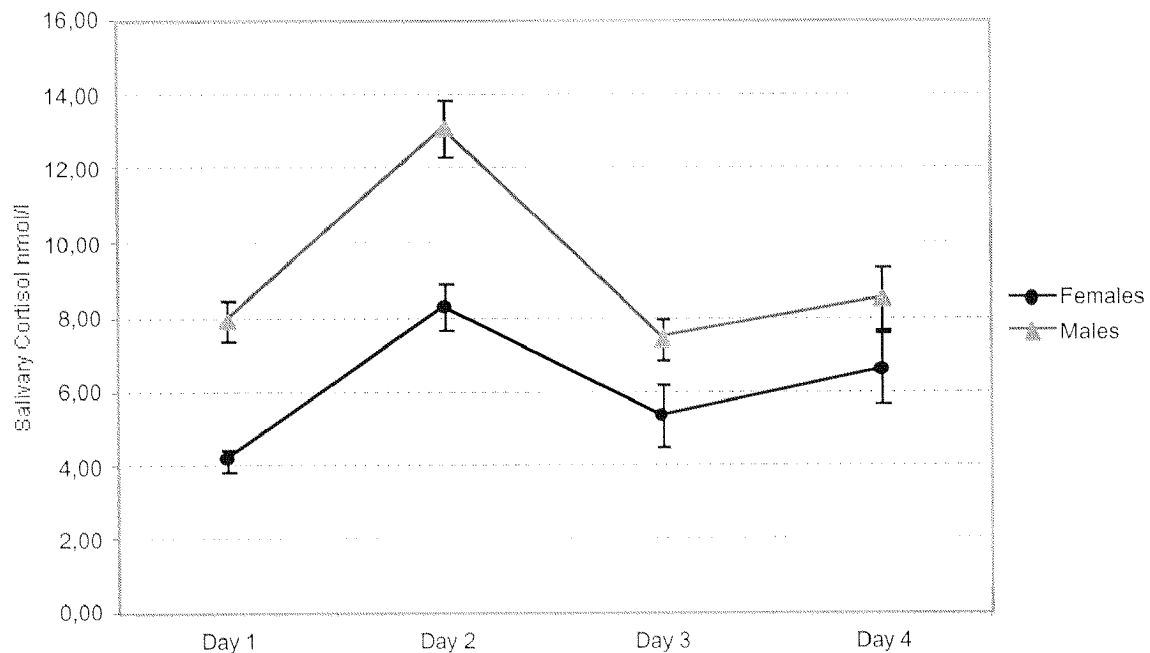
The task of completing psychological questionnaires before the examination on day 2 and before the Raven intelligence test on day 4 might have increased the subjective arousal. Therefore we compared the 5 p.m. cortisol levels of day 1 and day 3 (no questionnaires) to day 4 (samples collected after completing a questionnaire). We found a non-significant absolute increase on day 4 compared to the mean of the 5 p.m. levels on days 1 and 3 (1.1 nmol/l, $p = 0.14$). We found no difference between 5 p.m. levels of day 1 and 3 ($F = 0.1$, df 1/146, $p = 0.75$) although samples were taken four months apart and at different altitudes (450 m, April versus 1600 m, July).

The mean relative examination-related increase amounted to 85.6% (5 p.m. level prior to the examination divided by the mean 5 p.m. levels of the remaining observation days). Every second student showed a pre-examination increase of more than 50% (or more than one standard deviation) over the corresponding samples from other days. The gender difference was not significant ($F = 0.22$, df 1/146, $p = 0.64$). Table 2 cross-tabulates strata of relative increase by gender. Only twenty participants (13.3%) showed a further increase in cortisol levels after the examination (post-examination levels at 6 p.m.). This effect was probably not examination-related, but random, since a similar proportion of subjects showed an increase from 5 p.m. to 6 p.m. levels on observation days 3 and 4 (Chi-square, $p = 0.34$).

Table 2: *Relative increase prior to the examination over the mean of the other observation days.*

	Males (n = 99)	Females (n = 49)
Relative increase	number (percent)	number (percent)
Increase > 200 percent	13 (13%)	5 (10%)
Increase 50 – 200 percent	45 (46%)	23 (48%)
Increase < 50 percent	21 (21%)	11 (22%)
Decrease	20 (20%)	10 (20%)
Chi-square, p = 0.34		

3.4.3 Confounding of examination-related cortisol increases by oral contraceptives or smoking

Females who used oral contraceptives (n = 20, 41% of all women) showed a trend towards lower relative examination-related increases (60.2% versus 87.2%, $p = 0.29$). A similar trend was observed for habitual smokers (n = 21, 14.1% of all participants, relative examination-related increase 70.8% versus 88.1%, $p = 0.52$). However, neither oral contraceptives nor smoking acted as confounders in the multivariable analyses. The majority of women declined to complete the question regarding the menstrual cycle. Therefore, we were unable to evaluate the influence of this variable.

3.4.4 Association of examination-related cortisol increases with psychological variables

We performed a multivariable analysis to examine any association between absolute examination-related increases and psychological variables or other confounders. Entering psychological or baseline variables into the model, only gender, subjective stress perception prior to the examination, extraversion, positive attitude towards life, and examination-specific self-efficacy explained some of the variance (17.6%). When using the relative examination-related increase as the dependent variable, extraversion, perceived social support, positive attitude towards life, and subjective stress perception prior to the examination were the only variables which explained some of the observed variance (16.1%).

3.4.5 Awakening cortisol levels and post-awakening change

On average, participants awoke at 7:08 a.m. on observation day 1 and at 6:25 a.m. on the remaining days. The mean awakening cortisol level amounted to 18.4 nmol/l and did not differ between males and females (F = 0.69, df = 1/146, p = 0.41). Levels were similar between the first observation day (four months prior to day 2, altitude 450 m) and day 2 (after the first night at 1600 m altitude, mean 17.6 nmol/l versus 17.9 nmol/l). Awakening levels tended to increase towards the fourth observation day (20.1 nmol/l, not significant). In contrast, the 30 minutes post-awakening levels differed significantly between the first observation day (21.6 nmol/l) and observation days 2 through 4 (25.4, 27.4 and 27.4 nmol/l, respectively, F = 15.9, df = 3/144, p < 0.001). Neither gender (F = 2.65, df = 1/146, p = 0.106) nor gender-day interaction (p = 0.974, Greenhouse-Geisser adjustment) explained this difference. Mean peak morning levels were higher in females than in males (28.4 nmol/l versus 26.1 nmol/l, F = 12.8, df = 1/146, p = 0.004).

The grand mean circadian amplitude, defined as the mean of all subjects means, amounted to 25.5 nmol/l in females and to 22.5 nmol/l in males (p = 0.046). The grand mean standard deviation of the mean circadian amplitude was 6.4 nmol/l with no difference between gender (p = 0.87). The peak morning level was lower than the minimum afternoon cortisol level in 12 of 592 observations (2%). Seven (58%) of these 12 inverted circadian rhythms occurred on the examination day, and 11 of 12 (92%) in males.

3.4.6 Improvement of the models by including measures of circadian cortisol reactivity

In the final step of the analysis, we evaluated whether inclusion of any measures of individual non-stimulated circadian cortisol rhythm improved the two models which contained only psychological variables and gender. The optimized model using the absolute examination-related increase as the dependent variable resulted from including the individual mean circadian cortisol amplitude and its standard deviation. This model explained 29.7% of the observed variance. In this model, psychological variables and gender explain 16.0% of the variance. Examination-specific self-efficacy no longer satisfied the entry criterion of p < 0.15. The final model is presented in Table 3.

Table 3: *Final prediction model as to the absolute examination-related increase over the average 5 p.m. cortisol level. The model explains an amount of the variance when using the square root of the absolute increase as the dependent variable. The coefficients relate to presence or absence of a category or to the logarithm of cortisol values. Positive coefficients indicate a positive association between the factor and an increase of the pre-examination cortisol level over the average 5 p.m. level of the other observation days. Psychological variables and gender explain 16.0% of the variance.*

Variable	Coefficient β	P value of coefficient[a]	Percent of explained variance[b]
Intercept	-0.58	0.850	
Extraversion[c]	2.17	0.025	3.1
Positive attitude towards life[d]	-0.14	0.048	2.4
Subjective stress prior to examination[e]	0.33	0.037	4.6
Gender (male)	2.50	0.005	5.9
Mean circadian amplitude[f]	1.05	0.031	5.1
Standard deviation of the mean circadian amplitude[g]	0.38	0.001	8.6
Total model			29.7

[a] Test statistics for coefficient in regression model

[b] Determined from variance analysis in general linear models

[c] Increase attributable to a score in the upper third of test results

[d] Chance attributable to a one point change in the test score (mean $36 \pm$ SD 5.8)

[e] Increase attributable to male gender

[f] Increase attributable to each 10 nmol/l of the mean circadian amplitude

[g] Increase attributable to each 1 nmol/l of the standard deviation of the mean circadian amplitude

By contrast, when we used the relative examination-related increase as the dependent variable, introducing measures of the non-stimulated circadian cortisol reactivity only marginally improved the best model containing psychological and baseline variables (increase in explained variance from 16.1% to 17.9%).

3.5 Discussion

In this study, we examined the association between measures of non-stimulated circadian cortisol reactivity and stress-related responses of the hypothalamic-pituitary-adrenal axis. We used an examination counting towards a post-graduate Master's Degree as a real-life stressful event. We attempted to reduce the individual variability attributable to environmental factors by choosing a setting where the 152 participants lived for one week in a secluded boarding school. The main finding of this study is that absolute pre-examination-related cortisol increases were only weakly associated with psychological variables and that inclusion of the mean circadian amplitude and its variability (standard deviation) significantly improved the model. Like previous investigators, we found a higher absolute examination-related response in males than in females (Johansson et al. 1989, Spangler 1997). Thus, the absolute magnitude of an examination-related cortisol response appears to be driven in part by the individuals circadian cortisol reactivity and by gender.

However, the relative change compared to the individuals non-stimulated cortisol levels at corresponding circadian times is probably of higher biological relevance. When we used the relative examination-related increase as the dependent variable, the gender difference was negligible and measures of the non-stimulated circadian cortisol reactivity did not further improve the model. Thus, the relative increase appears to be independent of gender and non-stimulated circadian cortisol reactivity.

The magnitude of the endocrine response was comparable to the response reported from other studies investigating relevant oral or written university examinations (Hellhammer et al. 1985, Huwe et al. 1998, Nicolson et al. 1992). Several findings indicate that subjects in our study perceived the pre-examination situation as highly stressful and thus, we were able to observe a relevant real-life stressor. First, the subjective perception of stress increased by nearly two standard deviations above the level measured before attending a normal academic lecture. Second, examination-related anxiety scores were within the range reported for relevant written university exams (Hodapp et al. 1995). Third, awakening cortisol levels were similar on observation day 1 at 450 m of altitude and four months later, prior to the examination on observation day 2 at 1600 m of altitude, as were the 5 p.m. cortisol levels on days 1 and 3. Pre-academic task levels on day 3 and 4 were significantly correlated (Pearson's r = 0.54) indicating similar stability of afternoon cortisol levels as reported for awakening cortisol levels, provided that environmental factors are controlled (Prüssner et al. 1997). Finally, the 5 p.m. levels on day 4 were significantly lower than pre-examination levels. This indicates that the observed increase on day 2 could not be attributed to arousal following the task of completing questionnaires. We therefore believe that the major proportion of the observed cortisol response should be viewed as an anticipatory stress reaction to the upcoming examination, rather than as a response to completion of a questionnaire or to a change in environment.

The magnitude of the observed reactions should have increased the chance of identifying any associations with psychological measures. However, as reported from previous studies, we found only a limited association between examination-related cortisol changes and psychological measures (Armario et al. 1996, Huwe et al. 1998, Jones et al. 1986, Kahn et al. 1992, Malarkey et al. 1995). The observed relations of absolute or relative pre-examination cortisol increases and psychological or baseline variables were

weak. These data are consistent with neurobiological findings, which suggest that self-reported appraisal of unpredictable events and the anticipatory endocrine response are regulated by different central nervous circuits (LeDoux 1992, LeDoux 1998, Weinberger 1990).

The strengths of the study are the setting and the timing of the experiments. The setting in a secluded boarding school and the relatively homogeneous population allowed the study of endocrine reactions to a real-life stressor in a large group of humans under semi-experimental conditions. The timing of the academic tasks during the late afternoon minimized the influence of post-awakening or circadian variation. Finally, we achieved a high follow-up rate of potentially eligible subjects, which minimized selection bias.

However, some limitations must be considered. First, we evaluated a group of postgraduate students exposed to examination stress. This limits the generalizability of our findings to other populations or stressful events. Second, we cannot exclude a combined confounding by change in season, change in altitude, and change to the environment of a boarding school. These factors may have increased the perceived unpredictability of the situation, thus increasing the likelihood of a cortisol increase (Kirschbaum 1991, Kirschbaum and Hellhammer 1989). However, we believe that this bias did not influence our main findings on the association between measures of circadian cortisol reactivity and stress-related endocrine responses. Finally, more frequent sampling during the post-awakening period would have improved the accuracy of the morning peak estimate. The current design with two samples following awakening was chosen to avoid hampering a high follow-up rate.

In conclusion, we observed a significant association between the individual circadian cortisol amplitude and its variability and the absolute increase of salivary cortisol prior to a relevant written examination. These circadian measures failed to correlate with the relative pre-examination increase. Psychological measures were only weakly associated with endocrine responses. When environmental factors remained constant, non-stimulated afternoon levels showed comparable re-test reliability as did morning cortisol concentrations (Prüssner et al. 1997).

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Chapter 4: Association between stress-related endogenous releases of cortisol and higher order cognitive performance in an academic examination

4.1 Abstract

4.1.1 Objective

This prospective cohort study was designed to determine possible associations between stress-related endogenous cortisol releases and higher order cognitive performance in a real-life examination. We hypothesized that adrenocortical reactivity might account for an additional part of the observed variance in test results beyond that explained by individual baseline and psychological variables.

4.1.2 Methods

The study population comprised 148 post-graduate students (49 women, 99 men) who attended a one-week training seminar subjecting all participants to the same daily activities. Saliva samples were collected on 3 days: 4 months prior to the training seminar, and on the second and third day of the seminar. Participants collected samples immediately after awakening and 30 minutes thereafter, prior to different one-hour academic tasks at 5 p.m., and after the tasks (6 p.m. and 6:30 p.m.). The academic tasks consisted of a relevant written examination of the criterion-reference test type on observation day 2 and of academic lectures on the two remaining observation days.

4.1.3 Results

Cortisol levels immediately prior to the examination were two times higher as compared with the mean of the corresponding levels obtained at the two remaining observation days. The median difference amounted to 4.6 nmol/l in males and to 3.9 nmol/l in females. Univariate linear regression analysis revealed that none of the investigated indicators of cortisol reactivity explained any significant proportion of the observed variation in the examination scores (F = 2.34 – 0.61, df 1/146, p = 0.12 – 0.44).

Stepwise multivariable regression analysis resulted in a model explaining 12% of the observed variance ($R^2 = 0.12$). This model contained the following variables: perceived social support, learning motivation, examination-specific self-efficacy (trait), and gender. None of the indicators of adrenocortical reactivity increased the explained proportion of the variance, excluding that negative confounding had prevented to detect an existing association in the univariate analysis.

4.1.4 Conclusion

Our data fail to support the hypothesis of an association between stress-related endogenous cortisol releases and performance in the investigated real-life written academic examination.

4.2 Introduction

Test results obtained in written or oral examinations are major determinants of students' grades and academic achievements. Most examinations require recalling data from the verbal declarative memory. Concepts and findings from studies, which investigated test-like situations under laboratory conditions, may not be extended to real-life examinations. The external validity of such conclusions for naturalistic settings and multiple determined academic performance remains unclear (Deffenbacher 1986). Many investigators have attempted to attribute variance in academic test performance to differences in learning strategies and personality variables (Deffenbacher 1986). These variables account for a small, but meaningful part of academic achievement (Furnham and Mitchell 1991, Helmke and Weinert 1997). However, the major proportion of the variance remains unexplained (Furnham and Mitchell 1991).

In the present study, we aimed to elucidate whether examination-related endogenous cortisol releases explained an additional proportion of the observed variance in test results beyond that explained by individual baseline and psychological variables. We investigated a written examination counting towards the final grade in a post-graduate course. This examination belongs to the class of higher order cognitive tests in which students have to adapt or reorganize learned knowledge in essay-type questions.

Clinical evidence on the modulatory role of stress on memory functioning arises from several studies including traumatized patients (Bremner 1999, Bremner and Narayan 1998) or aging men (Kalmijn et al. 1998, Lupien et al. 1994, Lupien et al. 1997). Patients with chronically elevated endogenous cortisol levels (e.g. Cushing syndrome) show impaired memory functioning, suggesting a link between memory functioning and increased endogenous cortisol levels (Martignoni et al. 1992, Starkman et al. 1992, Starkman et al. 1981). In rats, endogenous cortisol releases after painful footshock induce the same impairment of spacial memory as exogenous administration of glucocorticoids (de Quervain et al. 1998). Moreover, administration of metyrapone, an agent blocking glucocorticoid synthesis, abolishes the stress-induced impairment of memory retrieval (de Quervain et al. 1998).

Glucocorticoids, which are secreted after stimulation of the hypothalamic-pituitary-adrenal axis, are crucial in the adaptation to stress. Amongst many other functions, cortisol regulates neuronal metabolism and gene expression (De Kloet et al. 1987). Neural cells in the hippocampus show a rich expression of Type 2 glucocorticoid receptors, which tend to be activated by peak cortisol levels (De Kloet et al. 1999, De Kloet et al. 1998). Effects of high glucocorticoid levels or glucocorticoid analogues on the hippocampus include inhibition of activity-related synaptic processes such as long-term potentiation and involution of dendritic processes (Foy et al. 1987). Accumulating evidence supports the central role of the hippocampus in memory storage and retrieval (Squire 1992).

Investigations in humans have further aimed to elucidate the dose-response relation between exogenous administration of cortisol or glucocorticoid analogues, acute laboratory psychological stressors and memory processes. Healthy students who were exposed to the Trier Social Stress Test showed impaired performance in declarative memory (Kirschbaum et al. 1996). Normal adults exhibited an impairment of verbal declarative memory performance after treatment with dexamethasone (Newcomer et al. 1994). Recently, Newcomer and coworkers studied the effects of orally administered cortisol

on various domains of memory functioning (Newcomer et al. 1999). The cortisol doses were chosen to model endocrine responses to mild stressors (40 mg/d of cortisol) and reactions to moderate or maximal stressors (160 mg/d). Plasma levels of cortisol in the high dosage group fell within the range observed after major surgery (Chernow et al. 1987) or strong psychological stressors such as the Trier Social Stress Test (Kirschbaum et al. 1993). Participants exposed to the high dose of cortisol showed a marked impairment in recall from verbal declarative memory task, but not in any other domain of memory performance. The impairment was fully reversible after a washout period (Newcomer et al. 1999). The observed treatment-induced differences in test performance were clinically relevant. Similar changes in paragraph recall of the Wechsler Memory Scale-Revised would lower a subject's classification of recall performance by one level (e.g. from average to low-average) (Wechsler 1987).

Several investigators have observed endogenous cortisol releases in anticipation of or after academic examinations. Current evidence indicates that a relevant number of students mount cortisol increases of similar magnitude as elicited by the Trier Social Stress Test (Armario et al. 1996, Cook et al. 1992, Hellhammer et al. 1985, Kahn et al. 1992). Altogether, these findings raise the possibility that sustained anticipatory stress reactions, which lead to marked elevations of endogenous cortisol levels, may impede verbal declarative memory, thereby interfering with the examination performance.

Such a relation between examination-related endocrine secretions and test performance has been postulated more than a decade ago (Jones et al. 1986). Investigations addressing this question in field studies have provided conflicting results. Jones and coworkers assessed 40 medical students undertaking their first major written examination. The investigators subdivided the study population according to the results from psychological screening aimed to identify students with Type A behavior pattern. Students showed a differential relation between cortisol values and examination scores depending on the status of Type A behavior (Jones et al. 1986). More recently, Huwe and coworkers investigated the associations between test performance during a 30-minute oral examination and various psychological or physiological measures in a selected population of 58 students (Huwe et al. 1998). High anxiety was associated with lower test performance. Unfortunately, cortisol levels were elevated both in the high anxiety and in the low anxiety group. The investigators proposed the hypothesis of a psychological "stress" threshold above which endocrine responses ensue. From a design perspective, both investigations followed a case-control study design. Thus, it remains elusive, whether endocrine responses above the threshold affect academic test results.

We therefore aimed to extend the existing knowledge by conducting a prospective cohort study. The sample size was calculated to be more than twice the size than that of previous trials, in order to allow multivariable covariate analysis comprising psychosocial and psychological variables as well as cortisol measures. In order to avoid selection biases, we attempted an accrual of 90 percent of all potentially eligible subjects. To allow controlling for confounding by circadian cortisol variability, we included measures of morning peak values (Prüssner et al. 1997). As all subjects participated in a one-week seminar in a secluded boarding school during which the academic examination was held, consistency in circadian rhythms was achieved. Two normal academic lectures held several weeks before and the day after the one-hour written examination served as control situations.

4.3 Methods

4.3.1 Subjects

Subjects were recruited from students participating in a post-graduate course leading to a Master's Degree in Science Education (n = 160). All students who intended to participate in a one-week training seminar at a Swiss boarding school were eligible. Eight students withdrew prior to the seminar or chose not to participate in the study. The remaining 152 students agreed to participate and gave written informed consent. Two male students failed to comply with the sampling instructions and two females were pregnant. The data of these subjects were omitted from the analysis. Thus, the final sample (n = 148) comprised 49 females and 99 males, corresponding to an accrual rate of 92.5 percent. The average age was 27.1 years (range 22 – 48 years). All subjects were in good health. No financial incentive was offered.

4.3.2 Study design

Salivary samples for determinations of cortisol were obtained during three observation days. During each day, students collected salivary samples at individual awakening time, 30 minutes thereafter (Prüssner et al. 1997), immediately prior to a one-hour academic task at 5 p.m. as well as at 6 p.m. and at 6:30 p.m. The first of these sampling days (baseline) was scheduled in April 1997 (four months prior to the seminar) and comprised the control academic task of a normal lecture scheduled at 5 p.m. The second observation day was the second day of the training seminar and comprised the test situation of the one-hour written examination. The third observation day was the following day, comprising again a control situation of a normal academic lecture at 5 p.m.

The written examination consisted of a criterion-reference test (Jäger 1988, Jäger et al. 1989, Klauer 1987). It contained seven essay test questions. Students were assured that grading of the examination would be performed against a priori defined and published criteria. The examination score contributed 20% towards the final post-graduate grade.

4.3.3 Samples

Each participant was given sampling kits including the collection material and written instructions on the sampling procedure (see appendix 2, p. 108-109). Subjects were requested to refrain from eating, smoking, brushing their teeth, and to take nothing by mouth except plain water prior to any sampling. Saliva samples were collected using purpose-designed tubes (Polyester swab, Salivette, Sarstedt, Chur, Switzerland). The participants first rinsed their mouths with plain water and then mouthed the salivette Polyester swab for two minutes. The swabs, soaked with saliva, were returned to the vial and frozen within 2 hours at $-25°$ C. Frozen samples were shipped on dry ice for assay. Cortisol levels were determined in duplicate by a time-resolved immunoassay described elsewhere (Dressendörfer et al. 1992). In the present study, the intra-assay coefficient of variation was 8.6% and the inter-assay coefficient of variation amounted to 10.5%. Thus, results from two samples differing by more than 1 nmol/l were regarded as indicative of a true difference.

4.3.4 Psychological variables and additional baseline information

Following the first sampling day, participants answered to items addressing psychosocial baseline information and several questionnaires assessing personality traits (see appendix 1, p. 89-96). Baseline characteristics included gender, age, body mass index, use of medications, pregnancy and use of oral contraceptives by women, smoking, alcohol and coffee consumption, specific disorders concerning the endocrine system, and actual employment status. Furthermore, students were asked about their results of previous performance tests.

Psychological data comprised a 30-item questionnaire investigating examination-related trait anxiety (Hodapp 1991, Hodapp et al. 1995), a 10-item instrument assessing general self-efficacy (Schwarzer 1993) as well as a 15-item questionnaire evaluating examination-specific self-efficacy (7 items) and examination-specific procrastination (8 items; Schwarzer, Haldemann, unpublished data). The personality traits of neuroticism and extraversion were evaluated using the correspondig scales (12 items each) from the German short form of the NEO-FFI personality inventory (Borkenau and Ostendorf 1993, Costa and McCrae 1992, McCrae et al. 1996). Perceived social support was estimated by an 18-item short version of the SOZU-K22 questionnaire after omitting the four items for practical support (Sommer and Fydrich 1991). Finally, positive attitude towards life was estimated by the 8-item Well-Being-Scale (Grob et al. 1991).

State variables were obtained prior to the academic tasks (see appendix 1, p. 97-100). Participants completed a 30-item questionnaire assessing examination-related state anxiety (adapted from (Hodapp 1991, Hodapp et al. 1995)) and a 24-item instrument assessing the coping behavior regarding the actual examination (adapted from (Endler and Parker 1990, Semmer et al. 1991)). A 20-item questionnaire evaluated individual learning and preparation (Metzger et al. 1995) and a 7-item questionnaire assessed the subjective appraisal of the forthcoming task (Perrez and Haldemann, unpublished data).

Moreover, subjects recorded their momentary subjective stress perception on a visual analogue scale graded from 1 to 10 whenever a saliva sample was collected (see appendix 1, p. 101).

4.3.5 Statistical analysis

In a first crude analysis, we performed univariate linear regression analysis entering the examination scores as the dependent variable and five measures of cortisol reactivity as the predictor variable. The measures of cortisol reactivity comprised:

a) the individual raw cortisol levels obtained at 5 p.m. immediately prior to the written examination

b) the log transformed 5 p.m. cortisol levels

c) the absolute examination-related change calculated as the 5 p.m. value of the examination day minus the mean of the 5 p.m. values from the remaining two sampling days

d) the relative examination-related change calculated as the 5 p.m value of the examination day divided by the mean of the 5 p.m. values from the remaining days and

e) the examination-related slope ratio, calculated as the slope of the circadian cortisol level of the examination day divided by the slope of the other observation days.

Slopes were calculated as the difference between the morning peak value and the 5 p.m. value divided by the hours elapsed between the morning peak and the 5 p.m. level (Prüssner 1997). The peak morning level was defined as the higher of the two cortisol measurements from the samples after awakening and 30 minutes post-awakening.

In this context, some of the individual baseline or psychological variables may cause negative confounding, obscuring an existing association between cortisol reactivity and test results. Therefore, a multivariable regression analysis was employed to test whether any of the five cortisol measures would significantly increase the proportion of the variance of the test results explained by psychological variables alone. The starting point to the model containing psychological or other baseline variables was the univariate screen for variables showing an independent association with the test result. Variables that demonstrated an association with the test scores at a significance level of $p < 0.05$ were considered as candidate predictor variables for the multivariable model. In this model, test results served as the dependent variable. Candidate predictor variables were entered in a stepwise forward selection and backward elimination procedure to derive a multivariable regression model which maximized the explained proportion of the observed variance. Each cortisol measure was independently added to the resulting model to check for the ability to further increase the explained proportion of the variance.

All analyses were performed using the SAS software package (version 6.12, SAS Inc., Cary, NC, USA). Tests were two-tailed. A probability of a type I error $p < 0.05$ indicated statistical significance.

4.4   Results

4.4.1   Test results

Test results showed the expected variability with a range extending from 8.50 points to 17 points (maximum score), a mean of 13.95 points and a standard deviation of 1.57 points. Females achieved higher scores (mean = 14.34) than males (13.76, p = 0.03).

4.4.2   Cortisol levels on the examination day

Salivary cortisol levels prior to the academic test on the examination day were higher as compared to the baseline and the post-examination day. The raw cortisol data, stratified by gender, are presented in Figure 1 (morning peak levels) and Figure 2 (5 p.m. values). The median difference of the cortisol levels immediately prior to examination to the corresponding 5 p.m. values of the other sampling days amounted to 4.6 nmol/l in males and to 3.9 nmol/l in females (p < 0.0001, Kruskal-Wallis test). Cortisol levels at 5 p.m. on the examination day were 1.98 times higher than the average of the two remaining days. This relative increase showed no gender differences (p = 0.88).

Figure 1:   *Morning peak salivary cortisol levels, stratified by gender and observation day; median split indicated. (The individual morning peak salivary cortisol levels was defined as the higher of the two cortisol measurements from the samples after awakening and 30 minutes post-awakening.)*
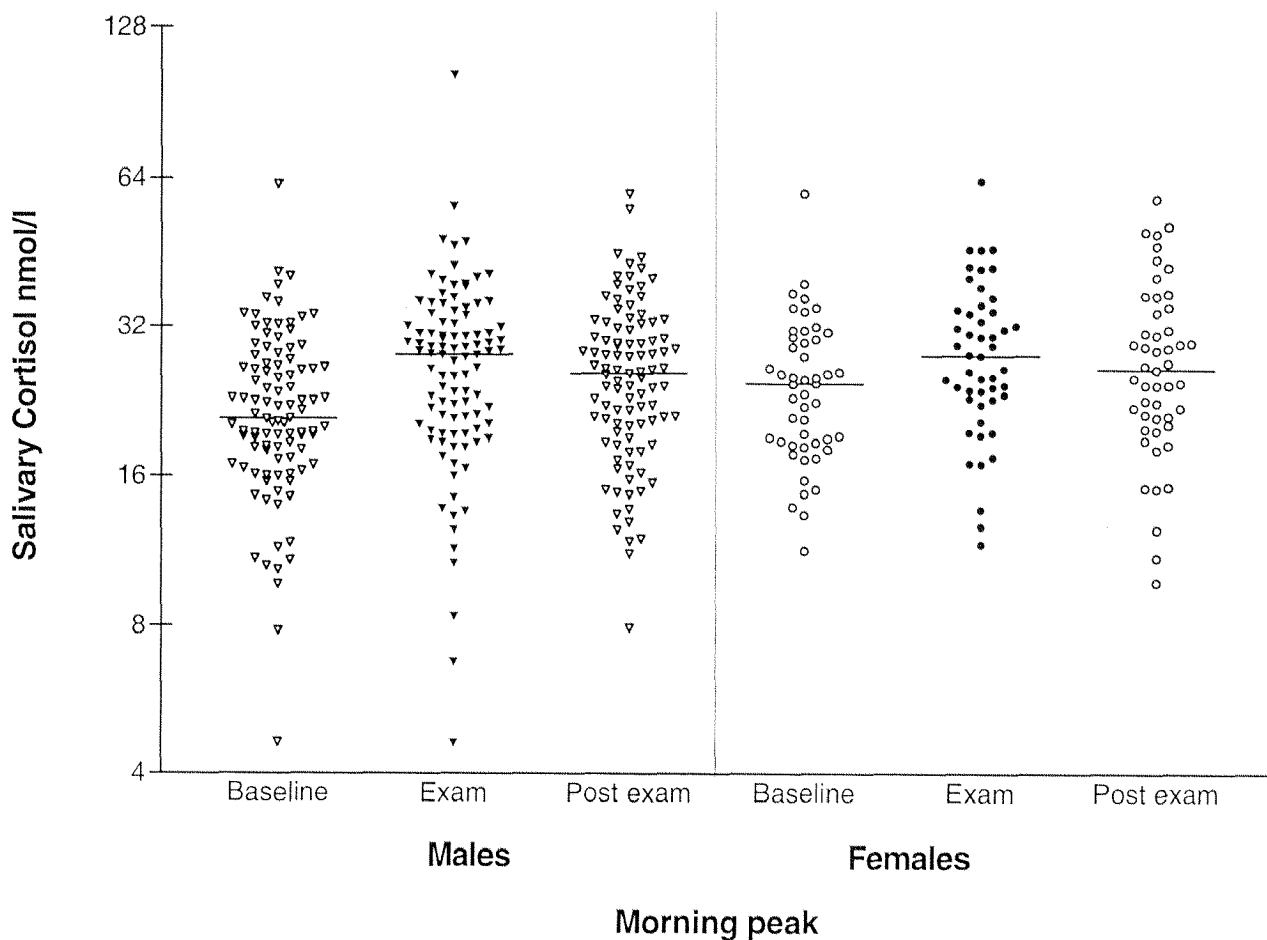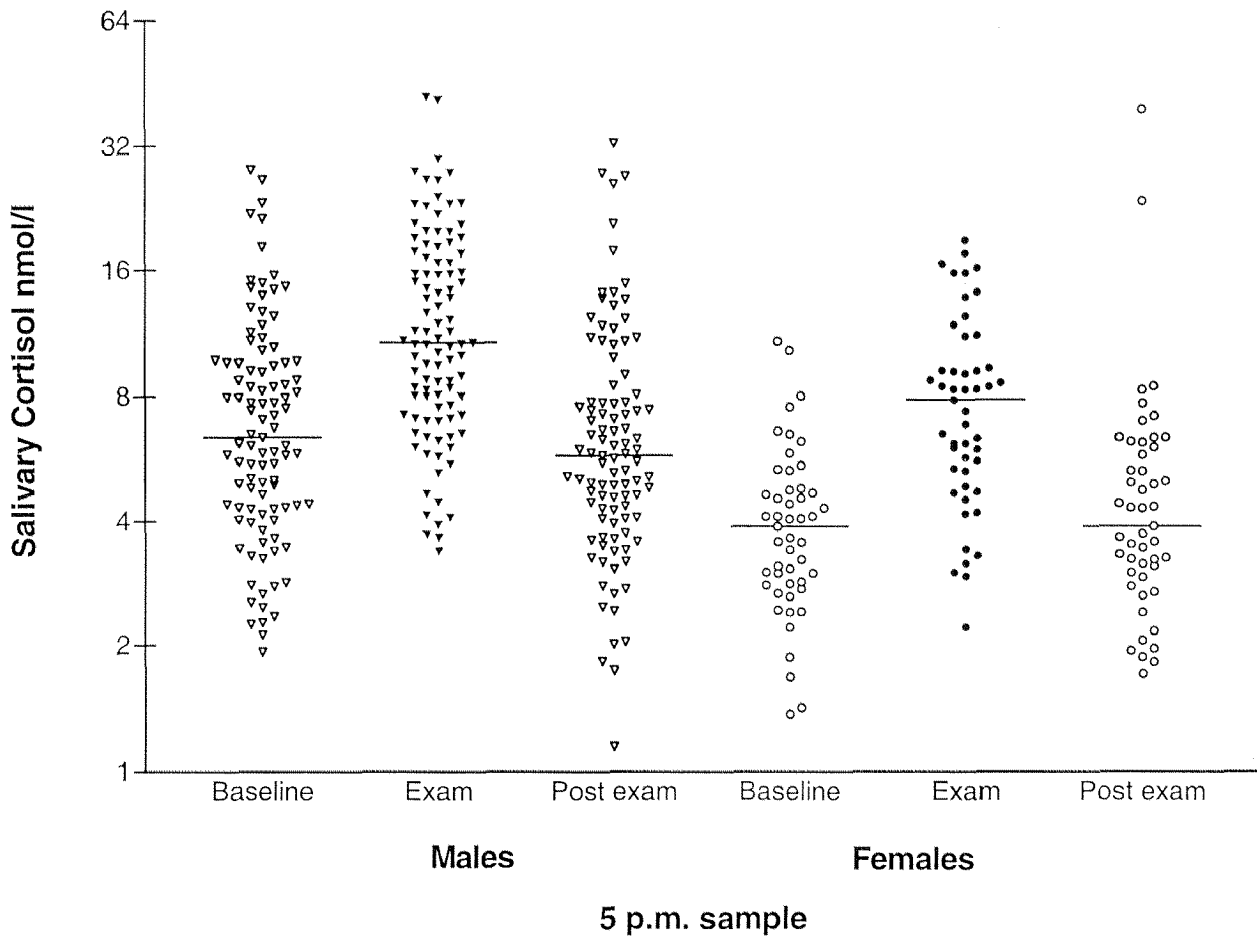
Figure 2: *Salivary cortisol levels immediately prior to the academic tasks at 5 p.m., stratified by gender and observation day (median split indicated).*

4.4.3 Measures of cortisol reactivity

The following five measures of cortisol reactivity were tested for an association with the examination scores:

a) the individual raw cortisol level obtained at 5 p.m.

b) the log transformed 5 p.m. level

c) the absolute examination-related change

d) the relative examination-related change and

e) the examination-related slope ratio.

The first main finding of the study is that none of these cortisol measures explained a significant proportion of the variation in test results (R^2 ranging from 0.004 – 0.016, F ranging from 2.34 – 0.61, df 1/146, p ranging from 0.12 – 0.44). Figure 3 shows a plot of test results versus relative examination-related cortisol changes.

Figure 3: *Association between observed test scores and the relative examination-related cortisol change (5 p.m. level of the examination day divided by the mean of the 5 p.m. levels of the two remaining observation days).*
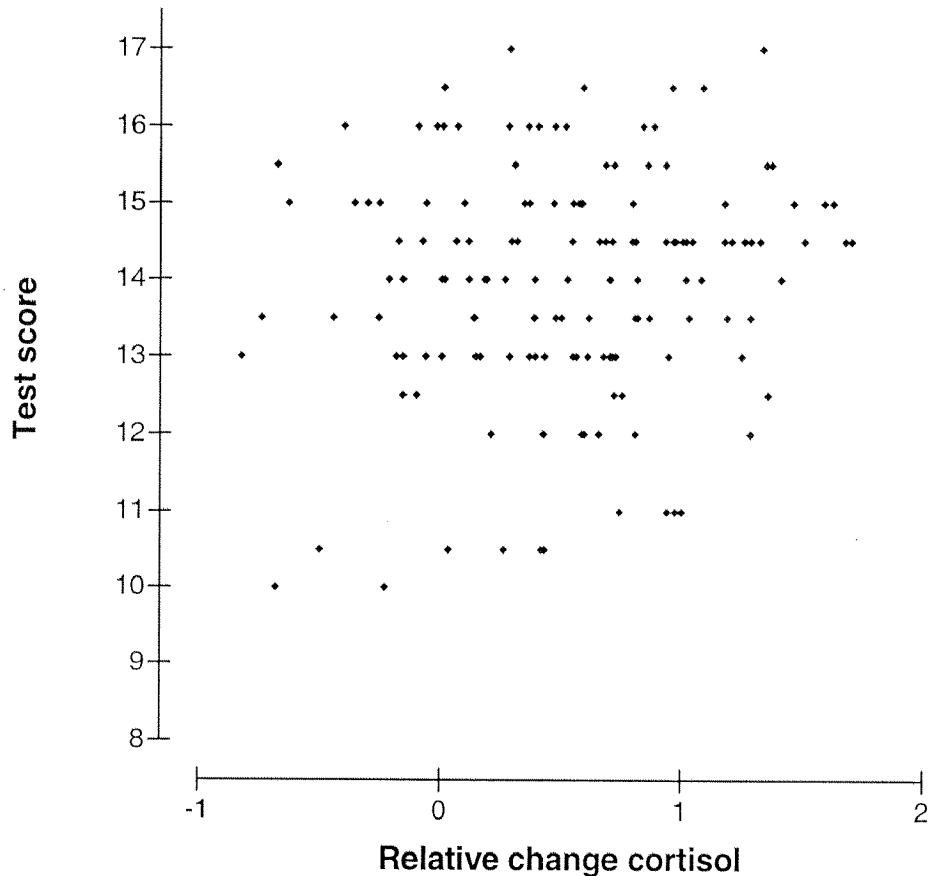
4.4.4 Control for possibility of negative confounding

Our second analysis aimed to exclude negative confounding by individual baseline or psychological variables. Univariate linear regression analysis identified several constructs, which appeared to be associated with the test results (Table 1). Stepwise multi-variable regression analysis resulted in a model, which explained 12 percent of the observed variance ($R^2 = 0.12$, $F = 4.85$, df 4/143, $p < 0.001$), consisting of the following variables: perceived social support, learning motivation, examination-specific self-efficacy (trait), and gender. Table 2 presents the summary statistics of the model. Figure 4 relates the test scores predicted by this model to the observed scores. Adding any of the five cortisol measures increased the explained proportion of the variance by less than 1.5%, thus ruling out negative confounding.

Table 1: *Univariate linear regression analysis investigating the association between test results and individual baseline or psychological variables.*
This univariate screen served to identify candidate variables for the multivariable regression analysis. Therefore no correction of significance levels for multiple testing was applied.

Variable	F value (df 1/146)	P value
General		
Gender	4.30	0.040
Age	1.89	n.s.
Body mass index	1.66	n.s.
Smoking	1.03	n.s.
Coffee intake	3.26	n.s.
Employment status	0.42	n.s.
Previous performance tests		
University entrance examination	1.07	n.s.
Score 2nd part of university exam (BA equivalent)	2.87	n.s.
Trait measures		
Examination-related anxiety, worry, trait	0.01	n.s.
Examination-related anxiety, emotionality, trait	0.03	n.s.
Examination-related anxiety, cognitive interference, trait	4.83	0.029
Examination-related anxiety, lack of confidence, trait	3.87	n.s.
General self-efficacy, trait	3.07	n.s.
Examination-specific self-efficacy, trait	4.00	0.047
Examination-specific procrastination, trait	4.96	0.028
Neuroticism, trait	0.35	n.s.
Extraversion, trait	1.71	n.s.
Task-oriented coping, trait	0.52	n.s.
Emotion-oriented coping, trait	0.01	n.s.
Avoidant coping, trait	3.00	n.s.
Perceived social support, trait	9.86	0.002
Positive attitude towards life, trait	1.96	n.s.
Variable	F	p

Table 1: *(continuation)*

Variable	F value (df 1/146)	P value
State measures		
Test anxiety, worry, state	1.06	n.s.
Test anxiety, emotionality, state	1.94	n.s.
Test anxiety, cognitive interference, state	0.42	n.s.
Test anxiety, lack of confidence, state	4.92	0.029
Task-oriented coping, state	2.10	n.s.
Emotion-oriented coping, state	0.54	n.s.
Avoidant coping, state	1.00	n.s.
Measures assessing the learning process		
Learning behavior, sum score	4.99	0.027
Learning behavior, motivation	4.49	0.036
Learning behavior, self control	2.02	n.s.
Learning behavior, concentration	1.89	n.s.
Learning behavior, time management	4.10	0.044
Subjective appraisal of the examination as threat	0.84	n.s.
Subjective appraisal as demanding	2.10	n.s.
Subjective appraisal as ambiguous	2.52	n.s.
Subjective appraisal as copable	0.68	n.s.
Subjective appraisal as positive challenge	0.04	n.s.
Subjective appraisal as unpredictable event	2.72	n.s.
Subjective stress perception prior to the exam (5 p. m.)	1.17	n.s.
Variable	F	p

Table 2: *Final model explaining 12 percent of the variance of the observed test scores.*

Variable	Range of variable[a]	Coefficient β	F (df 1/146)	Statistics	Partial R^2
Intercept		10.10	47.4	0.0001	
Gender[b]	1	-0.45	2.60	0.110	0.016
Perceived social support	31	0.027	3.45	0.065	0.037
Learning motivation	7	0.112	3.27	0.073	0.024
Examination-specific self-efficacy, trait	12	0.065	4.45	0.036	0.027
Total model			4.85 (df 4/143)	0.001	0.120

[a] Possible range of values / points (units).
The coefficient relates to an increase by one unit. For example, a difference by 8 points or two thirds of the observed range in the examination-specific self-efficacy scale translates into a predicted difference of 8 * 0.065 = 0.52 score points in the test results. A similar difference (0.58) was observed as the unadjusted difference between females and males. The adjusted difference according to the model amounts to 0.45.
[b] coding: females = 0, males = 1.

Figure 4: *Relation between the observed examination scores and the results predicted by a model containing the variables gender, perceived social support, learning motivation and examination-specific self-efficacy (trait).*
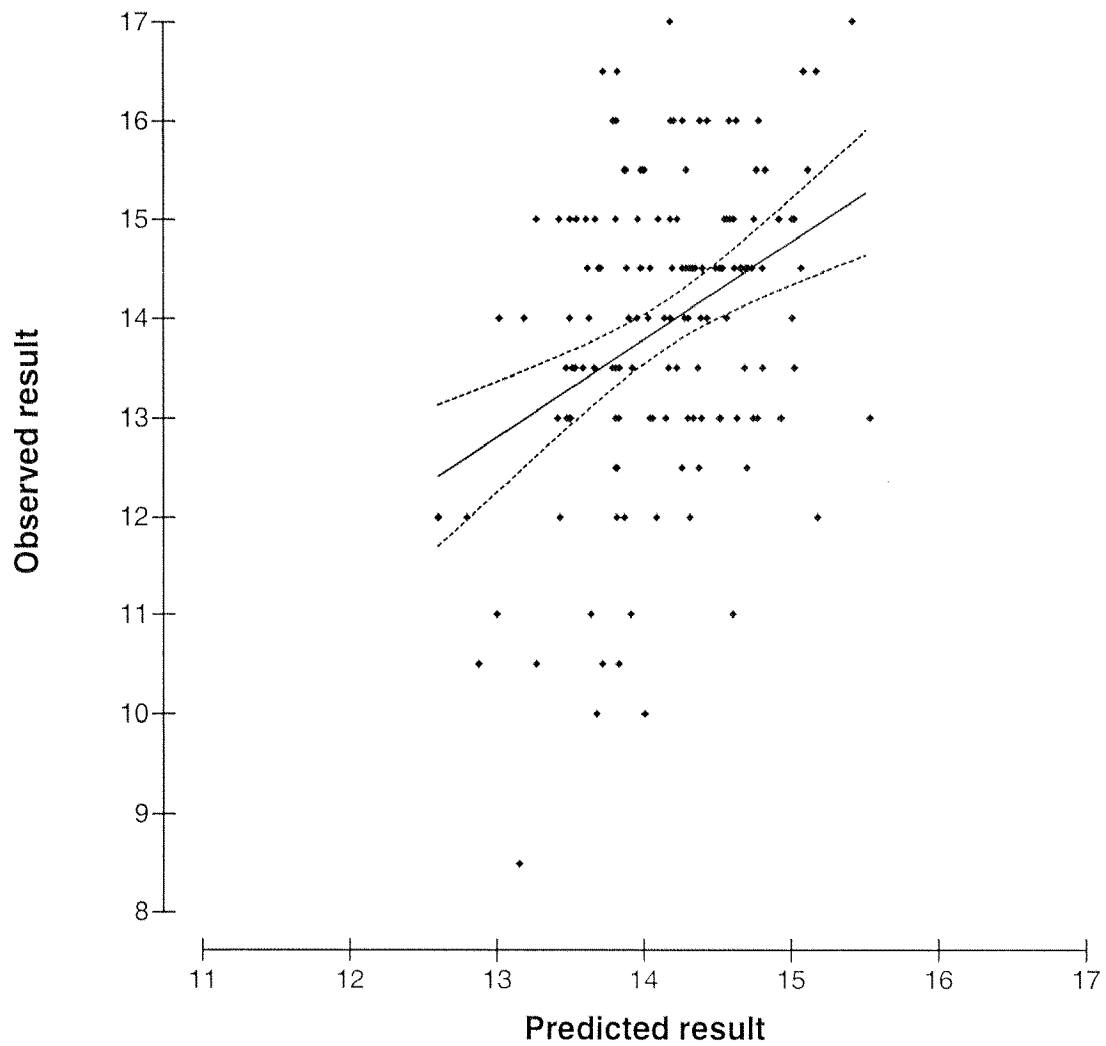
4.5 Discussion

Retrieving data from the declarative memory is one of the cognitive functions required to succeed in academic examinations. The present study aimed to elucidate whether increased levels of cortisol triggered by an anticipatory stress reaction to an academic examination are associated with impaired test performance. We deduced our hypothesis from recent findings that exogenous administration of cortisol analogues as well as endogenous cortisol secretions after strong laboratory psychological stressors cause a dose-dependent impairment of the recall from verbal declarative memory (Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999). We chose to investigate this real-life situation in order to gain insight into the clinical relevance of the reported laboratory findings. The main finding of our study is that examination-related anticipatory cortisol increases explained less than 1.5% – if any – of the observed variance in test results from an academic examination requesting to write brief essays on previously learned data.

The strengths of the study include a large sample size, which allowed controlling for several potentially confounding variables. In contrast to any previous study, attempts were made to standardize everyday living conditions as much as possible under non-laboratory conditions by performing the study during a one-week stay in a secluded boarding school. Moreover, in contrast to previous studies, our sampling procedure allowed to control for circadian variability of cortisol levels and included two baseline measures, one obtained four months prior to the examination and the second collected one day after the test. The observed increases in cortisol levels in our study were comparable to reported changes observed in the context of other real-life examinations (Hellhammer et al. 1985, Huwe et al. 1998, Nicolson et al. 1992). The observed variance of the academic test results was partially explained by psychological variables and gender – a finding consistent with previous research (Furnham and Mitchell 1991, Jones et al. 1986, Nicolson et al. 1992, Spangler 1997). Contrary to usual laboratory performance tests or multiple-choice tests that require simple recall of previously acquired knowledge, the criterion-reference test investigated in this study (Jäger 1988, Jäger et al. 1989, Klauer 1987) consisted of essay test questions. Answering to these questions calls upon complex cognitive capabilities of which recall from verbal declarative memory is only one of many necessary skills. Thus, the cortisol-induced impairment of declarative memory recall, which is observable in the laboratory experiment (Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999), may probably be compensated by other cognitive functions in the real-life academic examination of the essay-type style.

At first glance, this finding suggests that performance in real-life academic examinations is barely affected by endocrine stress reactions. However, this conclusion would be a serious misinterpretation of our data and warrants consideration of the limitations of this study. First, despite including almost 150 students, the observed cortisol increases have to be considered as moderate. Thus, the anticipatory stress reaction could have been either too mild or not sustained enough to interfere with memory recall sufficiently to affect test scores. Our data may therefore not be generalized to other academic test situations, which are either aimed to evoke a major stress reaction in the participants or have the potential to do so. It is conceivable that oral examinations or batteries of multiple choice-questions with very short answering times may cause much higher stress responses. Therefore, an alternative explanation of our findings is, that the inves-

tigated academic test-type and the preparation for this examination acted as moderate stressor comparable to the low dose experimental group in the study by Newcomer and coworkers (Newcomer et al. 1999).

In conclusion, we found that stress-related endogenous releases of cortisol prior to an essay-type academic examination showed no association with the test results in post-graduate students. By contrast, some psychological variables (perceived social support, examination-specific trait self-efficacy and learning motivation) as well as gender explained a small but significant proportion of the observed variance – a result consistent with the existing literature (Endler et al. 1994, Furnham and Mitchell 1991, Halamandaris and Power 1999, Helmke and Weinert 1997, Hudgens et al. 1989, Müller and Netter 1992).

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Chapter 5: Discussion

5.1 General discussion

This psychophysiological study assessed examination-related stress reactions in students at the Swiss Federal Institute of Technology Zurich. Possible associations between circadian salivary cortisol rhythm, stress-induced adrenocortical responses to an examination, individual psychosocial characteristics, and test performance were elucidated. Factors that modulate awakening-mediated cortisol activity and examination-related stress responses were identified. To this purpose, various individual psychosocial characteristics and health aspects as well as non-stimulated circadian cortisol amplitude and its variation were assessed. Awakening-mediated salivary cortisol levels were integrated into models explaining adrenocortical reactions to and performance on an academic examination as a real-life stressor.

The entire research project was realized in April (location Zurich, altitude 450 m) and July (location Zuoz, altitude 1600 m) of 1997. The participating 148 post-graduate students were candidates for a Master's Degree in Science Education who attended a one-week training seminar at a secluded boarding school.

What is extraordinary in this study? First, the psychophysiological effects of a real-life academic examination were investigated within a large population in a quasi-experimental setting. Second, the assessment of individual markers of adrenocortical (re)activity was complemented by numerous selected psychological trait and state variables as well as performance indices.

In **chapter 2**, the response of the HPA axis associated with awakening was assessed in order to define a suitable marker for individual non-stimulated circadian cortisol activity. Recent work by different laboratories has revealed that cortisol increases in response to awakening show quite high intraindividual stability across days and weeks (Kirschbaum 1991, Prüssner et al. 1997) and that these adrenocortical markers possibly allow differentiation among certain subgroups of individuals (Schulz et al. 1998).

Participants collected salivary cortisol immediately upon awakening and 30 minutes thereafter. The mean cortisol concentration at awakening was 18.1 nmol/l (± 8.9). The mean of the post-awakening sample amounted to 25.6 nmol/l (± 10.5). This absolute early morning increase of about 7.5 nmol/l corresponds to the findings of other studies (Hucklebridge et al. 1999, Prüssner et al. 1997, Schmidt-Reinwald et al. 1999). A post-awakening cortisol increase was detected in 79% of all cases investigated. While 46% of all individuals showed consistent increases in salivary cortisol concentrations from awakening to 30 minutes thereafter on all observation days, 51% of the individuals demonstrated a mixed pattern with increases and decreases. In the remaining 3% of all individuals, cortisol levels decreased on each sampling day.

These results might be partially due to the definition of awakening as the waking up time that immediately preceded the subject's getting up. In persons with decreases, "awakening" levels might have actually represented cortisol concentrations at final stages of transitory awakening processes, i.e. post-awakening levels. This interpretation is sustained by the fact that in cases with decreases, higher awakening concentrations

were observed than in cases with increases (24.7 nmol/l ± 10.6 versus 16.3 nmol/l ± 7.5, p ≤ 0.004). In contrast, concentrations 30 minutes post-awakening were lower in cases of decreases than in those of increases (19.5 nmol/l ± 10.3 versus 27.4 nmol/l ± 10.4, p ≤ 0.001). Current findings from other laboratories suggest that certain individuals apparently lack morning cortisol activation. No awakening responses were detected in about 10% of all individuals investigated in a study by Prüssner and associates (Prüssner et al. 1997). Consistent atypical flat cycles in 17% of all participants are reported by Smyth and associates (Smyth et al. 1997).

In the present study, awakening cortisol levels were independent of all covariables investigated. This result is in line with the findings of current research (Hucklebridge et al. 1998, Prüssner et al. 1997). In a recent study, cortisol awakening levels as well as morning peak levels were unrelated to sleep duration, absolute time of awakening, alcohol consumption on the previous day, smoking, weight, and age (Prüssner et al. 1997). In another study, the variance of the awakening peak value was not influenced by age or time of awakening (Hucklebridge et al. 1998). In the present study, however, cortisol levels 30 minutes post-awakening were found to be dependent upon the subject's gender, body mass index, level of neuroticism, and use of oral contraceptives by women. Future studies should try to clarify these equivocal findings.

30 minutes post-awakening, cortisol concentrations were higher in women than in men. In order to investigate this gender difference further, the occurence of the more common increases and the more frequent consistent patterns of increases in women was controlled for. With this data correction, the observed gender difference was no longer evident. Cortisol concentrations at awakening, 30 minutes thereafter, and post-awakening changes were no longer affected by gender. Therefore, higher cortisol concentrations in women 30 minutes post-awakening were obviously due to the observed unequal occurrence of post-awakening decreases in women and men. There is controversial evidence from current research about gender differences with respect to awakening-mediated cortisol activity. While some authors found no gender differences (Hucklebridge et al. 1998), other researchers have reported significantly higher awakening responses in women (Prüssner et al. 1997). Significant gender differences with larger absolute increases in women are also reported in a study investigating awakening-mediated cortisol changes in chronically stressed students (Schulz et al. 1998).

In women using oral contraceptives (OCs), lower cortisol levels than in non-users were observed 30 minutes post-awakening. The use of oral contraceptives seems to be associated with different kinetics of cortisol responses (Bonen et al. 1991, Kirschbaum et al. 1999, Kirschbaum et al. 1995, Reinberg et al. 1996).

The finding that post-awakening levels were higher in persons scoring above the median in neuroticism raises further questions. Are students scoring high in neuroticism more susceptible to "early morning stress" associated with awakening? Will they show higher responses to examinations as acute real-life stressors than less neurotic persons? However, the observed relation between post-awakening cortisol concentrations and neuroticism was only weak (F = 4.94, df = 1/99, p = 0.03). Further, this association is not supported by current research. In a recent study, no significant effect of neuroticism is reported on the awakening response in 41 normal healthy adults (Hucklebridge et al. 1998). The personality trait of neuroticism was neither closely related to basal nor stimulated concentrations of cortisol in another study (Schommer et al. 1999).

As in previous investigations, this study shows that strict reference to the individual awakening time is necessary in order to obtain individually stable and reliable cortisol levels (Prüssner et al. 1997). "Awakening" should be defined as the very first stage of the awakening process. It must be clearly distinguished from final stages of transitory awakening processes following repetitive cycles of awakening – falling asleep – awakening and from the very process of getting up. As a measure of individual stability, the higher of the two cortisol levels collected during the 30 minutes post-awakening should be taken. This procedure takes into account the fact that some individuals may show a decrease instead of an increase in HPA activity after awakening. It offers an easy-to obtain marker that shows good intraindividual stability ($0.40 \leq r \leq 0.62$), especially in combination with short sampling-day intervals.

In **chapter 3**, cortisol increases associated with an hour-long written academic examination were assessed. The test was announced in advance and was criterium-oriented (criterion-reference test), i.e. the students were informed about the precise context and demands of the test (Jäger 1988, Jäger et al. 1989, Klauer 1987). Each task consisted of a short lead-in to a topic and clearly defined questions. The required formal answering structure and the evaluation scale were given. These stressor-specific formal aspects must be taken into consideration when comparing the present results with findings from norm-oriented examinations or tests containing multiple-choice questions, tasks that require short answers only or knowledge learnt by heart.

In this study, an absolute examination-related cortisol increase was distinguished from a relative increase. When the mean of the corresponding cortisol levels of the other observation days was subtracted from the pre-examination cortisol level, a mean absolute cortisol increase of 5.2 in men versus 2.8 nmol/l in women was registered. When dividing the pre-examination cortisol level by the mean of the corresponding cortisol levels of the other observation days, a cortisol increase of 85.6% was observed. This relative response was independent of the student's gender.

How cortisol reactions to psychosocial stressors and to awakening differ in women and men is a topic under intensive discussion (Prüssner et al. 1997). Findings are controversial. There seems to be a puzzling contrast concerning these gender differences: As reported, the adrenocortical responses to awakening appeared to be higher in women than in men in the present population as well as in former studies (Prüssner et al. 1997, Schulz et al. 1998). On the other hand, following a psychosocial stressor, women showed consistently smaller free cortisol increases compared to men (Kirschbaum et al. 1992). For examination-related reactions, some researchers report the same gender difference, i.e. higher cortisol concentrations for men than for women (Johansson et al. 1989, Spangler 1997).

In this study, these gender differences were examined in detail. For the awakening-mediated cortisol increases, more increases as well as more consistent pattern of increases were found in women. Whereas the awakening cortisol levels were not influenced by gender, the cortisol concentrations 30 minutes post-awakening were higher in women. However, this gender difference was no longer observed when a correction for the unequal occurence of increases in women and men was performed. In anticipation of the examination, a higher absolute cortisol increase was observed in men compared to women. However, for the relative examination-related increase, this gender difference

was not evident. Lower baseline levels were observed in women on observation day 1 in April than on the other three observation days at the end of July. This might be due to change in altitude or to seasonal changes of cortisol levels in women (Malarkey et al. 1995). The present findings underline the importance of reliable baseline cortisol measures as well as of exact definition and operationalization of stressor-related cortisol reactions.

Females using oral contraceptives tended to show lower relative increases in anticipation of the examination compared to the non-users. This finding corresponds to the lower post-awakening cortisol levels observed in users of oral contraceptives compared to non-users. Women using oral contraceptives seem to display different kinetics of cortisol responses than non-users (Bonen et al. 1991, Kirschbaum et al. 1999, Kirschbaum et al. 1995, Reinberg et al. 1996).

Earlier studies show that prospective orientation to demanding tasks such as real-life examinations, i.e. the identification of future problems and the development of coping strategies for solving these problems, can be associated with elevated cortisol levels (Mason 1968). Such anticipatory processes could well be linked to the increased cortisol secretion found in this study. There are several reasons for assuming that the investigated examination should be conceived as a mild stressor. First, the examination was a criterion-reference test, announced in advance, and of moderate practical importance for the examinees. Second, the participating post-graduate students were familiar with academic tests and well prepared for this examination. Third, the observed cortisol increases are comparable to examination-related stress responses reported in various earlier studies (Armario et al. 1996, Cook et al. 1992, Hellhammer et al. 1985, Huwe et al. 1998, Nicolson et al. 1992). However, such comparisons must be made with caution because examination-related cortisol changes were operationalized differently. It seems to be crucial to clearly define specific examination-related cortisol changes and to distinguish between absolute and relative cortisol increases. Moreover, the investigated test situation and the setting of the study should be thoroughly described. Specific findings should not be generalized without caution (Furnham and Mitchell 1991, Helmke and Weinert 1997).

The individual appraisal of and coping process with the anticipated stressor was expected to show associations with the endocrine stress response. In order to determine which psychosocial or baseline variables modulate the examination-related stress response, the influence of different personality states and traits on examination-related endocrine responses was investigated. For the absolute examination-related cortisol increase, gender as well as psychological variables (extraversion, positive attitude towards life, examination-specific self-efficacy, and subjective stress perception prior to the examination) explained 17.6% of the observed variance. For the relative examination-related cortisol increase, psychological data (extraversion, perceived social support, positive attitude towards life, and subjective stress perception prior to the examination) explained 16.1% of the observed variance. In conclusion, there was little explanatory effect of psychosocial data on the endocrine stress response. This finding is in line with the literature (Armario et al. 1996, Huwe et al. 1998, Jones et al. 1986, Kahn et al. 1992, Malarkey et al. 1995). The cortisol response to this academic examination seemed to be determined by mechanisms other than the corresponding cognitive appraisal processes. This assumption is supported by neurobiological findings suggesting that the anticipa-

tory endocrine reaction to a stressful event is regulated by other nervous circuits than concomitant self-reported appraisal (LeDoux 1992, LeDoux 1998, Weinberger 1990).

Nevertheless, this topic was elucidated further. Research in the context of chronic stress suggests that anticipation of demanding tasks can be associated with elevated early morning cortisol levels (Schulz et al. 1998). In a recent study, these adrenocortical markers allowed differentiation between individuals scoring high on a "chronic work overload" stress inventory and individuals scoring low for chronic work stress (Schulz et al. 1998). Other studies support the finding that chronically stressed persons may show increased awakening-mediated cortisol activity (Ockenfels et al. 1995, Samuel et al. 1999, Schulz et al. 1998). To date, diurnal patterns of cortisol associated with a real-life acute stressor have not been examined concurrently and systematically. However, it was assumed that the awakening cortisol response might be not only sensitive to chronic stress, but also to acute stress provoked by a pre-announced examination. Accordingly, individuals with an excessive, examination-related cortisol increase would engage in the process of coping with this academic challenge as soon as they wake up in the morning. In this case, they would probably show elevated awakening responses.

Assuming that such measures of the non-stimulated circadian cortisol rhythm could improve the power of the models explaining the examination-related responses in the present study, psychosocial self-report data were complemented by non-stimulated circadian cortisol markers. For the absolute examination-related cortisol increase, adding the individual mean circadian cortisol amplitude and its standard deviation improved the model. The explained variance increased from 17.6% to 29.7%. For the relative examination-related cortisol increase however, including these variables into the model improved the explained variance only marginally (explained variance 17.9% instead of 16.1%). It was expected that physiological health measures and individual markers of awakening-mediated cortisol (re)activity would further improve the explanatory power of the present models, i.e. that the addition of such variables would increase the explained part of the observed variance to a higher extent. These results raise a number of questions: Why is the relative cortisol response, as the biologically more relevant issue, less dependent on the individual non-stimulated cortisol rhythm and its variance? What other psychophysiological factors might further explain individual differences in the absolute and relative cortisol increases? These questions cannot yet be answered.

Chapter 4 investigates possible associations between psychophysiological variables and academic performance. While much previous research has studied numerous psychosocial predictors of performance in the context of examination situations, little is known about possible physiological and endocrine mediators on performance in real-life settings. Therefore, this study focused on the influence of individual examination-related cortisol changes on examination performance. The investigated written one-hour examination consisted of a criterion-reference test and demanded higher order cognitive performance. Univariate linear regression analysis indicated that none of the investigated markers of cortisol reactivity explained a significant proportion of the observed variation in the examination results. Obviously, performance on the present examination was not significantly impaired by adrenocortical reactivity.

Maximal physiological stress approximated by high-dose glucocorticoid treatment has been reported to impair specific aspects of memory performance (De Quervain et al.

1998, Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999). In human declarative memory, dose-dependent cortisol-induced decreases were detected (Newcomer et al. 1999). Recall performance was significantly lower following a higher dose treatment compared to lower dose treatment interaction with recall condition. These empirical findings are supported by the "theory of the threshold" which suggests that cortisol concentrations have to reach a certain level to exert deteriorating effects on performance (Deffenbacher 1986). Accordingly, only high cortisol levels indicating a strong physiological arousal may impair cognitive performance. While intense stress produces anxiety and creates overarousal which hinders cognitive functioning including memory performance, minor stress may even facilitate memory performance because it raises the baseline level of arousal (Zeier 1997). As mentioned above, the examination in the present study should be conceived as a quite moderate stressor for the participants. Therefore, it is assumed that this real-life stressor did not have enough power to elicit the pronounced cortisol peaks necessary to impair cognitive performance. It is concluded that whereas hypersecretion of cortisol may impair performance, cortisol increases during the mild stress experienced in anticipation of the present real-life examination did not impair test performance.

By means of a stepwise multivariable regression analysis, the influence of individual baseline and psychological variables on test performance was elucidated, which may have confounded an existing association between cortisol reactivity and test results. To this purpose, general trait variables were complemented by specific instruments yielding information on examination-related trait and state factors. Test anxiety was operationalized by a multidimensional construct containing both cognitive and emotional components. Moreover, some former performance indices were assessed. The resulting model explained a significant proportion of the observed variance ($R^2 = 0.12$) and consisted of the variables perceived social support, learning motivation, examination-specific self-efficacy (trait), and gender.

These findings suggest that higher order cognitive performance in the investigated criterion-reference test is not affected by the observed anticipatory cortisol reactions. The cortisol-induced impairment of declarative memory recall, which was observed in laboratory settings (Kirschbaum et al. 1996, Newcomer et al. 1994, Newcomer et al. 1999), may probably be compensated by other cognitive functions in the real-life academic examination of the essay-type style.

5.2 General conclusions

Overall, specific awakening-mediated cortisol levels were defined as easy-to obtain, reliable, and stable individual markers of HPA activity. Furthermore, the anticipatory cortisol increase to a real-life examination was assessed. Its variance was partly explained by various psychophysiological variables. Finally, the influence of stress-related endogenous release of cortisol as well as psychosocial characteristics on individual performance on the examination was elucidated.

The **special features of the present study** are as follows:

- The relatively homogenous, rather large population (148 post-graduate students).

- The high follow-up rate of potentially eligible subjects. Consequently, there was little selection bias as a confounding influence.

- The longitudinal design (four observation days) which allowed intraindividual controlling and the evaluation of different sampling day intervals.

- The quasi-experimental design: a one-week training seminar at a secluded boarding school subjected all participants to the same daily rhythm with approximately the same awakening times, scheduled meals, and the same academic activities.

- The comparison of a pre-announced, hour-long, written academic examination as a real-life stressor with an unannounced test and two lectures on separate days.

- The timing of these academic tasks in the late afternoon, which allowed collection of salivary cortisol samples at a time of day of basal circadian adrenocortical activity. This timing minimized potential confounding by post-awakening changes or the circadian rhythm.

The **limitations of the present study** are the following:

- The limited sampling of cortisol in the early morning. More frequent sampling would probably have improved the estimation of awakening-mediated cortisol peaks.

- Combined confounding by change in season, altitude, setting, and environment on HPA activity and its intraindividual stability could not be ruled out.

- The sequence of the academic tasks was fixed. Therefore, possible effects of the fixed order (succession) of these different academic tasks could not be assessed.

- There was no control group (participants who did not absolve the examinations).

- For practical reasons, psychoendocrine responses could not be assessed during the examination itself. Saliva samples were taken immediately before and after as well as 30 minutes after the academic tasks. Subjects completed questionnaires assessing personal state variables immediately before the academic tasks.

- As the women participating mostly declined to answer the questions concerning their the menstrual cycle phase, possible impacts of this variable could not be evaluated.

- Psychological characteristics were assessed exclusively by various self-report questionnaires. Therefore, the methodological problem of potentially overlapping constructs arose.

- Contrary to usual laboratory performance tests or multiple-choice tests that require simple recall of previously acquired knowledge, the criterion-reference test was investigated in this study (Jäger 1988, Jäger et al. 1989, Klauer 1987). The present data may therefore not be generalized to other academic test situations, such as oral examinations or batteries of multiple choice-questions with very short answering times.

A great deal of care was taken to assure students of the strictly confidental treatment of their responses, which at the point of coding and analysis was anonymous. Outliers were taken into consideration in the statistical analysis. The present study design aimed to deliver maximal information without taxing the goodwill of the participants or endangering the high follow-up rate.

Future research should ...

- ... clarify whether more frequent sampling during the post-awakening period yields more accurate estimates of awakening-mediated cortisol activity.

- ... investigate how different definitions and operationalizations of "awakening" influence the individual salivary cortisol profile in the early morning. The very "first awakening" should be clearly separated from the "final awakening" (after transient awakening) and from the process of getting up.

- ... further focus on differences between absolute and relative stressor-related changes in cortisol levels.

- ... complement psychological self-report questionnaires by behavioral measures, peer ratings, or observations by neutral persons.

5.3 References

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Appendices

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Appendix 1: Instruments (Questionnaires)

Appendix 2: Instructions how to collect saliva samples

D   Instructions

ANLEITUNG

*Im Folgenden finden Sie eine Reihe von **allgemeinen Fragen**. Diese sind Bestandteil unserer Studie „Prüfungen Zuoz 1997". Wir benötigen diese Angaben, um die Einflussfaktoren auf den Kortisolspiegel und die Herzfrequenz erfassen zu können. Die gestellten Fragen entstammen standardisierten Fragebogeninstrumenten.*

Bei den meisten Fragen sind die Antwortmöglichkeiten in Form von ankreuzbaren Kästchen oder Zahlen vorgegeben. Lesen Sie bitte die einzelnen Fragen genau durch. Entscheiden Sie sich jeweils möglichst spontan, welche Antwort für Sie zutrifft. Kreuzen Sie dann bei jeder Frage die entsprechende Stelle an. Falls Sie irrtümlicherweise die falsche Stelle (falsches Kästchen / falsche Zahl) erwischen, können Sie diese Stelle übermalen und einfach über der zutreffenden Stelle ein Kreuz anbringen.

Es gibt keine „richtigen" und „falschen" Antworten, da jeder Mensch eigene Anschauungen und Meinungen besitzt und in einer spezifischen Situation lebt. Antworten Sie also bitte so, wie es für Sie zutrifft.

Sämtliche Daten werden absolut vertraulich behandelt und nur unter Code-Nummern abgespeichert. Die verschiedenen Fragebogen werden nach der statistischen Auswertung vernichtet. Die erhobenen Daten dienen ausschliesslich unserer Studie und werden nicht an Drittpersonen weitergegeben.

Wir danken Ihnen für Ihre Mitwirkung.

Maja Haldemann

Prof. Dr. Karl Frey

Prof. Dr. Hans Zeier

— dieser Teil wird von uns nach der Codierung entfernt —

Bitte notieren Sie hier Ihren vollständigen Namen sowie Ihr Geburtsdatum. Diese Angaben benötigen wir nur bis zur Codierung (zur eindeutigen Identifikation). Ihr Name erscheint nirgends auf den Fragebogen oder in der Auswertung. Vielen Dank.

(bitte gut leserlich schreiben!)

Name: ....

Vorname: ....

Geburtsdatum: ....

Bitte machen Sie hier einen Vermerk, falls Sie nicht bereit wären, an unserer Studie teilzunehmen.

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03.	Gegenwärtige Tätigkeit: 1 ❑ Student/-in 4 ❑ andere Tätigkeit: .... 2 ❑ Lehrer/-in 5 ❑ ohne Arbeit 3 ❑ Dozent/-in	11
04.	Körpergewicht: . . . kg	12-14
05.	Körpergrösse: . . . cm	15-17
06.	Rauchen Sie Zigaretten, Pfeifen oder Zigarren? 0 ❑ nein 1 ❑ ja	18
07.	Falls Sie Zigaretten rauchen: Wie viele Zigaretten rauchen Sie durchschnittlich pro Tag? (während der Woche) . . Zigaretten	19-20
08.	Wie viele Tassen Kaffee trinken Sie durchschnittlich pro Tag? (während der Woche) . . Tassen	21-22
09.	Wie oft trinken Sie im Durchschnitt (gemessen an den letzten drei Monaten) alkoholische Getränke (irgendwelcher Art, egal wieviel)? 0 ❑ nie 2 ❑ 2 bis 4 Mal pro Woche 1 ❑ weniger als 1 Mal pro Woche 3 ❑ täglich	23
10.	Wie oft haben Sie in den letzten zwölf Monaten so viel Alkohol getrunken, dass Sie nicht mehr guten Gewissens hätten Auto fahren können? 0 ❑ nie 1 ❑ 1-2 Mal 2 ❑ 3-10 Mal 3 ❑ mehr als 10 Mal	24

11.	Wie oft nehmen Sie die folgenden Medikamente ein?	selten oder nie	gelegentlich	fast täglich	
	Schmerzmittel, Kopfwehmittel:	0 ❑	1 ❑	2 ❑	25
	Schlafmittel:	0 ❑	1 ❑	2 ❑	26
	Beruhigungsmittel:	0 ❑	1 ❑	2 ❑	27
	Aufputschmittel:	0 ❑	1 ❑	2 ❑	28
	Magen- oder Darm-Medikamente:	0 ❑	1 ❑	2 ❑	29
	Antiallergika:	0 ❑	1 ❑	2 ❑	30
	andere Medikamente:	0 ❑	1 ❑	2 ❑	31

12.	Leiden Sie an einer Störung des Hormonsystems?	0 ❑ nein 1 ❑ ja	32
13.	Sind Sie wegen Depressionen in Behandlung?	0 ❑ nein 1 ❑ ja	33
14.	Leiden Sie an Herz-Kreislauf-Erkrankungen?	0 ❑ nein 1 ❑ ja	34
15.	*Nur Frauen:* Nehmen Sie orale Kontrazeptiva („Pille")?	0 ❑ nein 1 ❑ ja	35
16.	*Nur Frauen:* Wann hatten Sie Ihre Menstruation zum letzten Mal (erster Tag der Menstruation)? . . 19 . . Wie lange dauert Ihr Zyklus üblicherweise? (ganzer Zyklus, nicht Menstruationstage) . . Tage	36
17.	*Nur Frauen:* Besteht eine Schwangerschaft? 0 ❑ nein 1 ❑ ja	37

Zuoz 1997   *Studie „Prüfungen Zuoz 1997"*

Code-Nr.: . . . *740*

ANLEITUNG

Im Folgenden finden Sie eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann. Es geht um Ihre **Gefühle und Gedanken in Prüfungssituationen.**
Bitte lesen Sie jeden Satz durch. Zu jedem Satz gibt es vier mögliche Antworten:
1 = trifft überhaupt nicht zu, 2 = trifft kaum zu, 3 = trifft eher zu, 4 = trifft genau zu.
Kreuzen Sie diejenige Zahl an, die angibt, wie Sie sich **im allgemeinen bei Prüfungen und Tests** *fühlen und was Sie denken. Geben Sie Ihre Antwort* **unabhängig von Ihrer augenblicklichen Stimmung.** *Überlegen Sie nicht lange.*

		überhaupt nicht	kaum	eher	genau	
01.	Ich vertraue auf meine Leistung.	1	2	3	4	8
02.	Ich denke darüber nach, wie wichtig mir die Prüfung oder der Test ist.	1	2	3	4	9
03.	Ich spüre ein komisches Gefühl im Magen.	1	2	3	4	10
04.	Ich denke über meine Fähigkeit oder Begabung nach.	1	2	3	4	11
05.	Mir schiessen plötzlich Gedanken durch den Kopf, die mich blockieren.	1	2	3	4	12
06.	Ich mache mir Sorgen, ob ich auch alles schaffe.	1	2	3	4	13
07.	Ich bin am ganzen Körper verkrampft.	1	2	3	4	14
08.	Ich bin zuversichtlich, was meine Leistung betrifft.	1	2	3	4	15
09.	Ich denke über die Konsequenzen eines möglichen Misserfolges nach.	1	2	3	4	16
10.	Ich frage mich, ob meine Leistung ausreicht.	1	2	3	4	17
11.	Ich denke an andere Dinge und werde dadurch abgelenkt.	1	2	3	4	18
12.	Ich fühle mich unbehaglich.	1	2	3	4	19
13.	Ich weiss, dass ich mich auf mich selbst verlassen kann.	1	2	3	4	20
14.	Ich denke daran, wie wichtig mir ein gutes Ergebnis ist.	1	2	3	4	21
15.	Mich überkommt ein ungutes Gefühl, und schon verliere ich den Faden.	1	2	3	4	22
16.	Das Herz schlägt mir bis zum Hals.	1	2	3	4	23
17.	Ich mache mir Gedanken über mein Abschneiden.	1	2	3	4	24
18.	Ich fühle mich ängstlich.	1	2	3	4	25
19.	Ich vergesse Dinge, weil ich einfach zu sehr mit mir selbst beschäftigt bin.	1	2	3	4	26
20.	Ich bin mit mir zufrieden.	1	2	3	4	27
21.	Ich mache mir Gedanken, wie mein Resultat aussehen wird.	1	2	3	4	28
22.	Ich zittere vor Aufregung.	1	2	3	4	29
23.	Ich bin besorgt, dass etwas schief laufen könnte.	1	2	3	4	30
24.	Ich werde in meinem Gedankengang unterbrochen, weil mir etwas Nebensächliches einfällt.	1	2	3	4	31
25.	Ich habe ein beklemmendes Gefühl.	1	2	3	4	32
26.	Ich denke, dass ich alles schaffen werde.	1	2	3	4	33
27.	Ich denke daran, was passiert, wenn ich schlecht abschneide.	1	2	3	4	34
28.	Ich bin aufgeregt.	1	2	3	4	35
29.	Ich bin überzeugt, dass ich gut abschneiden werde.	1	2	3	4	36
30.	Ich habe das Gefühl, mir fällt alles so schwer.	1	2	3	4	37

Code-Nr.: . . . 750

(Fortsetzung)	überhaupt nicht	kaum	eher	genau	
31. Ich schiebe das Lernen für eine Prüfung oft vor mich hin.	1	2	3	4	8
32. Ich bin mir sicher, dass ich in Prüfungssituationen jeweils gute Leistungen erbringen kann, auch wenn ich mal an einem Prüfungstag nicht in absoluter Topform bin.	1	2	3	4	9
33. Ich nehme mir häufig vor, für eine Prüfung zu lernen, mache es dann aber doch nicht.	1	2	3	4	10
34. Ich bin mir sicher, dass ich in Prüfungen auch dann gute Leistungen erzielen kann, wenn etwas verlangt wird, das ich nicht erwartet hatte.	1	2	3	4	11
35. Wenn ich mir für eine bevorstehende Prüfung einen Lernplan mache, kann ich ihn meistens doch nicht einhalten.	1	2	3	4	12
36. Ich bin mir sicher, dass ich in Prüfungssituationen erfolgreich sein kann, auch wenn eine Prüfung mal nicht genau so abläuft, wie ich mir das vorgestellt habe.	1	2	3	4	13
37. Auch wenn ich mir jeweils bestimmte Zeiten reserviere, um für eine bevorstehende Prüfung zu lernen, tue ich es dann doch nicht.	1	2	3	4	14
38. Ich bin mir sicher, dass ich mich in Prüfungssituationen bewähren kann, auch wenn andere zuvor schlecht abgeschnitten haben.	1	2	3	4	15
39. Wenn ich mir vornehme, mich für eine Prüfung vorzubereiten, gelingt es mir meistens nicht, meinen Vorsatz zügig in die Tat umzusetzen.	1	2	3	4	16
40. Ich bin mir sicher, dass ich in Prüfungen ein gutes Resultat erzielen kann, da ich jeweils Mittel und Wege finde, mir das nötige Wissen anzueignen.	1	2	3	4	17
41. Mit den Prüfungsvorbereitungen beginne ich meistens erst im letzten Augenblick.	1	2	3	4	18
42. Ich bin mir sicher, dass ich Prüfungssituationen problemlos bestehen kann, da ich mich immer auf meine Fähigkeiten verlassen kann.	1	2	3	4	19
43. Beim Lernen für Prüfungen gehe ich planmässig vor.	1	2	3	4	20
44. Ich bin mir sicher, dass ich Prüfungssituationen bestens bewältigen kann, da ich meinen Lernprozess zu organisieren weiss.	1	2	3	4	21
45. Wenn ich mich auf eine Prüfung vorbereiten muss, gelingt es mir meistens.	1	2	3	4	22

Code-Nr.: . . . 810

ANLEITUNG

Im Folgenden finden Sie eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann. Es geht um Ihre **Gefühle und Gedanken im Allgemeinen.** *Denken Sie an verschiedene Situationen. Bitte lesen Sie jeden Satz durch. Zu jedem Satz gibt es vier mögliche Antworten: 1 = trifft überhaupt nicht zu, 2 = trifft kaum zu, 3 = trifft eher zu, 4 = trifft genau zu. Kreuzen Sie diejenige Zahl an, die angibt, wie Sie sich* **im allgemeinen** *fühlen. Geben Sie die Antwort* **unabhängig von Ihrer augenblicklichen Stimmung.** *Überlegen Sie nicht lange.*

		überhaupt nicht	kaum	eher	genau	
01.	Die Lösung schwieriger Probleme gelingt mir immer, wenn ich mich darum bemühe.	1	2	3	4	8
02.	Wenn mir jemand Widerstand leistet, finde ich Mittel und Wege, mich durchzusetzen.	1	2	3	4	9
03.	Es bereitet mir keine Schwierigkeiten, meine Absichten und Ziele zu verwirklichen.	1	2	3	4	10
04.	In unerwarteten Situationen weiss ich immer, wie ich mich verhalten soll.	1	2	3	4	11
05.	Auch bei überraschenden Ereignissen glaube ich, dass ich gut damit zurechtkommen kann.	1	2	3	4	12
06.	Schwierigkeiten sehe ich gelassen entgegen, weil ich mich immer auf meine Fähigkeiten verlassen kann.	1	2	3	4	13
07.	Was auch immer passiert, ich werde schon klarkommen.	1	2	3	4	14
08.	Für jedes Problem kann ich eine Lösung finden.	1	2	3	4	15
09.	Wenn ich mit einer neuen Sache konfrontiert werde, weiss ich, wie ich damit umgehen kann.	1	2	3	4	16
10.	Wenn ich mit einem Problem konfrontiert werde, habe ich meist mehrere Ideen, wie ich damit fertigwerden kann.	1	2	3	4	17

ANLEITUNG

Wie gut treffen die folgenden Aussagen auf Sie zu?

		ist total falsch (1)	ist sehr falsch (2)	ist eher falsch (3)	ist eher richtig (4)	ist sehr richtig (5)	ist total richtig (6)	
01.	Meine Zukunft sieht gut aus.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	18
02.	Ich habe mehr Freude am Leben als die meisten anderen Menschen.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	19
03.	Ich bin zufrieden mit der Art und Weise, wie sich meine Lebenspläne verwirklichen.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	20
04.	Ich komme gut zurecht mit den Dingen, die in meinem Leben nicht zu verändern sind.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	21
05.	Was auch immer passiert, ich kann die gute Seite daran sehen.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	22
06.	Ich freue mich zu leben.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	23
07.	Mein Leben scheint mir sinnvoll.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	24
08.	Mein Leben verläuft auf der rechten Bahn.	❏ 1	❏ 2	❏ 3	❏ 4	❏ 5	❏ 6	25

Code-Nr.: . . . 830

ANLEITUNG

Im Folgenden wird beschrieben, wie Menschen auf verschiedene schwierige, stressvolle oder ärgerliche Situationen reagieren können.

Sagen Sie uns bitte, was Sie **typischerweise tun, wenn Sie unter Stress stehen**. Die Bewertungsskala reicht von 1 = sehr untypisch für Sie bis 5 = sehr typisch für Sie **in Stress-Situationen**.

Das ist für mich:	sehr untypisch (1)	eher untypisch (2)	teils-teils (3)	eher typisch (4)	sehr typisch (5)	
01. Ich suche den Kontakt mit anderen Menschen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	08
02. Ich mache mir Vorwürfe, weil ich die Dinge vor mir herschiebe.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	09
03. Ich mache mir Vorwürfe, dass ich in diese Situation geraten bin.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	10
04. Ich mache einen Einkaufsbummel.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	11
05. Ich setze Prioritäten.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	12
06. Ich nasche oder gönne mir meine Lieblingsspeise.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	13
07. Ich habe die Befürchtung, dass ich die Situation nicht bewältigen kann.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	14
08. Ich bin sehr angespannt.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	15
09. Ich denke darüber nach, wie ich ähnliche Probleme gelöst habe.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	16
10. Ich gehe essen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	17
11. Ich gerate aus der Fassung.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	18
12. Ich erarbeite mir einen Plan und führe ihn auch aus.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	19
13. Ich mache mir Vorwürfe, weil ich nicht weiss, was ich machen soll.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	20
14. Ich denke über die Situation nach, damit ich sie verstehe.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	21
15. Ich denke über die Situation nach und versuche, aus meinen Fehlern zu lernen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	22
16. Ich wünsche mir, ich könnte ungeschehen machen, was passiert ist.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	23
17. Ich besuche einen Freund/eine Freundin.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	24
18. Ich verbringe Zeit mit einem mir nahestehenden Menschen.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	25
19. Ich durchdenke zuerst das Problem, bevor ich etwas unternehme.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	26
20. Ich rufe einen Freund/eine Freundin an.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	27
21. Ich werde wütend.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	28
22. Ich schaue mir einen Film an.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	29
23. Ich erarbeite mehrere Lösungsvorschläge für das Problem.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	30
24. Ich versuche, so planmässig und gezielt vorzugehen, dass ich die Situation in den Griff bekomme.	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	31

Code-Nr.: . . . 840

ANLEITUNG

*Im Folgenden werden Sie nach Ihren **Beziehungen zu Menschen** befragt, **die Ihnen wichtig sind** (z.B. Partner, Familienmitglieder, Freunde/Freundinnen und Bekannte).*
Bitte entscheiden Sie sich bei jeder Aussage für eine der fünf Einschätzungen: 1 = trifft nicht zu, 2 = trifft wenig zu, 3 = trifft mittelmässig zu, 4 = trifft ziemlich zu, 5 = trifft sehr zu. Kreuzen Sie das entsprechende Kästchen an. Überlegen Sie nicht lange.

		trifft nicht zu	trifft wenig zu	trifft mittelmässig zu	trifft ziemlich zu	trifft sehr zu	
01.	Es gibt Menschen, die mich so nehmen, wie ich bin.	❑	❑	❑	❑	❑	8
02.	Meinen Freunden/Angehörigen ist es wichtig, meine Meinung zu bestimmten Dingen zu erfahren.	❑	❑	❑	❑	❑	9
03.	Ich wünsche mir von anderen mehr Verständnis und Zuwendung.	❑	❑	❑	❑	❑	10
04.	Ich kenne einen sehr vertrauten Menschen, mit dessen Hilfe ich in jedem Fall rechnen kann.	❑	❑	❑	❑	❑	11
05.	Ich habe Freunde/Angehörige, die auch mal gut zuhören können, wenn ich mich aussprechen möchte.	❑	❑	❑	❑	❑	12
06.	Ich kenne fast niemanden, mit dem ich gerne ausgehe.	❑	❑	❑	❑	❑	13
07.	Ich habe Freunde/Angehörige, die mich auch einfach mal umarmen.	❑	❑	❑	❑	❑	14
08.	Wenn ich mal tief bedrückt bin, weiss ich, zu wem ich gehen kann.	❑	❑	❑	❑	❑	15
09.	Ich fühle mich oft als Aussenseiter.	❑	❑	❑	❑	❑	16
10.	Es gibt Menschen, die Leid und Freude mit mir teilen.	❑	❑	❑	❑	❑	17
11.	Bei manchen Freunden/Angehörigen kann ich auch mal ganz ausgelassen sein.	❑	❑	❑	❑	❑	18
12.	Ich habe einen vertrauten Menschen, in dessen Nähe ich mich sehr wohl fühle.	❑	❑	❑	❑	❑	19
13.	Es gibt Menschen, die zu mir halten, auch wenn ich Fehler mache.	❑	❑	❑	❑	❑	20
14.	Ich wünsche mir mehr Geborgenheit und Nähe.	❑	❑	❑	❑	❑	21
15.	Es gibt genug Menschen, zu denen ich ein wirklich gutes Verhältnis habe.	❑	❑	❑	❑	❑	22
16.	Es gibt eine Gemeinschaft von Menschen (Freundeskreis, Clique), zu der ich mich zugehörig fühle.	❑	❑	❑	❑	❑	23
17.	Durch meinen Freundes- und Bekanntenkreis erhalte ich oft gute Tips (z.B. guter Arzt, wichtige Informationen).	❑	❑	❑	❑	❑	24
18.	Es gibt Menschen, denen ich alle meine Gefühle zeigen kann, ohne dass es peinlich wird.	❑	❑	❑	❑	❑	25

ANLEITUNG Code-Nr.: , , 860

Im Folgenden finden Sie eine Reihe von Aussagen, mit denen man sich selbst beschreiben kann. Bitte lesen Sie jeden Satz durch. Wie gut trifft diese Aussage auf Sie persönlich zu? Zur Bewertung steht Ihnen eine fünffach abgestufte Skala zur Verfügung: 0 = starke Ablehnung (wenn Sie der Aussage auf keinen Fall zustimmen oder sie für völlig unzutreffend halten), 1 = Ablehnung (wenn Sie der Aussage eher nicht zustimmen oder sie für unzutreffend halten), 2 = neutral (wenn die Aussage weder richtig noch falsch, also weder zutreffend noch unzutreffend ist), 3 = Zustimmung (wenn Sie der Aussage eher zustimmen oder sie für zutreffend halten), 4 = starke Zustimmung (wenn Sie der Aussage nachdrücklich zustimmen oder sie für völlig zutreffend halten). Kreuzen Sie bei jeder Aussage diejenige Zahl an, die Ihre Sichtweise am besten ausdrückt. Überlegen Sie nicht lange.

		starke Ablehnung	Ablehnung	neutral	Zustimmung	starke Zustimmung	
01.	Ich bin nicht leicht beunruhigt.	0	1	2	3	4	8
02.	Ich habe gerne viele Leute um mich herum.	0	1	2	3	4	9
03.	Ich fühle mich anderen oft unterlegen.	0	1	2	3	4	10
04.	Ich bin leicht zum Lachen zu bringen.	0	1	2	3	4	11
05.	Wenn ich unter starkem Stress stehe, fühle ich mich manchmal, als ob ich zusammenbräche.	0	1	2	3	4	12
06.	Ich halte mich nicht für besonders fröhlich.	0	1	2	3	4	13
07.	Ich fühle mich selten einsam oder traurig.	0	1	2	3	4	14
08.	Ich unterhalte mich wirklich gerne mit anderen Menschen.	0	1	2	3	4	15
09.	Ich fühle mich oft angespannt und nervös.	0	1	2	3	4	16
10.	Ich bin gerne im Zentrum des Geschehens.	0	1	2	3	4	17
11.	Manchmal fühle ich mich völlig wertlos.	0	1	2	3	4	18
12.	Ich ziehe es gewöhnlich vor, Dinge allein zu tun.	0	1	2	3	4	19
13.	Ich empfinde selten Furcht oder Angst.	0	1	2	3	4	20
14.	Ich habe oft das Gefühl, vor Energie überzuschäumen.	0	1	2	3	4	21
15.	Ich ärgere mich oft darüber, wie andere Leute mich behandeln.	0	1	2	3	4	22
16.	Ich bin ein fröhlicher, gut gelaunter Mensch.	0	1	2	3	4	23
17.	Zu häufig bin ich entmutigt und will aufgeben, wenn etwas schiefgeht.	0	1	2	3	4	24
18.	Ich bin kein gut gelaunter Optimist.	0	1	2	3	4	25
19.	Ich bin selten traurig oder deprimiert.	0	1	2	3	4	26
20.	Ich führe ein hektisches Leben.	0	1	2	3	4	27
21.	Ich fühle mich oft hilflos und wünsche mir eine Person, die meine Probleme löst.	0	1	2	3	4	28
22.	Ich bin ein sehr aktiver Mensch.	0	1	2	3	4	29
23.	Manchmal war mir etwas so peinlich, dass ich mich am liebsten versteckt hätte.	0	1	2	3	4	30
24.	Lieber würde ich meine eigenen Wege gehen, als eine Gruppe anzuführen.	0	1	2	3	4	31

DAS WAR DIE LETZTE FRAGE!

Dürfen wir Sie bitten, diese Seiten nochmals durchzublättern? Haben Sie an allen verlangten Stellen eine Antwort angekreuzt? Wir danken Ihnen vielmals für Ihre Mitarbeit und Geduld.

Maja Haldemann

ANLEITUNG

Im Folgenden finden Sie eine Reihe von **allgemeinen Fragen**. Diese sind Bestandteil unserer Studie „Prüfungen Zuoz 1997". Wir benötigen diese Angaben, um die Einflussfaktoren auf den Kortisolspiegel und die Herzfrequenz erfassen zu können. Die gestellten Fragen entstammen standardisierten Fragebogen-instrumenten.

Bei den meisten Fragen sind die Antwortmöglichkeiten in Form von ankreuzbaren Kästchen oder Zahlen vorgegeben. Lesen Sie bitte die einzelnen Fragen genau durch. Entscheiden Sie sich jeweils möglichst spontan, welche Antwort für Sie zutrifft. Kreuzen Sie dann bei jeder Frage die entsprechende Stelle an. Falls Sie irrtümlicherweise die falsche Stelle (falsches Kästchen / falsche Zahl) erwischen, können Sie diese Stelle übermalen und einfach über der zutreffenden Stelle ein Kreuz anbringen.

Es gibt keine „richtigen" und „falschen" Antworten, da jeder Mensch eigene Anschauungen und Meinungen besitzt und in einer spezifischen Situation lebt. Antworten Sie also bitte so, wie es für Sie zutrifft.

Sämtliche Daten werden absolut vertraulich behandelt und nur unter Code-Nummern abgespeichert. Die verschiedenen Fragebogen werden nach der statistischen Auswertung vernichtet. Die erhobenen Daten dienen ausschliesslich unserer Studie und werden nicht an Drittpersonen weitergegeben.

Wir danken Ihnen für Ihre Mitwirkung.

Maja Haldemann

Prof. Dr. Karl Frey

Prof. Dr. Hans Zeier

✄ - - - - - - - ✄ - - - - - - - ✄

– dieser Teil wird von uns nach der Codierung entfernt –

Bitte notieren Sie hier Ihren vollständigen Namen sowie Ihr Geburtsdatum. Diese Angaben benötigen wir nur bis zur Codierung (zur eindeutigen Identifikation). Ihr Name erscheint nirgends auf den Fragebogen oder in der Auswertung. Vielen Dank.

(bitte gut leserlich schreiben!)

Name: ....

Vorname: ....

Geburtsdatum: ....

Bitte machen Sie hier einen Vermerk, falls Sie nicht bereit wären, an unserer Studie teilzunehmen.

....

Zuoz 1997 | **B-2** | *Studie „Prüfungen Zuoz 1997"*

ANLEITUNG

Im Folgenden finden Sie Fragen zu Ihrem Befinden und zu Ihrem Umgang mit der bevorstehenden Prüfungssituation. **Bitte beantworten Sie diese Fragen mit Rückblick auf die letzten beiden Tage Ihrer Prüfungsvorbereitung.** *Die Bewertungsskala reicht von 1 = gar nicht zutreffend für Sie bis 5 = sehr zutreffend. Unter dem Begriff „Situation" ist die aktuelle Prüfungssituation zu verstehen.*

Vielleicht treffen einige Fragen nicht gut auf Sie und diese beiden Tage zu. Kreuzen Sie bitte auch in diesem Fall das an, was **für Sie in den letzten beiden Tagen Ihrer Prüfungsvorbereitung** *am ehesten zutraf.*

Das ist für die letzten beiden Tage meiner Prüfungsvorbereitung:	gar nicht zutreffend (1)	eher nicht zutreffend (2)	teils zutreffend (3)	eher zutreffend (4)	sehr zutreffend (5)	
01. Ich suchte den Kontakt mit anderen Menschen.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	08
02. Ich machte mir Vorwürfe, weil ich die Dinge vor mir herschob.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	09
03. Ich machte mir Vorwürfe, dass ich in diese Situation geraten bin.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	10
04. Ich machte einen Einkaufsbummel.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	11
05. Ich setzte Prioritäten.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	12
06. Ich naschte oder gönnte mir meine Lieblingsspeise.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	13
07. Ich hatte die Befürchtung, dass ich die Situation nicht bewältigen kann.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	14
08. Ich war sehr angespannt.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	15
09. Ich dachte darüber nach, wie ich ähnliche Situationen bewältigt habe.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	16
10. Ich ging essen.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	17
11. Ich geriet aus der Fassung.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	18
12. Ich erarbeitete mir einen Plan und führte ihn auch aus.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	19
13. Ich machte mir Vorwürfe, weil ich nicht wusste, was ich machen sollte.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	20
14. Ich dachte über die Situation nach, damit ich sie verstand.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	21
15. Ich dachte über die Situation nach und versuchte, aus meinen Fehlern zu lernen.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	22
16. Ich wünschte mir, ich könnte ungeschehen machen, was passiert ist.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	23
17. Ich besuchte einen Freund/ eine Freundin.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	24
18. Ich verbrachte Zeit mit einem mir nahestehenden Menschen.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	25
19. Ich durchdachte die Situation zuerst, bevor ich etwas unternahm.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	26
20. Ich rief einen Freund/ eine Freundin an.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	27
21. Ich war wütend.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	28
22. Ich schaute mir einen Film an.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	29
23. Ich erarbeitete mehrere Lösungsvorschläge für die Situation.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	30
24. Ich versuchte, so planmässig und gezielt vorzugehen, dass ich die Situation in den Griff bekomme.	❑ 1	❑ 2	❑ 3	❑ 4	❑ 5	31

Code-Nr.: . . . 423

ANLEITUNG

Im Folgenden finden Sie eine Reihe von Feststellungen, mit denen man sich selbst beschreiben kann. Es geht um Ihre **Gefühle und Gedanken zur bevorstehenden Prüfungssituation**.
Bitte lesen Sie jeden Satz durch. Zu jedem Satz gibt es vier mögliche Antworten:
1 = trifft überhaupt nicht zu, 2 = trifft kaum zu, 3 = trifft eher zu, 4 = trifft genau zu.
Kreuzen Sie diejenige Zahl an, die angibt, wie Sie sich **jetzt**, d.h. **in diesem Moment** fühlen und was Sie denken. Überlegen Sie nicht lange.

		überhaupt nicht	kaum	eher	genau	
01.	Ich vertraue auf meine Leistung.	1	2	3	4	08
02.	Ich denke darüber nach, wie wichtig mir die Prüfung oder der Test ist.	1	2	3	4	09
03.	Ich spüre ein komisches Gefühl im Magen.	1	2	3	4	10
04.	Ich denke über meine Fähigkeit oder Begabung nach.	1	2	3	4	11
05.	Mir schiessen plötzlich Gedanken durch den Kopf, die mich blockieren.	1	2	3	4	12
06.	Ich mache mir Sorgen, ob ich auch alles schaffe.	1	2	3	4	13
07.	Ich bin am ganzen Körper verkrampft.	1	2	3	4	14
08.	Ich bin zuversichtlich, was meine Leistung betrifft.	1	2	3	4	15
09.	Ich denke über die Konsequenzen eines möglichen Misserfolges nach.	1	2	3	4	16
10.	Ich frage mich, ob meine Leistung ausreicht.	1	2	3	4	17
11.	Ich denke an andere Dinge und werde dadurch abgelenkt.	1	2	3	4	18
12.	Ich fühle mich unbehaglich.	1	2	3	4	19
13.	Ich weiss, dass ich mich auf mich selbst verlassen kann.	1	2	3	4	20
14.	Ich denke daran, wie wichtig mir ein gutes Ergebnis ist.	1	2	3	4	21
15.	Mich überkommt ein ungutes Gefühl, und schon verliere ich den Faden.	1	2	3	4	22
16.	Das Herz schlägt mir bis zum Hals.	1	2	3	4	23
17.	Ich mache mir Gedanken über mein Abschneiden.	1	2	3	4	24
18.	Ich fühle mich ängstlich.	1	2	3	4	25
19.	Ich vergesse Dinge, weil ich einfach zu sehr mit mir selbst beschäftigt bin.	1	2	3	4	26
20.	Ich bin mit mir zufrieden.	1	2	3	4	27
21.	Ich mache mir Gedanken, wie mein Resultat aussehen wird.	1	2	3	4	28
22.	Ich zittere vor Aufregung.	1	2	3	4	29
23.	Ich bin besorgt, dass etwas schief laufen könnte.	1	2	3	4	30
24.	Ich werde in meinem Gedankengang unterbrochen, weil mir etwas Nebensächliches einfällt.	1	2	3	4	31
25.	Ich habe ein beklemmendes Gefühl.	1	2	3	4	32
26.	Ich denke, dass ich alles schaffen werde.	1	2	3	4	33
27.	Ich denke daran, was passiert, wenn ich schlecht abschneide.	1	2	3	4	34
28.	Ich bin aufgeregt.	1	2	3	4	35
29.	Ich bin überzeugt, dass ich gut abschneiden werde.	1	2	3	4	36
30.	Ich habe das Gefühl, mir fällt alles so schwer.	1	2	3	4	37

Code-Nr.: . . . 723

Weitere Fragen zur bevorstehenden Prüfung Antwortmöglichkeiten: 1 = trifft überhaupt nicht zu, 2 = trifft kaum zu, 3 = trifft eher zu, 4 = trifft genau zu	überhaupt nicht	kaum	eher	genau	
31. Ich bin mir sicher, dass ich die bevorstehende Prüfung erfolgreich bewältigen kann, da ich mich auf meine Fähigkeiten verlassen kann.	1	2	3	4	38
32. Ich habe keine Ahnung, wie diese Prüfung ablaufen wird.	1	2	3	4	39
33. Diese Prüfung ist eine positive Herausforderung für mich.	1	2	3	4	40
34. Diese Prüfung wird schon irgendwie gut gehen, auch wenn ich mich aus irgendwelchen Gründen nicht voll dafür einsetzen könnte.	1	2	3	4	41
35. Ich habe keine Ahnung, welche Anforderungen genau an mich gestellt werden.	1	2	3	4	42
36. Ich empfinde diese Prüfung als bedrohlich.	1	2	3	4	43
37. Ich habe keine Ahnung, wie diese Prüfung beurteilt wird.	1	2	3	4	44
38. Ich erwarte eine anspruchsvolle Prüfung.	1	2	3	4	45
39. Ich komme unvorbereitet in diese Prüfung.	1	2	3	4	46
40. Ich arbeitete hart, um in dieser Prüfung eine gute Note bzw. Bewertung zu erzielen.	1	2	3	4	47
41. Für diese Prüfung stelle ich hohe Anforderungen an mich.	1	2	3	4	48
42. Die meiste Arbeit im Zusammenhang mit dieser Prüfung missfiel mir.	1	2	3	4	49
43. Ich schob das Lernen für diese Prüfung oft vor mich hin.	1	2	3	4	50
44. Ich nahm mir häufig vor zu lernen, machte es dann aber doch nicht.	1	2	3	4	51
45. Obwohl ich mir jeweils bestimmte Zeiten reservierte, um für die bevorstehende Prüfung zu lernen, tat ich es dann doch nicht.	1	2	3	4	52
46. Mit den Prüfungsvorbereitungen begann ich erst im letzten Augenblick.	1	2	3	4	53
47. Beim Lernen ging ich planmässig vor.	1	2	3	4	54
48. Ich erstellte einen Lernplan für die bevorstehende Prüfung.	1	2	3	4	55
49. Ich verbrachte zu viel Zeit mit anderen Aktivitäten, so dass meine Prüfungsvorbereitung darunter gelitten hat.	1	2	3	4	56
50. Bei der Prüfungsvorbereitung bin ich wegen Zeitdruck ins „Pauken" geraten.	1	2	3	4	57
51. Ich habe kurz vor der Prüfung (gestern Abend/ heute) noch neuen Stoff gelernt.	1	2	3	4	58
52. Ich vernachlässigte das Lernen auf diese Prüfung wegen Problemen ausserhalb des Studiums (finanzielle Schwierigkeiten, Probleme mit Partnern/Eltern, zeitraubende Verpflichtungen, ...).	1	2	3	4	59
53. Ich liess mich während der Prüfungsvorbereitung sehr leicht vom Lernen ablenken.	1	2	3	4	60
54. Ich war während der Prüfungsvorbereitung oft unruhig oder schlecht gelaunt.	1	2	3	4	61
55. Bei der Arbeit für diese Prüfung schweiften meine Gedanken ständig ab.	1	2	3	4	62
56. Währendem ich die Prüfung vorbereitete, dachte ich darüber nach, welche Fragen in der Prüfung vorkommen könnten.	1	2	3	4	63
57. Beim Lernen machte ich mir Zeichnungen und Skizzen, damit ich den Stoff besser verstehe.	1	2	3	4	64
58. Ich erstellte einfache Listen, Tabellen und schematische Darstellungen, um den Prüfungsstoff zu ordnen und zusammenzufassen.	1	2	3	4	65
59. Kurz vor dieser Prüfung bin ich meine Notizen noch einmal durchgegangen.	1	2	3	4	66

C-1

Bitte während Salivaprobe 1 (nach Aufwachen) ausfüllen. *Code:* ⬚⬚⬚ *2 1 1*

? "Stressmesser" ?
Wie aufgeregt sind
Sie in diesem Augenblick?

Bitte markieren Sie eines der zehn Felder:
Die Skala reicht von 1 = "überhaupt nicht aufgeregt" bis 10 = "sehr aufgeregt".

10   **10** = sehr aufgeregt

1   **1** = überhaupt nicht aufgeregt

ZUOZ 1997

C-2

102

Code-Nr.: . . 371

Morgenprotokoll Basismessung Zürich 1997

Der Kortisolspiegel wird von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.

Maja Haldemann

Datum der Salivaprobe: . . (Tag) . . (Monat) 1997			8-11
01. Wann sind Sie *heute Morgen* aufgewacht?	. . Uhr . . (bitte auf 5 Min. genau)		12-15
02. Zeitpunkt der ersten, blau markierten Salivaprobe? Uhr . . (bitte auf 1 Min. genau)	. . (Herausnahme der Watterolle aus dem Mund)		16-19
03. Zeitpunkt der zweiten, rot markierten Salivaprobe? Uhr . . (bitte auf 1 Min. genau)	. . (Herausnahme der Watterolle aus dem Mund)		20-21
04. Wie viele Stunden haben Sie *diese Nacht* geschlafen?	. . Std. (bitte auf ganze Stunden runden)		22
05. Haben Sie *diese Nacht* weniger lang geschlafen als sonst?	⁰ ☐ nein	¹ ☐ ja	23
06. Haben Sie *diese Nacht* schlechter geschlafen als sonst?	⁰ ☐ nein	¹ ☐ ja	

Die folgenden Fragen beziehen sich auf die Zeit zwischen Aufwachen und 2. Salivaprobe. (nur zur Kontrolle, damit wir Ihre Daten interpretieren können)

07. Haben Sie schon etwas gegessen?	⁰ ☐ nein	¹ ☐ ja. Nämlich:	24
08. Haben Sie schon etwas anderes als Leitungswasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)	⁰ ☐ nein	¹ ☐ ja. Nämlich:	25
09. Haben Sie bereits Zigaretten geraucht?	⁰ ☐ nein	¹ ☐ ja: . . Zigaretten (Anzahl) Das ist ¹ ☐ gleichviel ² ☐ weniger ³ ☐ mehr als sonst.	26-28 / 29
10. Haben Sie Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)	⁰ ☐ nein	¹ ☐ ja Name der Medikamente: .... Dosis:	30
11. Fühlen Sie sich gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)	⁰ ☐ nein	¹ ☐ ja. Nämlich:	31
12. Haben Sie schon Sport betrieben?	⁰ ☐ nein	¹ ☐ ja, und zwar ¹ ☐ gleichviel ² ☐ weniger ³ ☐ mehr als sonst.	32 / 33
13. Haben Sie Ihren Tag mit Yoga, Meditation oder ... begonnen?	⁰ ☐ nein	¹ ☐ ja. Nämlich:	34

Maja Haldemann

Morgenprotokoll Zuoz Montag, 28.7.1997

Code-Nr.: . . , 322

Der Kortisolspiegel wird von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.

Maja Haldemann

01. Wann sind Sie *heute Morgen* aufgewacht? (richtig aufgewacht, nicht Halbschlaf)	. . Uhr (bitte auf 5 Min. genau)	8-11
02. Zeitpunkt der ersten, blau markierten Salivaprobe? (bitte auf 1 Min. genau) (Herausnahme der Watterolle aus dem Mund)	. . Uhr	12-15
03. Zeitpunkt der zweiten, rot markierten Salivaprobe? (bitte auf 1 Min. genau) (Herausnahme der Watterolle aus dem Mund)	. . Uhr	16-19
04. Wie viele Stunden haben Sie *diese Nacht* geschlafen?	. . Std. (bitte auf ganze Stunden runden)	20-21
05. Haben Sie *diese Nacht* weniger lang geschlafen als sonst?	⁰ ☐ nein ¹ ☐ ja	22
06. Haben Sie *diese Nacht* schlechter geschlafen als sonst?	⁰ ☐ nein ¹ ☐ ja	23
07. *Nur Frauen:* Besteht eine Schwangerschaft?	⁰ ☐ nein ¹ ☐ ja	24
08. *Nur Frauen:* Nehmen Sie orale Kontrazeptiva („Pille")?	⁰ ☐ nein ¹ ☐ ja	25
09. *Nur Frauen:* Wann hatten Sie Ihre Menstruation zum letzten Mal (erster Tag der Menstruation)? . . . 1997 Wie lange dauert Ihr Zyklus üblicherweise? (ganzer Zyklus, nicht Menstruationstage) . . Tage		26

Die folgenden Fragen beziehen sich auf die **Zeit zwischen Aufwachen und 2. Salivaprobe.** *(nur zur Kontrolle, damit wir Ihre Daten interpretieren können)*

10. Haben Sie schon etwas gegessen?	⁰ ☐ nein ¹ ☐ ja. Nämlich:	27
11. Haben Sie schon etwas anderes als Leitungswasser oder kohlensäurefreies Mineralwasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)	⁰ ☐ nein ¹ ☐ ja. Nämlich:	28
12. Haben Sie bereits Zigaretten geraucht?	⁰ ☐ nein ¹ ☐ ja: . . Zigaretten (Anzahl) Das ist ⁰ ☐ gleichviel ¹ ☐ weniger ² ☐ mehr als sonst.	29-31 32
13. Haben Sie Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)	⁰ ☐ nein ¹ ☐ ja. Name der Medikamente: .... Dosis:	33
14. Fühlen Sie sich gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)	⁰ ☐ nein ¹ ☐ ja. Nämlich:	34
15. Haben Sie schon Sport betrieben?	⁰ ☐ nein ¹ ☐ ja, und zwar ⁰ ☐ gleichviel ¹ ☐ weniger ² ☐ mehr als sonst.	35 36
16. Haben Sie Ihren Tag mit Yoga, Meditation oder ... begonnen?	⁰ ☐ nein ¹ ☐ ja. Nämlich:	37

Code-Nr.: . . . 314

Abendprotokoll Basismessung Zürich 1997

Der Kortisolspiegel wird von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.

Datum der Salivaprobe: . . (Tag) . . (Monat) 1997
Exakter Zeitpunkt der Salivaprobe (Herausnahme der Watterolle aus dem Mund) . . Uhr . . (bitte auf 1 Min. genau) | 8

01. Haben Sie *seit 16.00 Uhr* etwas gegessen?   ◻ nein   ◻ ja. Nämlich: .... | 9

02. Haben Sie *seit 16.00 Uhr* etwas anderes als Leitungswasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)   ◻ nein   ◻ ja. Nämlich: .... | 10-12

03. Haben Sie *seit 16.00 Uhr* Zigaretten geraucht?   ◻ nein   ◻ ja: . . Zigaretten (Anzahl) Das ist ◻ weniger ◻ gleichviel ◻ mehr als sonst. | 13

04. Haben Sie *seit 16.00 Uhr* Sport betrieben?   ◻ nein   ◻ ja, und zwar ◻ weniger ◻ gleichviel ◻ mehr als sonst. | 14, 15

05. Haben Sie *seit 16.00 Uhr* ein Entspannungstraining durchgeführt? (Yoga, Meditation, ...)   ◻ nein   ◻ ja. Nämlich: .... | 16

06. Haben Sie *heute* Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)   ◻ nein   ◻ ja   Name der Medikamente: .... Dosis: .... | 17

07. Fühlen Sie sich *heute* gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)   ◻ nein   ◻ ja. Nämlich: .... | 18

08. Wann sind Sie *heute Morgen* aufgewacht? . . Uhr . . (wenn möglich auf 5 Min. genau) | 19-22

C-5

105

Zuoz Montag, 28.7.1997   17.00 Uhr

Der Kortisolspiegel wird von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.
Maja Haldemann

00. Exakter Zeitpunkt der Salivaprobe (Herausnahme der Watterolle aus dem Mund)   . . Uhr . .   (bitte auf 1 Min. genau)

01. Haben Sie *seit 16.00 Uhr* etwas gegessen?   □ nein   □ ja. Nämlich: ....

02. Haben Sie *seit 16.00 Uhr* etwas anderes als Leitungswasser oder kohlensäurefreies Mineralwasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)   □ nein   □ ja. Nämlich: ....

03. Haben Sie *seit 16.00 Uhr* Zigaretten geraucht?   □ nein   □ ja: . . . Zigaretten (Anzahl)   Das ist □ gleichviel □ weniger □ mehr   als sonst.

04. Haben Sie Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)   □ nein   □ ja. Name der Medikamente: .... Dosis: .... Zeitpunkt: . . Uhr . .

05. Fühlen Sie sich gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)   □ nein   □ ja. Nämlich: ....

Der Kortisolspiegel und die Herzfrequenz werden von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.

Maja Haldemann

00. Exakter Zeitpunkt der Salivaprobe (Herausnahme der Watterolle aus dem Mund) . . . Uhr . . (bitte auf 1 Min. genau)

01. Haben Sie *seit 17.00 Uhr* etwas gegessen?   □ nein   □ ja. Nämlich: .... (8)

02. Haben Sie *seit 17.00 Uhr* etwas anderes als Leitungswasser oder kohlensäurefreies Mineralwasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)   □ nein   □ ja. Nämlich: .... (9)

03. Haben Sie *seit 17.00 Uhr* Zigaretten geraucht?   □ nein   □ ja: . . Zigaretten (Anzahl) Das ist □ gleichviel □ weniger □ mehr als sonst. (10-12, 13)

04. Haben Sie *seit 17.00 Uhr* Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)   □ nein   □ ja. Name der Medikamente: .... Dosis: .... (14)

05. Fühlen Sie sich gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)   □ nein   □ ja. Nämlich: .... (15)

Zuoz Montag, 28.7.1997   18.30 Uhr

Code-Nr.: . . . 325

Maja Haldemann

Der Kortisolspiegel und die Herzfrequenz werden von mehreren Faktoren beeinflusst. Damit wir die Daten sinnvoll interpretieren können, sind wir auf verschiedene Angaben angewiesen. Diese werden streng vertraulich behandelt (Codierung). Wir danken Ihnen für möglichst präzise Auskunft.

00. Exakter Zeitpunkt der Salivaprobe (Herausnahme der Watterolle aus dem Mund) . . Uhr . . (bitte auf 1 Min. genau)

01. Haben Sie *seit 18.00 Uhr* etwas gegessen?   ☐ nein   ☐ ja. Nämlich: *8*

02. Haben Sie *seit 18.00 Uhr* etwas anderes als Leitungswasser oder kohlensäurefreies Mineralwasser getrunken? (Kaffee, Schwarztee, Orangensaft, Alkohol, Energydrinks ...)   ☐ nein   ☐ ja. Nämlich: *9*

03. Haben Sie *seit 18.00 Uhr* Zigaretten geraucht?   ☐ nein   ☐ ja: . . Zigaretten (Anzahl) Das ist ☐ gleichviel ☐ weniger ☐ mehr als sonst.   *10-12*   *13*

04. Haben Sie *seit 18.00 Uhr* Medikamente eingenommen? (z.B. Kopfwehmittel, Beruhigungsmittel, Betablocker ...)   ☐ nein   ☐ ja. Name der Medikamente: .... Dosis: *14*

05. Fühlen Sie sich gesundheitlich unwohl? (z.B. erhöhte Temperatur, Kopfschmerzen, Bauchweh ...)   ☐ nein   ☐ ja. Nämlich: *15*

ÜBERSICHT: SALIVAPROBE

VORBEREITEN

Bequemer Stuhl

Vor sich hinlegen:

① dieses gelbe Anleitungsblatt

② Glas mit Leitungswasser

③ Röhrchen (Salivette)

④ Blätter „Stressmesser", Protokoll, „Codeblatt"

⑤ Stift

DURCHFÜHREN

① **Mund** gut **spülen**

② **5 Minuten warten** (lesen, Musik hören, am Computer arbeiten ... nichts essen oder trinken, kein Kaugummi oder Bonbon, nicht rauchen, nicht Gymnastik oder Sport betreiben!)

③ **Röhrchen** (Salivette) nehmen, Watterolle aus Gefäss direkt in Mund schieben. Nicht mit Händen berühren! Während **exakt 2 Minuten** sanft und langsam kauen.

④ Nach 1 Minute: „**Stressmesser**" ausfüllen.

⑤ Nach 2 Minuten: Watterolle aus Mund direkt in Gefäss zurückgeben (nicht mit Händen berühren), Stopfen gut verschliessen.

⑥ **Protokoll** ausfüllen.

⑦ „**Codeblatt**" ausfüllen (nur in Zürich am 1. April abends und am 2. April morgens).

⑧ Alles ins **Couvert** packen: Röhrchen, „Stressmesser", Protokoll.

⑨ Couvert zukleben, abgeben! (Salivaproben müssen möglichst rasch tiefgefroren werden.)

❀ ❀ ❀ HERZLICHEN DANK ! ❀ ❀ ❀

Maja Haldemann

... SO NEHMEN SIE DIE SALIVAPROBEN ...

MORGENPROBEN

Wir brauchen vom Morgen zwei Salivaproben: die erste Probe direkt nach dem Aufwachen, die zweite Probe 30 Minuten später. Wir bestimmen daraus die Konzentration von Kortisol. Damit die Messung möglichst aussagekräftig ist, bitten wir Sie, folgendermassen vorzugehen:

PROBE 1: UNMITTELBAR NACH DEM AUFWACHEN

① **Bitte putzen Sie die Zähne heute Morgen noch nicht!** (erst nach der zweiten Salivaprobe)

② Spülen Sie stattdessen den Mund mit Wasser. Warten Sie dann bitte 5 Minuten. (Wichtig, da sonst Konzentrationsverdünnungen durch das Wasser.)

③ Entnehmen Sie Ihrem Couvert das **Röhrchen mit der blauen Etikette.**
Halten Sie das Röhrchen am Rand des eingefügten Gefässes fest. Entfernen Sie den Stopfen, indem Sie ihn ein wenig zur Seite abknicken. (Das eingehängte Gefäss sollte im durchsichtigen Röhrchen bleiben. Falls es herauskommt, stecken Sie es bitte wieder hinein.)

④ Schieben Sie nun die Watterolle aus dem Gefäss direkt in den Mund (möglichst nicht mit den Händen berühren). **Kauen Sie sie bitte sanft während exakt 2 Minuten!** Kauen Sie langsam.

⑤ **Füllen Sie nach einer Minute den mit einem blauen Punkt markierten „Stressmesser" aus** (dabei weiterkauen!).

⑥ Geben Sie die eingespeichelte Watterolle nach diesen 2 Minuten wieder in das eingefügte Gefäss zurück (möglichst nicht mit den Händen berühren).

⑦ Verschliessen Sie das Röhrchen unbedingt wieder fest mit dem Stopfen! Legen Sie es ins Couvert zurück.

⑧ **Schauen Sie auf die Uhr.**
Beantworten Sie jetzt die Fragen 01 und 02 auf dem Protokollblatt (Wann sind Sie aufgewacht? Wann genau haben Sie den Wattebausch der ersten Probe aus dem Mund genommen?). Diese Angaben sind sehr wichtig, um die Kortisolwerte zu interpretieren.

Wir hoffen, dass Sie nun 30 Minuten lang den neuen Morgen geniessen. Wir bitten Sie, in dieser Zeit noch nichts zu essen und zu trinken (ausser Leitungswasser), nicht zu rauchen und auch von anstrengendem Sport abzusehen. In Zuoz sorgen wir für Unterhaltung ...

!!! Bitte geniessen Sie auch das süsse Dankeschön erst nach der zweiten Salivaprobe !!!

PROBE 2: 30 MINUTEN NACH DEM AUFWACHEN

① Gehen Sie bitte wieder gleich vor wie bei der ersten Salivaprobe:
Mund mit Wasser spülen, 5 Minuten warten.

② Entnehmen Sie Ihrem Couvert das **Röhrchen mit der roten Etikette.**

③ Kauen Sie die Watterolle bitte wieder sanft während **exakt 2 Minuten!**

④ **Füllen Sie nach einer Minute den mit einem roten Punkt markierten „Stressmesser" aus**
(langsam weiterkauen).

⑤ Geben Sie die eingespeichelte Watterolle nach diesen 2 Minuten wieder in das eingehängte
Gefäss zurück.

⑥ Verschliessen Sie das Röhrchen wieder fest mit dem Stopfen! Legen Sie es ins Couvert zurück.

⑦ **Schauen Sie auf die Uhr.** Wann genau haben Sie den Wattebausch der zweiten Probe aus dem
Mund genommen? **Beantworten Sie bitte die restlichen Fragen auf dem Protokollblatt.**
Diese Angaben benötigen wir, um die Kortisolwerte zu interpretieren.

➡ Bevor Sie das **Couvert** verschliessen: Haben Sie die zwei Röhrchen und die Blätter mit
Ihrem Namen beigelegt? Vergessen Sie den **Absender auf dem Couvert** nicht.

Verschliessen Sie das Couvert mit den zwei **Spreizklammern** und **mit Bostichklammern.**

✈ **Bringen Sie das Couvert bitte möglichst rasch zur nächsten Poststelle oder zum
nächsten Briefkasten.** Wir müssen die Salivaproben sofort tiefkühlen.

Herzlichen Dank für Ihre wertvolle Mitarbeit!!
Maja Haldemann

Curriculum vitae

Date of birth	January 23, 1969
Place of origin	Winterthur (ZH), Eggiwil (BE)
Nationality	Swiss

Education

1976 – 1981	Primary School, Bottighofen (TG)
1981 – 1985	Secondary School (*Progymnasium*), Oberwil (BL)
1985 – 1988	High School (*Gymnasium*), Oberwil (BL)
1988 – 1992	Major in biology (systematic and ecological biology) at the Swiss Federal Institute of Technology (ETH), Zurich
1992 – 1995	Completion of Master's Degree in Education at the Swiss Federal Institute of Technology (ETH), Zurich
1992 – today	Scientific assistant to Prof. Dr. Karl Frey at the Institute for Behavioral Sciences of the Swiss Federal Institute of Technology (ETH), Zurich
1996 – 1999	Ph.D. thesis under the supervision of Prof. Dr. Hans Zeier and Prof. Dr. Karl Frey at the Institute for Behavioral Sciences of the Swiss Federal Institute of Technology (ETH), Zurich

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