Psychopathology research – quo vadis?

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Investigating potential improvements, expansions, and innovation of assessment methods

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To my unborn son
wishing him a successful adaptation
to all the challenges expecting him in this world

Acknowledgment

When I started my PhD in combination with my psychotherapy, I came in with plenty of ideas and plans to do “good clinical research” that is scientifical deliberate and also meaningful for patients and adapted to their needs. While planning a longitudinal study that investigates different biopsychosocial aspects of borderline personality disorder over the course of inpatient treatment, I realized the importance of a solid and reliable methodological foundation for such research endeavors. Due to this realization and the terminability of a PhD, I decided to focus my thesis on three conceptually different methodological components that provide a basis for my longitudinal clinical study.

First and foremost, I want to thank my supervisor, Jens C. Pruessner, for his guidance and support, his insights and support throughout the last five years. Having a boss and mentor, who not only encouraged all my ideas and ambitious plans but also offered advice and realistic but constructive objections, was a blessing for me. I couldn´t have wished for a better lab to do my PhD with. In this regard, I´d also like to thank my colleagues: Maria, Ulrike, Eva, Stephanie, Bernadette, and Raphaela – you all contributed in your own unique way to my PhD with interesting, nerdy, insightful, funny, distracting, but also personal conversations as well as helpful scientific support. Most of all every single member of the SHINE lab helped to create an inspiring atmosphere that I really enjoyed working and growing in.

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Abbreviations

ACM	Adaptive Calibration Model
ACTH	Adrenocorticotropic Hormone
ANS	Autonomic Nervous System
ART	Attention Restauration Theory
ASI	Anxiety Sensitivity Index
AUC	Area Under the Curve
AUCg	Area Under the Curve with respect to the ground
AUCi	Area Under the Curve with respect to increase
BDI (-II)	Beck’s Depression Inventory (revised version)
BMI	Body Mass Index
CAR	Cortisol Awakening Response
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit-Index
CRH	Corticotropin-Releasing-Hormone
CTQ(-SF)	Childhood Trauma Questionnaire (Short Form)
Dov	Day of ovulation
EFA	Exploratory Factor Analysis
ELA	Early Life Adversity
FEB	Fragebogen zur elterlichen Bindung
FFMQ	Five Facet Mindfulness Questionnaire
FM	Factor Model
GR	Glucocorticoid Receptor
HF-HRV	High-Frequency Heart Rate Variability
HPA	Hypothalamic-Pituitary-Adrenal (Axis)
HR	Heart Rate
HRV	Heart Rate Variability
ICC	Intra-Class Correlation Coefficient
KI/CI	Confidence Interval
MAP	Minimum-Average-Partial-Test
mCD	Average cycle duration
MEMS	Medication Event Monitoring System
ML	Maximum Likelihood

MLR	Robust version of ML-estimate
MR	Mineralocorticoid Receptor
OC	Oral Contraceptives
PBI	Parental Bonding Instrument
PBI-org	Parental Bonding Instrument (original version)
PBI-dt	Parental Bonding Instrument (German translation)
PNE	Psychoneuroendocrinological
PNS	Parasympathetic Nervous System
PVN	Paraventricular Nucleus
SNS	Sympathetic Nervous System
SRMR	Standardized Root Mean Square Residual
RMSEA	Root Mean Square Error of Approximation
RR-Interval	Beat-to-beat interval
RSA	Respiratory Sinus Arrhythmia
TLI	Tucker-Lewis-Index

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Graphical Abstract

Abstract

Understanding factors which are associated with or can predict psychopathological developments is key to a constant improvement of health care services. However, this line of research depends on sound and reliable methodological approaches. In this thesis, I investigated three biopsychosocial components of the adaptive calibration model that proposes a psychoneuroendocrinological adaptation process during sensitive periods in life, especially early childhood or puberty, in response to stressors such as endocrine or autonomic modulations in reaction to adversity (e.g. parental neglect or maltreatment).

First, I translated into German the Parental Bonding Instrument (PBI), a self-report questionnaire to retrospectively assess parental care and overprotection for mothers and fathers separately. An openly accessible and validated German translation of the well-established English original was missing so far. Upon evaluation, I could show that the data of a large online sample confirmed the psychometric qualities of this new German PBI version and supported both, a two and a three-factor model, with the latter dividing parental overprotection into discouragement of behavioral freedom and denial of psychological autonomy. Consequently, my first study offers a reliable instrument to measure parental care and overprotection in a German-speaking sample in future research e.g. on the association between parental bonding and psychopathology.

Second, I investigated potential benefits of an extended assessment of salivary cortisol concentrations up to 270 minutes after awakening in a healthy sample. Typically, cortisol after awakening is measured for 60 minutes. Results showed that circadian cortisol release follows a pulsatile rhythm with high inter-individual variability that might be related to sex and menstrual cycle phase. Furthermore, the data suggested that the traditional assessment of the cortisol awakening response of 60 minutes might not capture the complete first pulse in all participants.

Third, I developed a nature-based relaxation video paradigm to measure autonomic responsivity indicated by heart rate variability (HRV) during relaxation. I observed an increase in HRV and a decrease in heart rate during different video conditions suggesting a generic autonomic relaxation response to the paradigm.

While associations across parenting behavior, cortisol and HRV (dys-) regulation, and subsequent psychopathology, are well supported by the literature, both the quantitative (positive vs. negative associations) and qualitative (cause vs. effect) direction of these relations are still unclear. With the results of my thesis, I aimed to contribute to new developments in the assessment of these three concepts: first the improvement of an existing measure (an updated translation and psychometric examination of the PBI to assess parental bonding in German-speaking samples), and the development of two new assessment approaches (an extended measurement of cortisol after awakening and a suggestion for a new approach to measuring HRV reactivity to a relaxation induction). Even though these methods are still in their infancy, they can provide a foundation for future studies to show if basic and clinical research on either one of the concepts or all three combined will benefit from these new developments.

Zusammenfassung

Faktoren, die mit psychopathologischen Entwicklungen zusammenhängen oder diese sogar vorhersagen können, besser zu verstehen ist entscheidend für eine kontinuierliche Verbesserung psychotherapeutische Angebote. Für diese Forschung sind jedoch verlässliche und saubere methodische Ansätze unerlässlich. Mit der vorliegenden Thesis untersuchte ich drei (bio-) psychologische Komponenten des Adaptive Calibration Models, dass psychoneuroendokrinologische Anpassungsprozess in Reaktion auf Stressoren in sensiblen Entwicklungsperioden annimmt, wie zum Beispiel endokrine oder autonome Modulationen nach negativen Erfahrungen wie elterliche Vernachlässigung oder Missbrauch.

In meiner ersten Studie erstellte ich eine deutsche Übersetzung des Parental Bonding Instrument (PBI), ein auf Selbstauskunft basierender Fragebogen zur retrospektiven Erfassung elterlicher Fürsorge und Überbehütung. Eine frei verfügbare und validierte deutsche Übersetzung des etablierten englischen Originalfragebogens fehlte bisher. In einer Evaluation der Daten einer umfassenden Onlinestudie konnte ich die psychometrische Qualität der neuen deutschen PBI Version bestätigen. Die Daten unterstützten sowohl ein zwei- als auch ein drei-Faktorenmodell, wobei letzteres elterliche Überbehütung in die Subskalen Einschränkung der Verhaltensfreiheit und Verweigerung psychologischer Autonomie aufteilt. Damit bietet meine erste Studie ein verlässliches Instrument, um elterliche Fürsorge und Überbehütung in deutschsprachigen Stichproben zu messen und beispielsweise die Assoziation zwischen elterlicher Bindung und Psychopathologie zu untersuchen.

In meiner zweiten Studie untersuchte ich mögliche Vorteile einer erweiterten Erfassung der Cortisolkonzentration im Speichel bis zu 270 Minuten nach dem Aufwachen in einer gesunden Stichprobe. Typischerweise wird Cortisol bis 60 Minuten nach dem Aufwachen gemessen. Die Ergebnisse zeigten, dass die circadiane Cortisolausschüttung einem pulsatilen Rhythmus folgt, der eine hohe inter-individuelle Variabilität und Zusammenhänge mit biologischem Geschlecht und Zyklusphase aufweist.

In der dritten Studie entwickelte ich ein Video-Paradigma mit natur-basierten Entspannungsvideos, um die autonome Entspannungsreaktion operationalisiert durch die Herzratenvariabilität (HRV) zu messen. Hier konnte ich einen Anstieg der HRV und einen Abfall der Herzrate während aller Videobedingungen beobachten,

was eine allgemeine autonome Entspannungsreaktion in diesem Paradigma nahelegt.

Obwohl die Zusammenhänge zwischen Erziehungsverhalten, Cortisol- und HRV-Regulation und nachfolgenden psychischen Störungen in vielen Studien bestätigt werden konnten, ist sowohl die quantitative (positive vs. negative Korrelation) als auch die qualitative (Ursache vs. Wirkung) Richtung weiterhin unklar. Mit den Ergebnissen meiner Thesis hoffe ich, einen Beitrag zu neuen Entwicklungen in der Messung dieser drei Konzepte zu leisten: eine Verbesserung eines etablierten Instruments (eine aktualisierte Übersetzung und Überprüfung des PBI, um elterliche Bindung in deutschsprachigen Stichproben zu erfassen) und zwei neu entwickelte Messansätze (eine erweiterte Messung der morgendlichen Cortisolkonzentration, und ein neuer Vorschlag zur Messung der HRV Reaktivität nach Entspannungsinduktion). Auch wenn diese drei methodischen Ansätze noch in ihren Kinderschuhen stecken, kann ihr Nutzen für die Grundlagen- sowie Klinische Forschung auf dieser Basis in zukünftige Studien zu einem dieser Konzepte oder zu allen drei zusammen untersucht werden.

1 General Introduction

After mental health problems have been stigmatized and downplayed in the past (Stuart, 2012), the importance of mental health finally attracts growing attention in our modern society. More than 27% of the adult German population meet the criteria for at least one mental disorder according to a large-scale German study program (Jacobi et al., 2015). Worldwide, more than 1 in 5 people suffer from a mental disorder (Steel et al., 2014) and with the still ongoing COVID-19 pandemic the prevalence of mental health problems continue to grow (World Health Organization, 2022). This increase since the beginning of the pandemic sheds light on some of the factors that might be involved in the development of mental disorders, such as loneliness and perceived stress which have increased in connection with the global health threat of the COVID-19 pandemic (Benz et al., 2020) and governmental restrictions that were implemented (Steinmetz et al., 2020). But not only since this pandemic, relative risks of mortality of up to 2.22 (Walker et al., 2015), potential life loss of 10 years (Plass et al., 2014), and costs of more than 44 Billion Euro per year in Germany alone (looking at direct costs for health care only, Statistisches Bundesamt, 2019) associated with mental disorders are alarming.

In light of these significant consequences (and despite promising scientific evidence that we already gathered), it is of great importance to (further) improve our understanding of psychopathology – including its etiology, prediction (and thereby prevention if possible), and treatment.

According to the APA Dictionary of Psychology, the term “psychopathology” not only refers to “the scientific study of mental disorders, including their theoretical underpinnings, etiology, progression, symptomatology, diagnosis, and treatment” but is also used to describe “behavioral or cognitive manifestations of such disorders” (American Psychological Association, n.d.). In this context, psychopathology comprises a wide range of mental disorders from depression and anxiety disorders to substance use disorders or personality disorders to name just a few. Despite the large variety of symptoms associated with the different disorders, common underlying processes are involved in the development of various kinds of mental disorders. One such important factor is experiencing adverse environmental factors during an early stage of development which has been associated with manifold psychopathological outcomes such as depression (Marshall et al., 2018), borderline personality disorder

(Kuo et al., 2015), eating disorders (Tasca & Balfour, 2014), to name just a few (Shonkoff et al., 2012).

Here, one important question is why some people develop psychopathology while others in comparable circumstances do not, i.e. why some are more vulnerable, and others are more resilient to the development of some form of psychopathology. One often cited example is Hurricane Katrina, an intense tropical cyclone that made landfall in the United States in summer 2005 and caused tremendous damage. While this catastrophe led to an increase in mental health problems, a considerable percentage of affected people could be identified as resilient, i.e. showing a stable mental health record despite the negative experience of this natural disaster. This sparked multiple research endeavors to investigate predictors of poorer mental health outcomes as well as resilience factors (cf. An et al., 2019; Kim et al., 2008; Zoraster, 2010)

To approach the question of vulnerability and resilience, it is worth looking at etiological models first, that aim to explain potential causal or perpetuating factors of psychopathology. In fact, this is not a novel question but has already been elaborated on in ancient Greece. In the Hippocratic writings, different forms of psychopathological symptoms and their etiology are described and discussed. Here, the interactions of somatic (e.g. abnormalities in blood or brain status) and psychological factors (e.g. alterations of the mind, thought processes, or awareness are interpreted as prognostic signs of poor health outcomes (Matentzoglu, 2011).

Building on the Hippocratic idea that psychopathology does not occur out of the blue and is not a divine punishment, many theories look at the interaction of genetic predisposition and adaptation of an organism to potentially threatening environments or situations.

The Allostatic Load Model provided one of the first and most prominent extensive and well-structured theoretical approaches to the interaction of (early) stressors and health outcomes (McEwen, 1998). In this model, increased risk for disease is explained through the body´s response to environmental stressors via different biological systems that try to maintain homeostasis, a state of internal balance needed for optimal functioning. Though adaptive in the first place, these physical adjustments can lead to cumulated expenses in the long run, called allostatic load or overload. For example, childhood adversity or maltreatment during adolescence has been shown to be related to indicators of allostatic load, such as decreased prefrontal cortex volume, elevated cortisol reactivity, and increased inflammation levels (Danese & McEwen, 2012).

Building off the concept of allostatic load, the Biological Sensitivity to Context Theory added heritable genetic variations to the concept of adjustment to explain individual differences in the biological reactivity to adversity. Depending on the interaction of individual biological sensitivity and the presence of adverse or adjuvant context factors, the risk for psychopathology increases in a U-shaped fashion (Boyce & Ellis, 2005).

Over the years the fundamental ideas of adjustment to contextual factors and costs of adjustment, i.e. allostatic load, became more complex and differentiated. With the Adaptive Calibration Model (ACM), earlier models got expanded (Del Giudice et al., 2011). Again the ACM conceptualizes allostatic load as a cost of adaptation in case of extended stress exposure resulting in failed shut-off, or inadequate responses of one system (and, thus, the need for compensation through another system). In addition, the model proposes four prototypical responsivity patterns based on long-term calibration of the biological system depending on contextual and life-history demands. The ACM explains individual differences in stress responsivity (and consequently differences in vulnerability for psychopathology) as a result of conditional adaptation depending on individual status and abilities when confronted with stressful or supportive environmental conditions. As a constant trade-off, the organism has to allocate time and energy toward competing life functions (Del Giudice et al., 2011). This allows for specific predictions of different stress-response patterns related to developmental switch points, i.e. sensitive periods of development. These key predictions of the ACM were supported by a Dutch longitudinal study that reported differential aggressive and depressed behavior styles in relation to high- and low-responsivity patterns under low-stress and high-stress conditions (Ellis et al., 2017).

More recently, the stress coherence/compensation model focused on the interaction of different biological systems in reaction to a stressor depending on adverse experiences (followed by calibration mechanisms) earlier in life (Andrews et al., 2013). According to this model, the perception of a stressful stimulus is followed by a two-stage activation of cognitive and autonomic regulatory processes first and endocrine stress responses, namely activation of the (peripheral) hypothalamic-pituitary-adrenal (HPA) axis second, both providing energetic resources and coping mechanisms to deal with the stressor. While at the first stage subjective and autonomic responses are triggered in coherence only regulated by basal HPA activity, acute HPA activation at the second stage has a compensatory function for the other two systems, down-regulating their activation. Consequently, activation and termination of an adaptive stress response depends on reliable HPA regulation. However, especially those people who report adverse conditions or maltreatment early in life often show a dysfunctional HPA regulation resulting in maladaptive stress responses and an increased risk of disease. In conclusion, the authors of this model recommend to account for all three of these different components, subjective emotional and cognitive experience, HPA regulation, and autonomic functioning (Andrews et al., 2013).

All models share the notion that any confrontation with a stressor (which we have plenty of in our modern society not only since the COVID-19 pandemic) requires psychobiological systems to be flexible and adaptive to the different demands and challenges of life. However, if the demands exceed the organism's capability to adjust, for example, due to prior (now maladaptive) adjustments, it can lead to the development of psychopathology.

Consequently, not only psychosocial preconditions but also responsivity of biological systems are important etiological factors that should be considered when trying to explain why someone develops a mental illness (or even predict who does and who does not develop one) and to develop suitable treatment approaches. However, most of our methods to measure psychosocial preconditions, such as early life adversity, or biological responsivity are limited either due to a lack of standardization, limited resources, or simply the mere number of differing approaches. As a consequence, we often have only small windows into the different important factors that might shed more light on developmental trajectories of psychopathology. Thus, we should always strive for improved measurement approaches in an ongoing process as the basis of meaningful psychopathology research.

With my thesis, I aim to contribute to a better understanding of factors that are associated with or might predict psychopathological developments. To this end, I worked on three different aspects of components introduced before: subjective evaluation of early adversity, HPA regulation, and autonomic functioning, Fig. 1). Despite their conceptual difference (one translation and evaluation of a well-established questionnaire and two new paradigms to assess physiological parameters), all three studies intend to improve and expand existing and develop new assessment approaches for a standardized, valid, and more comprehensive measurement of potential predictors or correlates of psychopathology. First, I will introduce the three components in more detail, second, I will present the three papers – each focusing on one of these components – that I published as part of my thesis, and third, I will discuss the results of these three papers jointly in a general discussion and provide some thoughts on future research directions.

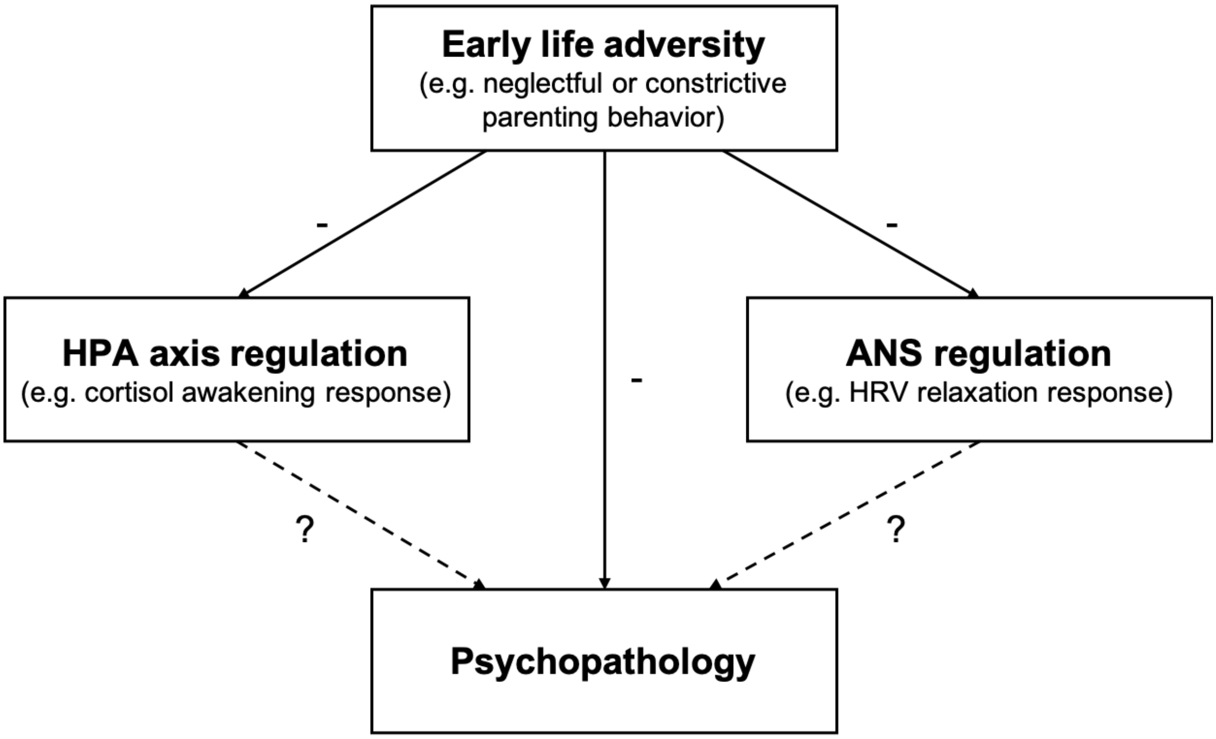

Fig. 1. Overview of main components studied in this thesis. HPA = hypothalamic-pituitary-adrenal, ANS = autonomic nervous system, HRV = heart rate variability.

1.1 Early life adversity

The importance of psychosocial and environmental conditions early in life becomes apparent in almost all models of psychopathology. Whether we look at early learning experiences from a behavioristic perspective (cf. Thompson, 1994) or at early unconscious conflicts from a psychodynamic perspective (cf. Friedman et al., 2018), the beforementioned adaptation or reaction to some form of stressor or demands – especially during vulnerable periods like early childhood or puberty – is crucial for later healthy or psychopathological development (Banyard et al., 2017; Green et al., 2010; Koss & Gunnar, 2018; Mian et al., 2022; Shonkoff et al., 2012). In addition, many disorder-specific theories explicitly include early vulnerability factors. For example, the biosocial model of the development of Borderline Personality Disorder by Marsha Linehan (Linehan, 1993) proposes that environmental influences, especially an invalidating environment (i.e. neglect or intolerance of a child´s emotional experiences and needs) in combination with individual and biological vulnerabilities are most formative for later increased emotional sensitivity and decreased emotion regulation capacity, some of the most important diagnostic criteria of a Borderline Personality Disorder (Lieb et al., 2004).

Moreover, a psychobiological modulation of neuroendocrine and autonomic systems in response to adverse conditions or experiences early that were present early in life is well documented. In line with the aforementioned idea of neurobiological adaptation processes in response to environmental demands, adults that report a history of adverse conditions or traumatic events, often have reduced hippocampal volume (Engert, 2010a), reduced gray matter volume in the dorsolateral prefrontal cortex (Narita et al., 2010), altered activity of stress-related systems (Koss & Gunnar, 2018), and difficulties in emotion processing and regulation (Young & Widom, 2014) that can be associated with dysregulations in the mesolimbic dopamine system (Pruessner et al., 2008) to name just a few examples. These modulations can even be observed on an epigenetic level (Unternaehrer et al., 2021). Moreover, the risk of developing a mental disorder increases drastically when such adverse factors are present early in life (Green et al., 2010).

However, while the association between early life adversities, biopsychological development, and mental health as an adult is well established (cf. Shonkoff et al., 2012 for a comprehensive review), a coherent definition and measurement approach to these adversities are yet lacking.

While we can clearly argue that a safe and supportive environment filled with love and care is best suited to foster a child´s healthy development, the question of which factors constitute an unhealthy environment and are thus definitive of early life adversities is still subject of ongoing debates (cf. Smith & Pollak, 2021). First and foremost, one approach is to collect the sum of specific events one experienced during sensitive periods early in life that were perceived as stressful and traumatic, causing a feeling of uncontrollability and helplessness, and exceeding one´s capabilities. For the assessment of these events, one can choose from a variety of self-report questionnaires or semi-structured interviews (e.g. Steele et al., 2016; Teicher & Parigger, 2015). Attempting to conceptualize early life adversity beyond cumulating specific events, adverse conditions can be differentiated by the categories deprivation and threat (Busso et al., 2017). Deprivation comprises being neglected and missing important developmental requirements (e.g. parental care, money, food, medical healthy services). Threat or maltreatment, on the other hand, describes active attacks on a child´s mental and/or physical well-being, such as emotional, physical, or sexual abuse. However, according to Smith & Pollak (2021), both approaches come with restrictions such as pre-determination of "stressful" events, co-occurrence or overlapping of categories, or missing evidence to support specific response mechanisms related to specific events or categories. Thus, new approaches suggest focusing more on how a specific event is perceived, as the perception of an event as uncontrollable and unpredictable might be more explanatory of resulting biological response mechanisms. Consequently, assessing a child´s subjective experience in combination with the notice of a safe and supportive support system could expand our understanding of neurobiological modulations in response to early life adversities (Smith & Pollak, 2021).

Thereby the quality of parent-child bonding plays a key role either as a supportive factor that can signal security and counteract other adversities in case of caring parental behavior or in cases of neglectful and constraining parental behavior as an adversity in itself. Parenting behavior can be described on multiple dimensions such as behavioral (e.g. fostering a child´s autonomy or controlling their decisions) and emotional characteristics (e.g. showing a child love, affection, and interest in their lives) (Unternaehrer et al., 2019). Especially the lack of a caring and loving attachment figure entails an adverse environment that often persists for a longer period early in life (Parker et al., 1995). Perceiving one or both parents as neglectful and remembering them as not caring about their basic needs negatively affects neuropsychological development (Kochanska et al., 2015) and increases the risk of mental disorders (Alonso et al., 2018; Marshall et al., 2018). While good and secure parental bonding buffers stress reactivity, poor caretaking also activates and modulates stress response systems (Unternaehrer et al., 2021).

One widely used approach to measure the perceived quality of parenting behavior is the Parental Bonding Instrument (PBI, Parker et al., 1979). Even though the maternal care subscale of the PBI is often used in international and German research protocols as an operationalization of early life adversity in terms of a neglectful upbringing, a freely accessible and validated German translation was still missing. With the first study of my dissertation, I therefore aimed at creating a new translation of the PBI and investigating its psychometric properties to provide a valid instrument for further research on the effects of early parental neglect or overprotection.

1.2 The cortisol awakening response

When trying to understand the manifold consequences of early life adversities and the mechanisms by which they affect e.g. adult psychopathology, looking at psychobiological modulations in people who did or did not experience such adversities yields many promising explanatory and interventional approaches. One of the biological systems affected by parental bonding is the hypothalamic-pituitary-adrenal (HPA) axis. The HPA axis is a fundamental part of the neuroendocrine stress system and should ensure adaptive stress reactivity by initiating a hormonal cascade when confronted with a challenge. As one of the first steps, the corticotropin-releasing-hormone (CRH) is synthesized in the paraventricular nucleus (PVN) of the hypothalamus and stimulates the release of the adrenocorticotropic hormone (ACTH) in the anterior pituitary into the systemic blood flow. Consequently, once ACTH arrives in the adrenal cortex, specific glucocorticoids, especially cortisol as the main glucocorticoid in humans, are synthesized and released into the bloodstream. Here, cortisol plays a crucial role in many metabolic mechanisms, such as energy mobilization, cardiovascular regulation, and immune modulation (Fries et al., 2009). Thereby, the HPA axis provides the organism with the energy needed to deal with the presented (or anticipated) challenge and helps to maintain or retain homeostasis. Importantly, the HPA cascade does not end with the cortisol release but rather continues in form of a feedback loop with cortisol inhibiting further CRH and ACTH release from the hypothalamus and the pituitary respectively (Ulrich-Lai & Herman, 2009). Overall the HPA axis provides an adaptive mechanism to adequately respond to potential stressors. However, dysregulations of the HPA axis that might occur e.g. in response to prolonged over or under stimulation are often associated with mental and somatic disorders (Chrousos, 2009).

Looking at cortisol, as one of the main (and easiest to access, cf. Kirschbaum & Hellhammer, 1989) outcomes of HPA activity, we can observe a distinct circadian profile: cortisol levels rise in the morning and decline thereafter reaching a nadir during the first half of the night (Spiga et al., 2014). This diurnal cortisol secretion is affected by many earlier or more recent preconditions such as child maltreatment (Doom et al., 2013) or loneliness (Jopling et al., 2021). What is more, flatter diurnal cortisol profiles are associated with poorer emotional and physical health outcomes, especially regarding inflammation indices (Adam et al., 2017). On top of this typical profile, morning cortisol levels are particularly high 30-45 minutes after awakening.

This cortisol awakening response (CAR) was introduced into psychoneuroendocrinological research in the 90s and is thought to represent a specific dynamic of cortisol release stimulated by awakening (Pruessner et al., 1997). As such it is associated with numerous trait variables such as sex and gender (Kudielka et al., 2009) or dispositional mindfulness (Daubenmier et al., 2014) and is sensitive to different state variables such as sleep quality (Lasikiewicz et al., 2008) or daily life stress (Giglberger et al., 2022). Furthermore, the CAR is linked to early life adversities (e.g. Engert et al., 2011). In light of the theories described before, dysregulations of the CAR (in either direction) can be interpreted as a (mal-)adaptive modulation in response to prolonged stimulation of the stress system early in life e.g. due to the experience of neglect or maltreatment during childhood (Strüber et al., 2014).

Beyond the circadian decline of cortisol levels, cortisol secretion follows a pulsatile ultradian rhythm peaking approximately every 60 minutes (Lightman & Conway-Campbell, 2010). Besides impulses to the PVN from the suprachiasmatic nucleus that are responsible for circadian rhythmicity (Clow et al., 2010), negative feedback from cortisol itself primarily to the pituitary gland but also to the PVN inhibits the described HPA cascade. Consequently, less cortisol is released from the adrenal cortex resulting in turn in a cancellation of the inhibitory action of cortisol on the pituitary and PVN and thus in a renewal of CRH and ACTH secretion and subsequently increased cortisol levels (Walker et al., 2010). The pulsatile character of cortisol secretion is well observed in animal studies (e.g. Rankin et al., 2012) and fewer human studies using blood plasma (Trifonova et al., 2013). Even though this pulsatile cortisol secretion seems to be related to stress and psychopathology (cf. Trifonova et al., 2013; Young et al., 2004), there is still a lack of research on its characteristics and associations let alone reliable and convenient research protocols (especially when compared to the vast literature on the CAR). Thus far, most studies looking at the relation between circadian neuroendocrine dysregulation and psychopathology focus on the CAR operationalized as the first 60 (or even less) minutes after awakening (Stalder et al., 2016). Yet, what happens after the initial 60 minutes remained more nebulous. On one hand, this could include the decline of the first strong increase of cortisol after awakening as we already know from stress research about the importance of the recovery phase, i.e. cortisol levels returning to baseline after they peaked roughly 20 minutes after stressor onset (cf. Koolhaas et al., 2011; Miller et al., 2007). On the other hand, we should take a closer look at characteristics of the first and subsequent pulses such as duration, amplitude, and frequency as these characteristics, for example, appear to be related to depression (e.g. Deuschle et al., 1997).

With the second study of my dissertation, I aimed to investigate cortisol levels in the 270 minute-period after awakening to investigate characteristics and associations of the first and subsequent ultradian cortisol pulses.

1.3 The autonomic relaxation response

While HPA axis regulation typically mirrors basic as well as stress-related adaptability peaking approximately 20 minutes after stressor onset, the autonomic nervous system (ANS) provides a more immediate response to changes in internal or external conditions and requirements (Kudielka et al., 2004). Consequently, the ANS plays a key role in the fight-or-flight response (Gibbons, 2019). Importantly, ANS responsivity goes hand in hand with HPA axis regulation and the psychological responses though they are separate systems that are not always activated in synchrony (e.g. Ali et al., 2017; Goldstein & Kopin, 2008). Thus, investigating all three systems in joined experimental designs is an important task for future research (cf. Andrews et al., 2013).

The two main branches of the ANS, the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), enable an organism's adaptive responses to environmental demands by predominantly reciprocal activation and deactivation. For example, when confronted with a stressor, the SNS is activated within milliseconds resulting in adrenaline and noradrenaline release and an increase in heart rate and energy mobilization (Ulrich-Lai & Herman, 2009). Moreover, an adequate restoration mechanism is just as important as the stress response to reinstate homeostasis. To this end, the PNS is involved in resting and digesting functions of the organism, e.g. by down-regulating heart rate (HR) via the vagus nerve. Thus, the PNS is often associated with relaxation (Thayer et al., 2012).

One of the most prominent indices of PNS activity is heart rate variability (HRV) as it is a reliable, cost-effective, and non-invasive measurement method (Laborde, 2017) that reflects beat-to-beat variation of the HR which is typically increased through sympathetic and decreased through parasympathetic activity. Due to the SNS reacting slower than the PNS, it is especially PNS activation or withdrawal that regulates alterations in HR which are in turn reflected by HRV (Berntson et al., 1997). Consequently, higher HRV implies healthy and functional adaptability of the heart and is associated with emotional stability, states of calmness and rest, and increased well-being (McCraty & Zayas, 2014). Contrary, lower HRV is a marker of psychopathology (Beauchaine & Thayer, 2015), such as e.g. affective disorders (Carr et al., 2018; Schiweck et al., 2019), anxiety (Cheng et al., 2022), or anorexia nervosa (Peyser et al., 2021). What is more, HRV is discussed to be influenced by the experience of early maltreatment. A recent meta-analysis summarized 32 studies pointing towards this conclusion but found no evidence for a direct association between early maltreatment and resting state HRV (Sigrist et al., 2020). However, these results are limited to resting state analysis as data on reactivity patterns are still sparse. Up to date, it is not clear (if at all) how and to which extent adverse experiences during childhood might induce modulations of autonomic regulation. Thus, understanding mechanisms that modulate healthy HRV regulation and responsivity and promoting interventions that foster HRV increases is an important task in clinical psychology.

Relaxation trainings constitute one popular approach to study and boost HRV responsivity (Chang et al., 2011). In this context, relaxation is defined as a restorative mechanism counterbalancing the stress response and thereby decreasing physiological arousal and increasing well-being (Benson, 1997). It involves changes in physiological activity (e.g. decreased oxygen consumption, blood pressure, and cardiovascular activity) and psychological states (e.g. increased mood and well-being, reduced anxiety) (Dusek & Benson, 2009). Furthermore, psychopathology is not only related to higher distress but also to a worse relaxation ability (Stenzel et al., 2013). In addition, relaxation trainings have shown to be effective e.g. in the treatment of depression and anxiety disorders in meta-analyses (Jia et al., 2020; H. Kim & Kim, 2018).

Despite the apparent benefit of relaxation inductions, standardized research protocols are rare (Meier et al., 2020). Many studies on the effect of relaxation and responsivity of HRV either focus on established relaxation techniques, such as progressive muscle relaxation (Groß & Kohlmann, 2021), autogenic training (Miu et al., 2009), or meditation (Lumma et al., 2015), or on more direct stimulations of the PNS respectively the vagus nerve, such as cold stimulation (Jungmann et al., 2018), transcutaneous auricular vagus nerve stimulation (Machetanz et al., 2021), or paced breathing (Laborde et al., 2022). However, what relaxation techniques lack standardization due to diverging instruction characteristics (e.g. length, pace, voice characteristics, phrasing, etc.), stimulation methods often lack feasibility (e.g. cost-intensive equipment, complex experimental set-ups) or heterogeneity of responses (i.e. most participants reacting in a similar way potentially producing ceiling effects).

Therefore, with my third study, I aimed to design and test a new research protocol to study changes in HRV in response to a relaxation induction that is easy to implement in various settings and does allow some variance in inter- and intraindividual responsivity (e.g. due to psychopathology, mood, or stress).

2 Psychometric Properties of a German Translation of the Parental Bonding Instrument

Parental Bonding – or rather a negative bonding experience, e.g. due to a lack of parental care and love – is one important aspect of early life adversity (Unternaehrer et al., 2021). According to the models discussed above (e.g. ACM), the experience of adverse conditions early in life results in an adaptation or calibration of biological systems to deal with the stressor of adversity, e.g. not feeling loved by one's parents. To quantify the extent of adversity and predict its consequences with respect to biological modulations, a reliable and valid measurement of parental bonding amongst other types of adversity is essential. Though widely used in German stress and resilience research (e.g. Bentele et al., 2021; Leithner et al., 2015; Willinger et al., 2005), the Parental Bonding Instrument (PBI; Parker et al., 1979) is only well validated in English and many other languages. In contrast, there are only two older, alternative German translations, both without sufficient validation or examination of psychometric properties.

I stumbled across this gap repeatedly during my early PhD times when I tried to design empirical research studies that involved the PBI. Thus, decided to first translate and examine a new – openly accessible – German version of the PBI. Even though the existing English version of the PBI is widely used and therefore, my first study presented in this thesis does not investigate a newly developed measurement approach, I believe that a well-validated questionnaire is an important foundation for future well-designed research projects. I consequently searched for a Bachelor student, Liliane Vanessa Kloker, who assisted me with the translation and data collection process. Tim Kuhlmann, a member of the division for Research Methods, Assessment, and iScience chaired by Ulf-Dietrich Reips, provided advice on methodological aspects of online surveys and questionnaire translations. Jens C. Pruessner supervised the planning and design of this project. Other members of my lab, Maria Meier, Eva Unternaehrer, Ulrike U. Bentele, Stephanie J. Dimitroff, and Bernadette F. Denk, were involved in discussing the results and editing the manuscript which I finally published in the German Journal "Psychotherapie, Psychosomatik, Medizinische Psychologie":

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2.1 Zusammenfassung

Das elterliche Erziehungsverhalten beeinflusst sowohl die Entwicklung eines Kindes als auch die Entstehung und Behandlung psychischer Störungen. Das Parental Bonding Instrument (PBI; Parker, Tupling & Brown, 1979) ist ein bekanntes Instrument zur retrospektiven Erfassung des elterlichen Erziehungsstils. Bisher existiert jedoch keine ausreichend validierte deutsche Version. Daher entwickelten wir eine sprachlich aktuelle, deutsche Übersetzung des PBI (PBI-dt) und untersuchten in einer Onlinestudie anhand einer deutschsprachigen Stichprobe (N = 791) die psychometrischen Eigenschaften des PBI-dt hinsichtlich Item- und Reliabilitätskennwerten, Konstrukt- und Kriteriumsvalidität sowie der faktoriellen Struktur.

Die Analysen ergaben gute Item- und Reliabilitätskennwerte (α = .86-.95). Die Skalen des PBI korrelierten in den erwarteten Richtungen mit den Skalen des Childhood Trauma Questionnaire (CTQ). Außerdem wurden signifikante Unterschiede im berichteten elterlichen Erziehungsstil zwischen Personen mit und ohne psychische Erkrankung sowie zwischen übergewichtigen und normalgewichtigen Personen gefunden. Diese Ergebnisse weisen auf das Vorliegen von hoher Konstrukt- und Kriteriumsvalidität hin. Konfirmatorische Faktorenanalysen ergaben in allen untersuchten Fitindizes eine akzeptable Modellanpassungsgüte sowohl für das 2-Faktorenmodell von Parker et al. (1979) als auch für das 3-Faktorenmodell mit den Subskalen Fürsorge, Einschränkung der Verhaltensfreiheit sowie Verweigerung psychologischer Autonomie. Die Verwendung einer Drei-Faktorenstruktur konnte zudem inhaltlichen Mehrwert bieten, z. B. eine bessere Differenzierung zwischen normal- und übergewichtigen Personen. Insgesamt weist die vorliegende deutsche Übersetzung des PBI somit gute psychometrische Eigenschaften auf und stellt ein reliables Messinstrument dar.

Schlüsselwörter: Parental Bonding Instrument, Erziehungsstil, Deutsche Übersetzung, Psychometrische Eigenschaften, Faktorenstruktur

2.2 Abstract

Parenting behaviors affect a child's development as well as the etiology and treatment of mental disorders. The Parental Bonding Instrument (PBI; Parker, Tupling & Brown, 1979) is a well-known measurement tool to retrospectively assess parenting styles. Yet, no sufficiently validated German version exists to date. Therefore, we developed an updated translation of the German PBI version (PBI-dt) and analyzed its psychometric properties in an online survey based on a sample of *N* = 791 German-speaking participants with a focus on item and reliability characteristics, construct and criterion validity as well as factorial structure of the PBI-dt.

Results indicated good item characteristics and reliability (α = .86-.95). Correlations between PBI and CTQ-SF (Childhood Trauma Questionnaire Short Form) scales are in line with the literature. Significant differences in the reported parenting style were found between people with and without mental illness as well as between normal-weight and overweight people. These results indicate the presence of good construct and criterion validity. Confirmatory factor analyses indicated an acceptable model fit for all fit indices in the original 2-factor model of Parker et al. (1979) as well as in the 3-factor model with the scales Care, Discouragement of behavioral freedom and Denial of psychological autonomy. A 3-factor structure provided additional information, e.g., a better differentiation between normal and overweight people. Hence, this German translation of the PBI has good psychometric properties and is a reliable measuring instrument.

Keywords: Parental Bonding Instrument, Parenting Style, German Translation, Psychometric Properties, Factor analysis

2.3 Einleitung

Die Beziehung zwischen einem Kind und seinen Eltern ist nicht nur entscheidend für die frühen Entwicklungsphasen, sondern stellt auch entscheidende Weichen für das spätere Leben (Kochanska et al., 2015; Zaslow et al., 2006). So beeinflusst die Qualität dieser Bindungserfahrung die psychosoziale Entwicklung in der Kindheit ebenso wie die körperliche und psychische Gesundheit im Erwachsenenalter (Alonso et al., 2018; Marshall et al., 2018) und kann sowohl Stress auslösen als auch die Stressreaktion abmildern (Unternaehrer et al., 2021). Diese Bindung ist – neben individuellen Unterschieden im Bindungsverhalten des Kindes – besonders durch den elterliche Erziehungsstil geprägt, der sich aus mehreren Dimensionen zusammensetzt (Bowlby, 1969; Unternaehrer et al., 2019), darunter emotionale Aspekte wie Fürsorge und Wärme, sowie kognitive und Verhaltensaspekte wie Autonomieförderung oder Kontrolle und Überfürsorglichkeit (Cummings & Cummings, 2002). Kinder, die mit fürsorglichen und autonomie-fördernden Eltern aufwachsen, weisen oft ein stabileres Selbstbild und bessere interpersonale Kompetenzen (Schumacher, 2002) auf als Kindern von weniger fürsorglichen und stärker kontrollierenden Eltern. Diese berichten häufiger Schwierigkeiten im Umgang mit Stress und einen schlechteren psychischen Gesundheitszustand (Ohtaki et al., 2017). Diese negativen Bindungs- und Erziehungserfahrungen begünstigen die Entwicklung psychischer Erkrankungen wie Depressionen (Marshall et al., 2018) und Essstörungen, aber auch Übergewicht (Amianto et al., 2016) und sind darüber hinaus mit dem Therapieerfolg assoziiert (Asano et al., 2013). Verschiedene Theorien erklären diesen Zusammenhang u. a. mit neurobiologischen Veränderungen im Stresssystem (Engert, 2010b).

Um die Rolle des elterlichen Erziehungsstils für die Ätiologie und Therapie psychischer Erkrankungen besser zu verstehen, ist eine reliable, valide und international vergleichbare Erfassung des elterlichen Erziehungs- und Bindungsverhalten unerlässlich. Das Ende der 70er Jahre von Gordon Parker und Kollegen in Australien entwickelte originale Parental Bonding Instrument (PBI-org) bietet ein häufig genutztes Messinstrument mit jeweils 25 Items für Mutter und Vater (Parker et al., 1979), das auf der subjektiven Beurteilung des erinnerten Erziehungsstil während der ersten 16 Lebensjahre beruht. Auch wenn die zeitliche Stabilität des Erziehungsverhaltens ebenso wie die Validität des PBI-org als retrospektiver Selbstbericht häufig kritisch diskutiert wurde (Parker, 1990; Wilhelm et al., 2005), weist das PBI-org gute Testgütekennwerten auf und ist in viele Sprachen verfügbar (u. a. niederländisch (Arrindell et al., 1989), spanisch (Gómez-Beneyto et al., 1993), japanisch (Kitamura & Suzuki, 1993)). Für die Verwendung des PBI im deutschsprachigen Raum ergeben sich jedoch zwei weitere Schwierigkeiten: zum einen die psychometrische Qualität der verfügbaren deutschen Übersetzungen des PBI und zum anderen die Faktorenstruktur. Zum einen existieren für die zwei vorliegenden deutschen Übersetzungsversionen keine oder nur unvollständige Überprüfungen psychometrischer Eigenschaften. Dabei handelt es sich um eine Übersetzung von Leonhardt (1991) in Zusammenarbeit mit Kommer (Leonhardt, 1991) und eine zweite freiere Übersetzung mit veränderter Itemreihenfolge und Skalierung von Lutz, Heyn und Kommer von 1995, die als Fragebogen zur elterlichen Bindung (FEB) veröffentlicht wurde (Lutz et al., 1995). Während der FEB zwar einen nützlichen Ausgangspunkt für die deutschsprachige Anwendung des PBI mit einer 2-Faktorenstruktur und guter bis sehr guter interner Konsistenz bietet, fehlen jedoch Informationen zum Analyseprozess (Moosbrugger & Kelava, 2012). Zum anderen ist die Faktorenstruktur des PBI umstritten. Parkers Team identifizierte bereits in der Entwicklungsphase des PBI mittels explorativer Faktorenanalyse drei Faktoren, die sie aufgrund statistischer und inhaltlicher Überlegungen auf zwei Faktoren, *Fürsorge* (Care) und *Kontrolle* (Overprotection), reduzierten. Diese zwei Skalen ermöglichen mithilfe von Schwellenwerten eine oft genutzte Einteilung in vier Erziehungsstile: *optimale Bindung* (hohe Fürsorge und geringe Kontrolle), *liebevoll-einschränkend* (hohe Fürsorge und Kontrolle), *lieblos-kontrollierend* (geringe Fürsorge und hohe Kontrolle) und *fehlende oder schwache Bindung* (geringe Fürsorge und Kontrolle) (Parker et al., 1979). Während diese ursprünglich vorgeschlagene 2-Faktorenstruktur mehrfach repliziert wurde (u. a. Arrindell et al., 1989), konnten andere Forschungsgruppen je nach Übersetzungsversion des PBI Belege für 3-Faktorenlösungen (Mohr et al., 1999), sowie für eine 4-Faktorenlösung finden (Uji et al., 2006). Neben methodischen scheinen dabei auch kulturelle Aspekte für die unterschiedlichen Faktorenlösungen relevant zu sein. Während der ursprünglich von Parker berichtete Faktor *Fürsorge*, d. h. das Erleben von elterlicher Wärme, Zuneigung und Unterstützung, als eindeutiger Faktor identifiziert werden konnte, wurde der Faktor *Kontrolle* oftmals in zwei unterschiedliche Faktoren, insbesondere

Einschränkung von Verhaltensfreiheit und *Verweigerung von psychologischer Autonomie unterteilt*. Diese teilen überbehütendes und kontrollierendes Verhalten der Eltern auf in verhaltensbezogene Einschränkungen, z. B. strenge Regeln bezüglich Kleidung oder Freizeitgestaltung, und die Begrenzung der Selbständigkeit eines Kindes (Mohr et al., 1999). Eine Darstellung drei verschiedener Faktormodelle und deren Itemzuordnung findet sich im Zusatzmaterial (Tab. Z2).

Ziel dieser Studie war die psychometrische Überprüfung einer aktuellen deutschen Version des PBI, da für eine zuverlässige Verwendung einer Fragebogenübersetzung nicht ohne Weiteres von den gleichen psychometrischen Eigenschaften wie im Original ausgegangen werden kann (Eysenck & Eysenck, 1983). Dazu erstellten wir eine aktuelle deutsche Übersetzung des PBI (PBI-dt), die sich nah am Originalfragebogen (PBI-org) orientiert und dessen Itemreihenfolge und Skalierung beibehält. Die psychometrischen Eigenschaften des PBI-dt und die Modellanpassungsgüte verschiedener Faktorenlösungen prüften wir anhand einer großen Online-Stichprobe. Zur Abschätzung der konvergenten sowie diskriminanten Konstruktvalidität untersuchten wir als erste Annäherung Zusammenhänge der PBI-dt Subskalen mit Skalen des Childhood Trauma Questionnaire Short-Form (CTQ-SF) (Wingenfeld et al., 2010). Der CTQ-SF erfasst belastende und traumatische Erlebnisse in Kindheit und Jugend auf fünf Subskalen (emotionaler, körperlicher und sexueller Missbrauch, sowie emotionale und körperliche Vernachlässigung), die unterschiedlich stark mit den PBI Skalen korrelieren (McGinn et al., 2005). Die Hypothese, dass psychisch Erkrankte sowie Übergewichtige weniger Fürsorge und mehr Kontrolle von den Eltern berichten, diente der Abschätzung der Kriteriumsvalidität.

2.4 Methode

2.4.1 Übersetzungsprozess

Um eine sprachlich aktuelle, deutsche Übersetzung des PBI zu erstellen und dabei sprachliche, konzeptionelle und metrische Vergleichbarkeit zum PBI-org zu schaffen, führten wir einen mehrstufigen Übersetzungsprozess entsprechend der European Social Survey Translation Guidelines zur Übersetzung von Fragebögen durch (European Social Survey, 2018). Der Übersetzungsprozess wurde fortlaufend dokumentiert und umfasste Parallelübersetzungen, einen moderierten Review-

Prozess, die sprachliche Überprüfung durch unabhängige Experten und einen kognitiven Pretest. Der Ablauf des Übersetzungsprozesses und die finale Übersetzungsversion des PBI-dt inklusive Auswertungshinweise sind im Anhang (Appendix, Zusatzmaterial Z1 und Z2) zu finden.

2.4.2 Stichprobe

Die Daten dieser Onlinestudie wurden im Sommer 2019 über multiple Rekrutierungskanäle (u.a. Flyer, soziale Netzwerke, Internetforen, Details s. Zusatzmaterial Abb. Z1) im deutschsprachigen Raum erhoben (Reips & Franek, 2004). Basierend auf Indikatoranzahl pro Faktor (*p/f* = 12 bzw. *p/f* = 13) und in früheren Studien berichteten Faktorladungen im PBI-org zielten wir auf eine Minimalstichprobengröße von N_{min} = 400 (Gagne & Hancock, 2006). Von insgesamt 1,203 Rückmeldungen wurden *N* = 791 Personen (82% Frauen, mittleres Alter = 28.37 ±8.53 Jahre, Range: 18-67, weitere Details in ***Tab. 1***) in die Analysen eingeschlossen. Ausschlusskriterien waren: (1) fehlende Einverständniserklärung zur Studienteilnahme und Datenspeicherung (*n* = 3), (2) Alter < 18 Jahre (*n* = 0), (3) vorzeitiger Abbruch der Umfrage (*n* = 215), (4) falsche Beantwortung zweier Kontrollitems („Bitte kreuzen Sie hier *‚trifft nicht zu‘* an.“; vgl. Gummer et al., 2021), *n* = 58), (5) mangelnde Deutschkenntnisse (unter C1-Niveau, *n* = 7), (6) Werte > 20% fehlende in PBI-dt und CTQ-SF (*n* = 8), (7) fehlender Kontakt zu beiden leiblichen Eltern während der ersten 16 Lebensjahre (*n* = 121). (Flussdiagramm zum Ablauf des Rekrutierungs- und Fallausschlussprozesses und zusätzliche Stichprobenmerkmale s. Appendix, Abbildung Z1, Tabelle Z1a und b).

Tab. 1. Soziodemographische und psychologische Merkmale der Stichprobe (*N* = 791)

	n	**%**
Deutsche Sprachkenntnisse		
Muttersprache	766	96.84
Fließend	25	3.16
Ausbildungsniveau		
Haupt-/Realschulabschluss	33	4.17
Abitur oder Fachhochschulreife	291	36.79
Berufsausbildung	105	13.27
Hochschulabschluss	339	42.86
Anderes Niveau (inklusive Promotion)	23	2.91

	n	%
Studierende (*n*=789)		
Kein Studierender	354	44.75
Studierende im Voll- der Teilzeitstudium	435	54.99
Psychische Erkrankung (*n*=734)		
Keine psychische Erkrankung	599	57.73
Psychische Erkrankung	135	17.07.
BMI (*n*=718)		
Normalgewicht (18.5≤BMI<25)	505	70.33
Übergewicht (25≤BMI≤40)	213	29.67
Bezugsperson [a]		
Beide leiblichen Eltern	393	49.68
Leibliche Mutter	320	40.46
Leiblicher Vater	39	4.93
Keine Hauptbezugsperson vorhanden	21	2.65
Andere Hauptbezugsperson (z.B. Großmutter)	18	2.28

Anmerkungen. Abweichender Stichprobenumfang bei fehlender Angabe in Klammern. *n* = absolute Häufigkeit, % = relative Häufigkeit gerundet auf zwei Nachkommastellen, sodass in einzelnen Fällen 100% überstiegen werden kann.
[a] Ggf. weitere Person wie Bruder/Schwester als zusätzliche Bezugspersonen möglich

2.4.3 Studienablauf

Die Teilnahme an der 15-minütigen Onlinestudie wurde anonym und über qualtrics.com (Qualtrics, Provo, UT) durchgeführt. Der Fragebogen erfasste neben den nachfolgend erläuterten Messinstrumenten soziodemographische Daten, Gewicht und Größe zur Berechnung des Body Mass Index (BMI), Informationen zur Kindheit und den Eltern, sowie die psychische Gesundheit. Der aktuell subjektiv wahrgenommene psychische Gesundheitszustand wurde unter Berücksichtigung der zeitlichen Dauer des Fragebogens mit einem globalen dichotomen Item erfragt („Leiden Sie aktuell an einer psychischen Erkrankung?“). Basierend auf dieser subjektiven Einschätzung wurden die Versuchspersonen im Folgenden in psychisch Gesunde und psychisch Erkrankte eingeteilt. Am Ende der Befragung wurden unter allen Teilnehmenden zehn Amazon-Gutscheine im Wert von jeweils 50€ verlost. Studierende der Universität Konstanz erhielten zusätzlich eine halbe Versuchspersonenstunde. Ein positives Votum der Ethikkommission der Universität Konstanz lag vor.

2.4.4 Messinstrumente

2.4.4.1 PBI

Der elterliche Erziehungsstil wurde mit der neu erstellten Version des PBI-dt erfasst, die zusammen mit Auswertungshinweisen sowie der Itemzuordnung in den unterschiedlichen Faktormodellen in den Zusatzmaterialien zu finden ist (Zusatzmaterial Z2; Tab. Z2). Befragte werden instruiert, sich an ihre Eltern während ihrer ersten 16 Lebensjahre zu erinnern und jeweils 25 Items für Vater und Mutter auf einer vierstufigen Likert-Skala (0 = trifft überhaupt nicht zu, 3 = trifft absolut zu) zu beurteilen. Wenn ein Elternteil fehlte (nicht bekannt, frühzeitig verstorben, keine Erinnerung), wurde der jeweilige Fragebogenteil nicht vorgelegt und die Person entsprechend der zuvor gelisteten Einschlusskriterien für die Analysen dieser Studie ausgeschlossen. Nach der Rekodierung invers formulierter Items wurden die entsprechenden Skalensummenwerte gebildet.

2.4.4.2 CTQ-SF

Die deutsche Version des CTQ-SF (Wingenfeld et al., 2010) erfasst traumatische Erlebnisse in Kindheit und Jugend. Befragte beurteilen retrospektiv das Auftreten traumatischer Erfahrungen anhand von 28 Items auf einer fünfstufigen Likert-Skala (1=überhaupt nicht, 5=sehr häufig). Der Fragebogen umfasst fünf Unterskalen: *Emotionale Vernachlässigung*, Emotionaler Missbrauch, *Körperliche Vernachlässigung*, *Körperliche Misshandlung*, *Sexueller Missbrauch*. Zusätzlich wird mit drei Items die *Bagatellisierungstendenz* erfasst. Nach der Rekodierung inverser Items wurden Skalensummenwerte gebildet, wobei höhere Werte ein größeres Ausmaß an Misshandlung oder Vernachlässigung abbilden.

2.4.5 Statistische Analyse

Nachdem Fälle mit >20% fehlender Werte in PBI-dt und CTQ-SF ausgeschlossen wurden und eine Missing Value Analyse keine systematischen Muster und Abhängigkeiten ergab, wurden fehlende Werte mit einer einfachen Median-Imputation ersetzt (insgesamt i = 15 Items im PBI-dt und i = 7 Items im CTQ-SF) [32]. Nach ersten deskriptiven Berechnungen verglichen wir die Skalenmittelwerte entsprechend des PBI-org mit einem t-Test für verbundene Stichproben zwischen Mutter und Vater. Anschließend untersuchten wir die faktorielle Struktur getrennt für Mutter und Vater zunächst in exploratorischen Faktorenanalysen (EFA) mittels Minimum-Average-Partial-Test (MAP-Test), Parallelanalyse und Maximum-Likelihood (ML) Faktorenanalyse mit Varimax-Rotation. Darauf aufbauend verglichen wir das in der EFA ermittelte Faktorenmodell zusammen mit drei unterschiedlichen in früheren Studien berichteten Faktorenmodelle hinsichtlich ihrer Modellanpassungsgüte: das 2-Faktorenmodell nach Parker et al. (2-FM-Parker; Parker et al., 1979), mit den zwei Faktoren *Fürsorge* und *Kontrolle*, das 3-Faktorenmodell nach Mohr et al. (3-FM-Mohr; Mohr et al., 1999), mit den drei Faktoren *Fürsorge*, *Einschränkung der Verhaltensfreiheit* und *Verweigerung psychologischer Autonomie*, und das 4-Faktorenmodell nach Uji et al. (4-FM-Uji; Uji et al., 2006), mit den vier Faktoren *Fürsorge*, *Indifferenz*, *Kontrolle* und *Autonomie*. Eine detaillierte Auflistung der jeweiligen Subskalen und Itemzuordnungen ist im Anhang (Tabelle Z2) zu finden. Um die Modellanpassungsgüte dieser Modelle zu überprüfen und zu vergleichen, berechneten wir im nächsten Schritt eine konfirmatorische Faktorenanalyse (CFA) (Weiber & Mühlhaus, 2014). Dazu nutzen wir eine robuste Variante des ML-Schätzers mit Yuan-Bentler-Korrektur und nach Huber-White geschätzten Standardfehlern (MLR), um einer Verletzung der Multinormalverteilungsvoraussetzung entgegenzuwirken, und berücksichtigten a-priori-korrelierte Residuen auf Item-Ebene zwischen Items mit paralleler oder sehr ähnlicher Formulierung und Semantik (Item 8 und 13, Item 7 und 15, Item 11 und 18). Vier verschiedene Fitindizes dienten der Evaluation der Modellanpassungsgüte: (1) Inferenzstatistischer RMSEA (Root Mean Square Error of Approximation), (2) deskriptiver SRMR (Standardized Root Mean Square Residual), (3) CFI (Comparative Fit-Index) sowie (4) TLI (Tucker-Lewis-Index). Für eine gute Anpassungsgüte sollten RMSEA und SRMR Werte ≤ .05 bzw ≤ .06 aufweisen, mit besserer Anpassung bei geringeren die Werten. Eine ausreichende Anpassungsgüte ist hier Simulationsstudien zufolge ab Werten von ≤ .08 erreicht. CFI und TLI zeigen dagegen bei höheren Werten eine bessere Anpassung an und sollten nach gängigen Bewertungskriterien Werte von ≥ .90 erreichen (Hu & Bentler, 1999). Für die Fitindizes RMSEA, CFI und TLI berichten wir jeweils die robuste Variante. Die Kombination von EFA und CFA mit den gewählten vier Fitindizes soll die Komplexität des Konzepts der Modellanpassungsgüte berücksichtigen (Weiber & Mühlhaus,

2014) und Fehler erster und zweiter Art reduzieren (Hu & Bentler, 1999). Auf das Ergebnis der CFA aufbauend berechneten wir gängige Item- und Reliabilitätskennwerte auf Indikator- und Konstruktebene (Moosbrugger & Kelava, 2012). Eine ausführliche Erklärung des Vorgehens und aller berechneten Kennwerte mit den jeweils empfohlenen Schwellenwerten findet sich im Zusatzmaterial (Tab. Z3). Zur Abschätzung der Konstrukt- sowie Kriteriumsvalidität berechneten wir Pearson-Korrelationen zwischen PBI-dt- und CTQ-SF-Subskalen sowie t-Tests für unabhängige Stichproben zwischen psychisch Erkrankten und psychisch Gesunden und zwischen Normal- ($18.5 \leq BMI < 25$) und Übergewichtigen ($25 \leq BMI > 40$). Untergewichtige Personen mit einem BMI < 18.5 ($n = 45$) und schwer übergewichtige Personen mit einem BMI ≥ 40 ($n = 11$) wurden aus der Analyse ausgeschlossen, um zu unbalancierte Gruppen im statistischen Mittelwertsvergleich zu vermeiden. Aufgrund ausgeschlossener und fehlender Werte basierten die Berechnungen bezüglich der psychischen Gesundheit auf $n = 734$ Personen, bezüglich des BMI auf $n = 718$ Personen. Effektgrößen der Mittelwertsvergleiche wurden mit Cohen‘s d und 95%-igem Konfidenzintervall (KI) ermittelt.

Die Analysen wurden mit den Software-Programmen SPSS Version 25.0 (IBM SPSS, 2017), Mplus 4.21 (Muthén & Muthén, 2006) und R Studio Version 3.6.1 (R Core Team, 2021) unter Verwendung der R-Packages stats (R Core Team, 2021), psych (Revelle, 2020), lavaan (Rosseel, 2012) durchgeführt. Zur Beurteilung der Ergebnisse wurde ein Signifikanzniveau von 5% festgelegt und die für den jeweiligen Kennwert gängigen Schwellenwerte herangezogen (Bagozzi & Yi, 1988).

2.5 Ergebnisse

2.5.1 Stichprobenmerkmale

Tab. 2 stellt die durchschnittlichen Ausprägungen der im PBI-dt berichteten mütterlichen und väterlichen Fürsorge und Kontrolle in dieser Stichprobe den Werten im PBI-org der australischen Normstichprobe (Parker et al., 1979) gegenüber. Unsere Versuchspersonen bewerteten Mütter signifikant fürsorglicher, $t(790) = 12.24$, $p < .001$, und kontrollierender, $t(790) = 8.20$, $p < .001$, als Väter.

Tab. 2. Durchschnittliche berichtete mütterliche und väterliche Fürsorge und Kontrolle in der aktuellen deutschen (2019) und der von Parker und Kollegen 1979 untersuchten australischen Stichprobe

	Fürsorge		Kontrolle		Stichprobengröße
Studie	Mutter	Vater	Mutter	Vater	(N)
Aktuelle Onlinestudie PBI-dt (2019)	26.9 (±8.2)	23.3 (±8.7)	11.4 (±7.6)	9.2 (±7.5)	791
Parker et al. (1979)	26.9	23.8	13.3	12.5	410

Anmerkung. Aufgrund fehlender Angaben zur Standardabweichung in der australischen Normstichprobe ist nur die Standardabweichung in der deutschen Stichprobe bekannt und in Klammer angegeben.

2.5.2 Faktorielle Validität

In einer EFA ergab die Parallelanalyse ebenso wie die ML-Faktorenanalyse mit Varimax-Rotation für Mutter bzw. Vater beste Varianzaufklärung bei einer 3-Faktorenlösung (kumulierte Varianzaufklärung: .57 bzw. .58, Faktorladungen .47 – .83 bzw. .48 – .80), die in ihrer Itemzuordnung vollständig dem 3-FM-Mohr entsprach (Details s. Zusatzmaterial Tab. Z4). Darauf aufbauend prüften wir in einer CFA getrennt für die PBI-dt-Versionen für Mutter und Vater die Modellanpassungsgüte der drei zuvor ausgewählten Faktorenmodelle: 2-FM-Parker, 3-FM-Mohr (identisch zu der Faktorenlösung unserer EFA), 4-FM-Uji.

Alle drei Modelle wiesen insgesamt in allen betrachteten Fitindizes eine ausreichende bis gute Modellanpassungsgüte auf (s. ***Tab. 3***). Während die Inter-Faktorkorrelationen im 2-FM-Parker und im 3-FM-Mohr alle im empfohlenen Bereich ≤ .90 lagen (Bagozzi & Yi, 1988), wiesen teilweise hohen Inter-Faktorkorrelationen im 4-FM-Uji ($r_{F1, F2}$ = .98-.99) auf eine mangelnde Diskriminanzvalidität der Faktoren dieses Modells hin (vollständige Auflistung s. Appendix, Tabelle Z5). Für den PBI-dt können wir das 4-FM-Uji daher nicht empfehlen. Das 3-FM-Mohr konnte die Datenstruktur auf Basis dieser Analysen ebenso gut reproduzieren wie das gängige 2-FM-Parker. Da das 3-FM-Mohr eine deskriptiv geringfügig bessere Modellanpassungsgüte aufweist, werden alle nachfolgenden Ergebnisse unter Verwendung dieses Modells berichtet und die Ergebnisse unter Verwendung des 2-FM-Parker in den Zusatzmaterialien aufgeführt. Im 3-FM-Mohr (siehe Fig. 2) entspricht der erste Faktor dem von Parker ursprünglich berichteten Faktor *Fürsorge* und der ursprünglich postulierte Faktor Kontrolle wird in die zwei Faktoren

Einschränkung der Verhaltensfreiheit und *Verweigerung psychologischer Autonomie* aufgeteilt (Mohr et al., 1999).

Tab. 3. Fitindizes der drei untersuchten Faktorenmodelle für PBI-dt Mutter und Vater

	2-FM-Parker (1979)	**3-FM-Mohr (1999)**	**4-FM-Uji (2006)**
Mutter			
RMSEA	.074	.065	.065
SRMR	.064	.062	.062
CFI	.91	.93	.93
TLI	.90	.92	.92
Chi^2 (df)	1260.65 (271)	1040.24 (269)	1028.63 (266)
Vater			
RMSEA	.079	.071	.070
SRMR	.065	.063	.063
CFI	.90	.92	.92
TLI	.89	.91	.91
Chi^2 (df)	1405.76 (271)	1174.44 (269)	1144.78 (266)

Anmerkungen. Konfirmatorische Faktorenanalyse (CFA) mit Maximum Likelihood Robust-Schätzer (MLR) und a-priori-korrelierten Residuen auf Item-Ebene für die PBI-dt-Versionen der Mutter und des Vaters. RMSEA = Root Mean Square Error of Approximation, SRMR = Standardized Root Mean Square Residual, CFI = Comparative Fit-Index, TLI = Tucker–Lewis-Index. Für die Fitindizes RMSEA, CFI und TLI berichten wir jeweils die robuste Variante, für die Chi^2-Teststatistik berichten wir die robuste Variante mit Yuan-Bentler Korrektur. Besserer Modell-Fit wird durch kleinere RMSEA- und SRMR-Werte und durch höhere CFI- und TLI-Werte angezeigt.

Neben den in ***Tab. 2*** berichteten Fürsorge-Werte wurde im Durchschnitt eine Einschränkung der Verhaltensfreiheit durch die Mutter von *M* = 5.5 (*SD* = 3.7), durch den Vater von *M* = 4.9 (*SD* = 4.0) berichtet. Das Ausmaß erlebter mütterlicher Verweigerung psychologischer Autonomie lag in der Stichprobe bei *M* = 5.8 (*SD* = 4.6), väterlicherseits bei *M* = 4.3 (*SD* = 4.2).

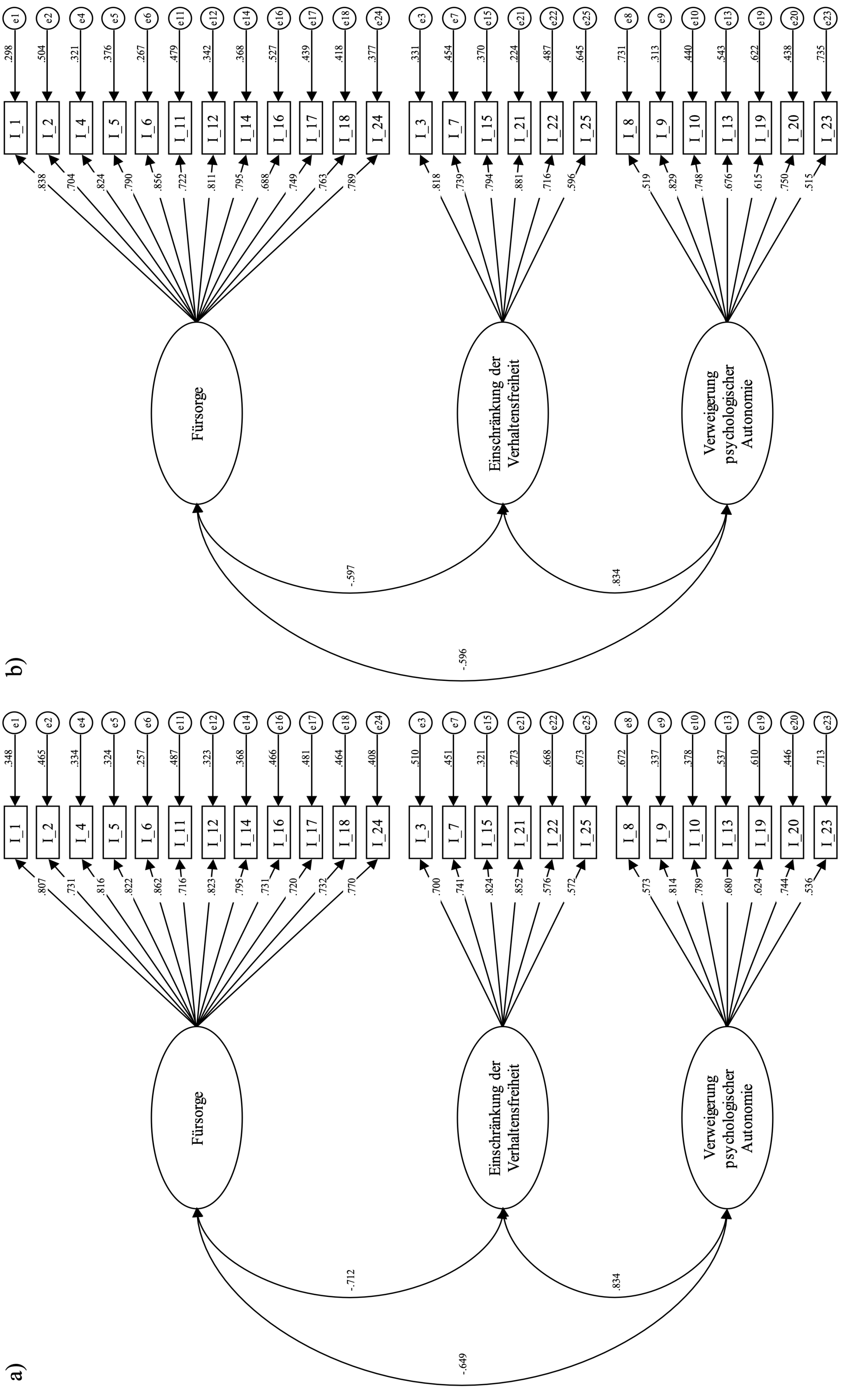

Fig. 2. Messmodell der Konfirmatorischen Faktorenanalyse (CFA) für das 3-FM-Mohr PBI a) für den PBI-dt Mutter und b) für die PBI-dt Vater-Version. Standardisierte Faktorladungen der CFA auf den drei latenten Variablen, standardisierte Inter-Faktor-Korrelationen und Residualvariablen. Direkt beobachtbare Messvariablen (Items) sind in Kästchen, latente Variablen/Faktoren in Ellipsen und Residuen durch Kreise dargestellt.

Tab. 4. Itemstatistiken PBI-dt Mutter und Vater

Item	Mutter M (SD)	Mutter r_{it}	Mutter Faktorladung	Vater M (SD)	Vater r_{it}	Vater Faktorladung
Skala Fürsorge	(Cronbach´s α = .95, McDonald´s ω_t = .95)			(Cronbach´s α = .95, McDonald´s ω_t = .95)		
1. „Sprach mit einer warmen und freundlichen Stimme zu mir."	2.34 (0.76)	.77	.81	2.05 (0.83)	.80	.84
2. „Half mir nicht so sehr, wie ich es gebraucht hätte." (R)	2.09 (0.99)	.71	.73	1.89 (1.04)	.69	.70
4. „Wirkte mir gegenüber gefühlskalt." (R)	2.46 (0.85)	.79	.82	2.17 (0.92)	.79	.82
5. „Schien meine Probleme und Sorgen zu verstehen."	1.97 (0.90)	.80	.82	1.59 (0.88)	.78	.79
6. „War liebevoll zu mir."	2.48 (0.75)	.83	.86	2.22 (0.81)	.82	.86
11. „Besprach gern Dinge mit mir."	2.00 (0.92)	.70	.72	1.55 (0.95)	.72	.72
12. „Lächelte mich häufig an."	2.21 (0.86)	.80	.82	1.93 (0.85)	.78	.81
14. „Schien nicht zu verstehen, was ich brauchte oder wollte." (R)	1.99 (0.92)	.77	.80	1.73 (0.96)	.78	.80
16. „Gab mir das Gefühl, nicht erwünscht zu sein." (R)	2.60 (0.78)	.71	.73	2.57 (0.77)	.66	.69
17. „Konnte mich beruhigen, wenn ich aufgebracht war."	1.98 (0.86)	.70	.72	1.61 (0.91)	.73	.75
18. „Redete nicht sehr viel mit mir." (R)	2.44 (0.81)	.72	.73	1.90 (0.99)	.76	.76
24. „Lobte mich nicht." (R)	2.30 (0.90)	.75	.77	2.08 (1.00)	.76	.79
Skala Einschränkung der Verhaltensfreiheit	(Cronbach´s α = .86, McDonald´s ω_t = .87)			(Cronbach´s α = .89, McDonald´s ω_t = .88)		
3. „Ließ mich die Dinge tun, auf die ich Lust hatte." (R)	0.87 (0.70)	.68	.70	0.83 (0.82)	.78	.82
7. „Mochte es, wenn ich meine eigenen Entscheidungen traf." (R)	0.96 (0.83)	.66	.74	0.82 (0.82)	.68	.74
15. „Ließ mich meine eigenen Entscheidungen treffen." (R)	0.84 (0.75)	.74	.82	0.76 (0.73)	.75	.79
21. „Gab mir so viel Freiraum, wie ich brauchte." (R)	0.92 (0.79)	.76	.85	0.81 (0.82)	.80	.88
22. „Ließ mich ausgehen, so oft ich wollte." (R)	1.16 (0.92)	.57	.58	1.03 (0.94)	.69	.72
25. „Ließ mich anziehen, was mir gefiel." (R)	0.80 (0.77)	.56	.57	0.63 (0.78)	.58	.60
Skala Verweigerung psychologischer Autonomie	(Cronbach´s α = .87, McDonald´s ω_t = .85)			(Cronbach´s α = .86, McDonald´s ω_t = .85)		
8. „Wollte nicht, dass ich erwachsen werde."	0.73 (0.82)	.59	.57	0.63 (0.81)	.54	.52
9. „Versuchte alles, was ich tat, zu kontrollieren."	0.91 (0.92)	.71	.81	0.64 (0.84)	.71	.83
10. „Drang in meine Privatsphäre ein."	0.91 (0.94)	.66	.79	0.57 (0.80)	.63	.75
13. „Neigte dazu, mich wie ein kleines Kind zu behandeln."	0.96 (0.86)	.67	.68	0.81 (0.86)	.67	.68
19. „Versuchte, dass ich mich abhängig von ihr/ihm fühlte."	0.63 (0.84)	.58	.62	0.52 (0.81)	.57	.62
20. „Glaubte, dass ich ohne sie/ihn nicht zurechtkommen würde."	0.72 (0.90)	.70	.74	0.58 (0.83)	.71	.75
23. „War überbehütend."	0.96 (0.87)	.54	.54	0.58 (0.76)	.51	.52

Anmerkungen. Darstellung der Mittelwerte (*M*) und Standardabweichungen (*SD*) der Item-Rohwerte sowie korrigierter Trennschärfekoeffizienten (r_{it}) und Faktorladungen der Items im 3-FM-Mohr. Varianz und Schiefe können der ausführlichen Tabelle in den ergänzenden Materialien entnommen werden. (R) = Items, die invers kodiert wurden.

2.5.3 Item-und Reliabilitätsanalyse

In **Tab. 4** sind relevante Itemkennwerte sowie Cronbach's α für die jeweiligen Subskalen dargestellt. Dabei zeigt sich, dass mit einer Spannweite von 0–3 alle Antwortkategorien ausgeschöpft wurden und alle Itemmittelwerte im oder sehr nah am empfohlenen Bereich lagen. Sie können direkt als Schwierigkeitsindex interpretiert werden und ermöglichen eine optimale Differenzierung (Moosbrugger & Kelava, 2012). Ebenso sind alle Trennschärfen und standardisierten Faktorladungen mit Werten über .50 als gut oder sogar sehr gut (≥ .70) zu bewerten, wobei Item 23 für beide Kenngrößen die geringsten Werte aufwies. Die interne Konsistenz kann mit Werten für Cronbach's α zwischen .86 und .95 und für McDonald's ω_t zwischen .85 und .95 als sehr gut bewertet werden. Weitere Reliabilitätskennwerte auf Konstrukt- und Indikatorebene, die insgesamt eine gute Reliabilität nahelegen, können dem Anhang entnommen werden (Appendix, Tabelle Z6).

2.5.4 Konstrukt- und Kriteriumsvalidität

Zur Einschätzung der Validität des PBI-dt wurden erstens Korrelationen zwischen den Subskalen des PBI-dt und des CTQ-SF zur Abschätzung der konvergenten und diskriminanten Validität und zweitens Unterschiede im PBI-dt in Bezug auf den psychischen Gesundheitszustand und den BMI zur Abschätzung der Kriteriumsvalidität untersucht. Die a priori aufgestellten Erwartungen bezogen sich explizit auf die Zwei-Skalenlösung, wobei aufgrund der Ergebnisse der CFA die Skalen des 3-FM-Mohr mitberücksichtigt wurden.

2.5.4.1 CTQ-SF

Die Skala Fürsorge wies eine hohe negative Korrelation mit der CTQ-SF-Skala Emotionale Vernachlässigung auf (Mutter: $r = -.84$, $p < .001$; Vater: $r = -.68$, $p < .001$). Die Skala Kontrolle zeigte eine hohe positive Korrelation mit der CTQ-SF-Skala Emotionaler Missbrauch (Mutter: $r = .58$, $p < .001$; Vater: $r = .49$, $p < .001$). Ebenso wiesen die Skalen Verweigerung psychologischer Autonomie (Mutter: $r = .52$, $p < .001$; Vater: $r = .46$, $p < .001$) und Einschränkung der Verhaltensfreiheit (Mutter: $r = .55$, $p < .001$; Vater: $r = .45$, $p < .001$) einen mittleren bis hohen positiven Zusammenhang mit der Skala Emotionaler Missbrauch auf. Die niedrigsten Korrelationskoeffizienten der PBI-dt- und CTQ-SF-Skalen fanden sich in Bezug auf die CTQ-SF-Skala Sexueller Missbrauch. Die CTQ-SF-Skala Sexueller Missbrauch korrelierte mit allen PBI-dt Skalen nur schwach ($r \leq .20$) (Moosbrugger & Kelava, 2012) (alle Interkorrelationen s. Appendix, Tabelle Z8).

2.5.4.2 Psychische Gesundheit

Personen, die an einer psychischen Erkrankung litten, berichteten im PBI-dt eine signifikant geringere mütterliche, $t(732) = 10.35$, $p < .001$, $d = .99$, 95% KI [.79, 1.18], und väterliche Fürsorge, $t(732) = 7.96$, $p < .001$, $d = .76$, 95% KI [.57, .95], sowie eine signifikant höhere mütterliche, $t(732) = -8.37$, $p < .001$, $d = -.80$, 95% KI [-.99, -.61], und väterliche Kontrolle, $t(732) = -7.20$, $p < .001$, $d = .69$, 95% KI [-.88, -.50], als psychisch Gesunde. In der 3-Faktorenlösung zeigte sich, dass Personen, die an einer psychischen Erkrankung litten, eine signifikant höhere mütterliche, $t(732) = -6.84$, $p < .001$, $d = -.65$, 95% KI [-.84, -.46], und väterliche Einschränkung der Verhaltensfreiheit, $t(732) = -6.33$, $p < .001$, $d = -.60$, 95% KI [-.79, -.41], sowie eine signifikant höhere mütterliche, $t(732) = -8.20$, $p < .001$, $d = -.78$, 95% KI [-.97, -.59], und väterliche Verweigerung psychologischer Autonomie, $t(732) = -6.86$, $p < .001$, $d = -.65$, 95% KI [-.84, -.46], als psychisch Gesunde berichteten. Unsere Hypothesen konnten hiermit für beide Faktorenlösungen gestützt werden.

2.5.4.3 BMI

Übergewichtige Personen berichteten im PBI-dt eine signifikant geringere mütterliche, $t(716) = 3.31$, $p = .001$, $d = .27$, 95% KI [.11, .43], und väterliche Fürsorge, $t(716) = 4.27$, $p < .001$, $d = .35$, 95% KI [.19, .51], sowie eine signifikant höhere mütterliche, $t(716) = -2.68$, $p = .007$, $d = -.22$, 95% KI [-.38, -.06], und väterliche Kontrolle, $t(716) = -3.71$, $p < .001$, $d = -.30$, 95% KI [-.46, -.14], als Normalgewichtige. In der 3-Faktorenlösung zeigte sich, dass übergewichtige Personen eine signifikant höhere mütterliche, $t(716) = -3.94$, $p < .001$, $d = -.32$, 95% KI [-.48, -.16], und väterliche Einschränkung der Verhaltensfreiheit, $t(716) = -4.26$, $p < .001$, $d = -.35$, 95% KI [-.51, -.19], sowie eine signifikant höhere väterliche Verweigerung psychologischer Autonomie, $t(716) = -2.62$, $p = .009$, $d = -.21$, 95% KI [-.37, -.05], im Vergleich zu normalgewichtigen Personen berichteten. Dieser signifikante Unterschied zeigte sich jedoch nicht in der Verweigerung der psychologischen Autonomie durch die Mutter, $t(716) = -1.30$, $p > .05$, $d = -.11$, 95% KI [-.27, .05]. Unsere Hypothesen konnten hiermit gestützt werden mit Ausnahme der auf Basis der Faktorenanalyse ergänzend untersuchten mütterlichen Verweigerung der psychologischen Autonomie.

2.6 Diskussion

Diese Studie untersuchte eine aktualisierte deutsche Übersetzung des Parental Bonding Instrument (PBI-dt) hinsichtlich seiner psychometrischen Eigenschaften, insbesondere die Faktorenstruktur, Item- und Reliabilitätskennwerte sowie Konstrukt- und Kriteriumsvalidität. Unsere Stichprobe zeigte vergleichbare elterliche Fürsorge und geringere mütterliche und väterliche Kontrolle als in der australischen Normstichprobe von Parker (Parker et al., 1979), wobei Veränderungen im Erziehungsstil zwischen 1979 und 2019 diese Diskrepanz erklären könnten. Die konfirmatorischen Faktorenanalysen ergaben eine ausreichende bis gute Modellanpassungsgüte des ursprünglich postulierten 2-Faktorenmodells (Parker et al., 1979), wobei das 3-FM-Mohr sowie das 4-FM-Uji eine geringfügig bessere Anpassungsgüte aufwiesen. Folglich konnten alle drei Modelle die Datenstruktur angemessen reproduzieren. Aufgrund der hohen Inter-Faktorkorrelationen und somit mangelnder Diskriminanzvalidität einzelner Faktoren im 4-FM-Uji stellte dieses Modell auf Basis dieser Daten jedoch keine geeigneten Faktorenlösung für das PBI-dt dar. 4-Faktorenlösungen wurden bisher ausschließlich in östlichen Kulturkreisen beobachtet (u. a. Liu et al., 2011). Da der elterliche Erziehungsstil als kulturabhängig gilt, könnte der vierte Faktor Indifferenz kulturelle Unterschiede zwischen westlichen-individualistischen und östlichen-kollektivistischen Kulturen widerspiegeln (Xu et al., 2018). Unsere Daten legen somit eine vergleichbar gute Anwendbarkeit des 2- und des 3-Faktorenmodells nahe. Dies steht im Einklang mit früheren Studien, die sowohl die Verwendung des 2-Faktorenmodells unterstützen (Parker, 1990) als auch eine gute Eignung des 3-Faktorenmodells postulieren (Murphy et al., 1997).

Hinsichtlich der konvergenten und diskriminanten Konstruktvalidität des PBI-dt ergaben Korrelationen zwischen PBI-dt und konstruktnahen Subskalen des CTQ-SF wie erwartet hohe Zusammenhänge (emotionaler Missbrauch und emotionale Vernachlässigung), Korrelationen zwischen PBI-dt und konstruktfernen Subskalen des CTQ-SF (sexueller Missbrauch) dagegen niedrigere Zusammenhänge. Die in dieser Studie ermittelten Zusammenhänge zwischen den PBI-dt- und CTQ-SF-Skalen stehen im Einklang mit früheren Analysen (McGinn et al., 2005) und weisen auf das Vorhandensein konvergenter sowie diskriminanter Validität hin. Die signifikanten Unterschiede des elterlichen Erziehungsstils bei psychisch erkrankten im Vergleich zu psychisch gesunden Personen sowie bei übergewichtigen im Vergleich zu normalgewichtigen Personen lassen auf das Vorhandensein von Kriteriumsvalidität des PBI-dt schließen. Beim Vergleich von normal- und übergewichtigen Personen wurde außerdem der bereits aufgeführte inhaltliche Mehrwert der 3-Faktorenlösung deutlich, die differenziertere Zusammenhänge zwischen den verschiedenen Kontroll-Aspekten und Übergewicht aufzeigen konnte: übergewichtige Personen berichteten eine stärkere Einschränkung der Verhaltensfreiheit durch die Eltern als Normalgewichtige, aber keine Unterschiede in der Verweigerung psychologischer Autonomie durch die Mutter.

Zusammenfassend empfehlen wir aufgrund der statistisch gleichermaßen zufriedenstellender Modellanpassungsgüte entweder das 2-Faktorenmodell oder das 3-Faktorenmodell basierend auf inhaltlich-theoretischen Überlegungen je nach Forschungsfrage zu verwenden. Während beide Faktorlösungen die Skala Fürsorge beinhalten, kann das 3-Faktorenmodell die Skala Kontrolle aus der 2-Fakotrenlösung weiter ausdifferenzieren in die beiden Skalen Einschränkung der Verhaltensfreiheit und Verweigerung psychologischer Autonomie. Diese zusätzliche Differenzierungsmöglichkeit kann wie in unserer Stichprobe anhand des BMI gezeigt einen inhaltlichen Mehrwert bieten. So war in den letzten Jahrzehnten der Trend in der Erziehungsstilforschung zu beobachten, elterliche Kontrolle weiter auszudifferenzieren und insbesondere zwischen psychologischer und verhaltensbezogener Kontrolle zu unterscheiden (Barber, 1996). Psychologische Kontrolle charakterisiert sich dabei insbesondere durch das Erzeugen psychologischer Abhängigkeit, elterlicher Dominanz, Grenzüberschreitung und Einsatz manipulativer Praktiken, die die Verhaltens- und Denkweisen des Kindes beeinflussen (Cubis et al., 1989; Uji et al., 2006). Verhaltenskontrolle hingegen bezieht sich auf konkrete Verhaltensaspekte, beispielsweise Kleidungs- und Ausgangregelungen und das Treffen eigenständiger Entscheidungen (Xu et al., 2018). Auch die vorliegenden Ergebnisse deuten auf einen Informationszugewinn bei einer differenzierteren Betrachtung verschiedener Arten elterlicher Kontrolle hin.

Bei der Interpretation der vorliegenden psychometrischen Überprüfung des PBI-dt sollten jedoch auch einige limitierende Aspekte berücksichtigt werden. Erstens ist die Bevölkerungsrepräsentativität unserer Stichprobe eingeschränkt aufgrund der Freiwilligkeit der Teilnahme sowie des hohen Anteils an jungen, gebildeten, weiblichen Personen. Besonders der hohe Anteil weiblicher Studienteilnehmerin schränkt die Vergleichbarkeit mit der ausgeglicheneren Originalarbeit von Parker und Kollegen ein. In Bezug auf aktuell geltende Schwellenwerte der PBI-Skalen in der deutschen Bevölkerung, insbesondere auch im Hinblick auf eine 3-Faktorenstruktur, könnte eine separate Normierungsstudie mit einer bevölkerungsrepräsentativeren Stichprobe vielleicht mehr Aufschluss geben. Zudem wurde hier lediglich die Teilstichprobe betrachtet, die zu beiden Eltern während der ersten 16 Lebensjahre Kontakt berichtete. Vor dem Hintergrund bereits berichteter Ergebnisse hinsichtlich des Effekts des frühen Verlusts eines Elternteils auf psychische Prozesse, wie das Stresserleben (Luecken, 2000), ist ein ausführlicher Vergleich der Gütekriterien des PBI-dt auch bei Personen, die während der ersten 16 Lebensjahre nicht Kontakt zu beiden Eltern hatten, ratsam. Die Generalisierbarkeit dieser Studie ist damit vor allem für jüngere, weibliche Personen, die mit beiden Elternteilen aufgewachsen sind, gegeben. Für zuverlässige Aussagen über andere soziodemographische Gruppen, sind weitere Untersuchungen zu empfehlen, weshalb in dieser Studie auf die Präsentation von Normwerten verzichtet wurde. Zweitens wurde die Kriteriumsvalidität mithilfe zweier globaler Items (psychischer Gesundheitszustand und BMI) abgeschätzt. Somit sind weder Aussagen zu spezifischen psychischen Störungen oder dem generellen Gesundheitsstatus noch zu Zusammenhängen mit differenzierteren psychopathologischen Aspekten möglich und die vorliegenden Ergebnisse lediglich als erste Hinweise auf Konstrukt- und Kriteriumsvalidität zu sehen. Die Ergänzung weiterer Messinstrumente könnte in künftigen Studien zusätzliche Informationen bieten. Drittens wurde diese Studie entsprechend der heutzutage üblichen Praxis im Rahmen einer Onlinestudie durchgeführt. Eine Überprüfung der Konstruktvalidität mittels Multitrait-Multimethod-Ansatz (Campbell & Fiske, 1959), der die Messungen der Konstrukte mit mindestens zwei unterschiedlichen Methoden (z.B. Fragebögen und Interviews) einschließt, war so nicht möglich. Jedoch wurde für die englische Originalversion des PBI bereits eine gute Konstruktvalidität berichtet (u.a. Parker, 1990). Ebenso konnte aufgrund des

Online-Formats keine Prüfung der Messäquivalenz der Paper-Pencil- und onlinebasierten Version des Fragebogens erfolgen. Empirische Befunde weisen jedoch darauf hin, dass unter sonst gleichen Bedingungen ein Online-Fragebogen psychometrisch äquivalent zu einem Papierfragebogen ist (Reips & Franek, 2004).

Die aktualisierte, deutsche Übersetzung des PBI bietet nichtsdestotrotz gute psychometrische Eigenschaften zur Messung des elterlichen Erziehungsstils. Sowohl die Items als auch die Subskalen zeigen mindestens akzeptable bis sehr gute statistische Kennwerte und die Analyseergebnisse lassen auf das Vorhandensein von Konstrukt- und Kriteriumsvalidität der Übersetzung schließen. Das 3-Faktorenmodell mit den Skalen Fürsorge, Einschränkung der Verhaltensfreiheit sowie Verweigerung psychologischer Autonomie ergab eine geringfügig bessere Modellanpassungsgüte als das ursprüngliche 2-Faktorenmodell. Beide Faktorlösung sind somit für den PBI-dt gut geeignet. Die Differenzierung verschiedener Formen elterlicher Kontrolle in der 3-Faktorenlösung könnte einen inhaltlichen Mehrwert bieten. Eine Messinvarianzprüfung, die Prüfung der faktoriellen Validität anhand explorativer Strukturgleichungsmodelle, sowie weiterer Validitätsaspekte sollten in künftigen Studien untersucht werden. Basierend auf einer 3-Faktorenlösung könnten diese künftigen Studien detaillierterer Zusammenhänge zwischen dem Erziehungsverhalten und seinen Konsequenzen aufzeigen als dies bisher mit der ursprünglichen 2-Faktorenstruktur möglich war.

2.7 Fazit für die Praxis

Die aktualisierte deutsche Version des Parental Bonding Instruments (PBI-dt) zeigt gute teststatistische Kennwerte und stellt ein reliables und valides Messinstrument zur Erfassung des elterlichen Erziehungsverhaltens dar. Je nach Einsatzgebiet oder Forschungsfrage können elterliche Verhaltenstendenzen retrospektiv für die ersten 16 Lebensjahre getrennt für Vater und Mutter entweder auf den zwei Dimensionen Fürsorge und Kontrolle oder mit geringfügig besserer Modellanpassungsgüte und stärkerer inhaltlicher Differenzierung auf den drei Dimensionen Fürsorge, Einschränkung der Verhaltensfreiheit und Verweigerung psychologischer Autonomie erfasst werden.

3 THE DURATION OF THE CORTISOL AWAKENING PULSE EXCEEDS SIXTY MINUTES IN A MEANINGFUL PATTERN

One of the biological systems that is affected by calibration processes in response to early life adversity is the hypothalamic-pituitary-adrenal (HPA) axis (Strüber et al., 2014). The HPA axis is an important component of an adaptive stress response and involved in energy mobilization to deal with daily hassles. Looking at the general regulation of the HPA axis, the cortisol awakening response (CAR) provides a well-established parameter to operationalize the integrity of the HPA axis and thus a valuable focus of research questions directed at (psychobiological) consequences of early life adversity and their potential role in the development of mental disorders. From a psychopathological perspective, the CAR seems to play a role as both a cause and effect of psychopathology. Thus, a rigorous assessment of the CAR is crucial to clarify its role and discover mechanisms involved in the modulation of the CAR.

The study presented in this chapter examined cortisol dynamics after awakening beyond the customary assessment duration of 60 minutes to investigate ultradian rhythmicity as a starting point for further research of correlates of cortisol pulsatility. Together with Bachelor student Mara Mankin I refined the research design initially developed by Jens C. Pruessner. Mara Mankin collected the cortisol data, that we preprocessed under supervision of Jens C. Pruessner. I performed the statistical analyses and wrote the manuscript together with Jens C. Pruessner. Eva Unternaehrer and Maria Meier assisted in discussing different statistical approaches and editing the manuscript that we published in the international Journal “Psychoneuroendocrinology” in a Special Issue in honor of Dirk Hellhammer:

Benz, Annika, Meier, M., Mankin, M., Unternaehrer, E., & Pruessner, J. C. (2019). The Duration of the Cortisol Awakening Pulse Exceeds Sixty Minutes in a Meaningful Pattern. *Psychoneuroendocrinology,* 105, 187–94. https://doi.org/10.1016/j.psyneuen.2018.12.225.

3.1 Abstract

The cortisol awakening response (CAR) is a well-established biomarker for the integrity of the hypothalamic-pituitary-adrenal (HPA) axis in healthy as well as clinical samples. Cortisol rise during the first 60 min after awakening is often used as a proxy of HPA axis regulation in health and disease. Ultradian pulsatility of cortisol is known to superimpose its circadian rhythmicity with the CAR being the first rise after awakening. However, the exact length of the complete first pulse (rise and fall) after awakening, as well as the association between the CAR, the complete first pulse, and successive ultradian pulses, has not yet been studied systematically.

Aim of this study was to investigate cortisol dynamics after awakening beyond the standard assessment duration of 60 min in order to assess the cortisol awakening pulse, in relation to ultradian rhythmicity of cortisol after awakening. In a sample of 51 healthy participants, salivary cortisol was collected for the first 270 min after awakening in intervals of 30 min, on two separate days. Different parameters describing individual cortisol pulses over time with respect to inter- and intraindividual variations such as duration, amplitude and area under the curve (AUC) were calculated. Special emphasis was put on the first rise and fall after awakening, called the cortisol awakening pulse (CAP).

Mean duration of the CAP was 108 min with high interindividual differences. Duration of first and second pulse were associated with subject’s sex and menstrual cycle status, with a longer first pulse and an attenuated second pulse in male and female subjects in the luteal phase, compared to female subjects in the follicular phase, or women taking oral contraceptives.

These results point to the potential usefulness of a longer sampling period for assessing ultradian pulsatility of cortisol in the morning, especially the CAP. To assess the complete pulse rather than the rise alone, measurement of cortisol levels after awakening for 120 min is recommended.

3.2 Introduction

The cortisol awakening response (CAR) enjoys a long history in psychoneuroendocrinological (PNE) research. One of the earliest mentions of a spike in cortisol after awakening in the morning stems from the work by Rivest et al. (1989), who investigated the relationship between the ultradian regulation of cortisol and melatonin in healthy men and noted that “... a burst of cortisol may follow awakening” (Rivest et al., 1989, p. 727). This suggested that cortisol levels rise and fall in response to waking, creating an individual spike with rapidly changing values over a short period of time. At the same time, clinical textbooks specified that the cortisol concentration in plasma taken early in the morning can range from 140 to 690 nmol/l without being considered conspicuous, or abnormal (Thomas, 2000). For PNE research, this was of little use as variations of 500% prevent meaningful association with subgroups and psychological associations. Thus, in the mid 1990s, Clemens Kirschbaum and Dirk Hellhammer from Trier, Germany, had the idea to investigate patterns in cortisol concentrations in the morning more systematically, in the hope of replacing the 8 a.m. cortisol standard measure with something more consistent. The approach to measure cortisol in reference to awakening seemed logical as it would mark the earliest time point for measuring an individual’s cortisol levels, regardless of absolute daytime. Since measurement of cortisol from saliva had just been introduced as a convenient and non-invasive method in PNE research (Kirschbaum & Hellhammer, 1989), it allowed for repeated testing in larger number of subjects. As it was unclear when cortisol levels would show highest consistency after awakening, the initial studies measured cortisol repeatedly with the simple goal to identify the time point showing highest consistency. While those studies failed to demonstrate that one particular point in time was superior over another, two observations stood out: First, measuring cortisol in reference to awakening led to more consistency across days in the same individual as compared to the traditional 8 a.m. measure, and second, cortisol showed a significant increase in response to awakening, confirming Rivest’s earlier finding through controlled experiments (Pruessner et al., 1997). As recently summarized by Stalder et al. (2016), publications on the CAR have been steadily on the rise since these first systematic studies and have consistently surpassed more than 100 articles per year since 2013. Currently, the CAR is an established marker of HPA axis integrity and shows stable associations with a number of clinical phenomena like depression (Dedovic & Ngiam, 2015), psychosis (Pruessner et al., 2013), and anxiety (Merswolken et al., 2013), to name just a few.

Although the rise of cortisol after awakening (i.e. the CAR) has been studied extensively over the last decades, several authors have highlighted the importance of the return of cortisol levels to baseline after their rise due to a stressor (e.g. Koolhaas et al., 2011; Scheurink et al., 1999). Koolhaas et al. could show that in rats, the corticosterone rise in response to a competitive social interaction is not inherently different in winners or losers; however, the recovery rate significantly differs between the two groups and hence provides additional information (Koolhaas et al., 2011). We suggest that this assumption is equally applicable for the cortisol dynamics in response to awakening. From researching the literature to find support for this model, it became clear, however, that the majority of studies assessing cortisol dynamics (A) restricted sampling protocols to the first 60 min after awakening to measure the rise in cortisol (i.e. the CAR), or (B) assessed a diurnal cortisol profile over the course of the day, such as a comprehensive large-scale analysis of diurnal cortisol profiles by Miller et al., 2016, without looking at the return of cortisol levels after their first rise in response to awakening. Thus, there seems to be a lack of studies looking at the 60 to 120 min time period past awakening. One single study standing out from the literature recently investigated the cortisol dynamics in 15 min intervals over the course of 8 h after awakening (Trifonova et al., 2013). As the sample size of this study was limited to 18 men, and the analyses focused on the comparison of ultradian cortisol pulsatility on saliva and plasma, we aim to build on these findings and measure the complete first cortisol pulse in response to awakening in a sample of healthy men and women. As the term CAR usually refers to the rise of cortisol in response to awakening, we want to distinguish the current approach from this well-established and valuable marker of HPA axis integrity. To this end, we introduce the term ‘cortisol awakening pulse’ (CAP) in the following to refer to the complete first pulse after awakening - comprising the rise, peak and fall of cortisol levels after awakening.

As such, the CAP shares characteristics with any pulsatile hormone release: it possesses an acrophase (distance from onset to peak, typically measured in time), a mesor (overall mean across time adjusted for rhythm), and an amplitude (distance from mesor to peak). If the oscillation is rhythmic, then the duration of the first pulse would also inform about the duration of the period (the distance in time from the start of one acrophase to the start of the following acrophase). These standard chronobiological terms have rarely been applied to cortisol dynamics in the morning, but it might be important to look at the CAP in the context of these descriptors (Fig. 3) as it has been shown that a dysregulation of the pulsatility of the HPA axis is associated with blunted cortisol responses to acute stress (Lightman & Conway-Campbell, 2010).

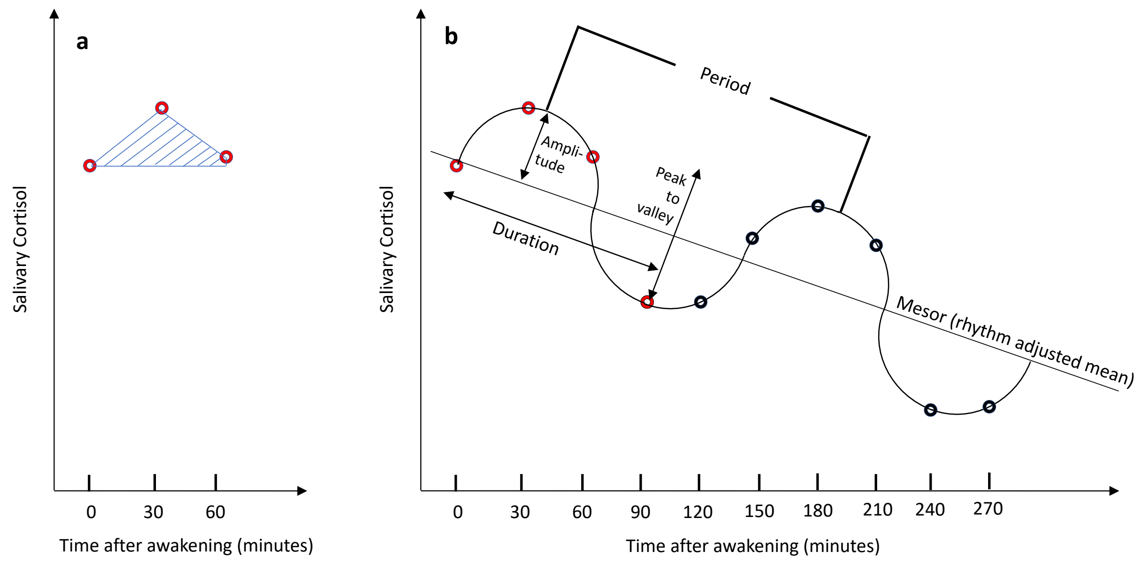

Fig. 3. Illustration of (a) traditional computation of the cortisol awakening response (CAR) as the AUCi(CAR) and (b) additional parameters computed individually per subject taking the complete cortisol awakening pulse (CAP; depicted by the first four red circles) into account. From the complete pulse, AUCi(CAP), amplitude, peak-to-valley value, and duration can be computed. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article).

A recent article by Strüber et al. (2014) suggests that depending on the ratio of mineralocorticoid (MR) to glucocorticoid (GR) receptors in the hippocampus, the pulsatility of cortisol circadian rhythmicity might be affected, for example, in the aftermath of early traumatic events. Specifically, Strüber et al. argued that low maternal care together with the presence of the L-allele of the serotonin receptor gene could lead to a change in the ratio of MR to GR in the hippocampus which in turn could lead to a flattened stress response and shortened ultradian pulses of cortisol. To establish the exact length of the CAP, one needs to determine not only the amplitude (i.e. the CAR), but also the total time interval that cortisol needs to return from the CAR peak back to basal level. It further implies that the CAP is associated with subsequent pulses, i.e., a flatter CAP would be followed by a flatter second pulse.

To sum up, measuring for 60 min is in line with the guidelines for assessing the CAR (Stalder et al., 2016), and has produced many interesting findings over the years. Yet, expanding the standard CAR monitoring protocols temporally and thus, assessing the CAP, might potentially offer new insights into HPA (dys)regulation and its link to the pathogenesis of stress-related disorders (Lightman & Conway-Campbell, 2010). As Miller et al. (2007) point out in conclusion of a comprehensive analysis of a meta-dataset of HPA responsivity in association with chronic stress, future research needs to focus on the decline of HPA activity supplementing well-established associations of cortisol increase after awakening.

Aim of the current investigation was therefore to investigate cortisol dynamics beyond the first 60 min after awakening (i.e. the CAR) and to describe and evaluate the CAP as a potential additional marker of HPA axis integrity. Thus, we hypothesized that the CAP (as defined by the time interval from the start to the first cortisol peak and the subsequent trough) would be significantly longer than 60 min as most CAR studies report cortisol levels not back at baseline after 60 min.

Further, if the model of Strüber et al. (2014) is correct, then amplitude and duration of the CAP should be systematically associated with subsequent ultradian pulsatility. Thus, our second hypothesis was that the CAP would be a significant predictor of subsequent pulses, and that the higher the amplitude and the longer the duration of the CAP, the higher the amplitude and the longer the duration of the second pulse.

Finally, as previous studies have shown significant associations of sex, and associated hormonal status with the CAR, we wanted to determine whether sex and hormonal status would be associated with amplitude and duration of the CAP. As the majority of our sample consisted of young adult women, we estimated the menstrual cycle phase from self-report and assessed the use of oral contraceptives (OC) of female participants, in comparison to men, to determine if and how these factors are related to amplitude and duration of the CAP. Based on findings with the CAR, we hypothesized that we would find these associations with the CAP as well.

3.3 Methods

3.3.1 Procedure

Data for this study was collected in a sample of students from the University of Constance, Germany, from December 2017 until February 2018. After subjects completed a prescreening and psychological measurements (see 3.3.3), those eligible for the study were instructed to provide salivary samples on two weekdays for 270 min after awakening, at intervals of 30 min (mean interval between days of sample collection = 4.94, range: 1–8 days), resulting in ten saliva samples per day and two observations per participant. Subjects were instructed to collect these samples over the course of the first 4 1⁄2 hours after awakening while following their normal daily routine. They were asked to record the time of sample collection, as well as the time and nature of any unusual activities (e.g. sleep disturbance, arguments with peers, physical activity) on a protocol sheet. Participants were instructed to rinse their mouth with water prior to each sample collection. The importance of adhering to the study protocol and following the exact sampling times and guidelines for saliva collection as outlined by Stalder et al., 2016 was emphasized.

3.3.2 Participants

A total of 55 subjects participated in this study. Participants were prescreened to exclude those with current, or any history of medical or psychiatric illness known to affect HPA axis activity (exclusion of $n = 2$). In addition, symptoms of moderate to severe depression (as suggested by Beck Depression Inventory [BDI]: BDI > 19, Beck et al., 1996), being over- or underweight (17.5 < body mass index (BMI) < 29.9; Gwirtsman et al., 1989; Kumari et al., 2010), current pregnancy (Mastorakos & Ilias, 2003), medication known to affect HPA axis (exclusion of $n = 1$), or drug use, served as additional exclusion criteria. Individual observations, defined as a single day of sample collection, were excluded in case of non-compliance to the study-protocol (exclusion of $n = 1$ due to heavy exercise). Finally, data of 51 healthy subjects (10 men, mean age = 24.90 ±3.00 years, range = 20–30 years; 41 women, mean age = 21.32 ±3.28 years, range = 18–32 years) was analyzed.

Self-reports from female participants on use of OC and menstrual cycle phase were used to estimate hormonal status. Women reported the first day of their menses from the last two cycles and provided information about their regular cycle length so that estimates for their menstrual cycle phase at the two sampling days could be determined. Female participants without OC use provided information on the beginning of their last menstrual cycle (*M1(latest)*) and their average cycle duration (*mCD*). An average luteal phase length of about 14 days was assumed as suggested by Lenton et al. (1984). The predicted day of ovulation (*Dov*) was estimated as

$$Dov = mCD - 14$$

The menstrual phase of a participant was estimated according to the following rules: If the number of days since the *M1(latest)* was greater than the *Dov*, participants were estimated to be in the luteal phase. Otherwise, they were estimated to be in the follicular phase. Women who reported to have no or only irregular menstrual cycle were excluded from analysis including this variable.

The study was approved by the Ethics Committee of the University of Constance and written informed consent was obtained from each participant. Subjects received financial compensation (€ 25) or experiment participation credit (2.5 h) for study participation.

3.3.3 Measurements

3.3.3.1 Psychological & demographic assessment

All demographic and study variables needed to determine eligibility (inclusion / exclusion criteria) and for further data analysis, including sex, age, height and weight, mental and medical health status, use of drugs or medication, menstrual cycle information, were collected as part of the prescreening via online self-report in-house questionnaires. Menstrual cycle phase information was additionally provided by female participants on both study days via paper-pencil self-report in the protocol sheet. Symptoms of depression and anxiety were assessed to control for their possible impact on HPA axis function. Severity of depression was assessed using the German version of the Beck Depression Inventory (Beck et al., 1996). The BDI is a self-report inventory with 21 questions about emotional, cognitive and physical symptoms of depression assessed on a 4-point Likert Scale with good test-retest reliability (Kühner et al., 2007). Anxiety sensitivity was assessed using an abbreviated version of the Anxiety Sensitivity Index (ASI-3; Taylor et al., 2007) with 16-item assessing fear of symptoms associated with sympathetic activation (e.g. elevated heartbeat) on a 5-point Likert Scale.

3.3.3.2 Salivary cortisol sampling procedure and assay

Salivary free cortisol was sampled using Salivette® devices (Sarstedt AG & Co, Sarstedt, Germany). To determine the exact time of sample collection, Salivettes given to the participants were kept inside vials of the medication event monitoring system (MEMS®, AARDEX Group, Sion, Switzerland) and date and time of their opening and closing was automatically recorded by the accompanying TrackCap® via integrated microcircuits. Data was read out from the TrackCap at the time of sample return. In addition, participants noted sampling time and any unusual / special occurrences, together with menstrual cycle information in the case of female subjects, on the protocol sheet filled out on each testing day. After sampling, participants were instructed to store the collected saliva samples in a dry place away from direct heat sources, such as sunlight, until the return of the samples to the re- searchers.

Previous studies reported a significant increase of subjects' compliance by using electronic monitoring devices and by explaining sub- jects how these devices verify their self-reported sampling times, even if dummy devices are used (Kudielka et al., 2003). The importance of collecting saliva samples immediately after awakening was highly emphasized by the experimenter.

Biochemical analysis of the saliva samples for cortisol levels was performed at the laboratory of the University of Trier, Germany. Cortisol samples were stored at -20° until final analysis. Prior to analysis, samples were thawed and centrifuged at 3000 rpm for 6 min. Saliva cortisol determination was completed using a reliable and validated fluorescence immunoassay with proven validity and reliability (Dressendörfer et al., 1992).

3.3.4 Data preprocessing and statistical analysis

Data preprocessing of the cortisol data included winsorizing of outliers and interpolation of missing values after visual inspection of raw data. Recorded times from the MEMS caps were checked against the times written down on the protocol sheets to allow identification of discrepancies. Special occurrences noted on the protocol sheets like heavy exercise or sickness were used to discard individual observations. For calculation of the conventional CAR, the area under the curve with respect to increase (AUCi, Pruessner et al., 2003) was computed for the first 60 min.

As comparison with markers of change was the focus of the current paper, we limited our approach to the AUCi – in chronobiological terms, the level at which change takes place is typically discarded, hence a comparison of AUCi with these parameters seemed unnecessary. In the context of the current paper, we refer to the standard CAR AUCi measure as AUCi(CAR). To optimize the description of cortisol pulsatility, four additional parameters were calculated for every distinct pulse seen over the first 270 min after awakening, for every subject and every day individually, after detrending the data for circadian decline (see Fig. 1). The first measure, called AUCi(CAP), was computed as AUCi taking into account the total number of cortisol samples depicting the first pulse after awakening within each individual. As the individual duration of the CAP varied in length, this measure included all cortisol samples for each individual, which ranged from waking to the first trough. For every following pulse, the AUCi included all cortisol samples ranging from one trough to the next. The second measure, the amplitude, was defined as the distance from peak value of the current pulse to the (detrended) mesor. The third measure, called peak-to-valley value, was defined as the distance from the peak value of the individual pulse to the successive trough (detrended). Last, we computed the duration of each pulse in minutes, defined as the time (in minutes) from one trough to the next, or in the case of the first pulse, from waking to the first trough.

If a participant's cortisol level showed a descending trend in the first two measures a pulse could still be computed by mirroring along the vertical axis. However, for comparisons of the CAR with the CAP, i.e. AUCi(CAR) versus AUCi(CAP), those cases with a descending trend after awakening were removed from the comparison to not introduce bias in the analysis.

To allow focusing on the physical characteristics of cortisol pulsatility and increase statistical power, especially for comparison of amplitude, duration and AUCi(CAP), with AUCi(CAR), we investigated the two days separately, resulting in a total sample of 101 observations after excluding one observation at the second day of sampling due to insufficient quantity of saliva. To allow examination of cortisol pulsatility during the first 270 min after awakening in relation to menstrual cycle phase and demographic characteristics, we performed correlational analyses, t- and F-tests by comparing men, women with oral contraceptives, and women in their luteal versus women in their follicular phase. Type III ANOVAs were computed if necessary to control for unbalanced groups.

As a study protocol with sampling intervals of 30 min does not allow for precise inferences about cortisol levels between two intervals, we estimated the probability of missing a peak between two intervals mathematically. To this end, maximum cortisol increase and maximum cortisol decrease were estimated for each time of measure before, during, and after a measured peak employing an estimated maximum cortisol increase after awakening of ca. 30 nmol/l as reported by Wüst et al., 2000, together with the cortisol half-life estimates of 28 min reported by Trifonova et al., 2013. Intersections of increase and accordingly decrease functions and the respective highest value measured were used to estimate a confidence interval for each observation in which a potentially missed peak could have happened. Mathematically estimated confidence intervals for observations with plausible end-points were summarized by mean values grouped by observed time of cortisol peaks. All statistical analyses were completed using R (version 3.4.2; R Development Core Team, Vienna, Austria), including the packages (car, psych, reshape2, pracma, Hmisc, ggplot2).

3.4 Results

Analysis of data on the overall adherence to the study protocol as monitored with MEMS® vials and compared to the protocol sheets indicated good compliance. One-sample t-tests revealed small but significant deviations from the cortisol sample timing schedule. The mean time of the total sampling period was significantly greater than 270 min (mean total duration = 275.2 min, 95% CI [271.5, 278.9]; $t(100) = 2.79$, $p = .006$) and the mean absolute deviation from the 30 min interval between samples significantly differed from 0 (mean absolute deviation = 3.5 min, 95% CI [3.1, 3.9]; $t(1008) = 15.88$, $p < .001$). According to the consensus guidelines for the CAR (Stalder et al., 2016), deviations of up to five minutes are acceptable. We reran all analyses after excluding subjects with a deviation of the sampling times greater than five minutes and achieved the same results; thus, we kept those samples in the analysis, and thus no further adjustment of the data was undertaken. The estimation of menstrual cycle resulted in four groups: $n = 39$ observations for women using OC (mean age 21.4 ± 2.8 years; BDI = 6.0 ± 4.3), $n = 19$ observations for women in the follicular phase (mean age 21.1 ± 3.4 years; BDI = 4.2 ± 3.8), and $n = 19$ observations for women in the luteal phase of their cycle (mean age 21.1 ± 4.2 years; BDI = 8.8 ± 5.0), and $n = 20$ observations for male subjects (mean age 24.9 ± 2.9 years; BDI = 4.6 ± 3.9). Two subjects were not able to provide information on their menstrual cycle, thus those were excluded from analyses investigating effects of hormonal status. The four resulting groups differed significantly in terms of age ($F(393) = 6.69$, $p < .001$; with male subjects being significantly older compared to all other groups) and BDI ($F(393) = 4.59$, $p = .005$; with women in the luteal phase reporting more depressive symptoms compared to men and women in the follicular phase, but no differences for any other post hoc comparison), but not for BMI and ASI. All analyses were calculated with age and BDI as co-variables. As no differences between models with and without co-variables were found, results are reported for the more frugal models without covariates only.

A significant elevation of salivary cortisol within the first 60 min after awakening was observed, revealing the typical and traditional CAR pattern (mean CAR as defined by AUCi(CAR) = 183.6, mean increase 106%). 19 observations had a peak at the time of the first measure and descended thereafter; these observations were included for calculations of the AUCi(CAP) but excluded from the correlational analysis with the AUCi(CAR).

Determination of the absolute length of the first pulse revealed a mean duration of 108 min, significantly longer than 60 min (one sample t-test: $t(100) = 9.67$, $p < .001$, 95% CI [98.2, 118.0], range 60–240 minutes). From the total sample, 36% of observations showed a duration of 60 min for the first cortisol pulse after awakening. In 23% the duration was 90 min, while for another 30% of observations the first pulse lasted 120 min (for more details see ***Tab. 5***).

The cortisol peak occurred at 30 min after awakening in 43% of observations. In 33% of observations the peak was observed at 60 min, while in 6% of observations it occurred at 90 min. Complete details on mean duration and time of peak of the first pulse are also shown in ***Tab. 5***. The absolute cortisol levels during the first 270min after awakening can be drawn from Fig. 4 depicting mean values over time for all observations and separated by groups according to the number of pulses observed during the sampling period.

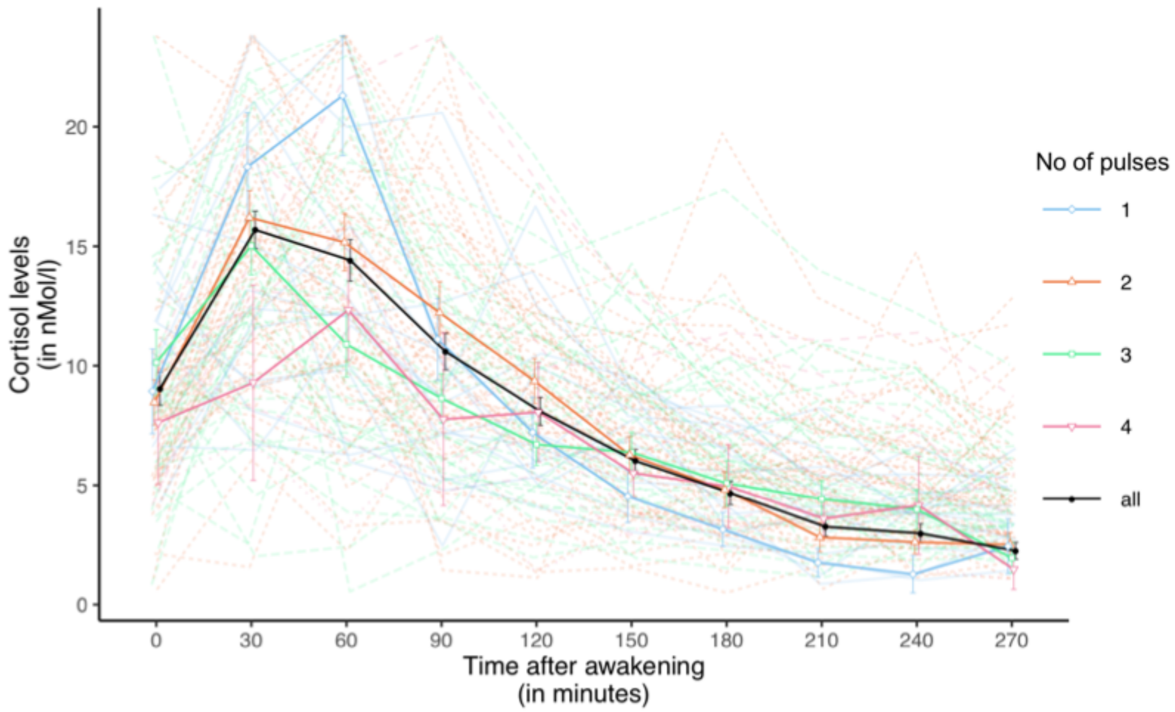

Fig. 4. Absolut cortisol levels for all observations and mean cortisol levels grouped by observed number of pulses during the first 270 min after awakening before detrending.

Tab. 5. Distribution of first pulse duration and timing of peak in percent of total observations (N = 101). Percentage points do not accumulate to 100 due to rounding up.

Pulse duration in minutes	60	90	120	150	180	210	240
Total (*N* = 101)	36	23	13	11	12	4	2
OC (*n* = 39)	18	9	5	3	2	1	1
Follicular (*n* = 19)	8	4	2	2	1	2	0
Luteal (*n* = 19)	5	3	3	3	5	0	0
Male (*n* = 20)	3	6	3	3	4	0	1

Timing of first peak (minutes since awakening)	0	30	60	90
Total (*N* = 101)	19	43	33	6
OC (*n* = 39)	5	21	9	4
Follicular (*n* = 19)	5	4	8	2
Luteal (*n* = 19)	2	6	11	0
Male (*n* = 20)	6	10	4	0

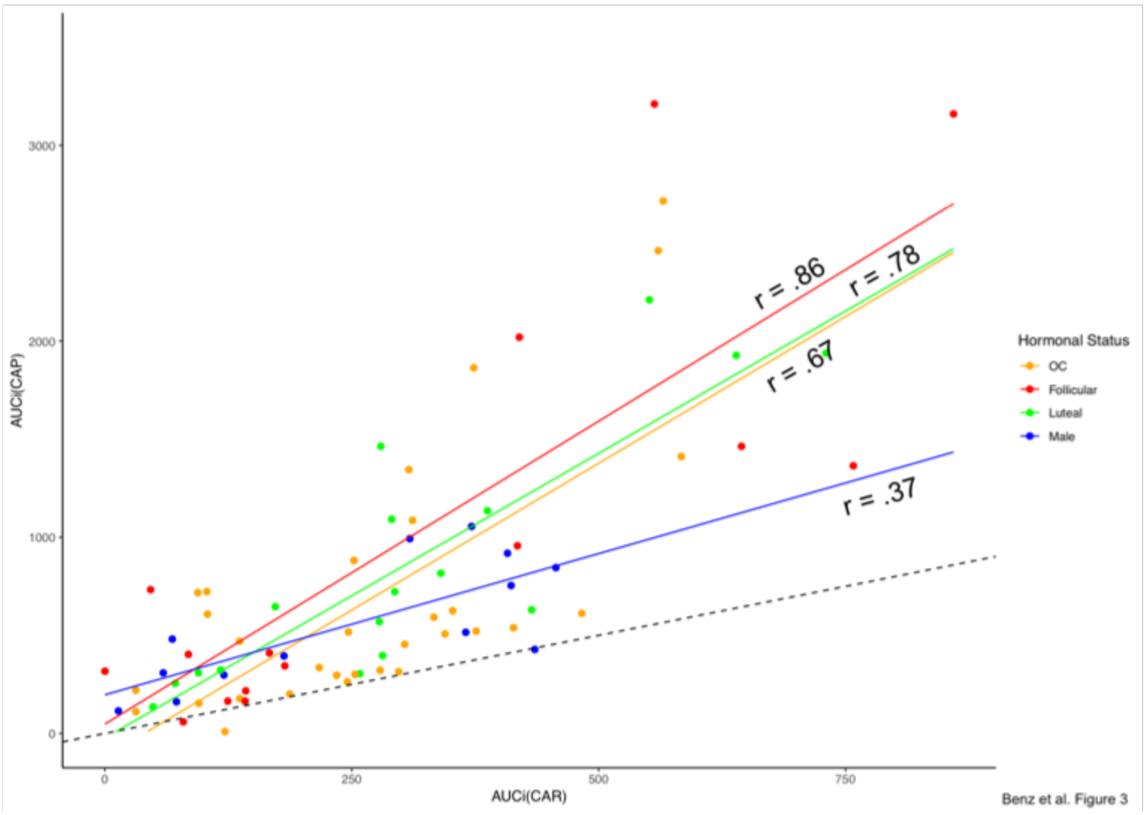

Fig. 5. Scatterplot of the correlation between CAR calculated as AUCi(CAR), over 60 min and AUCi(CAP), based on the assumed length of pulse taking into account hormonal status (luteal phase, follicular phase, use of oral contraceptives), and gender. Subjects with negative AUCi(CAR) were excluded from this analysis.

Correlations between the AUCi(CAR) and the AUCi(CAP) were high, shown in ***Tab. 6*** and illustrated in Fig. 5. R-square (the amount of explained variance) varied between 49% and 10%, suggesting that between 50% and 90% of variance among the various measures remained unexplained. More importantly, a systematic contortion appeared when observing the results separately for the hormonal status groups intermixed with gender in our sample. In men, the slope of the correlation of the AUCi(CAR) with the AUCi(CAP) is shallower, while in women, the slope of the correlation is steeper, suggesting that stronger increases in the AUCi(CAR) were associated with stronger increases in the AUCi(CAP). This interaction of hormonal status and gender with the slope was significant ($F(393) = 5.86$, $p = .017$; Fig. 5).

Tab. 6. Associations between first and subsequent pulses in different parameters describing cortisol release.

	First to second pulse				Second to third pulse			
Variable	*r*	*t*	*df*	*p*	*r*	*t*	*df*	*p*
AUCi(CAP)	- .20	- 1.90	85	.061	**.35**	**2.30**	**38**	**.027**
Amplitude	**- .21**	**- 1.99**	**85**	**.050**	.25	1.61	38	.115
Peak-to-valley	**- .30**	**- 2.91**	**85**	**.005**	.21	1.33	38	.192

When looking at pulse duration, additional differences between these groups emerged. In our sample, men showed a significantly longer duration of the first pulse than women with 124.5 min for men versus 96.2 min for women taking OC, 104.2 for women in the follicular phase, and 120 min for women in the luteal phase ($F(195) = 5.80$, $p = .018$). Investigating the peak-to-valley measure, differences between groups emerged as well: for the first pulse, women taking OC showed the smallest peak-to-valley value while women in the luteal phase showed the largest measure (5.3 vs 7.8, $F(195) = 4.39$, $p = .039$). For the second pulse of the day, the opposite was the case, with women taking OC showing the highest peak-to-valley measure and women in the luteal phase the smallest (4.8 vs. 2.7, $F(182) = 5.18$, $p = .025$). Differences in duration and relative increase and decline of cortisol release are depicted in Fig. 6.

Thus, contrary to our hypothesis, a longer first pulse appears to be associated with a weaker second pulse when taking into account gender and estimated menstrual cycle phase ($F(281) = 4.09$, $p = .047$). These differences could not be observed when assessing the first pulse using the traditional CAR formula (AUCi(CAR) ($F(195) = .58$, $p = .45$).

These relationships are also visible when investigating inter-correlations among these factors (see **Tab. 6**). The first pulse was negatively associated with the second pulse, whereas a positive association between the second and third pulse was observed.

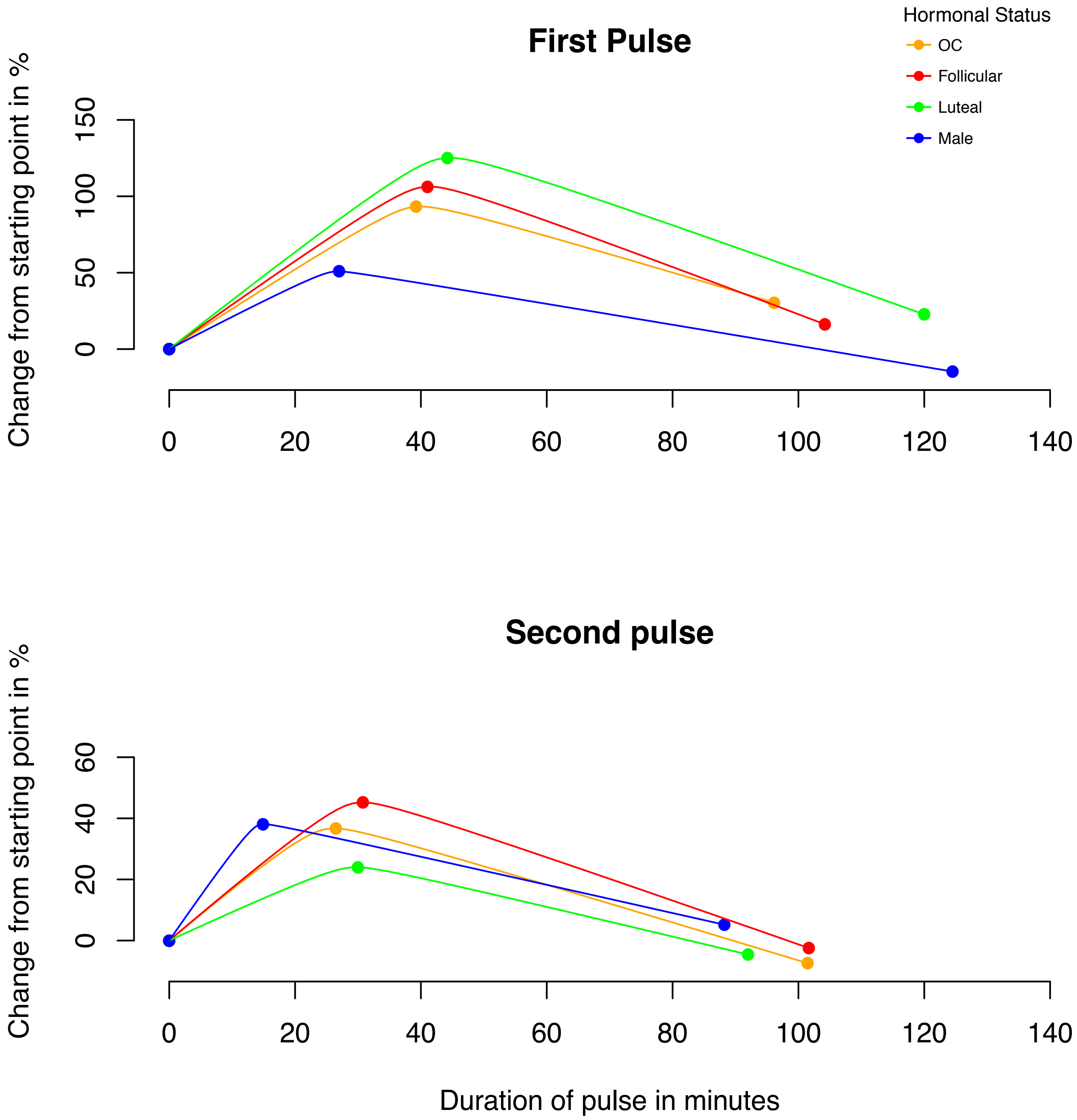

Fig. 6. Percentage of increase and decrease of cortisol release during the first and second pulse relative to the respective starting point with respect to hormonal status.

Finally, while 40% of daily observations consisted of three to five pulses, around 47% consisted of two pulses, and 14% showed only one pulse over the 270 min assessment period. No other associations among the variables sex, age, BDI, ASI, or BMI and parameters describing cortisol release during the first 270 min after awakening were found.

Further exploratory analysis revealed that, according to the modulated estimations of potentially missed peaks, mean confidence interval for peak time in *n* = 41 (out of 43) observations with a measured peak at 30 min after awakening is at 27.59–35.27 (or 7.83–46.83) minutes, in *n* = 31 (out of 33) observations with a measured peak at 60 min after awakening at 44.01–62.31 (or 34.42–72.75) minutes, and in *n* = 5 (out of 6) observations with a measured peak at 90 min after awakening at 71.39–91.48 (or 64.81–101.04) minutes.

3.5 Discussion

With the aim of investigating the dynamic regulation of cortisol pulsatility beyond awakening, the present study measured salivary cortisol for the first 270 min after awakening in intervals of 30 min in a sample of healthy young men and women with a total sample of 101 observations. A significant increase of salivary cortisol was observed after awakening followed by up to four additional pulses over the 270min observation period. We could demonstrate that the mean duration of the cortisol awakening pulse (CAP) was 108 ±50 min for the entire sample. First, we would like to point out the high variability in the duration of the CAP with a range from 60 to 240 min. Secondly, the CAP was completed after 60 min in about a third (36%) of observations only, with the majority of CAPs lasting significantly longer. Thus, when measured for 60 min, the recovery phase of the first rise of cortisol in the morning is missed in most cases, and even the peak could be missed in some cases. The review paper by Koolhaas et al., (2011) specifically discussing cortisol response dynamics suggests to put more emphasis on the recovery phase to avoid missing important group differences. What – if any – health, stress or lifestyle characteristics might be associated with the recovery phase is at this point pure speculation, since our study did not include such information, but appears as an interesting object of investigation for future studies. There are studies suggesting that the cortisol decline during recovery does have a distinct share in explanation of variance of psychological variables (Miller et al., 2007).

Meanwhile, the observed time points of peaks are in line with the literature on CAR, reporting decreasing cortisol levels with the beginning of the first measure in about 13–20% of observations (Stalder et al., 2016) and later peaks at 75 or 90 min in about 10% of observations (Trifonova et al., 2013).

Significant associations with pulse dynamics emerged from taking into account gender and estimated menstrual cycle phase, i.e. separating the sample into men and women in the luteal or follicular phase, or women taking OC. Women who assumably had higher levels of circulating estrogen, i.e. women in the follicular phase and OC users, showed a shorter first pulse and a stronger second pulse. In line with previous research on estradiol-associated changes in cortisol regulation (Kudielka et al., 2009; Kumsta et al., 2007), our results suggest differential cortisol release with respect to hormonal status for the CAP. Previous studies had also shown significant associations between hypothalamic-pituitary-gonadal axis activity and the timing and characteristics of the CAR: women after menarche show a peak 45 min after awakening (Oskis et al., 2009), and women across the menstrual cycle phase show distinct CAR profiles (Wolfram et al., 2011).

At least in the current sample, the differences we observed using the revised pulse computations did not emerge when looking for group differences with the traditional CAR measure, suggesting increased sensitivity to capture hormonal interactions with the CAP when investigating the awakening pulse for its entire duration as compared to the 60-minute time period.

With regard to ultradian pulsatility, our data revealed a negative association between the first and second pulse and a positive association between the second and third pulse. We had hypothesized that the CAP would be significantly positively associated with subsequent pulses of cortisol, following the argumentation of Strüber et al. (2014). The current data does not support this assumption; however, it is important to point out the possibility that the CAR as well as the CAP are simply different measures of ultradian HPA axis regulation. Buchanan et al. (2004) could previously demonstrate that hippocampal lesions are associated with an absent CAR, which suggests that the awakening response is distinct from ultradian regulation (Buchanan et al., 2004). This is also in line with Stalder et al. (2016), who suggested a distinct nature of the CAR within ultradian regulation of cortisol. While only for 40 observations a complete third pulse could be recorded, the finding of a significantly positive correlation between the second and the third pulse supports the assumption of a positive correlation among pulses, as stated in the model by Strüber et al. (2014), who emphasized that the negative feedback of cortisol of the current pulse could contribute to the stimulation of the next pulse via hippocampal interneurons. Thus, the findings from the current study support the idea that the CAP is a distinct feature of HPA axis activity, and not part of ultradian regulation.

Albeit preliminary, the current results allow for a few recommendations for future CAR and CAP research. To begin with, the finding of the first pulse being substantially longer than 60 min suggests that the current practice of assessing the CAR for a duration of no more than 60 min might not be ideal for all studies and research questions as it does not allow for additional information provided by the fall from peak to trough. While admittedly adding cost and inconvenience, a sample at 90 and 120 min would allow to capture the complete duration of the CAP in the vast majority of subjects and thus a more comprehensive estimation of the amount of cortisol present in saliva after awakening. What is important to note here is the observation that simply calculating the AUCi over 90 or 120 min alone would not add useful information: since individual pulses vary in length, it is instead necessary to establish the exact duration of the CAP individually for each subject, and then calculate the AUCi(CAP) accordingly. This would result in a dataset where the number of samples used for the calculation of the CAP would vary for each subject. In a review on cortisol pulsatility, Young et al. (2004) discussed the intrinsic rhythmicity of HPA axis activity. The authors also recommended to measure cortisol for longer periods of time to avoid loss of information and 'blurring' of data when averaging across peaks and troughs. Although this was based mainly on rodent studies and without precise assumptions about timing and duration of pulses, it did emphasize the idea of ultradian pulsatility. Trifonova et al. (2013) built on this re-commendation and analyzed cortisol data for assessment of ultradian cortisol profiles in men for 8 h, in 15-minute intervals in both blood and saliva, demonstrating the plausibility of this approach.

An important finding from the current study is that the conventional CAR calculation over 60 min is very different from the complete first pulse of cortisol after awakening (i.e. the CAP), for the majority of subjects. As the current sample consisted of young healthy subjects only, it is unclear whether duration and amplitude of the CAP is systematically linked to clinical and psychopathological factors. Thus, by extending sampling periods in future studies evidence could be obtained to reveal such associations.

A number of significant limitations need to be acknowledged. First, in the current study, we measured salivary cortisol in 30-minute intervals which might be considered too long a time period between samples to accurately determine individual pulses. As we set out to expand the current practice of CAR research, a sampling protocol which is used in more than 70% of studies between 2013–2014 with 3 or less samples during the first 1 h after awakening (Stalder et al., 2016) appeared feasible. However, precise information about the peak might be lost, or individual pulses even be overlooked. Previous studies have shown that half-life of salivary cortisol is about 30 min (Trifonova et al., 2013) and that after stimulation it takes between 20–30 minutes for cortisol to reach its peak (Engert et al., 2011; Wüst et al., 2000). However, in accordance with these studies and the reported confidence intervals for peaks as measured in this sample, we still feel that the finding of the first complete pulse after awakening exceeding 60 min in a meaningful pattern still stands out. Nonetheless, the 30-minute interval is not ideal and will likely have led to missing the exact peak of the awakening pulse in many cases, especially in women, who are re- ported to have their mean peak at 45 min once menarche is reached (Oskis et al., 2009). The reason for selecting the current design was related to feasibility; when piloting the design in a small sample, a 15-minute interval for 270 min was perceived as rather disruptive and not feasible for subjects to follow.

Further, while the use of MEMS caps has to be considered a strength, lack of objective assessment of wake time has to be considered a limitation. For optimal monitoring of sampling times and adherence to the study protocol, a combination of MEMS caps together with an objective recording of awakening, through for example use of Actigraph would have been ideal. By this means, control of compliance and at the same time high ecological validity due to the domestic setting could have been ensured (cf. Stalder et al., 2016). Further, a detailed protocol of a participant’s day (e.g. food and exercise logs), combined with a more frequent sampling method, could have provided a more accurate representation of subjects’ HPA axis activity. While we recommend these steps, ecological and financial constraints prevented us from employing them in the current study.

Furthermore, heterogeneity of this small sample in terms of sex, OC use, and menstrual cycle has to be considered as a limitation. Larger samples with accurate measurements of confounding hormone levels, e.g. assessing surge of luteinizing hormone as defined by a chromato- graphic ovulation predictor test kit (e.g. Wolfram et al., 2011), should be collected to confirm and extend our findings. Future research should take these limitations into consideration, and improve upon the experimental design when financially and ecologically feasible.

Taken together, the cortisol awakening response measured over a 60-minute period provides important information about HPA axis regulation which we suggest can be extended to 120 min to capture the cortisol awakening pulse, which potentially reveals additional associations with psychological and clinical factors. In our study of healthy young men and women, associations with sex and estimated hormonal status of the women emerged when analyzing the AUCi of the CAP, and the length of the first pulse. To account for the complete CAP in the majority of cases, we recommend an extension of the assessment period to 120 min.

4 NATURE-BASED RELAXATION VIDEOS AND THEIR EFFECT ON HEART RATE VARIABILITY

Besides the HPA axis, the autonomic nervous system (ANS) is another biological system that responds to adverse or traumatic circumstances early in life with (mal-) adaptive calibration processes (e.g. Kuras et al., 2016). One prominent measure of the parasympathetic branch of the ANS, which is associated with relaxation and restoration after stress regulation, is heart rate variability (HRV) which is often measured during and after stress induction or during resting state (Thayer et al., 2012). Though crucial for regeneration and maintenance of homeostasis (and thus a potential marker for the effects of early life adversity as well as psychopathology, Beauchaine & Thayer, 2015), relaxation mechanisms are less well researched compared to the variety of research on stress reactivity.

As I was searching for a paradigm that activates the parasympathetic nervous system (PNS) (beyond a standard resting state assessment) and is easy to implement and standardize at the same time, I was not perfectly satisfied with approaches reported in other studies. Thus, together with Jens C. Pruessner, I developed a new paradigm: watching a (nature-based) relaxation video similar to the type streamed by millions of viewers on YouTube. To test the effect of these videos on HRV, I developed a research design with the assistance of three Master students, Simona Scharndke, Clara Jupe, and Maya Wenzel, who collected data in two consecutive studies including different additional psychometric measurements under the supervision of Jens C. Pruessner. I performed the preprocessing of HRV data and the statistical analysis with consultation with Eva Unternaehrer who reviewed the R script that I wrote for the statistical analysis. Raphaela Gaertner, a new PhD student of our lab, who plans to continue this line of research and investigate autonomic activity in response to nature settings presented via virtual reality, assisted in drafting parts of the manuscript. Other lab members, Maria Meier, Ulrike U. Bentele, Stephanie J. Dimitroff, and Bernadette F. Denk, were involved in discussing the results and editing the manuscript which I finally published in “Frontiers of Psychology”:

Benz, Annika B. E., Gaertner, R. J., Meier, M., Unternaehrer, E., Scharndke, S., Jupe, C., Wenzel, M., Bentele, U. U., Dimitroff, S. J., Denk, B. F., & Pruessner, J. C. (2022). Nature-Based Relaxation Videos and Their Effect on Heart Rate Variability. *Frontiers in Psychology, 13,* 866682. https://doi.org/10.3389/fpsyg.2022.866682.

4.1 Abstract

Growing evidence suggests that natural environments – whether in outdoor or indoor settings – foster psychological health and physiological relaxation, indicated by increased well-being, reduced stress levels, and increased parasympathetic activity. Greater insight into differential psychological aspects modulating psychophysiological responses to nature-based relaxation videos could help understand modes of action and develop personalized relaxation interventions.

We investigated heart rate variability (HRV) as an indicator of autonomic regulation, specifically parasympathetic activity, in response to a 10-minute video intervention in two consecutive studies as well as heart rate (HR). We hypothesized that a nature-based relaxation video elicits HRV increase and HR decrease, with response magnitude being affected by aspects of early life adversity (conceptualized as low parental care and high overprotection/constraint) and trait mindfulness.

In Study 1, N = 60 participants (52% female, age_{mean} = 23.92 ±3.13 years, age_{range} = 18–34 years*)* watched a relaxation video intervention depicting different natural scenery. We analyzed changes in HR and respiratory sinus arrhythmia (RSA) as a standard HRV measure, both based on 3-minute segments from the experimental session, in multiple growth curve models. We found a decrease in HR and increase of RSA during the video intervention. Higher paternal care and lower trait mindfulness observing skills (assessed via questionnaires) were associated with higher RSA values before but not during video exposure.

In Study 2, N = 90 participants (50% female, age_{mean} = 22.63 ±4.57 years*,* age_{range} = 18–49 years*)* were assigned to three video conditions: natural scenery from Study 1, meditation video, or short clip from "The Lord of the Rings". Again, HR decreased, and RSA increased during video segments, yet without expected group differences across different video types. We found higher parental care and lower parental overprotection to predict higher RSA at different times during the experiment. Interestingly, lower paternal overprotection predicted overall higher RSA.

These results suggest a generic relaxation effect of video interventions on autonomic regulation that we discuss in light of different theories mapping restorative effects of natural environments. Further, psychological characteristics like aspects of early life adversity and trait mindfulness could contribute to individual differences in autonomic regulation. This study contributes to a better understanding of autonomic and psychological responses to relaxation videos.

Keywords: nature video, relaxation, heart rate variability, early life adversity, trait mindfulness

4.2 Introduction

Relaxation videos gained in popularity not only on online streaming platforms like YouTube but in empirical research as well as indicated by a massive growth in publications related to the topic “relaxation video” over the past decades, with 8 publications listing “relaxation video” in the title in 1989, and 114 in 2020 (https://pubmed.ncbi.nlm.nih.gov/?term=relaxation%20video&timeline=expanded). To understand the psychological and physiological effects of relaxation videos, standardized measures to identify the various aspects of reactivity to relaxation are needed (Meier et al., 2020). In addition to subjective changes in affect and arousal, relaxation triggers changes in the autonomic nervous system (Chang et al., 2011). It can be described as a decrease in physiological arousal (Smith, 2007). Various physiological markers have been used to assess the changes associated with relaxation, such as a decrease in blood pressure and heart rate (HR). However, taking a closer look at the autonomic nervous system, which regulates the stress and relaxation response, shows that it is the increased activity of the parasympathetic nervous system that is associated with relaxation (e.g. Bertsch et al., 2012). Parasympathetic activity is related to decreased cardiovascular, respiratory, and electrodermal activity (Kreibig, 2010) and increase in positive mood (Shaffer & Ginsberg, 2017a). A reliable measurement for parasympathetic activity is a vagally-mediated marker of heart rate variability (HRV), high-frequency HRV (HF-HRV), which corresponds with respiratory sinus arrhythmia (RSA) (Acharya et al., 2006). Therefore, in this study we will look at relaxation as the increase in parasympathetic activity as indicated by RSA changes. While HF-HRV and RSA are the most specific indicators of parasympathetic activity (Thayer et al., 2012), HR is frequently reported in relaxation research and thus included as an additional parameter in this study.

Previous studies suggest an effect of relaxation videos including natural environments on autonomic regulation. For example, participants watching 360° nature videos (Irish countryside or Australian beaches) after a cognitive stressor showed significant stronger physiological relaxation than the control group, who viewed a video of an empty classroom, indicated by a reduction in electrodermal activity and an increase in HRV (Anderson et al., 2017). This line of research builds on several theories that explain why nature environments have a restorative effect, associated with an increase in parasympathetic activity, positive mood and replenish resources. For one, the Biophilia Hypothesis (Kellert & Wilson, 1993) describes biophilia as an inherent longing for connection to other living things, including flora and fauna. Further, the Attention Restauration Theory (ART; Kaplan, 1995) focuses on the aspects of nature that help with recovery from mental fatigue, stating that the effortless preference for natural scenes is the needed counterpole to the stressful challenges of everyday life. Finally, the Psychoevolutionary Theory (Ulrich, 1983) emphasizes the aesthetic preference for natural scenes and focuses on the evolutionary advantage of a quicker recovery from stressful situations. Recovery involves a positive affective reaction with a decrease in negative emotions like fear and reduction of physiological arousal. This reaction can be seen, for example, in the effects of a short walk in a forest which has been shown to reduce blood pressure and HR, increase HF-HRV (Lee et al., 2014), increase positive affect (Payne & Delphinus, 2019) and decrease negative affect, e.g. anxiety (Song et al., 2018). This effect of real-life nature seems to translate to sole representations of nature, like pictures or videos of rivers, forests, or even fireplaces (Dana Lynn, 2014). Watching nature pictures increased HRV in a resting state (Gladwell et al., 2012) and in a recovery phase after a stressor (D. K. Brown et al., 2013) but watching urban pictures did not. This hints at nature exposure leading not only to benefits in recovery phases but as well having buffering effects (Beute & De Kort, 2014). However, not all studies come to this conclusion. Van den Berg and colleagues (2015) found a greater recovery after a stressor while watching nature pictures compared to urban pictures, but no buffering effect. A two hour long forest bathing experience (Yu et al., 2017) and looking at fresh roses (Song et al., 2017) had no significant effect on parasympathetic activity measures by HF-HRV. One study even found an opposite effect: HRV (indicated by RSA) decreased and heart rate increased when exposed to real-life nature during a five-day field trip (Scott et al., 2021). However, most of these studies used real-life nature stimuli. While it can be assumed that real-life and virtual nature stimuli might elicit comparable effects (Browning et al., 2020) real-life nature stimuli lack standardization capability and accessibility across different research sites and sample composition. Moreover, these mixed results show, that further studies are needed to investigate, why exposure to natural stimuli only sometimes has relaxing effects. Keeping especially virtual nature interventions in mind when investigating this question is important since, video-based nature interventions could help scientific studies as they are easier to implement and standardize than a real-life outdoor setting that is subject to e.g. weather conditions.

Even though there are studies showing an increase in relaxation in reaction to either a real (e.g., Song et al., 2018) or virtual nature environment (e.g., Anderson et al., 2017) as described above, there is little research about individual predispositions influencing the relaxation response. A first review suggests that physiological relaxation (e.g. HRV, blood pressure) in reaction to indoor nature stimuli (e.g. pictures of forests, potted plants) is influenced by age, gender and personality (Jo et al., 2019). Jo and colleagues (2019) referred to interindividual differences in general, without taking a closer look at specific factors. One of the factors possibly influencing the relaxation response could be early life adversity, i.e. the experience of adverse and potentially harmful situations in childhood and adolescence, like poverty, neglect or child abuse (Smith & Pollak, 2021). Such experiences can influence the autonomic nervous system and lead to lower resting levels of HRV (Sigrist et al., 2020), which might moderate the influence of early life adversity as a risk factor for psychological disease (Shonkoff et al., 2012). Moreover, early life adversity could alter an organisms capability to relax and thereby counteract negative effects of stress (Bhasin et al., 2013) as well, which could play a role in the mechanisms behind early live adversity being a risk factor for psychopathology (Lima et al., 2010). This could, for example, be demonstrated through a decreased HF-HRV in reaction to a nature based relaxation intervention, as can be observed in depressed patients (Matsui et al., 2016). On the opposite endpoint of the physiological activation-deactivation continuum, early life adversity is a prominent research factor that is assumed to alter the psychophysiological stress response (Tarullo & Gunnar, 2006). It is often operationalized as a lack of parental care (Engert, 2010a; Luecken, 2000).

In contrast, trait mindfulness, i.e. the general ability of being aware of one's present surroundings, emotions and thoughts, is associated with life satisfaction, optimism and mental health (Brown & Ryan, 2003) and could thus positively contribute to the relaxation response. It is part of a mindfulness practice to concentrate on what one can see and hear, without letting the thoughts wander to different, potentially stressful topics. Therefore, trait mindfulness could be an advantage when exposed to relaxation videos and increase their effects on the parasympathetic nervous system.

In two independent experiments, we aimed to investigate autonomic responses to different video contents and their generic ability to induce physiological relaxation in two consecutive studies, while exploring the potential impact of interindividual differences. In Study 1, we investigated whether popular nature-based videos (including audio) showing either a river stream in a forest, rain in the thicket, the crackling of burning wood in a fireplace, or waves crashing on a beach induce a psychophysiological relaxation response. We hypothesized that HR decreases and HRV increases as a result of the (video-based) nature exposure alone in comparison to a questionnaire baseline controlling for sex, age, and depressive symptoms (cf. Laborde, 2017). Building on the results of Study 1, we conducted Study 2 to extend the findings by adding a physiological baseline and two more video conditions: a guided meditation video and a control condition using a movie clip of “The Lord of the Rings”. In Study 2, we hypothesized that HR decreases and HRV increases during the nature videos and during the guided meditation video but not during the movie clip. In addition to the effect of different video contents, in both studies we investigated the potential influence of two psychological factors that might modulate the relaxation response: early life adversity as a risk factor for psychopathology and trait mindfulness as a protective factor associated with metal health. We thereby aimed to investigate their influence on relaxation as proxies for psychological or personality-related factors as reported by Jo and colleagues (2019). We hypothesized that early life adversity would lead to less increase of HRV values in reaction to the relaxation videos and trait mindfulness would increase the relaxing effects of those videos, leading to stronger increases of HRV.

4.3 Study 1

4.3.1 Method

4.3.1.1 Participants

In Study 1, we assessed *N* = 60 students (sex assigned at birth: 52% female, 48% male; age: *mean* = 23.92 ± 3.13 years, range 18–34 years) who responded to our advertisements posted on site at the University of Konstanz (flyers and online participant recruitment platform of the University of Konstanz). For inclusion in the study, participants were required to be at least 18 years of age, have sufficient German language skills, and be free of cardiovascular diseases (e.g. coronary heart disease or heart implants) that could influence HRV measures. Inclusion criteria were part of the advertisements and verified during the laboratory assessment. Data collection for Study 1 took place from April to May 2018. All participants received 10€

or 1 hour of course credit as study compensation after debriefing. The study protocol was approved by the Ethics Committee of the University of Konstanz and followed the guidelines outlined in the Declaration of Helsinki. Sample size was determined using the tool G*Power (Faul et al., 2007) based on within-between interactions (two groups, male and female participants, and four time points) and medium effect size, power = 90%, alpha = 0.05 as well as feasibility considerations and previous studies on HRV reactivity (Gladwell et al., 2012).

4.3.1.2 Procedure

After providing informed consent and applying the HRV sensors, participants completed a first set of paper and pencil questionnaires, assessing sociodemographic information and trait mindfulness. Subsequently, we presented all participants with the relaxation video intervention, consisting of one of the relaxation videos described below. Finally, participants completed a second set of questionnaires, including measures of early life adversity and depressive symptoms. We split all questionnaires into the two sets to be minimally arousing before the relaxation video intervention. Laboratory assessments took place between 8.00 a.m. to 1.15 p.m. in a windowless room. An overview of the procedure of both studies is depicted in Fig. 7.

4.3.1.3 Video material

For the 10-minute video intervention, participants chose two out of four relaxation themes based on personal preference to avoid aversive associations with one of the themes: (1) river stream in the forest and bird sounds (Lawson, 2013), (2) rain falling in the thicket (Paunchev, 2017), (3) sunny tropical beach (Outstanding Videos, 2012), and (4) fireplace (Balu, 2017). We selected these relaxation video clips based on the YouTube search terms "relaxation videos", "calm nature", and "relaxation" and their respective number of views. Each clip had more than two million views by March, 2018 and was presented on a 17-inch ThinkPad (Lenovo, Hongkong, China). We took 5 minutes from each of the videos and merged them to avoid distraction during clip transition. Using circumaural earphones (Sennheiser, Wedemark, Germany), we tried to maximize video audio and minimize ambient noise.

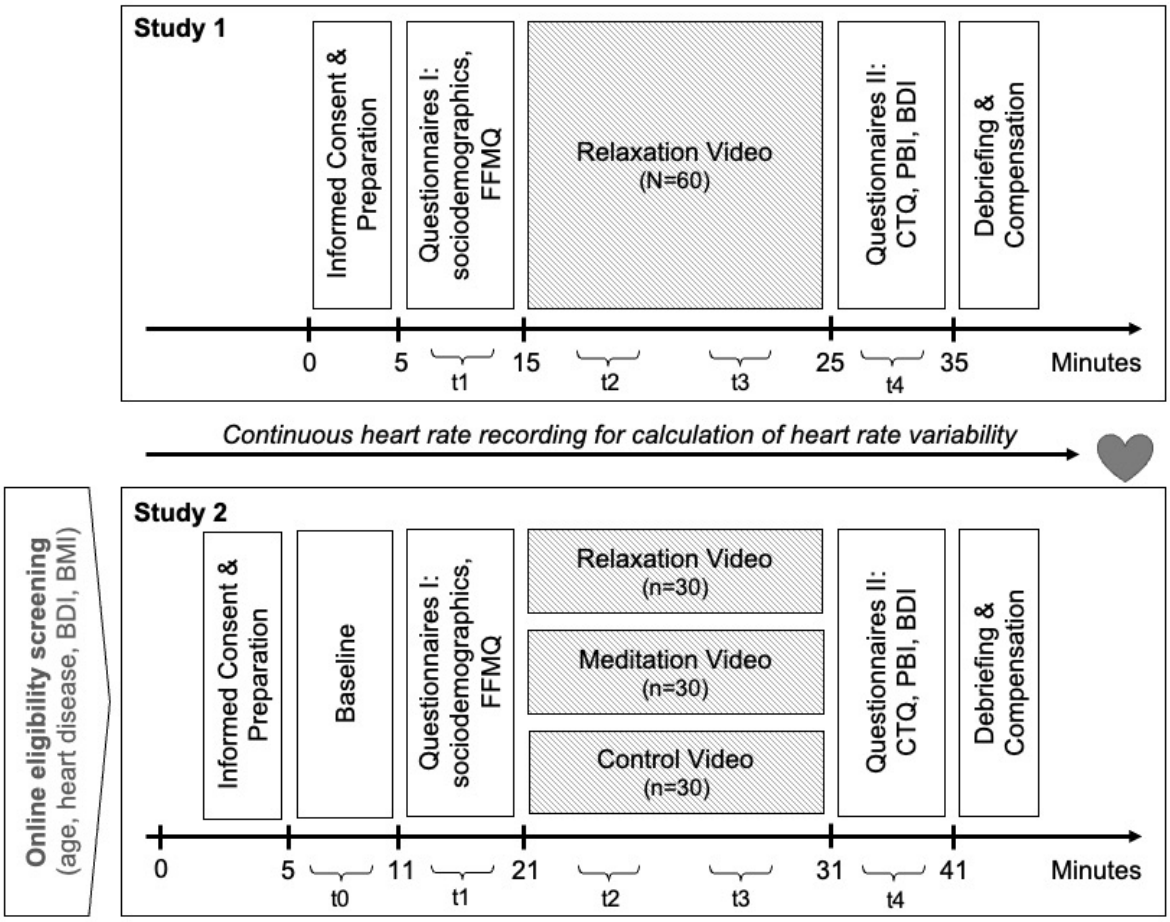

Fig. 7. Schematic representation of the study design for study 1 and 2; t0 – t4: 180-sec time segments that were extracted from the continuous heart rate recording for calculation of heart rate and heart rate variability resulting in four time points for the multiple growth curve analysis in Study 1 and five time points in Study 2. A comprehensive list of all measures assessed during both studies can be found at https://osf.io/wcdku/.

4.3.1.4 Measurements

4.3.1.4.1 Heart rate variability

To investigate autonomic regulation during the different experimental phases, we recorded HR continuously using the Polar H7 heart rate sensors (Polar Electro Oy, Kempele, Finland) on a two-electrode chest belt. The HR sensors were connected via Bluetooth with an 11-inch iPad (Apple Computer, Cupertino, CA, USA) running the HRV Logger App for iOS (Altini, 2013) that records and stores HR and beat-to-beat intervals (RR-intervals) at a sampling rate of 1000Hz together with event markers, set manually throughout the session to allow separating the experimental phases. After transferring data to local desktop computers in the lab, we processed RR data using R (version 4.1.0) together with its user interface R-Studio (version

1.4.1717) to remove ectopic beats, artefacts and interpolate missing beats based on visual inspection and facilitated by in-house R scripts (available at https://osf.io/wcdku/). As it is recommend to calculate HRV in constant time intervals lasting between one to five minutes (Laborde, 2017), we subsequently extracted 180-second segments, each from the middle of the respective experimental phases: one segment from each of the two sets of questionnaires before (t1) and after the video (t4) and two segments from the video section (t3 and t4), which we split in half before segment extraction to maximize information gain. Finally, using the R package RHRV (García Martínez et al., 2017), we computed RSA, in the context of this study defined as the natural logarithm of HF-HRV. For the calculation of HF-HRV in the fixed frequency bandwidth of 0.15 – 0.4 Hz (Shaffer & Ginsberg, 2017b), we applied the frequency analysis provided by RHRV with a Fast Fourier Transformation using a window of 60 seconds and a shift of 30 seconds (Protocol and R scripts available at https://osf.io/wcdku/).

4.3.1.4.2 Early life adversity

We retrospectively assessed self-reported early life adversity with the Parental Bonding Instrument (PBI, Parker et al., 1979). The PBI focuses on attachment aspects of perceived parenting behavior which can be considered one type of early life adversity if it is disadvantageous (lack of care and/or high overprotection and constraint) (Unternaehrer et al., 2021). Participants rate perceived parenting behavior of their mothers and fathers respectively on the two dimensions care and overprotection with 25 Items per parent on a 5-point Likert-Scale. Higher sum scores on the care dimension indicate warm and thoughtful parenting and are associated with beneficial parenting effects. Higher scores on the overprotection dimension indicate controlling and restrictive parenting and are associated with disadvantageous parenting effects. For this study we used a German translation of the PBI that was not validated when we conducted the study (Lutz et al., 1995). However, a very similar version has since been validated by our group, demonstrating good psychometric properties (Benz et al., 2021).

4.3.1.4.3 Trait mindfulness

We used the Five Facet Mindfulness questionnaire (FFMQ, Baer et al., 2006) to measure trait mindfulness, the general ability to deliberately direct one's attention towards the present moment without judgment or immediate reaction. In the FFMQ, participants rate their trait mindfulness via 39 items on a 5-point Likert-Scale. As the FFMQ describes trait mindfulness as a multifaceted construct, answers can be grouped to different mindfulness skills on five subscales: observing, describing, non-reacting, non-judging, acting with awareness. The German version of the FFMQ showed good reliability and validity (Michalak et al., 2016). Additionally, we asked participants if they had any previous experience with mindfulness-based practices (e.g. yoga or meditation practice or a structured course program) and if so, for how many years and how regularly they engage in mindfulness practices.

4.3.1.4.4 Depressive symptoms

Using the Beck's Depression Inventory II (BDI-II, Hautzinger et al., 2006), we assessed depressive symptoms, which has been associated with HRV previously (Kemp et al., 2010) and thus included as a potential covariate. The BDI-II entails different symptoms of a depressive episode according to the ICD-10 (Graubner, 2013), with a total of 21 questions answered on a 4-point Likert-Scale with verbal anchor descriptions.

4.3.1.5 Statistical Analysis

Before statistical analysis, we checked for outliers in HR and RSA and winsorized values that lay more than three standard deviations above or below the mean across all conditions and timepoints. Missing items in one of the questionnaires were imputed with the item median (k = 13 missing items in the PBI, k = 7 missing items in the FFMQ). If a participant omitted more than 20% of the items of a given subscale, this variable was coded as NA and excluded from the respective analysis (compare Tab. 1).

To run our analyses, we used R version 4.1.0 (R Core Team, 2021), RStudio version 1.1.463 (RStudio Team, 2016), and the packages ‘arsenal’ (Heinzen et al., 2021) for descriptive analyses and ‘nlme’ (Pinheiro et al., 2021) for mixed model analyses. Graphs were created using ‘ggplot2’ (Wickham, 2016). The level of significance was set to an alpha level of .05, and Bonferroni corrections were applied as necessary.

In a first step, we used multilevel mixed models to calculate growth curve analyses to model trajectories for HR and RSA over time. In multilevel models one can account for individual differences in average HR and RSA levels as well as different time trajectories (change over time). If addition of a random effect significantly improved model fit, we assumed that there was a significant amount of variance explained by inter-individual differences, either regarding average outcome values (intercept) or regarding change in outcome values over time (slope). The analysis of Study 1 included four time points: first set of questionnaires (t1), first half of videos (t2), second half of videos (t3), and second set of questionnaires (t4). We first defined the basic model structure regarding fixed and random effects by comparing model fit indices to find the model that best explained the data using LogLikelihood ratio tests. If the addition of the respective step improved the model fit significantly, this change was retained for the next step. We first introduced a fixed intercept, then random intercept on participant level, followed by fixed time effects for linear, quadratic and cubic trends over time (each evaluated one after the other), and finally random effects of the best-fitting time trend. To this basic model, we added potential covariates (sex, age, and BDI-II) one at a time to examine their effects on HR or RSA. Finally, we investigated the influence of the secondary predictors, early life adversity and trait mindfulness by adding each of the four PBI subscales (maternal and paternal care and overprotection) and each of the five FFMQ subscales (observing, describing, non-reacting, non-judging, acting with awareness) individually as interaction with trend of time to the final model. For these secondary predictors, we applied Bonferroni corrections for $k = 4$ or $k = 5$ tests, respectively, thus adjusting the level of significance to $_{\text{Bonferroni}} = \alpha/k$.

Using the R package 'performance' (Lüdecke et al., 2021), we checked model assumptions and performance including the function R2() to evaluate effect size for all final models. An R Markdown file with the statistical analysis can be found at https://osf.io/wcdku/.

4.3.2 Results

4.3.2.1 Sample Characteristics

We assessed N = 60 students in Study 1.

Tab. *7* displays the demographic and psychometric characteristics of both samples and the different video conditions. Regarding nature video content, we found that most participants chose "rain falling in the thicket" (36%); followed by "river stream in the forest" (31%), "beach" (23%), and "fireplace" (11%). Due to the unbalanced distribution of the selected video contents, this factor was not included in the subsequent analysis.

Tab. 7. Sample Characteristics in Study 1.

	Study 1
	Relaxation (*N*=60)
Sex (% female) [a]	51.7%
Age (in years)	23.92 (±3.13)
Job (% students)	100%
BDI-II	9.78 (±8.75)
Mindfulness experience	
Any experience	36.7%
Years of experience [b]	2.88 (±2.50)
Regularity of practice [b] (% at least weekly)	20%
FFMQ	
Total Score	3.44 (±0.42)
Observing	3.48 (±0.65)
Describing	3.55 (±0.69)
Non-judging	3.73 (±0.77)
Non-reacting	3.09 (±0.58)
Acting with awareness	3.33 (±0.64)
PBI	
Mother	
Maternal care	27.03 (±6.70)
Maternal overprotection	12.22 (±7.70)
Father (*n*=56) [c]	
Paternal care	24.61 (±7.85)
Paternal overprotection	7.54 (±5.73)

Notes: [a] self-reported sex as assigned at birth, with the response options “female”, “male”, “diverse”, *n*=0 answered “diverse”, thus only two categories (female/male) are reported; [b] based on *n*=24 participants with mindfulness experience only; [c] reduced sample sizes are due to missing items as described in the method section; BDI-II=Beck Depression Inventory; FFMQ=Five Facet Mindfulness Questionnaire; PBI=Parental Bonding Instrument.

4.3.2.2 Heart rate and heart rate variability

In Study 1, we analyzed HR and RSA over four time points (t1: first set of questionnaires, t2: first half of videos, t3: second half of videos, and t4: second set of questionnaires) looking at the effect of the nature-based relaxation videos in contrast to the two sets of questionnaires before and after the video. We found a significant decrease of HR and increase of RSA, respectively, while watching the video (see Fig. 8a and b). For HR, in a mixed model with random intercept (*Intra-Class*

Correlation Coefficient (ICC) = .90) and fixed slope, the model including a cubic trend of time (omnibus test: $F(3,177) = 16.14$, $p < .001$, marginal $R^2 = .17$) to predict HR decrease during the video segments showed the best fit. For HRV, the best model fit was achieved by a random intercept (*ICC* =.74) and random slope for the linear time trend in combination with a fixed quadratic effect of time (omnibus test: $F(2,178) = 33.80$, $p < .001$, *conditional* $R^2 = .84$, *marginal* $R^2 = .05$) predicting RSA increase during the video segments. Potential covariates (age, sex, and BDI-II) did not change the results nor improve model fit for HR or RSA and were thus not included in the final model (see Table 2).

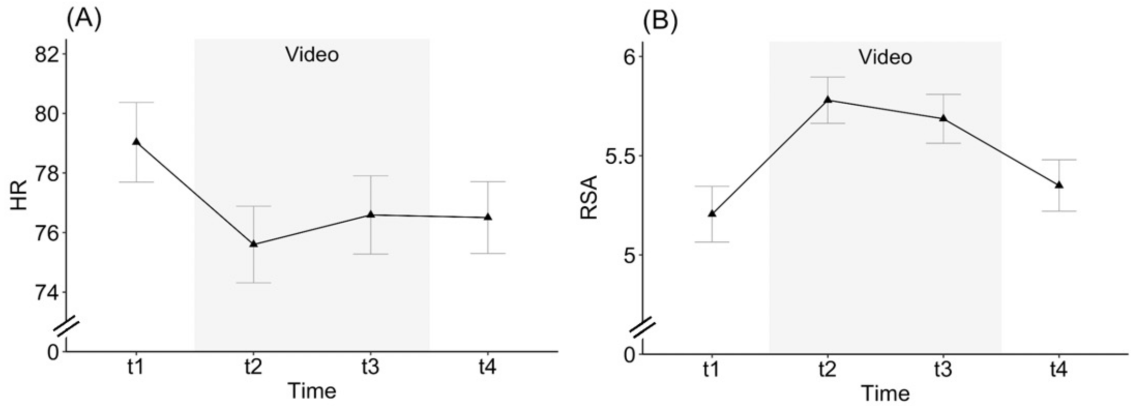

Fig. 8. (A) Heart rate (HR) and (B) respiratory sinus arrhythmia (RSA) over time in Study 1 (t1: first set of questionnaires, t2: first half of video, t3: second half of video, t4: second set of questionnaires); error bars depict standard errors of the mean.

Tab. 8. Summary of final model to predict HR and HRV in Study 1.

Effects	Statistics	p-value
HR		
Intercept	$F(1,177) = 3810.43$	< .001
$Time^3$	$F(3,177) = 16.14$	< .001
HRV		
Intercept	$F(1,178) = 2231.60$	< .001
$Time^2$	$F(2,178) = 33.80$	< .001

*Note*s: Linear mixed-effects model fit by maximum likelihood; HR-Model with random intercept and fixed cubic effect of time; HRV-Model with random intercept and fixed and random quadratic effect of time; HR=Heart Rate; HRV=Heart Rate Variability.

4.3.2.3 Early life adversity and trait mindfulness

Adding PBI subscales as secondary predictors to the mixed model regarding HR, we found a significant interaction for the quadratic time effect with maternal care (model coefficients: *estimate* = -0.92, *se* = 0.42, $t(174) = -2.19$, $p = .030$) and paternal care (model coefficients: estimate = 0.79, se = 0.35, $t(162) = 2.25$, $p = .026$). Higher maternal care was associated with lower HR before and during the first half of the video (t1 and t2); higher paternal care was associated with lower HR during the first half of the video only (t2). For RSA, only the interaction of quadratic time and paternal care reached significance (mode coefficients: *estimate* = 0.15, *se* = 0.05, $t(164) = 2.81$, $p = .006$) participants with higher paternal care showing higher RSA before and after (t1, t4) but not during the video (t2, t3). However, after Bonferroni correction for four tests ($\alpha_{Bonferroni} = .013$), only the interaction effect of paternal care and quadratic time to predict RSA remained significant.

Concerning trait mindfulness and HR, we found an interaction between quadratic time and FFMQ-observing (model coefficients: *estimate* = 11.6, *se* = 4.27, $t(174) = 2.71$, $p = .007$). For RSA, we found an interaction between the quadratic time trend and FFMQ-observing (model coefficients: *estimate* = -1.90, *se* = 0.65, $t(176)= -2.91$, $p = .004$). Both effects of FFMQ-observing skills survived Bonferroni correction for five tests ($\alpha_{Bonferroni} = .01$). Higher FFMQ-observing scores were associated with higher HR and lower RSA before (t1) but not during the video segment (t2, t3).

4.3.3 Discussion

In Study 1, we investigated changes of HR and RSA as indicators of autonomic regulation in response to a nature-based relaxation video intervention. During the video, HR decreased, and RSA increased in line with our hypotheses in female and male participants alike. Additionally, we observed lower RSA in participants with low paternal car and high mindfulness observing skills with the latter contradicting to our expectations. These results suggest a positive effect of the nature-based relaxation video intervention on autonomic regulation. However, some methodological limitations should be considered in the interpretation of these observations especially regarding the secondary predictors, early life adversity and trait mindfulness. First of all, power analysis for this was based on a comparison of HR and RSA changes across four time points between female and male participants. Thus, the sample size might have been too small to detect effects of the secondary predictors and extension and replication of these findings in bigger samples is needed. In addition, only few exclusion criteria were applied here. Even though the BDI-score did not influence the present results, many studies reported a negative effect of depressive symptoms and other factors on HRV (Kemp et al., 2010). A more rigorous sampling that accounts for effects of depressiveness, and under- or overweight (Peyser et al., 2021; Strüven et al., 2021) could benefit future studies. Furthermore, this study only looked at one video condition in comparison to questionnaires before and after the videos. It would be interesting to include a resting-state baseline (Laborde, 2017) and compare the nature-based relaxation videos to other video types. Finally, we did not assess any subjective measures on feelings of relaxation after watching the video or whether a participant was familiar with the video content beforehand. For example, it might be possible, that one of the videos being someone´s favorite relaxation video could have influenced the results.

4.4 Study 2

Based on the observed effect of the nature-based relaxation videos on autonomic regulation in Study 1 and the partial modulation by aspects of early life adversity and trait mindfulness, we aimed to replicate and extent this finding in an independent sample in Study 2. In addition to employing more rigorous exclusion criteria and a physiological baseline, we added two video conditions to compare the nature-based relaxation videos from Study 1 with other video types: a meditation video, as a different approach to relaxation via inducing mindfulness (Jain et al., 2007), and a movie clip from “The Lord of the Rings”, as a control condition that is attention grabbing without aiming at relaxation (Zeidan et al., 2010).

4.4.1 Method

4.4.1.1 Participants

Data collection for Study 2 took place from October to November 2018. In addition to the exclusion criteria used in Study 1, we used an online pre-screening to exclude interested students if they reported being under- or overweight, i.e. a body mass index (BMI) < 17.5 or > 30, or having clinically relevant depressive symptoms, i.e. a BDI-II score > 18 . A total of *N* = 90 students (sex assigned at birth: 50% female, 50% male; age: *mean* = 22.63 ±4.57, range 18–49) participated in the study. Sample size was determined using the tool G*Power (Faul et al., 2007) based on within-between interactions (three video conditions groups and four time points) and medium effect size, power = 90%, alpha = 0.05 as well as feasibility considerations and previous studies on HRV reactivity (e.g. Gladwell et al., 2012).

4.4.1.2 Procedure

The laboratory assessment in Study 2 resembled Study 1 if not described otherwise (see Fig. 1). After giving their informed consent and applying the HRV sensor, participants first underwent a 6-minute physiological baseline (resting-state, eyes open, sitting upright with both feet on the ground) before completing the first set of questionnaires. Subsequently, all participants completed the video intervention. In Study 2, we created a quasi-randomization of subject to video condition by generating a random condition-by-sex list using the R sample function to distribute group assignment randomly across experimenter, day, time and participant´s sex. This way, we assigned participants to one of three video conditions: the same nature-based relaxation video intervention as in Study 1, a meditation video, or a control video (see below). For all three conditions, they were instructed to concentrate on the video without mentioning the word “relaxation”. Finally, participants completed the second set of questionnaires. Additionally, we asked them to rate the videos on a 5-point Likert scale with respect to familiarity, pleasantness, and subjective relaxation effect of the videos. Laboratory sessions were scheduled between 8 a.m. and 7 p.m. in empty classrooms at the University of Konstanz, where we seated participants facing a white wall.

4.4.1.3 Video material

In addition to the nature-based relaxation videos (describe above), two more video conditions were added to the design in Study 2. Participants watched the 10-minute videos on a 13-inch MacBook Air (Apple Computer, Cupertino, CA, USA) and used circumaural earphones (Sennheiser, Wedemark, Germany) to maximize video audio and minimize ambient noise.

The meditation video used in Study 2 invited participants to practice a beginner's mindfulness exercise guided by a female voice (Morrison, 2017). Meditation instructions included the two-fold observation of breathing and thoughts without analyzing, judging, or changing them. For comparability to the relaxation group, we combined the meditation instructions with the beach scenery (Outstanding Videos, 2012) and calm, melodic music.

As a control condition, we presented the third group in Study 2 with a film clip from the movie "The Lord of the Rings: The Fellowship of the Ring" (Jackson, 2001, min[6.40-16:40]), specifically with the arrival of Gandalf, a wizard and main character of the movie, at the Shire, a hilly green inland area. We aligned this control condition with other meditation studies, that used an audio segment of the same movie series for their control condition (Zeidan et al., 2010). In addition, we expected this film clip to resemble the relaxation group in the general appearance (naturalistic landscape, no distressing or startling aspects) but without the relaxation focus.

4.4.1.4 Measurements

The measurements used in Study 2 to assess HRV, early life adversity, trait mindfulness, and depressive symptoms resembled Study 1 except two modifications: First, the physiological baseline implemented in Study 2 before the first set of questionnaires was added as the first time point (t0). To analyze this segment, we extracted one 180-second RR-interval from the middle of the 6-minute baseline. Second, we used a BDI-II score > 18 in a pre-screening as an exclusion criterion for the laboratory assessment.

4.4.1.5 Statistical Analysis

We applied the same pre-processing rational to outliers and missing values and the same growth curve analysis procedure as in Study 1. The available HRV time intervals entering into the analysis were: physiological baseline (t0), first set of questionnaires (t1), first half of videos (t2), second half of videos (t3), and second set of questionnaires (t4). After exploring random effects for intercept (outcome value) and slope (time variable) in addition to a linear, quadratic, and cubic time trend and adding potential covariates (sex, age, BDI-II, and mindfulness experience) as described for Study 1, we examined the main effects of video condition and the interaction between video condition and the time trends on HR or RSA. Finally, as in Study 1, we investigated the influence of the secondary predictors, early life adversity and trait mindfulness by adding each of the four PBI subscales (maternal and paternal care and overprotection) and each of the five FFMQ subscales (observing, describing, non-reacting, non-judging, acting with awareness) individually as interaction with trends of time to the final model. For these secondary predictors, we applied Bonferroni corrections for $k = 4$ or $k = 5$ tests, respectively, thus adjusting the level of significance to $\alpha_{Bonferroni} = \alpha/k$. Again, for every step of model building, resulting model fits were evaluated using the Log-Likelihood Ratio as described above. An R Markdown file with the statistical analyses of Study 1 and study 2 can be found at https://osf.io/wcdku/.

4.4.2 Results

4.4.2.1 Sample Characteristics

In Study 2, we assessed *N* = 90 people. ***Tab. 9*** displays the demographic and psychometric characteristics of the three video condition groups (*n* = 30 each). Except for mindfulness experience the groups did not differ in any of these characteristics. Furthermore, the movie clip was rated as significantly more familiar, while all three videos were mostly rated as pleasant and relaxing. Regarding nature video content, we found that most participants chose “rain falling in the thicket” (32%); followed by “river stream in the forest” (27%), “fireplace” (22%), and “beach” (20%). Due to the unbalanced distribution of the selected video contents, this factor was not included in the subsequent analysis.

Tab. 9. Sample characteristics and group comparison in Study 2.

	Study 2			
	Control (*n*=30)	Meditation (*n*=30)	Relaxation (*n*=30)	p-value
Sex (% female) [a]	50%	50%	50%	> .999
Age (in years)	22.43 (±3.28)	23.07 (±5.87)	22.40 (±4.22)	.820
BMI	22.03 (±2.13)	22.23 (±2.69)	22.80 (±2.77)	.483
Job (% students)	90%	86.6%	90%	.513
BDI-II	5.97 (±4.61)	5.97 (±4.65)	5.80 (±5.05)	.988
Mindfulness experience				
Any experience	**53.3%**	**50%**	**23.3%**	**.036**
Years of experience [b]	4.31 (±3.38)	4.69 (±4.80)	2.29 (±0.95)	.369
Regularity of practice [b] (% at least weekly)	20%	23.3%	13.3%	.600
Video ratings				
Familiarity [b]	**3.87 (±1.07)**	**2.87 (±1.04)**	**2.67 (±1.24)**	**< .001**
Pleasantness [d]	1.73 (±0.87)	1.33 (±0.55)	1.73 (±0.91)	.083
Feeling relaxed [e]	1.93 (±0.87)	1.60 (±0.77)	1.87 (±0.94)	.289
FFMQ				
Observing	3.40 (±0.56)	3.44 (±0.63)	3.54 (±0.50)	.587
Describing	3.56 (±0.70)	3.47 (±0.60)	3.59 (±0.77)	.777
Non-judging	3.73 (±0.76)	3.73 (±0.61)	3.34 (±0.83)	.063
Non-reacting	3.21 (±0.59)	3.18 (±0.75)	3.13 (±0.68)	.916
Acting with awareness	3.44 (±0.60)	3.20 (±0.56)	3.13 (±0.59)	.105
Total Score	3.47 (±0.37)	3.41 (±0.37)	3.34 (±0.48)	.515

	Study 2			p-value
	Control (*n*=30)	Meditation (*n*=30)	Relaxation (*n*=30)	
PBI				
Mother (*n*=89)				
Maternal care	27.83 (±5.60)	28.57 (±5.16)	26.52 (±7.83)	.452
Maternal overprotection	11.10 (±4.85)	9.2 (±5.99)	11.52 (±6.18)	.253
Father (*n*=85)				
Paternal care	23.54 (±7.21)	24.33 (±7.25)	22.60 (±6.60)	.648
Paternal overprotection	7.86 (±4.42)	7.85 (±5.86)	8.90 (±6.77)	.730

Notes: p-values are reported for group comparisons based on Chi^2-Tests or ANOVAs depending on data properties; significant group differences at a level of α<.05 are printed in bolt; if not indicated otherwise the total sample of *N*=90 participants was included in the comparison between the three groups, reduced sample sizes are due to missing items as described in the method section; [a] self-reported sex as assigned at birth, with the response options “female”, “male”, “diverse”, *n*=0 answered “diverse”, thus only two categories (female/male) are reported; [b] based on *n*=36 participants with mindfulness experience only; [c] Video familiarity rated on a 5-point Likert-Scale from 1 = very unfamiliar to 5 = very familiar; [d] Video pleasantness rated on a 5-point Likert-Scale from 1 = very pleasant to 5 = very unpleasant; [e] Feeling of relaxation after video rated on a 5-point Likert-Scale from 1 = very relaxed to 5 = not relaxed at all; BMI=Body Mass Index; BDI-II=Beck Depression Inventory; FFMQ=Five Facet Mindfulness Questionnaire; PBI=Parental Bonding Instrument.

4.4.2.2 Heart rate and heart rate variability

In Study 2, we compared three different video interventions at five time points (t0: baseline, t1: first set of questionnaires, t2/t3: two video segments, t4: second set of questionnaires). Comparable to Study 1, we found a significant decrease in HR and increase in RSA during the video segment compared to baseline (see Fig. 9a and b). For HR, in a mixed model with random intercept (*ICC* = .89) and random slope, the quadratic term of time (omnibus test: $F(2,354) = 2.53$, $p = .041$) and the interaction effect between group and quadratic time (omnibus test: $F(2,354) = 7.91$, $p < .001$, *conditional* $R^2 = .93$, *marginal* $R^2 = .03$) significantly predicted decrease of HR during the video segment. The interaction effect of group with the quadratic time trend was mainly driven by a stronger decrease of HR during the video segment in the meditation group (model coefficients: *estimate* = -23.13, *se* = 7.44, $t(354) = -3.11$, $p = .002$). For HRV, the mixed model with random intercept (*ICC* = .76) and fixed slope controlled for age as a covariate (omnibus test: $F(1,86) = 15.32$, $p < .001$) the cubic effect of time (omnibus test: $F(3,357) = 5.92$, $p < .001$) showed a main effect of group (omnibus test: $F(2,68) = 7.07$, $p = .001$, *conditional* $R^2 = .78$, *marginal* $R^2 = .21$) predicting RSA increase during the video segment.

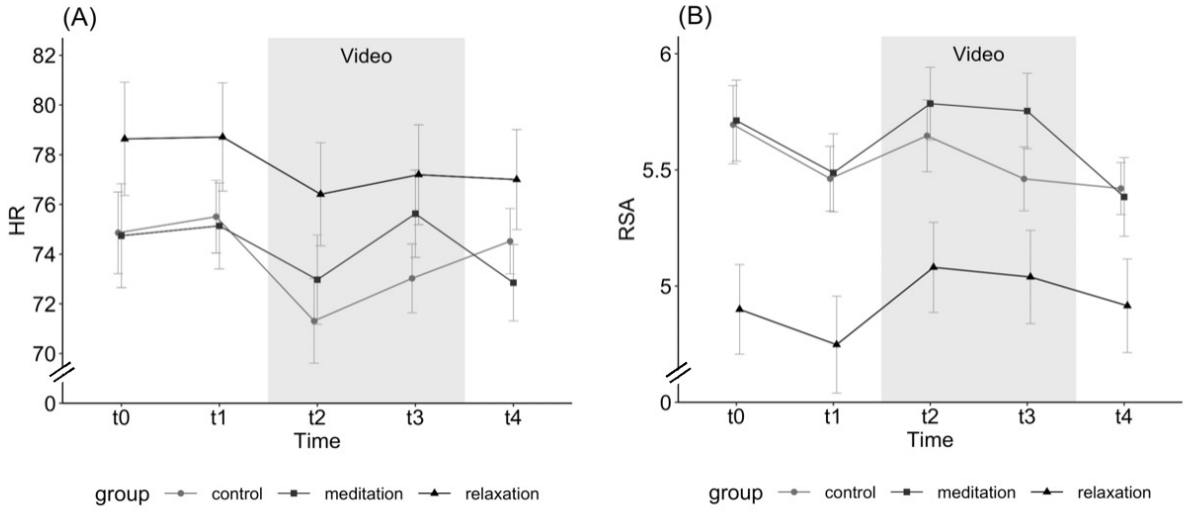

Fig. 9. (A) Heart rate (HR) and (B) respiratory sinus arrhythmia (RSA) over time in study 2 (t0: baseline, t1: first set of questionnaires, t2: first half of video, t3: second half of video, t4: second set of questionnaires) in all three groups: nature-based relaxation video, meditation video, control video; error bars depict standard errors of the mean.

Notably, the relaxation video group presented a reduced RSA throughout the experimental session independent of time (model coefficients: *estimate* = -0.60, *se* = 0.20, $t(86) = -3.03$, $p = .003$). As expected, higher age was associated with lower RSA. Other potential covariates (sex, BDI-II, mindfulness experience, and video familiarity) did not improve model fit neither for HR nor for RSA and were thus not included in the final model (see **Tab. 10**).

Tab. 10. Summary of the final model to predict HR and HRV in Study 2.

Effects	Statistics	p-value
HR		
Intercept	$F(1,354) = 6528.15$	< .001
Time^2	$F(2,354) = 7.91$	< .001
Video condition	$F(2,87) = 1.19$	.308
Time^2 * Video condition	$F(4,354) = 2.53$	.041
HRV		
Intercept	$F(1,357) = 4355.38$	< .001
Time^3	$F(3,357) = 5.92$	.001
Video condition	$F(2,86) = 7.07$	.001
Age	$F(1,86) = 15.32$	< .001

Notes: Linear mixed-effects model fit by maximum likelihood; HR-Model with random intercept and fixed and random quadratic effect of time including the main and interaction effect of video condition; HRV-Model with random intercept and fixed cubic effect of time including age as a covariate and the main effect of video condition; HR=Heart Rate; HRV=Heart Rate Variability.

4.4.2.3 Early life adversity and trait mindfulness

When adding PBI subscales as secondary predictors to the mixed models regarding RSA, we found a significant interaction for the quadratic time effect with maternal care (model coefficients: *estimate* = -0.4, *se* = 0.07, $t(350) = -3.24$, $p = .001$) and overprotection (model coefficients: *estimate* = 0.18, *se* = 0.08, $t(350) = 2.20$, $p = .028$). Higher maternal care and lower maternal overprotection predicted a more pronounced increase of RSA during the video segment (t2). In addition, we found a main effect of paternal overprotection, with higher overprotection predicting lower RSA throughout the experiment (model coefficients: *estimate* = -0.03, *se* = 0.02, $t(80) = -2.09$, $p = .040$). Only the interaction of maternal care and quadratic time to predict RSA survived Bonferroni correction for four tests ($\alpha_{Bonferroni} = .013$). None of the PBI subscales significantly predicted HR. Concerning trait mindfulness, none of the FFMQ subscales revealed significant results when added to the models predicting HR or RSA.

4.4.3 Discussion

In Study 2, we investigated changes of HR and RSA in response to three different video conditions, a nature-based relaxation video intervention, a meditation video, and a control movie clip. During all three video interventions, HR decreased, and RSA increased in line with our hypotheses. Looking at group effects, we observed a stronger RSA increase in the meditation group, and higher HR and lower RSA in the relaxation group throughout the whole experimental session. Mindfulness practices have been shown to elicit an increase in HRV (Azam et al., 2015), thus, the interaction effect for the meditation video is in line with our hypothesis and previous research. On the other side, the main effect of the relaxation group was more surprising. As this higher HR and lower RSA was present in this group even before the video intervention, it is likely not related to video characteristics but rather to group differences that might explain baseline differences in RSA. When comparing the relaxation group in Study 2 with the other groups, significantly less mindfulness experience stood out. Mindfulness expertise (Burg et al., 2012) has been linked to autonomic regulation, and HRV in particular, previously and, thus, might have contributed to lower RSA observed in this group. Yet, a number of other variables that were not measured in our study could play an important role as well, such as menstrual cycle, physical fitness, or psychopathology other than depression, which we could only speculate about.

Additionally, we observed higher RSA in participants with higher maternal car during the videos as expected. Overall, the results of Study 2 suggest a more general relaxation effect of all three video intervention on autonomic regulation.

4.5 General Discussion

To investigate the effect of a nature-based relaxation video intervention on autonomic regulation, we measured HR and RSA throughout a 10-min video intervention in two consecutive studies. As intervention material, we used a nature-based relaxation video in Study 1 and compared this relaxation video to a meditation video and a control movie clip in Study 2. Both studies found an increase in RSA and a decrease in HR during the video segments in relation to the questionnaires before and after the video in the two independent samples as expected. However, contrary to our hypothesis on group differences in Study 2, the only interaction effect that we observed indicated a stronger HR decrease during the videos in the meditation video group.

The overall decrease in HR and increase in RSA in response to the videos suggests a successful activation of the parasympathetic system as a result of video exposure (Acharya et al., 2006; Shaffer & Ginsberg, 2017b) in general. This is backed by the majority of subjective rating of the videos as pleasant and relaxing. Thus, the focus of the general discussion shifts from nature-based relaxation videos to relaxation videos in general. Our findings are in line with recent empirical evidence on the effects of relaxation videos. For example, watching videos at the workplace is helpful to recover from the stress and demands of work, increasing well-being, work satisfaction and relaxation (Janicke et al., 2018). Additionally, a video-based relaxation program successfully reduced anxiety, depressive and somatic symptoms in elderly participants with an anxiety disorder (Gould et al., 2019). Because of this and the convenience to standardize video interventions, they appear as a seminal method to induce relaxation in research settings and psychotherapy. Beyond that, experiencing relaxation is beneficial and linked to well-being and mental and physical health (D. S. Yu et al., 2010). However, standardized protocols with adequate control conditions and longitudinal investigations of the long-term effects of relaxation videos are missing.

While we hypothesized that nature and meditation videos would lead to a stronger relaxation response than the movie clip, we found a general response to any video that participants watched in both of our studies. First and foremost, this could be a general effect of sustained attention to a pleasant and non-threatening video stimulus. In contrast to the physiological baseline, looking at a blank classroom wall, or the questionnaire phases, looking down on a paper with the different questionnaires, the video intervention required participants to direct their attention to the screen which by itself might affect autonomic regulation (Holzman & Bridgett, 2017). Looking closer at movie clip content reveals another possible explanation for the comparable increase in RSA in this condition. The movie scene from "The Fellowship of the Ring" is set in the Shire with green hills, widespread meadows, and a blue sky underpinned with beautiful calm music. The contents are similar to those of the relaxation videos: a calm nature scene accompanied with instrumental music. When planning this study, we attempted to align the control condition as much as possible with the relaxation video, e.g., in colors and general atmosphere, yet without the specific aim of a relaxation video but with a distracting movie content similar to other studies (Zeidan et al., 2010). However, these features that made the movie clip comparable to the nature relaxation videos might have induced a comparable level of relaxation in the control condition compared to the other videos. According to the ART (Kaplan, 1995), an environment needs four different aspects to trigger relaxation: *Fascination*, an environment's ability to capture involuntary attention, *Being Away*, a physical and mental distance to everyday life, *Extent*, the sufficiency of an environment to engage the viewer's mind, and *Compatibility*, the fit between the viewers' intentions and the possibilities the environment offers. All four aspects of the ART can be identified in the nature-based relaxation videos, the meditation video, and the movie clip alike, giving a possible explanation of why RSA as an index of relaxation increased in all conditions. As such, our choice of a control condition using this particular excerpt from the movie was perhaps not a control condition, but a relaxing intervention as well.

After analyzing the effect of the different video conditions on autonomic regulation, we included parental care and overprotection, and trait mindfulness measures as secondary predictors to the mixed models and found inconclusive results with regard to HR. While higher maternal and paternal care predicted lower HR during the video segment in Study 1, we found no significant influence of parental care or overprotection on HR in Study 2. This speaks perhaps for a smaller effect, however our statistical power and hence our chances to detect a smaller effect were actually improved in Study 2 with a larger sample size. Results appear more consistent for RSA and measures of early life adversity. In Study 1, higher paternal care predicted higher RSA before and after but not during the video. In Study 2, maternal care was related to higher RSA, while maternal overprotection was associated with lower RSA in response to the video. In addition, in Study 2 , higher paternal overprotection predicted lower RSA independent of time.

While the link between HRV and psychopathology, e.g. in post-traumatic stress disorder or depression, is well established (Beauchaine & Thayer, 2015), the discussion to which extent early life adversity, particularly careless or overprotective parenting, in particular, contribute to autonomic dysregulations or an overall lower HRV is still ongoing. For example, lower resting HRV was predicted by higher inconsistent discipline, corporal punishment, and lower parental involvement (Graham et al., 2017) and a blunted HR stress response is linked to the experience of early life adversity (Voellmin et al., 2015).

It is important to consider the various means of observing HRV. While many studies look at RSA at baseline, or resting condition, there is also a number of studies who have looked at RSA changes in response to stress. These have not shown systematic effects, however. For example, RSA change in reaction to the Trier Social Stress Test (Busso et al., 2017) could not be associated with experiences of interpersonal violence or poverty. Similarly, in healthy women with adverse childhood experiences RSA did not mediate the physiological reaction to the Montreal Imaging Stress Task (Winzeler et al., 2017). It is conceivable that a stressor is not the right experimental manipulation to observe systematic associations between the parasympathetic nervous system and variables of personality, or early life adversity. The parasympathetic system is not being stimulated by a stressful situation, but will withdraw; thus, in these cases the experiment will investigate not whether the system can be activated, but if it can be shut down. The null findings in these studies could be a consequence of this distinction.

Our results support the findings that lower parental care and higher parental overprotection might lead to parasympathetic dysregulation that could be associated with psychopathological development later in life (Meyer et al., 2016). Especially the observation that higher paternal overprotection was associated with an overall lower

HRV sheds light on the often-overlooked role of fathers' parenting behavior in psychophysiological development. For example, it was found that fathers appropriate mind-related comments (e.g., "validation of infant's internal state") increased the baseline HRV of their one-year old child, independent of the mothers influence (Zeegers et al., 2018). In other aspects the influence of fathers' parenting behavior on children is similar to the influence of mothers parenting, for example, the same behaviors promote secure attachment (Fagan et al., 2014). Additionally, the effect of mothers and fathers parenting style on their children influence each other (Fagan et al., 2014). Because fathers influence is less well understood and researched as mothers influence (Unternaehrer et al., 2021), it seems highly recommended to include both aspects of parenting in our research on the influence of early life adversity and parenting behavior.

On the other hand, for trait mindfulness, again mixed findings were observed: contrary to our expectations, we found higher scores on the observing subscale (indicating better mindful observing skills) to predict higher HR and lower RSA during the video in Study 1 only. This finding that higher scores of trait mindfulness, especially mindful observing skills, are associated with higher HR and lower RSA seems counterintuitive at first since it suggests less relaxation during the video. We assessed trait mindfulness using the FFMQ, including observing as one subscale, which can be seen as a cognitive function linked to attention. It was found that mindfulness positively influences executive control (Verhaeghen, 2021), self-regulation (Tang & Posner, 2009) and attention (Jha et al., 2007; Tang & Posner, 2009; Verhaeghen, 2021). This link between mindfulness and cognitive functions in general, and attention in particular, might explain why parasympathetic activity was lower during the videos for participants who scored high on the FFMQ-observing subscale. When a cognitive challenge, like focusing on something, arises, it decreases parasympathetic activity and, therefore, HRV (Giuliano et al., 2018). Thus, it is possible that scoring high on mindful observing skills goes along with increased attention to one's surroundings and internal processes. This association between mindful observing and cognitive effort could affect innervation of the parasympathetic nervous system. Additionally, higher FFMQ scores are associated with better performance in sustained attention (Rice & Liu, 2017) and higher flexibility in changing one's attention focus, for example directing attention from unimportant stimuli to those needed to accomplish a task (Sørensen et al., 2018). These links suggest that mindfulness contributes to the ability to willingly direct attention, which can be interpreted as voluntary attention, as mentioned in the ART (Kaplan, 1995). According to this theory, voluntary attention stands opposite to involuntary attention, which is needed to achieve restoration. Therefore, it could be concluded that the aspects of mindfulness focusing on voluntary directing attention counteract the achievement of restoration. This counteraction could inhibit relaxation and therefore explain the low HRV while viewing the videos. In line with this argumentation, Watford and colleagues reported overall lower HF-HRV in persons scoring higher on a trait mindfulness questionnaire. These results seemed to be linked to heightened vigilance and cognitive load in more mindful participants (Watford et al., 2020). In our data, this effect was only visible in Study 1 and could not be replicated in Study 2 and should thus be interpreted with caution.

The relationship between HRV and mindfulness experience is a complex one. We found that less mindfulness experience is associated with a lower HRV in general but scoring high on trait mindful observing skills leads to reduced HRV during the video. It is important to note that there is a fundamental difference between resting-state HRV and HRV in reaction to a stimulus. Therefore, it is not counterintuitive that mindfulness skills might lead to an increase in baseline HRV but prohibit a strong increase in reaction to a relaxation video.

4.5.1 Limitations and future research

Several limitations should be considered when interpreting these results. First and foremost, we planned Study 1 with more liberal exclusion criteria and included a questionnaire baseline only. Adding a physiological baseline (Laborde, 2017) in Study 2 allowed for a more rigorous design but at the same time limited comparability between the two studies. Since the baseline measure of Study 1 was taken while participants filled out questionnaires it is possible that this activity influenced the HRV, making it difficult to compare the baseline levels of HR and HRV with the video response. In Study 2, however, neither HR nor HRV changed significantly between the physiological baseline and the first paper-pencil questionnaire segment. Nevertheless, it was not possible to combine data from Study 1 and Study 2. Thus, sample size might have been too small to detect small effects for secondary predictors and replications in bigger samples are needed to investigate the influence of different psychological characteristics like early life adversity or trait mindfulness on autonomic regulation.

Second, as discussed previously, the selected video material might not have been appropriate to investigate differential effects of a nature videos for several reasons: a) content of the control video, b) video presentation on laptop screens, and c) unbalanced nature sceneries in the nature video condition. The control video, as discussed before, might have been too similar to the experimental condition and thus, we failed to investigate group differences even though we attempted to create comparable control intervention with the movie clip. Many studies researching the relaxing effects of a natural environment have used urban environments to search for group differences. This can be seen in real-life experiments, for example, the effect of a walk in a forest compared to a walk through a city (Song et al., 2018). The forest walk shows a positive effect on anxiety and negative affect. Some experimenters used virtual representations of nature and urban environments to compare their effects on physiological and psychological parameters (Gladwell et al., 2012; Tang et al., 2017). Intervention material displaying urban environments in comparison to nature environments might thus be better suited for this line of research. Furthermore all videos were presented on rather small laptop screens (17-inch in Study 1 and 13-inch in Study 2). As we cannot exclude the possibility that screen size might have influenced relaxation effect, a more systematic investigation of effects of presentation mode (e.g. screen size and resolution, seating distance, acoustic properties) would be helpful for future studies. Moreover, we abstained from analyzing differential effects of nature video content (e.g. forest vs. fireplace) due to unbalanced groups even though. As soundscape studies have revealed, not only visual but also acoustic characteristics of rural videos elicit a psycho-physiological relaxation effect (e.g. subjective ratings as pleasant and restorative, HR decrease) with differential effects e.g. of water sound compared to bird songs (Ratcliffe, 2021). While we weren´t able to compare different video characteristics within the nature video condition, future research should focus on this particular comparison or determine only one scenery at the start, for example “rain falling in the thicket” which was the most prominent video in this study.

The observation of overall lower RSA during the video condition in Study 2 was unexpected, but as this main effect was independent of the video intervention, it is most likely linked to group differences that exist beyond the experimental manipulation of our study. Though we tried to form comparable groups by quasi-randomly assigning participants to the different conditions, a more comprehensive pre-screening might be necessary in future studies to prevent such an effect. This should be applied especially when psychological characteristics that could constitute group differences are part of the research focus.

Fourth, both study samples consisted of relatively young participants, with an age range of 18 to 49 and only n=4 participants older than 30 years. Taking age into account when measuring HRV is especially important since HRV decreases with age in our and other studies, mainly between 20 and 35 years (Hirsch & Bishop, 1981). Therefore, our study findings are limited to young adulthood, and future studies might want to recruit a sample with a wider age range to be able to measure the reaction to the intervention over the whole lifespan. Additionally, the sample consisted of mostly healthy participants. Only in Study 1 were some participants with a BDI-II score above 18 (n = 9) which suggests clinically relevant depressive symptoms (Hautzinger et al., 2006). Like age, mental and physical diseases influence HRV (Acharya et al., 2006; Shaffer & Ginsberg, 2017b) and should be taken into account. Only adding healthy participants to the sample was necessary to maximize the comparability of the different groups and limit additional factors influencing the HRV. Beyond age and health, various factors influence HRV, which future studies should take into account: for example, the menstrual cycle (Vallejo et al., 2005), sleep (Glos et al., 2014) and smoking (Barutcu et al., 2005). In addition, it would be interesting to not only look at sex effects but take gender effects into account as well. Furthermore, we measured BMI in Study 2 only and cannot draw any conclusions about its influence in the sample of Study 1. The impact of between-subject differences is reflected by the inter-individual variance as indicated by random effects. While this points towards individual factors that might explain additional variance, the control for random effects in the multilevel model approach is a strength of this data-driven approach (Curran et al., 2010), Those factors could be measured to control their influence or a within-subject design could ensure that those factors do not influence the differences between two interventions. Yet, when using a within-subject design, sequence effects must be taken into account.

4.5.2 Conclusion

In conclusion, the nature videos, the meditation video and the movie clip we used in these two studies, were effective in producing a robust increase in RSA as a standard HRV measure, together with a decrease in HR. This autonomic response, which is in line with a state of relaxation, may be attributed to the restorative properties of the video material. Looking at secondary predictors, we found evidence of an attenuated relaxation response in association with lower parental care and higher parental overprotection as expected. The observing facet of trait mindfulness seemed to be associated with an attenuated autonomic relaxation response as well. Future research could focus on determining which features of video-based nature scenes specifically promote relaxation when engaged in video viewing. Such videos could thus become useful tools for promoting relaxation in clinical and therapeutic setting.

5 General Discussion

When trying to understand mechanisms of psychopathology – how it develops, who it affects, which systems it modulates, and most importantly how it could be prevented, buffered, or treated – numerous theoretical models can be consulted. In general, as discussed in Chapter 0, we can assume that the experience of adverse conditions during sensitive periods of development, e.g. early childhood or puberty (cf. Chapter 1.1), leads to adaptive calibration processes regarding modulations of different biological systems such as the hypothalamic-pituitary-adrenal (HPA) axis (cf. Chapter 1.2) or the autonomic nervous system (ANS, cf. Chapter 1.3). These initially adaptive modulations eventually become maladaptive and thereby promote psychopathological developments later on. At the same time, mental disorders are often associated with subsequent alterations in these biological systems as well. While clinical studies investigating the potential interaction of the different components would help dismantle the question of chicken versus egg, first of all, informative and reliable research methods are required.

To this end, I investigated three different aspects related to the three components introduced before (subjective evaluation of early adversity, HPA regulation, and autonomic functioning), to improve and expand existing and develop new assessment approaches for standardized, valid, and more comprehensive measurements of potential correlates, predictors, or consequences of psychopathology. Even though the translation and examination of an existing psychometric questionnaire (Chapter 2) is conceptually different from the investigation of novel physiological parameters (extension of assessment of cortisol after awakening, Chapter 3, and development of nature-video paradigm to assess autonomic relaxation responsivity, Chapter 4), a reliable questionnaire constitutes an important basis for future deliberate research designs that include a measure of parental care or overprotection as indicators of early life adversity.

A brief summary of the main results of the three papers presented in this thesis is depicted in Fig. 10 followed by a more elaborated summary and evaluation of each paper and a general integration and discussion of all three papers together.

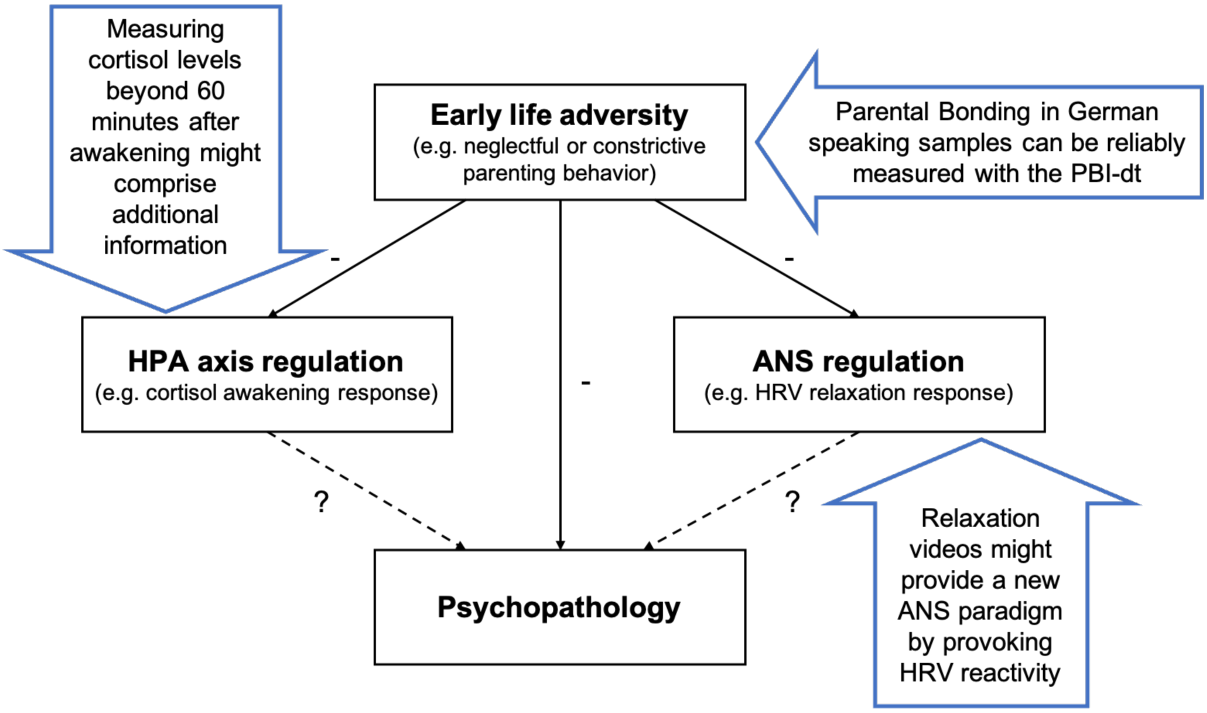

Fig. 10. Overview of key results of the three papers presented in this thesis. HPA = hypothalamic-pituitary-adrenal, ANS = autonomic nervous system, HRV = heart rate variability.

5.1 Summary and evaluation of the main findings

5.1.1 Improved assessment of parental bonding as a form of early life adversity

First, I translated the Parental Bonding Instrument (PBI; Parker et al., 1979), a widely used questionnaire for the retrospective assessment of parenting styles, and examined its psychometric properties. The PBI comprises the dimensions of care and overprotection for maternal and paternal parenting behavior respectively, both of which are important drivers of a child’s development as well as the etiology and treatment of psychopathology. As a sufficient German version of the PBI was still missing, I developed an updated translation of the well-established English original version and analyzed its psychometric properties, such as item and reliability characteristics, construct and criterion validity as well as factorial structure, in an extensive online survey. Besides good item characteristics and reliability, I observed the expected associations of the PBI with indicators of construct (Childhood Trauma Questionnaire, CTQ) and criterion (self-report of a mental illness and Body Mass Index, BMI) validity. In addition, I found support for two established factor models, the original 2-factor model with the dimensions of care and overprotection, and a 3-factor model with the dimensions of care, discouragement of behavioral freedom, and denial of psychological autonomy. Interestingly, the 3-factor structure yielded some additional information. For example, being overweight was associated with higher parental discouragement of behavioral freedom and higher paternal denial of psychological autonomy, but was, in contrast, not related to maternal denial of psychological autonomy. This not only hints at the importance of looking at both, maternal and paternal parenting behavior, but also at the difference between behavioral and psychological constraints. Further research focusing on other differential effects of behavioral and psychological constraints as different parenting components could help to better understand the various consequences of parenting behavior as well as the mechanisms by which beneficial or obstructive and adverse parenting might affect later psychopathological developments.

In general, the impact of parental bonding on psychopathology and well-being is well-documented (Abbaspour et al., 2021; Huppert et al., 2010; Lima et al., 2010; Marshall et al., 2018; McGinn et al., 2005; Monteleone et al., 2020). In addition, it seems to even affect therapy outcomes (Asano et al., 2013). Yet, we are still dealing with many open questions, especially regarding mechanisms that might explain what types of parenting style or childhood adversity might result in what form of psychopathology, and even more important which factors might constitute a protective environment. For one, disadvantageous parenting might influence emotion regulation – either because affected children miss out on learning adequate regulation strategies, because they have to adapt dysfunctional regulation strategies, or because they take over the maladaptive strategies of their parents (Brumariu, 2015). Furthermore, obstructive parenting, either due to a lack of care or due to excessive constraint, might constitute an adverse environment that provokes (mal-) adaptive psychobiological calibration processes. Yet again, mechanisms that could explain the particular direction of or protective factors against this development are still nebulous (Strüber et al., 2014).

The new German version of the PBI (PBI-dt), which presents an updated timely translation and an openly accessible examination of psychometric properties that match the original version, could support future research projects directed at these mechanisms or psychotherapeutic processes.

However, the PBI poses some open questions and limitations as discussed in Chapter 2.6. Most importantly, the current version is primarily directed toward traditional family models (one mother and one father who are both present during childhood and adolescence). However, many other constellations (e.g. single parents, step-parents, same-sex parents) as well as the loss of one parent at some point during childhood or adolescence are common and should be incorporated into PBI guidelines as they might have differential effects on psychobiological adaptation (Luecken, 2000). Especially in clinical samples, we often see patients who report not having any parent figure – either because they were abandoned early in life or because their biological parents were in fact present but could not fulfill a parental role. So far, this would result in a missing value in an analysis involving the PBI, even though the negative impact of such an experience seems obvious. Consequently, a rigorous assessment of different parenting constellations and their (psychopathological) consequences is essential to provide extensive recommendations for a broad application of the PBI.

Furthermore, the influence of psychotherapy that might change subjective evaluations of perceived parenting is yet unclear – despite proposed stability over time (Wilhelm et al., 2005). Thus, an extensive validation of the PBI-dt should include pre-post comparisons in a clinical sample before and after psychotherapy.

Taken together, the new German translation of the PBI presents a reliable measuring instrument to assess parental bonding with good psychometric properties. Depending on the research question one might choose between a two- or a three-factor model. Importantly, future research of consequences of early life adversity (especially when looking at psychopathology as one consequence) depends – besides reliable and validated assessment methods – on a coherent definition of such adversities (Smith & Pollak, 2021).

5.1.2 Extended assessment of the cortisol awakening response

Second, I examined cortisol dynamics during the first 270 minutes after awakening to extend the typical assessment duration of the cortisol awakening response (CAR) a well-established biomarker of HPA integrity, which is assumed to be modulated by adverse experiences early in life (Strüber et al., 2014). From the data of 51 healthy participants, I calculated different parameters describing individual cortisol pulses over time with respect to inter- and intraindividual variations such as duration, amplitude, and area under the curve (AUC). Special emphasis was put on the first rise and fall after awakening that we called the cortisol awakening pulse (CAP).

This first pulse lasted on average for 108 min with high inter-individual differences. In addition, I observed a longer first pulse and an attenuated second pulse in male and female subjects in the luteal phase, compared to female subjects in the follicular phase, or women taking oral contraceptives. In other cross-sectional studies, the CAR did not differ between the follicular and luteal phases (Bouma et al., 2009; Kudielka & Kirschbaum, 2003). Furthermore, a systematic within-subject comparison of differences in the CAR across the menstrual cycle in a small female sample (N = 29) reported comparable cortisol levels at awakening but pronounced elevations and a delayed peak during ovulation. Our observation of systematic differences between women in the luteal and follicular phase when looking at a longer measurement period adds to this line of research potentially yielding additional valuable information.

While menstrual cycle is only one factor associated with HPA activity, this finding supports the idea that a prolonged measurement of the CAR or rather the CAP could provide further insight into HPA regulation and advance further research on psychobiological mechanisms related to HPA dysregulation. For example, future studies could focus on the effect of early life adversity on specific aspects of cortisol trajectories after awakening or on associations with psychopathology. Both factors were discussed as components of the Adaptive Calibration Model (ACM, Chapter 0).

On one hand, exposure to early adverse circumstances modulates HPA (re-) activity (Koss & Gunnar, 2018; Strüber et al., 2014). For example, growing up in poverty is associated with a lower CAR (Desantis et al., 2015), while other studies propose a curvilinear relationship between parenting quality and basal cortisol levels, i.e. high negativity or low responsivity resulting in both attenuated and elevated cortisol levels (Suor et al., 2015; Zalewski et al., 2016). Regarding childhood maltreatment again both increased as well as decreased basal cortisol levels have been reported (Strüber et al., 2014). This heterogeneity could be partly explained by changes in glucocorticoid and mineralocorticoid receptor expression on a biological level and the presence or absence of maternal care in the face of (other) adverse circumstances. Consequently, increased or decreased emotional sensibility could bring forth differential psychopathological outcomes (Strüber et al., 2014). Moreover, additional research addressing the direction of HPA modulation in response to early life adversity – amongst others by using extended methodology such as a prolonged cortisol measure after awakening – is essential to understand the mechanisms linking early life adversity, psychobiological dysfunction, and psychopathology.

On the other hand, psychopathology is linked to both, the experience of early life adversity and (consequent) HPA dysregulation (Koss & Gunnar, 2018). An altered CAR has been reported for many different mental disorders, e.g. depression (Dedovic & Ngiam, 2015), anxiety (Merswolken et al., 2013), schizophrenia (Pruessner et al., 2013), or Borderline Personality Disorder (Rausch et al., 2015). However, not only the direction (hyper- or hypocortisolism) but also the sequence of this association is still an open yet highly interesting question. Can HPA dysregulations predict the development of a mental disorder or the course of psychotherapy? Do HPA dysregulations occur as a result of a mental disorder? Or do HPA dysregulations rather depict a biomarker that mirrors other (psychological or biological) pathogenic processes? Some recent studies looked at the CAR as a predictor of psychopathology. For example, a blunted CAR predicted the development of a new mental disorder (affective or anxiety disorders, major depressive disorder, or dependence disorders) in a large prospective cohort study of Dutch adolescents (Nederhof et al., 2015). Looking at depression specifically, more symptom improvement of inpatients with a major depressive episode could be predicted by lower CAR levels at admission (Refsgaard et al., 2022) In another longitudinal study, a blunted CAR at admission predicted higher depressive symptom severity post-treatment (Eikeseth et al., 2019). These mixed results for the CAR as a predictor of psychopathology already hint toward the difficulties we face when trying to look at causal relations between the two factors. On the other hand, the majority of research on the relation between the CAR and psychopathology is still cross-sectional and thus merely correlational with many researchers interpreting the CAR as an indicator of mental health. Furthermore, improvements of the CAR in response to treatment reflecting symptom reduction have been reported, e.g. a prolonged increase in cortisol levels after awakening alongside reduced stress and depression levels after a mindfulness-based stress reduction program for women with breast cancer (Matousek et al., 2010).

Thus, to tackle these interesting questions, future research would benefit from improved and expanded research methods. However, despite promising new research questions, just because it is interesting does not always mean it is better. In addition to the study-related limitations discussed in Chapter 3.5, some further issues should be carefully considered when implementing a prolonged CAR. First and foremost, a longer measurement period inevitably interferes more with daily life. While it is important to maintain normal routines while sampling (Stalder et al., 2016), it would not be feasible to interdict food intake and activity for more than one or two hours after awakening. However, this might lead to (more) confounding factors, as both food intake and (intense) physical activity could influence cortisol levels in the morning (Hill et al., 2008; Rohleder & Kirschbaum, 2007) and consequently result in higher heterogeneity between participants, that would be even more difficult to account for in statistical analysis than other known factors such as awakening time or mode (Kudielka & Kirschbaum, 2003). In general, more potential confounders mean more complex research designs and statistical analysis and often less statistical power (Pourhoseingholi et al., 2012; Westfall & Yarkoni, 2016).

Furthermore, the measurement procedure itself might influence the CAR. For example, in every CAR study so far, I observed at least a few participants reporting feeling stressed or worried due to the anticipated sampling procedure and consequently experiencing decreased sleep quality which is another factor influencing the CAR (Devine & Wolf, 2016; Lasikiewicz et al., 2008). These measurement-related effects might be even more pronounced in clinical samples (which should be the target population of psychopathology or psychotherapy research), where I would, for example, expect a measure during a group therapy session to potentially create disturbances in the group or discomfort or even shame for the individual (which would be unpreventable for inpatient samples with typical therapy schedules starting in the morning around 8 or 9 am and prolonged cortisol measures lasting over four hours after awakening).

Above all, we should always keep in mind that every measurement we introduce affects the item we try to measure. Thus, it is essential – depending on the research question – to weigh the cost and benefit of a prolonged measurement, which might be more informative but also more susceptible to confounders and more afflicting for participants. Nonetheless, these results provide a first starting point to further investigate the potential usefulness of a longer sampling period for assessing ultradian pulsatility of cortisol in the morning, especially the CAP. To assess the complete pulse rather than the rise alone, measurement of cortisol levels after awakening for 120 min is recommended.

5.1.3

5.1.4 New assessment approach to induce and measure autonomic regulation

Third, I investigated heart rate variability (HRV) as an indicator of autonomic regulation, specifically parasympathetic activity, in response to a 10-minute video intervention in two consecutive studies and examined the differential effect of psychological aspects modulating a psychophysiological relaxation response to potentially help understand modes of action and develop personalized relaxation interventions. In the first study, I observed a decrease in heart rate (HR) and an increase in HRV during the video intervention. In addition, higher paternal care was associated with higher HRV values before but not during the video exposure.

In the second study, comprising a larger sample and some methodological adjustments, I observed again a decrease in HR and an increase in HRV during the video intervention. With respect to parental bonding, higher parental care and lower parental overprotection predicted higher HRV at different times during the experiment. Interestingly, lower paternal overprotection predicted overall higher HRV.

First of all, this project provides a new protocol (i.e. the relaxation video intervention) to activate the PNS in healthy participants with a reasonable inter-individual variation that could potentially be linked to different psychological or psychopathological factors in future studies. However, I was not able to identify specific video characteristics that generate PNS responsivity. All three video types from Study 2 (nature-based relaxation videos, meditation video with beach background, and movie clip from “The Lord of the Rings”) were associated with an increase in HRV. This suggests that video content – whether we presented a distracting movie, an active meditation, or an explicit but unguided relaxation – is rather unimportant. Instead, the general atmosphere might play a bigger role. All videos (except the fireplace option in the relaxation video condition, however, only chosen by 11 respectively 22%) depicted more or less green surroundings. Correspondingly, increased well-being, improved emotion regulation, and better general health have been related to spending time in nature (White et al., 2019) or real-life urban green space exposure (Tost et al., 2019). Building on these benefits, a video paradigm could represent a useful tool for relaxation research that is easy to standardize and implement in various research settings including online research. Moreover, it could serve as a low-threshold intervention, e.g. in the workplace.

Compared to other relaxation induction methods, the video approach seems easier to standardize, more feasible, and more economical (low costs, positive reception by participants). Yet, this evaluation is only based on my subjective impression and needs confirmation from comparative research contrasting different approaches including paced breathing or vagus nerve stimulation.

A reliable relaxation induction paradigm could be particularly helpful for research questions targeting the relation between early life adversity, ANS dysregulation, and psychopathology. As discussed in Chapter 4.5, results about the association between early life adversity and resting-state (Sigrist et al., 2021) as well as stress-related HRV (Young-Southward et al., 2020) are still inconclusive. These ambiguities can be partially explained by methodological and conceptual differences, both in the definition and assessment of early life adversity and in the operationalization of ANS regulation.

Another interesting correlate of altered HRV is psychopathology. Numerous mental health issues are related to a dysregulated HRV (Beauchaine et al., 2019; Beauchaine & Thayer, 2015), e.g. depression (Schiweck et al., 2019), post-traumatic stress disorder, bipolar disorder, and borderline personality disorder (Carr et al., 2018; Koenig et al., 2016; Meyer et al., 2016). Interestingly, there seems to be an “ideal range” of HRV as both low and extremely high HRV have been associated with psychopathology (Heiss et al., 2021). In addition, HRV improvement can be targeted in psychological interventions (Steffen et al., 2021) and also used as a biomarker indicating therapy outcomes (Blanck et al., 2019). In this latter study, HRV over the course of psychotherapy was monitored. As a result, baseline HRV predicted symptom reduction and increased during treatment (Blanck et al., 2019). Furthermore, HRV might even provide (in combination with brain morphological markers) a predictor of stress resilience and stress-related psychiatric disorders (Carnevali et al., 2018). Yet again, most of these studies focus on resting-state HRV values or stress-related HRV reactivity. Even though the ability to relax and restore resources, is both aggravated in the context of several mental disorders and essential to their psychological treatment, research on autonomic relaxation responses is still lacking. Yet, especially clinical research could benefit from relaxation-inducing paradigms, as they provide two advantages over stress-inducing paradigms: relaxation is far less adverse compared to common stress paradigms that might be considered disruptive in a clinical context and habituation that is typically observed in stress research (Kothgassner et al., 2021) might be less problematic. Next research steps in this direction could include clinical samples, work that will be continued in our research group by Raphaela Gaertner who plans to investigate autonomic and psychological relaxation in patients with BPS in response to breathing exercises and virtual nature exposure in comparison.

Taken together, the results from my third project suggest a generic relaxation effect of the different video interventions used in this study on autonomic regulation. Further, early life adversity might contribute to individual differences in autonomic regulation with differential influences of maternal versus paternal care or overprotection. This study presents one approach to induce and measure parasympathetic activity and thereby might contribute to a better understanding of autonomic and psychological relaxation responses.

5.2 Implications and limitations

Overall, these three papers provide evidence for refined research methods of psychological preconditions and biological markers of potential psychopathological development. Even though the associations between early life adversity, HPA and ANS (dys-)regulation, and subsequent psychopathology are – as discussed in previous chapters – well supported by the literature, both the quantitative (positive vs. negative effects) and qualitative (cause vs. effect) direction of these relations are still unclear. While we assume that early life adversity triggers an adaptive calibration process that manifests in altered HPA and ANS activity based on chronologic order, many other questions on these relations remain in the dark and require a reliable and valid measurement to be answered. Fascinating follow-up questions include, for example, why and how the mind changes fundamental processes like thought or emotion processing and regulation once the body is no longer capable of adapting (e.g. after prolonged exposure or overstimulation as proposed by the ACM), i.e. mechanisms of psychopathological development and maintenance and treatment of mental disorders.

With the results of my thesis, I aimed to contribute to an improved assessment of these three concepts: an updated translation and psychometric examination of the PBI to assess parental bonding in German-speaking samples, an extended measurement of the CAR as an indicator of HPA integrity, and a suggestion for a novel approach to measure HRV reactivity to a relaxation induction as an indicator of ANS regulation. However, this far, these methods have only been tested in predominantly healthy samples and results should be interpreted as starting points only, which require a continued search for the development of new and the improvement of existing informative and standardized assessment approaches. While clinical research clearly benefits from improved methods that are first established in healthy samples, a consequent transfer and combination of these approaches in clinical samples or a population with a specific psychopathological focus is a necessary next step.

Nevertheless, taken together these methodological considerations provide a solid groundwork for future research on either of the concepts alone or – what would be even more interesting in the context of psychopathological and psychotherapy research – on all three concepts together. For example, measuring all three components in a clinical sample in comparison to a matched control group, at best over the course of a specific psychological treatment, could help to better understand not only the relationship between the different components but also their plasticity in response to treatment. Interestingly, however, neither HPA nor ANS dysregulation could (even partially) explain the association between child maltreatment and posttraumatic stress disorder symptoms in a longitudinal study (Shenk et al., 2014). The authors assessed HRV and cortisol at rest and during a stressor at two points in time with one year time lag in N = 110 adolescents (age 14 – 19) with and without childhood maltreatment. Results revealed the expected association between maltreatment and symptom severity, but only experiential avoidance to mediate this relation. Yet these results might be limited by some methodological weaknesses such as maltreatment measurement (non-standardized caseworker interviews prior to study onset leading to dichotomous classification), type of stressor (combined affect recognition and video watching task with no significant difference of cortisol levels between resting and stress condition pointing towards a failed stress induction), or HRV assessment (unequal time intervals for parameter calculation). Considering the highly relevant research question, these limitations reinforce the need for sound assessment approaches. These include careful selection of the investigated sample and thorough planning of assessment methods.

Looking at the bigger picture of psychopathology and psychotherapy research, methodological advances have provided us with a great amount of etiological and interventional insights over the past decades. However, our gaps of knowledge are still huge and methodological inconsistencies and limitations delude our conclusions over and over again. Quite recently, for example, the serotonin hypothesis of depression has been (again) found to be obsolete. According to a recent systematic review, there is no convincing empirical basis for lowered or altered serotonin concentrations or activity in depressed people. The authors explain the widespread (outdated) belief in serotonergic explanation for depression by methodological shortcomings and miscommunication (Moncrieff et al., 2022). In my work as a psychotherapist, I recently worked with a patient who came to us with the idea that her depression is entirely explained by her “dysfunctional brain” and all we had to do is to find the right medication that “fixes” her brain. However, depression, and any psychopathology, is in fact way more complex than this and to understand the development of a mental disorder and to find the right treatment – both important tasks for psychotherapy – we first need to improve our methods – an important task for psychotherapy research. Consequently, a big part of my initial work with said patient was focused on gaining a better understanding of the mechanisms leading to her depression and developing an individual multifactored disorder model. While I always enjoy this kind of therapeutic “detective work”, I thereby really appreciate having my research work and my doctoral thesis in mind that help me provide my patients with an informed and considerate psychoeducation and treatment – a joint approach, combining scientific and practical knowledge, that seems consistently important (Luyten, 2015).

5.3 Concluding remarks

Taken together, in collaboration with my colleagues, I investigated three (bio-) psychological components of the ACM that proposes a psychoneuroendocrinological adaptation process in response to stressors during sensitive periods in life such as the modulation of the HPA axis or the ANS in reaction to detrimental parenting behavior (e.g. neglect or maltreatment). With this work I provided three expansions to traditional assessment approaches: a more reliable and robust assessment of self-reported retrospective parental care and overprotection based on the English version of a well-established questionnaire, an extended HPA assessment by measuring cortisol concentrations after awakening for a longer time interval, and a novel assessment suggestion to quantify cardiac relaxation responsivity. Even though all three methods are still in their infancy and require further validation, an ongoing improvement of research methods is the unquestionable basis for good fundamental as well as clinical research.

Furthermore, these approaches might offer a more salutogenic approach by looking a functional HPA regulation in response to awakening, beneficial parenting behavior (high care and low overprotection), and the ability to relax and restore resources indicated by functional HRV responsivity.

Author Contributions[1]

Chapter 2: Psychometric Properties of a German Translation of the Parental Bonding Instrument

ABEB: Project administration, Conceptualization, Methodology, Data Curation, Investigation, Formal analysis, Visualization, Writing - Original Draft & Editing. LVK: Methodology, Data Collection, Writing – Review & Editing. TK: Methodology, Writing – Review & Editing. EU: Formal analysis, Writing – Review & Editing. MM, UUB, SJD, BFD: Writing - Review & Editing. UDR: Methodology, Writing – Review & Editing. JCP: Supervision, Conceptualization, Methodology, Resources, Writing - Original Draft. All authors approved the final version.

Chapter 3: The duration of the cortisol awakening pulse exceeds sixty minutes in a meaningful pattern

ABEB: Project administration, Methodology, Data Curation, Investigation, Formal analysis, Visualization, Writing - Original Draft & Editing. MMe, EU: Formal analysis, Writing – Review & Editing. MMa: Methodology, Data Collection, Writing – Review & Editing. JCP: Supervision, Conceptualization, Methodology, Resources, Writing - Original Draft. All authors approved the final version.

Chapter 4: Nature-based relaxation videos and their effect on heart rate variability

ABEB: Project administration, Conceptualization, Methodology, Data Curation, Investigation, Formal analysis, Visualization, Writing - Original Draft & Editing. RG: Writing – Original Draft & Editing, Formal analysis, Visualization. SS, CJ, MW: Methodology, Data Collection, Writing – Review & Editing. MM: Writing - Review & Editing. EU: Formal analysis, Writing – Review & Editing, Methodology. UU, BD, SJD: Writing - Review & Editing. JCP: Formal analysis, Resources, Writing - Original Draft, Supervision, Conceptualization, Methodology. All authors approved the final version.

[1] Based on CRediT recommendations (cf. Allen, L., O'Connell, A., & Kiermer, V. (2019). How Can We Ensure Visibility and Diversity in Research Contributions? How the Contributor Role Taxonomy (CRediT) Is Helping the Shift from Authorship to Contributorship. *Learned Publishing* 32(1): 71–74. https://doi.org/10.1002/leap.1210.

Supplemental Material

For Chapter 2 and 4, supplemental material including data sheets and additional tables and figures, are stored at the Open Science Framework (OSF):

- Chapter 2: https://osf.io/4396u/ DOI 10.17605/OSF.IO/4396U (cf. Appendix)
- Chapter 4: https://osf.io/wcdku/ DOI 10.17605/OSF.IO/WCDKU

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Appendix

Psychometric Properties of a German Translation of the Parental Bonding Instrument

Zusatzmaterial Z1. *Ergänzende Erläuterungen zum Übersetzungsprozess des PBI-dt*

Allgemeine Erklärung des Übersetzungsprozesses:

Der Übersetzungsprozess orientierte sich an den Richtlinien des European Social Survey Programms zur Übersetzung von Fragebögen (Harkness et al., 2007). Unter dem Akronym TRAPD schlagen die Autoren einen fünfstufigen Übersetzungsprozess vor: *Translation, Review, Adjudication, Pretest* und *Documentation*. Im ersten Schritt der Parallelübersetzung fertigen mehrere Personen selbstständig eine Übersetzung an, worauf in einem anschließenden Review-Prozess die Varianten untereinander verglichen und diskutiert werden. Auf dieser Grundlage entscheidet man sich für eine Version, die schließlich von einer Expertenstelle noch einmal auf sprachliche Feinheiten geprüft wird.

PBI-dt Projekt:

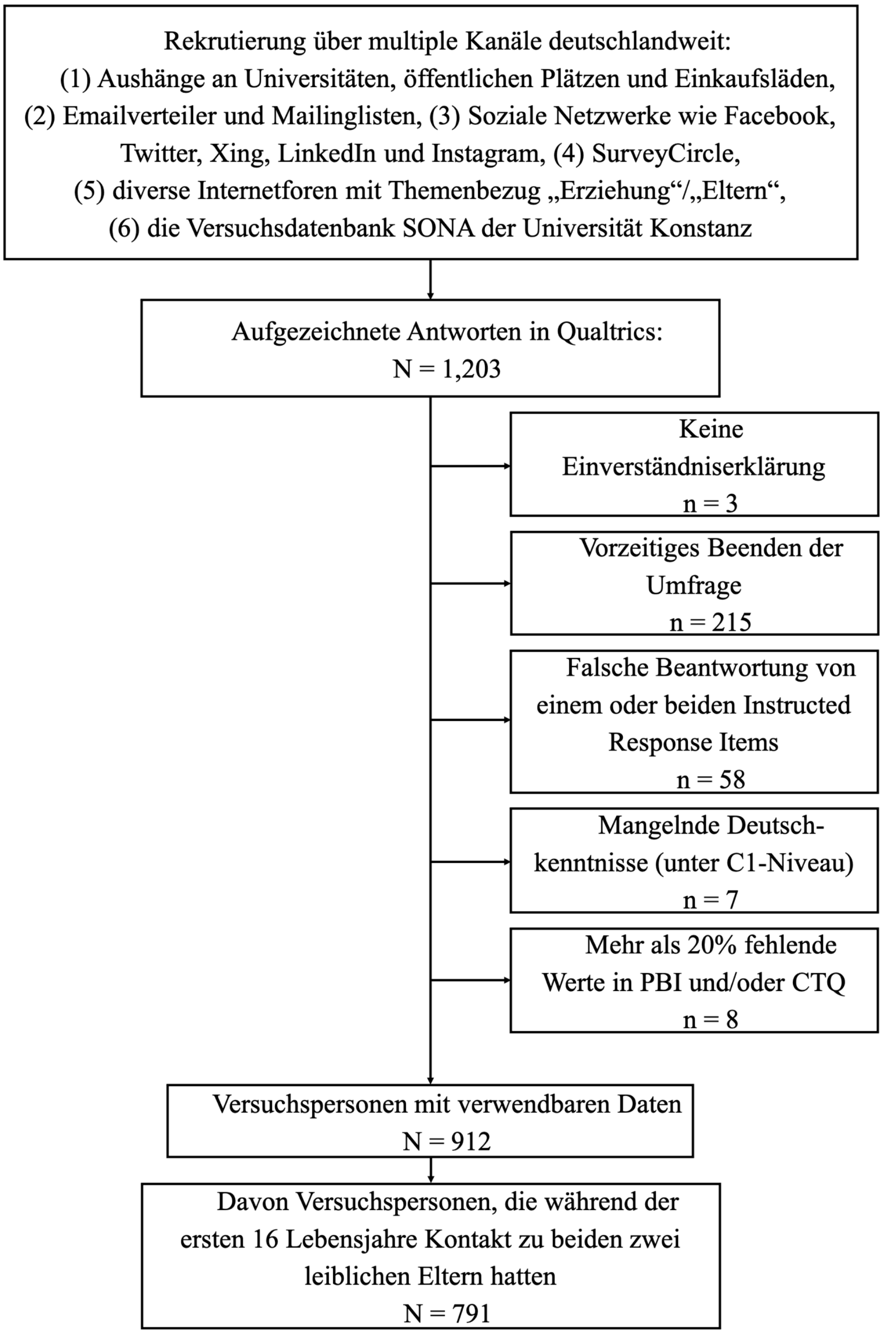
Translation: In diesem Projekt übersetzten drei Personen, die sich freiwillig bereit erklärten, im ersten Schritt parallel und unabhängig voneinander den englischen PBI-Originalfragebogen von Parker et al (1979) ins Deutsche. Bei den ausgewählten Personen handelte es sich um Studenten, die folgende, vorab festgelegte Kriterien erfüllen mussten: Englischkenntnisse mindestens auf C1-Niveau, Auslandsaufenthalt über einem Jahr in einem englischsprachigen Land und Deutsch auf muttersprachlichem Niveau. Zwei dieser Personen waren Masterstudenten im Bereich Economics, die bisher keine Berührungspunkte mit der Thematik und dem *Parental Bonding Instrument* hatten. Bei der anderen Person handelt es sich um eine Psychologiestudentin, die mit der psychologischen Thematik vertraut war, mit dem PBI selbst aber noch nie gearbeitet hatte.
Die Personen erhielten ein Dokument mit einer Erklärung und Instruktion zur Übersetzung sowie auf der zweiten Seite den englischen Originalfragebogen, damit sie sich vorab einen Eindruck des Originalfragebogens verschaffen konnten. In einem separaten Dokument waren die einzelnen Items aufgeführt, worunter jeweils genügend Platz für die Übersetzung sowie für Kommentare war.
Bei zwei Personen wurde die Methode des Lauten Denkens (Think Aloud) angewandt. Es handelt sich um ein Verfahren, bei dem die Personen aufgefordert sind, sämtliche Gedanken, die ihnen während dem Übersetzungsprozess durch den Kopf gehen, spontan und unselektiert zu äußern. Diese Verbalisierungen wurden notiert und im Nachhinein zu Protokollen des Lauten Denkens (Thinking Aloud Protocols) verarbeitet. Dadurch erhielt man einen Eindruck, welche Items sehr leicht beziehungsweise schwer verständlich waren, welche Items leicht oder schwer zu übersetzen waren und ob und welche Probleme auftreten. Daraus entstanden Ideen und Denkanstöße, die im Reviewprozess mitdiskutiert wurden.

Review: Im zweiten Schritt des Übersetzungsprozesses (Review) wurde ein kleiner Arbeitskreis mit zwei Mitstudierenden ins Leben gerufen. Ziel dieses Arbeitskreises war es, die drei unabhängigen Übersetzungen gemeinsam durchzugehen und zu diskutieren. Jedes Item wurde dabei diskutiert und die durch die Thinking Aloud- Methode entstandenen Ideen- und Denkanstöße miteinbezogen. Ziel war es, für jedes Fragebogenitem eine Lösung zu finden und eine Übersetzungsversion zusammenzustellen. Dabei ist zu erwähnen, dass ein paar Items in den drei unabhängigen Übersetzungen übereinstimmten und man bereits durch die Think-Aloud Methode erfahren hat, dass diese leicht zu übersetzen waren. Bei anderen Items gab es Unterschiede in der Übersetzung, die intensiv im Arbeitskreis diskutiert wurden.

Adjudication*:* Auf Nachfrage wurde eine Kooperation mit dem Übersetzungsteam der Universität Konstanz ermöglicht. Dieser Schritt des Übersetzungsprozesses (Adjudication) wurde daher vom Übersetzungsteam der Universität Konstanz übernommen. Hierbei wurde die durch den Reviewprozess entstandene Übersetzungsversion noch einmal auf sprachliche Feinheiten geprüft.

Pretest & Documentation: Anschließend wurde ein Pretest durchgeführt, um die Items an einer kleinen Stichprobe der Zielbevölkerung zu testen und zu untersuchen, inwieweit die Übersetzung verstanden wird beziehungsweise wo Probleme und Verständnisschwierigkeiten auftreten. Dabei wurde ebenso die Technik des Lauten Denkens angewandt, bei der die Personen aufgefordert waren, sämtliche Gedanken, die ihnen während der Beantwortung des Fragebogens durch den Kopf gingen, spontan und unselektiert zu äußern. Dieser Pretest wurde im Rahmen des Pretests des gesamten, fertiggestellten Fragebogens durchgeführt, bei dem nicht nur die Verständlichkeit der Items, sondern auch die technische Kompatibilität auf verschiedenen Geräten getestet wurde. Der gesamte Prozess wurde fortlaufend dokumentiert.

Abbildung Z1. *Rekrutierungsprozess inklusive Rekrutierungskanäle und Fallausschlussprozess.*



Zusatzmaterial Z2. *Offizielle Fragebogenversion mit Auswertungshinweisen*

PBI-dt: Mutter

In diesem Fragebogen sind verschiedene Einstellungen und Verhaltensweisen von Eltern aufgelistet. Bitte markieren Sie bei den folgenden Aussagen jeweils die Antwortmöglichkeit, die am ehesten mit Ihrer Erinnerung an **Ihre Mutter** während Ihrer **ersten 16 Lebensjahre** übereinstimmt.

Meine Mutter	Trifft überhaupt nicht zu	Trifft eher nicht zu	Trifft eher zu	Trifft absolut zu
1. Sprach mit einer warmen und freundlichen Stimme zu mir.	☐	☐	☐	☐
2. Half mir nicht so sehr, wie ich es gebraucht hätte.	☐	☐	☐	☐
3. Ließ mich die Dinge tun, auf die ich Lust hatte.	☐	☐	☐	☐
4. Wirkte mir gegenüber gefühlskalt.	☐	☐	☐	☐
5. Schien meine Probleme und Sorgen zu verstehen.	☐	☐	☐	☐
6. War liebevoll zu mir.	☐	☐	☐	☐
7. Mochte es, wenn ich meine eigenen Entscheidungen traf.	☐	☐	☐	☐
8. Wollte nicht, dass ich erwachsen werde.	☐	☐	☐	☐
9. Versuchte alles, was ich tat, zu kontrollieren.	☐	☐	☐	☐
10. Drang in meine Privatsphäre ein.	☐	☐	☐	☐
11. Besprach gern Dinge mit mir.	☐	☐	☐	☐
12. Lächelte mich häufig an.	☐	☐	☐	☐
13. Neigte dazu, mich wie ein kleines Kind zu behandeln.	☐	☐	☐	☐
14. Schien nicht zu verstehen, was ich brauchte oder wollte.	☐	☐	☐	☐
15. Ließ mich meine eigenen Entscheidungen treffen.	☐	☐	☐	☐
16. Gab mir das Gefühl, nicht erwünscht zu sein.	☐	☐	☐	☐
17. Konnte mich beruhigen, wenn ich aufgebracht war.	☐	☐	☐	☐
18. Redete nicht sehr viel mit mir.	☐	☐	☐	☐
19. Versuchte, dass ich mich abhängig von ihr fühlte.	☐	☐	☐	☐
20. Glaubte, dass ich ohne sie nicht zurechtkommen würde.	☐	☐	☐	☐
21. Gab mir so viel Freiraum, wie ich brauchte.	☐	☐	☐	☐
22. Ließ mich ausgehen, so oft ich wollte.	☐	☐	☐	☐
23. War überbehütend.	☐	☐	☐	☐
24. Lobte mich nicht.	☐	☐	☐	☐
25. Ließ mich anziehen, was mir gefiel.	☐	☐	☐	☐

Vielen Dank für Ihre Teilnahme!

Bitte überprüfen Sie Ihre Angaben noch einmal auf Vollständigkeit!

PBI-dt: Vater

In diesem Fragebogen sind verschiedene Einstellungen und Verhaltensweisen von Eltern aufgelistet. Bitte markieren Sie bei den folgenden Aussagen jeweils die Antwortmöglichkeit, die am ehesten mit Ihrer Erinnerung an **Ihren Vater** während Ihrer **ersten 16 Lebensjahre** übereinstimmt.

Mein Vater	Trifft überhaupt nicht zu	Trifft eher nicht zu	Trifft eher zu	Trifft absolut zu
1. Sprach mit einer warmen und freundlichen Stimme zu mir.	☐	☐	☐	☐
2. Half mir nicht so sehr, wie ich es gebraucht hätte.	☐	☐	☐	☐
3. Ließ mich die Dinge tun, auf die ich Lust hatte.	☐	☐	☐	☐
4. Wirkte mir gegenüber gefühlskalt.	☐	☐	☐	☐
5. Schien meine Probleme und Sorgen zu verstehen.	☐	☐	☐	☐
6. War liebevoll zu mir.	☐	☐	☐	☐
7. Mochte es, wenn ich meine eigenen Entscheidungen traf.	☐	☐	☐	☐
8. Wollte nicht, dass ich erwachsen werde.	☐	☐	☐	☐
9. Versuchte alles, was ich tat, zu kontrollieren.	☐	☐	☐	☐
10. Drang in meine Privatsphäre ein.	☐	☐	☐	☐
11. Besprach gern Dinge mit mir.	☐	☐	☐	☐
12. Lächelte mich häufig an.	☐	☐	☐	☐
13. Neigte dazu, mich wie ein kleines Kind zu behandeln.	☐	☐	☐	☐
14. Schien nicht zu verstehen, was ich brauchte oder wollte.	☐	☐	☐	☐
15. Ließ mich meine eigenen Entscheidungen treffen.	☐	☐	☐	☐
16. Gab mir das Gefühl, nicht erwünscht zu sein.	☐	☐	☐	☐
17. Konnte mich beruhigen, wenn ich aufgebracht war.	☐	☐	☐	☐
18. Redete nicht sehr viel mit mir.	☐	☐	☐	☐
19. Versuchte, dass ich mich abhängig von ihm fühlte.	☐	☐	☐	☐
20. Glaubte, dass ich ohne ihn nicht zurechtkommen würde.	☐	☐	☐	☐
21. Gab mir so viel Freiraum, wie ich brauchte.	☐	☐	☐	☐
22. Ließ mich ausgehen, so oft ich wollte.	☐	☐	☐	☐
23. War überbehütend.	☐	☐	☐	☐
24. Lobte mich nicht.	☐	☐	☐	☐
25. Ließ mich anziehen, was mir gefiel.	☐	☐	☐	☐

Vielen Dank für Ihre Teilnahme!

Bitte überprüfen Sie Ihre Angaben noch einmal auf Vollständigkeit!

Parental Bonding Instrument – deutsche Version (PBI-dt)
Auswertungshinweise

Aufbau des Fragebogens:

- Das PBI-dt besteht aus jeweils 25 Items für Mutter und Vater, die anhand einer vierstufigen Likertskala beurteilt werden können.
- Die beiden Fragebogenteile können je nach Hintergrund der Versuchsperson gemeinsam oder einzeln vorgelegt werden und werden getrennt ausgewertet.
- Wenn mehr als 20% der Items für einen Teil nicht beantwortet werden, sollte das PBI-dt nicht ausgewertet werden.

Skalierung:

0 = Trifft überhaupt nicht zu
1 = Trifft eher nicht zu
2 = Trifft eher zu
3 = Trifft absolut zu

Inverse Items:
Folgende Items wurden invers formuliert und müssen entsprechend vor der Auswertung rekodiert werden: 2, 3, 4, 7, 14, 15, 16, 18, 21, 22, 24, 25

Faktorzuordnung:
Hinweis: Für die jeweiligen Subskalen können durch Aufsummieren der Itemwerte Summenwerte berechnet werden. Dafür werden zwei unterschiedliche Skalenlösungen vorgeschlagen. Zur Modellanpassungsgüte und ausführlichen Diskussion der beiden Faktorenmodelle siehe Benz et al. (2020). Psychometrische Kennwerte einer deutschen Version des Parental Bonding Instrument. Konstanz (preprint)

Drei-Faktorenlösung

1) Fürsorge: Items 1, 2, 4, 5, 6, 11, 12, 14, 16, 17, 18, 24
2) Einschränkung der Verhaltensfreiheit: Items 3, 7, 15, 21, 22, 25
3) Verweigerung psychologischer Autonomie: Items 8, 9, 10, 13, 19, 20, 23

Zwei-Faktorenlösung

1) Fürsorge: Items 1, 2, 4, 5, 6, 11, 12, 14, 16, 17, 18, 24
2) Kontrolle: Items 3, 7, 8, 9, 10, 13, 15, 19, 20, 21, 23, 22, 25

Tabelle Z1a. *Soziodemographische und psychologische Merkmale der Stichprobe unterteilt in Personen mit und ohne psychische Erkrankung*

n (%[a])	**Gesamt (*N*=791)**	**Ohne psychische Erkrankung (*n*=599)**	**Mit psychischer Erkrankung [b] (*n*=135)**
Geschlecht			
Männlich	143 (18.1)	120 (20.0)	13 (9.6)
Weiblich	647 (81.8)	479 (80.0)	121 (89.6)
Divers	1 (0.1)	-	-
Alter			
18-24	347 (43.9)	278 (46.4)	40 (29.6)
25-30	207 (26.2)	163 (27.2)	33 (24.4)
31-40	166 (21.0)	107 (17.9)	45 (33.3)
41-50	43 (5.4)	27 (4.5)	13 (9.6)
51-60	19 (2.4)	17 (2.8)	2 (1.5)
61-70	8 (1.0)	6 (1.0)	2 (1.5)
Keine Angabe	1 (0.1)	-	-
Staatsangehörigkeit			
Deutsche Staatsangehörigkeit	749 (94.7)	564 (94.2)	129 (95.6)
Andere Staatsangehörigkeit	42 (5.3)	35 (5.8)	6 (4.4)
Deutsche Sprachkenntnisse			
Muttersprache	766 (96.8)	577 (96.3)	133 (98.5)
Fließend	25 (3.2)	22 (3.7)	2 (1.5)
Familienstand			
Ledig	292 (36.9)	228 (38.1)	35 (25.9)
In einer Partnerschaft	281 (35.5)	219 (36.6)	45 (33.3)
Verheiratet	206 (26.0)	144 (24.0)	51 (37.8)
Geschieden	6 (0.8)	3 (0.5)	3 (2.2)
Eingetragene Lebenspartnerschaft	4 (0.5)	3 (0.5)	1 (0.7)
Getrennt lebend	1 (0.1)	-	-
Verwitwet	1 (0.1)	-	-
Ausbildungsniveau			
Hauptschulabschluss	7 (0.9)	3 (0.5)	3 (2.2)
Realschulabschluss	26 (3.3)	18 (3.0)	7 (5.2)
Fachhochschulreife	16 (2.0)	12 (2.0)	4 (3.0)
Abitur	275 (34.8)	218 (36.4)	34 (25.2)
Berufsausbildung	105 (13.3)	70 (11.7)	28 (20.7)
Bachelor	196 (24.8)	147 (24.5)	34 (25.2)
Master/Diplom/Staatsexamen	143 (18.1)	113 (18.9)	21 (15.6)
Promotion	15 (1.9)	12 (2.0)	2 (1.5)
Anderes Niveau	8 (1.0)	6 (1.0)	2 (1.5)
Studierende			
Kein Studierender	354 (44.8)	244 (40.9)	88 (65.2)
Studierende im Vollzeitstudium	405 (51.2)	330 (55.3)	43 (31.9)
Studierende im Teilzeitstudium	30 (3.8)	23 (3.9)	4 (3.0)
Keine Angabe	2 (0.3)	-	-

n (%[b])	Gesamt (*N*=791)	Ohne psychische Erkrankung (*n*=599)	Mit psychischer Erkrankung [a] (*n*=135)
Erwerbstätigkeit			
Ja, Teilzeit	221 (27.9)	167 (27.9)	40 (29.6)
Ja, Vollzeit	152 (19.2)	116 (19.4)	27 (20.0)
Nein, da Vollzeitstudium	265 (33.5)	220 (36.8)	24 (17.8)
Nein, da arbeitssuchend/ Rentner:in/ Hausfrau:mann/Elternzeit etc.	152 (19.2)	95 (15.9)	44 (32.6)
Keine Angabe	1 (0.1)	-	-
Gehalt			
bis 1000€	358 (45.3)	289 (49.3)	50 (37.9)
1001 - 2500€	199 (25.2)	141 (24.1)	41 (31.1)
2501 - 3500€	90 (11.4)	65 (11.1)	19 (14.4)
3501-4500€	42 (5.3)	32 (5.5)	10 (7.6)
4501-5500€	19 (2.4)	15 (2.6)	3 (2.3)
5501-6999€	10 (1.3)	9 (1.5)	1 (0.8)
≥ 7000€	7 (0.9)	6 (1.0)	1 (0.8)
Keine Angabe	66 (8.3)	42 (7.0)	10 (7.6)
Psychische Erkrankung			
Keine psychische Erkrankung	599 (57.7)	-	-
Psychische Erkrankung	135 (17.1)	-	-
Keine Angabe	57 (7.2)	-	-
Bezugsperson [c]			
Beide Eltern leiblich	393 (49.7)	323 (53.9)	49 (36.3)
Leibliche Mutter	320 (40.5)	225 (37.6)	65 (48.1)
Leiblicher Vater	39 (4.9)	31(5.2)	6 (4.4)
Keine Hauptbezugsperson vorhanden	21 (2.7)	11 (1.8)	6 (4.4)
Andere Hauptbezugsperson (z.B. Oma)	18 (2.3)	9 (1.5)	9 (6.7)
Aufgewachsen bei			
Beiden Elternteilen	716 (90.5)	558 (93.2)	108 (80.0)
Mutter	54 (6.8)	31 (5.2)	18 (13.3)
Vater	9 (1.1)	3 (0.5)	6 (4.4)
Bei jemand anderem	12 (1.5)	7 (1.3)	3 (2.2)
Familienstand der Eltern			
Verheiratet	678 (85.7)	528 (88.3)	104 (77.0)
Geschieden	65 (8.2)	39 (6.5)	21 (15.6)
Ledig, in Beziehung	12 (1.5)	7 (1.2)	3 (2.2)
Ledig, getrennt	12 (1.5)	9 (1.5)	3 (2.2)
Verwitwet (ein Elternteil verstorben)	2 (0.3)	-	-
Keine Antwort trifft zu	20 (2.5)	13 (2.2)	4 (3.0)
Keine Angabe	2 (0.3)	-	-

Anmerkungen. Merkmale der analysierten Stichprobe mit *N* = 791. Es wurden nur Personen berücksichtigt, die leibliche Eltern während der ersten 16 Lebensjahre hatten, ausreichend Deutschkenntnisse aufwiesen sowie mehr als 80% im PBI und CTQ ausgefüllt haben. *n* = absolute Häufigkeit, % = relative Häufigkeit.

[a] Die relative Häufigkeit wurde auf eine Nachkommastelle gerundet, sodass dadurch in vereinzelten Fällen 100% überstiegen werden kann.

[b] Einteilung in Personen mit und ohne psychischer Erkrankung gemäß Globalitem („Leiden Sie aktuell an einer psychischen Erkrankung?"); bei Kategorien mit $n \leq 2$ wurde auf eine Einteilung verzichtet.

[c] Ggfs. weitere Person wie Bruder/Schwester als zusätzliche Bezugspersonen möglich

Tabelle Z1a. *Soziodemographische und psychologische Merkmale der Stichprobe unterteilt in normal- und übergewichtige Personen*

n (%[a])	Gesamt (*N*=791)	normalgewichtig (*n*=505)	übergewichtig [b] (*n*=213)
Geschlecht			
Männlich	143 (18.1)	101 (20.0)	39 (18.3)
Weiblich	647 (81.8)	404 (80.0)	173 (81.2)
Divers	1 (0.1)	-	-
Alter			
18-24	347 (43.9)	266 (52.7)	49 (23.0)
25-30	207 (26.2)	129 (25.5)	64 (30.0)
31-40	166 (21.0)	82 (16.2)	64 (30.0)
41-50	43 (5.4)	18 (3.6)	20 (9.4)
51-60	19 (2.4)	5 (0.2)	13 (6.1)
61-70	8 (1.0)	5 (0.2)	3 (1.4)
Keine Angabe	1 (0.1)	-	-
Staatsangehörigkeit			
Deutsche Staatsangehörigkeit	749 (94.7)	480 (95.0)	201 (94.4)
Andere Staatsangehörigkeit	42 (5.3)	25 (5.0)	12 (5.6)
Deutsche Sprachkenntnisse			
Muttersprache	766 (96.8)	491 (97.2)	204 (95.8)
Fließend	25 (3.2)	14 (2.8)	9 (4.2)
Familienstand			
Ledig	292 (36.9)	211 (41.8)	51 (23.9)
In einer Partnerschaft	281 (35.5)	187 (37.0)	64 (30.0)
Verheiratet	206 (26.0)	101 (20.0)	92 (43.2)
Geschieden	6 (0.8)	1 (0.2)	5 (2.3)
Eingetragene Lebenspartnerschaft	4 (0.5)	3 (0.6)	1 (0.5)
Getrennt lebend	1 (0.1)	-	-
Verwitwet	1 (0.1)	-	-
Ausbildungsniveau			
Hauptschulabschluss	7 (0.9)	3 (0.6)	3 (1.4)
Realschulabschluss	26 (3.3)	12 (2.4)	11 (5.2)
Fachhochschulreife	16 (2.0)	3 (0.6)	11 (5.2)
Abitur	275 (34.8)	203 (40.2)	48 (22.5)
Berufsausbildung	105 (13.3)	42 (8.3)	50 (23.5)
Bachelor	196 (24.8)	149 (29.5)	35 (16.4)
Master/Diplom/Staatsexamen	143 (18.1)	80 (15.8)	49 (23.0)
Promotion	15 (1.9)	9 (1.8)	3 (1.4)
Anderes Niveau	8 (1.0)	4 (0.8)	3 (1.4)
Studierende			
Kein Studierender	354 (44.8)	174 (34.5)	140 (66.0)
Studierende im Vollzeitstudium	405 (51.2)	310 (61.5)	65 (30.7)
Studierende im Teilzeitstudium	30 (3.8)	20 (4.0)	7 (3.3)
Keine Angabe	2 (0.3)	-	-
Erwerbstätigkeit			
Ja, Teilzeit	221 (27.9)	147 (29.2)	56 (26.3)
Ja, Vollzeit	152 (19.2)	83 (16.5)	49 (23.0)
Nein, da Vollzeitstudium	265 (33.5)	200 (39.7)	42 (19.7)
Nein, da arbeitssuchend/ Rentner:in/ Hausfrau:mann/Elternzeit etc.	152 (19.2)	74 (14.7)	66 (31.0)
Keine Angabe	1 (0.1)	-	-

n (%[a])	Gesamt (*N*=791)	normalgewichtig (*n*=505)	übergewichtig [b] (*n*=213)
Gehalt			
bis 1000€	358 (45.3)	265 (53.3)	70 (33.5)
1001 - 2500€	199 (25.2)	111 (22.3)	67 (32.1)
2501 - 3500€	90 (11.4)	46 (9.3)	32 (15.3)
3501-4500€	42 (5.3)	22 (4.4)	17 (8.1)
4501-5500€	19 (2.4)	10 (2.0)	9 (4.3)
5501-6999€	10 (1.3)	5 (1.0)	4 (1.9)
≥ 7000€	7 (0.9)	5 (1.0)	2 (1.0)
Keine Angabe	66 (8.3)	33 (6.6)	8 (3.8)
Psychische Erkrankung			
Keine psychische Erkrankung	599 (75.7)	397 (78.6)	152 (71.4)
Psychische Erkrankung	135 (17.1)	66 (13.1)	54 (25.4)
Keine Angabe	57 (7.2)	42 (8.3)	7 (3.3)
Bezugsperson [c]			
Beide Eltern leiblich	393 (49.7)	261 (51.7)	101 (47.4)
Leibliche Mutter	320 (40.5)	195 (38.6)	92 (43.2)
Leiblicher Vater	39 (4.9)	27 (5.3)	7 (3.3)
Keine Hauptbezugsperson vorhanden	21 (2.7)	12 (2.4)	7 (3.3)
Andere Hauptbezugsperson (z.B. Oma)	18 (2.3)	10 (2.0)	6 (2.8)
Aufgewachsen bei			
Beiden Elternteilen	716 (90.5)	461 (91.3)	191(89.7)
Mutter	54 (6.8)	33 (6.5)	14 (6.6)
Vater	9 (1.1)	5 (1.0)	4 (1.9)
Bei jemand anderem	12 (1.5)	6 (1.2)	4 (1.9)
Familienstand der Eltern			
Verheiratet	678 (85.7)	432 (85.9)	184 (86.4)
Geschieden	65 (8.2)	39 (7.8)	18 (8.5)
Ledig, in Beziehung	12 (1.5)	8 (1.6)	3 (1.4)
Ledig, getrennt	12 (1.5)	11 (2.2)	1 (0.5)
Verwitwet (ein Elternteil verstorben)	2 (0.3)	-	-
Keine Antwort trifft zu	20 (2.5)	12 (2.4)	6 (2.8)
Keine Angabe	2 (0.3)	-	-

Anmerkungen. Merkmale der analysierten Stichprobe mit *N* = 791. Es wurden nur Personen berücksichtigt, die leibliche Eltern während der ersten 16 Lebensjahre hatten, ausreichend Deutschkenntnisse aufwiesen sowie mehr als 80% im PBI und CTQ ausgefüllt haben. *n* = absolute Häufigkeit, % = relative Häufigkeit.

[a] Die relative Häufigkeit wurde auf eine Nachkommastelle gerundet, sodass dadurch in vereinzelten Fällen 100% überstiegen werden kann.

[b] Einteilung nach Body Mass Index (BMI) entsprechend WHO – normalgewichtig: 18.5≤BMI<25, übergewichtig: 25≤BMI>40; bei Kategorien mit *n* ≤ 2 wurde auf eine Einteilung verzichtet.

[c] Ggfs. weitere Person wie Bruder/Schwester als zusätzliche Bezugspersonen möglich

Tabelle Z2. *Postulierte Faktorenmodelle bezüglich der PBI-Faktorenstruktur*

Modell	**Faktoren-anzahl**	**Faktoren-bezeichnung**	**Itemzuordnung**	**Analyse-methode**
Parker et al., 1979 (Australien)	2	Fürsorge	1, 2, 4, 5, 6, 11, 12, 14, 16, 17, 18, 24	EFA
		Kontrolle	3, 7, 8, 9, 10, 13, 15, 19, 20, 21, 22, 23, 25	
Mohr et al., 1999 (Frankreich)	3	Fürsorge	1, 2, 4, 5, 6, 11, 12, 14, 16, 17, 18, 24	CFA
		Einschränkung der Verhaltensfreiheit	3, 7, 15, 21, 22, 25	
		Verweigerung psychologischer Autonomie	8, 9, 10, 13, 19, 20, 23	
Uji et al., 2006 (Japan)	4	Fürsorge	1, 5, 6, 11, 12, 17	EFA und CFA
		Indifferenz	2, 4, 14, 16, 18, 24	
		Kontrolle	8, 9, 10, 13, 19, 20, 23	
		Autonomie	3, 7, 15, 21, 22	

Anmerkungen. EFA = Explorative Faktorenanalyse, CFA = Konfirmatorische Faktorenanalyse. Die Bezeichnungen der Faktoren wurden aus dem Englischen ins Deutsche übersetzt.

Tabelle Z3. *Statistische Analyseprozesse und Hypothesentests zur Überprüfung der Faktorstruktur, psychometrischen Qualität und Konstrukt- und Kriteriumsvalidität des PBI-dt*

Analyseverfahren und ergänzende Informationen	Berechnete Parameter	Interpretation und Schwellenwerte
Stichprobenmittelwerte		
Finden sich in der aktuell untersuchten Stichprobe vergleichbare Mittelwerte wie in der Originalstudie von Parker und Kollegen (1979)?		
Deskriptive Statistik	Mittelwert, Standardabweichung	
Die von Parker berichteten Unterschiede zwischen erinnerter mütterlicher und väterlicher Bindungserfahrung lässt sich replizieren, konkret wird angenommen, dass Mütter als fürsorglicher und als kontrollierender wahrgenommen werden.		
t-Test für verbundene Stichproben		Statistisches Signifikanzniveau: α = 0.05
Faktorenstruktur		
Welche Faktorenstruktur ergibt sich aus den vorliegenden Daten bei exploratorisches Analyse?		
Exploratorische Faktorenanalyse - Berechnung in R Studio mit der Funktion fa() - Extraktionsmethode: Maximum Likelihood, Rotationsmethode: Varimax	Fitindizes [3] (1) Tucker-Lewis-Index der Faktorreliabilität (TLI) (2) Root Mean Square of Error Approximation (angegeben mit 90% Konfidenzintervall) (RMSEA) (3) Bayesian Information Criterium (BIC)	
Wie gut bilden die drei aus der Literatur ausgewählten Modelle die Datenstruktur der aktuellen Studie ab? Welches Modell ist zu bevorzugen?		
Konfirmatorische Faktorenanalyse - Robuste Variante des ML-Schätzers mit Yuan-Bentler-Korrektur und nach Huber-White geschätzten Standardfehlern (MLR) bei Vorliegen einer Verletzung der Multinormalverteilungs-voraussetzungen, [1] - Inklusion von a-priori-korrelierte Residuen auf Item-Ebene zwischen Items mit paralleler oder sehr ähnlicher Formulierung und Semantik (Item 8 und 13, Item 7 und 15, Item 11 und 18) [2]	Fitindizes [3] (4) Root Mean Square Error of Approximation (RMSEA) (5) Standardized Root Mean Square Residual (SRMR) (6) Comparative Fit-Index (CFI) (7) Tucker- Lewis-Index (TLI)	Interpretationsrichtlinien zur Bewertung der Modellanpassungsgüte: RMSEA und SRMR ≤ .08 für ausreichende Anpassung, ≤ .05 bzw .06 für gute Anpassung CFI und TLI ≥ .90 [4]
Welches Modell liefert ausreichend diskriminante Faktoren (Diskriminanzvalidität)?		
Konfirmatorische Faktorenanalyse	Inter-Faktor-korrelationen	Betrag der Faktorkorrelation ≤ .90 [5]

Itemanalyse		
Besitzen die Items des PBI-dt geeignete Eigenschaften zur Messung der Konstrukte?		
Itemanalyse	Mittelwert mit Standardabweichung Schiefe Varianz	Mittelwert direkt als Schwierigkeitsindex interpretierbar, sollte im Bereich von 15% bis 85% der Skala liegen: psychometrisch schwer: < .45 optimale Differenzierung: .45 – 2.55 psychometrisch leicht: > 2.55 [6]
	Spannweite	Sollte alle Antwortkategorie (0 - 3) ausschöpfen
	korrigierter Trennschärfekoeffizient (r_{it})	Schwache Trennschärfe: $r_{it} < .40$ Gute Trennschärfe: $.40 < r_{it} < .70$ Sehr gute Trennschärfe: $r_{it} \geq .70$ [6]
Konfirmatorische Faktorenanalyse	standardisierte Faktorladung	Akzeptable Faktorladung: > .50 Gute Faktorladung: ≥ .70 [7]
Reliabilität		
Wie messgenau und verlässlich misst der PBI-dt?		
Reliabilitätsanalysen	**Indikatorebene**	
	Korrigierte Trennschärfe r_{it}	$r_{it} \geq .50$
	Cronbachs α ohne Item	$\alpha_{\text{ohne Item}} \leq \alpha_{\text{Gesamtskala}}$
	Indikatorreliabilität	≥ .20 - ≥ .40 [6]
	Konstruktebene	
	Cronbachs α	≥ .80 [8]
	McDonald's ω_t	≥ .80 [9]
	Inter-Item-Korrelation (MIC)	≥ .30 [10]
	Faktorreliabilität	≥ .60 [5]
	Durchschnittlich erfasste Varianz (DEV)	≥ .50 [11]

Validität

Konvergente und diskriminante Validität

Die berichteten Zusammenhänge zwischen PBI-dt und CTQ-SF lassen sich replizieren, konkret wird angenommen, dass die PBI-dt Subskala Fürsorge stark negativ mit den CTQ-SF Subskalen emotionale Vernachlässigung und emotionaler Missbrauch korreliert und gering negativ mit der CTQ-SF Subskala sexueller Missbrauch; sowie dass die PBI-dt Subskala Kontrolle stark positiv mit den CTQ-SF Subskalen emotionale Vernachlässigung und emotionaler Missbrauch korreliert und gering positiv mit der CTQ-SF Subskala sexueller Missbrauch. Es wird erwartet, dass sich die Korrelationen CTQ-SF Subskalen körperliche Vernachlässigung und körperlicher Missbrauch mit den beiden BPI-dt Subskalen jeweils dazwischen einsortiert. Diese Annahmen gelten gleichsam für Mutter und Vater.

Pearson-Korrelationsanalyse	Pearson-Korrelationskoeffizienten r	Geringe/schwache Korrelation: r = .10 Mittlere/moderate Korrelation: r = .30 Große/starke Korrelation: r = .50 [12]

Kriteriumsvalidität

Psychische Gesundheit: *Die berichteten Unterschiede lassen sich replizieren, konkret wird angenommen, dass Personen, die berichten an einer psychischen Störung zu leiden, weniger mütterliche und väterliche Fürsorge und mehr mütterliche und väterliche Kontrolle berichten als Personen, die angeben, an keiner psychischen Störung zu leiden.*

t-Test für unabhängige Stichproben	Statistisches Signifikanzniveau: $\alpha = 0.05$

BMI: *Die berichteten Unterschiede lassen sich replizieren, konkret wird angenommen, dass übergewichtige Personen (BMI ≥ 25) weniger mütterliche und väterliche Fürsorge und mehr mütterliche und väterliche Kontrolle berichten als normalgewichtige Personen, (18.5 ≤ BMI < 25).*

t-Test für unabhängige Stichproben	Statistisches Signifikanzniveau: $\alpha = 0.05$

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Tabelle Z4: *Exploratorische Faktorenanalyse des PBI-dt*

1) Prüfung der Voraussetzung:
   - Korrelation der Items in R Studio mit der Funktion cortest.bartlett()
     - PBI-dt Mutter: $p < .001$ → Items korrelieren signifikant miteinander
     - PBI-dt Vater: $p < .001$ → Items korrelieren signifikant miteinander
   - Berechnung des Kaiser-Meyer-Olkin Measure of Sampling Adequacy in R Studio mit der Funktion KMO()
     - PBI-dt Mutter: MSA = .97 (Range .91-.98)
     - PBI-dt Vater MSA = .96 (Range .92-.98)

2) Parallelanalyse:
   - Parallelanalyse der Daten zur Berechnung der Eigenwerte und Erstellung eines Screeplots in R Studio mit der Funktion fa.parallel()

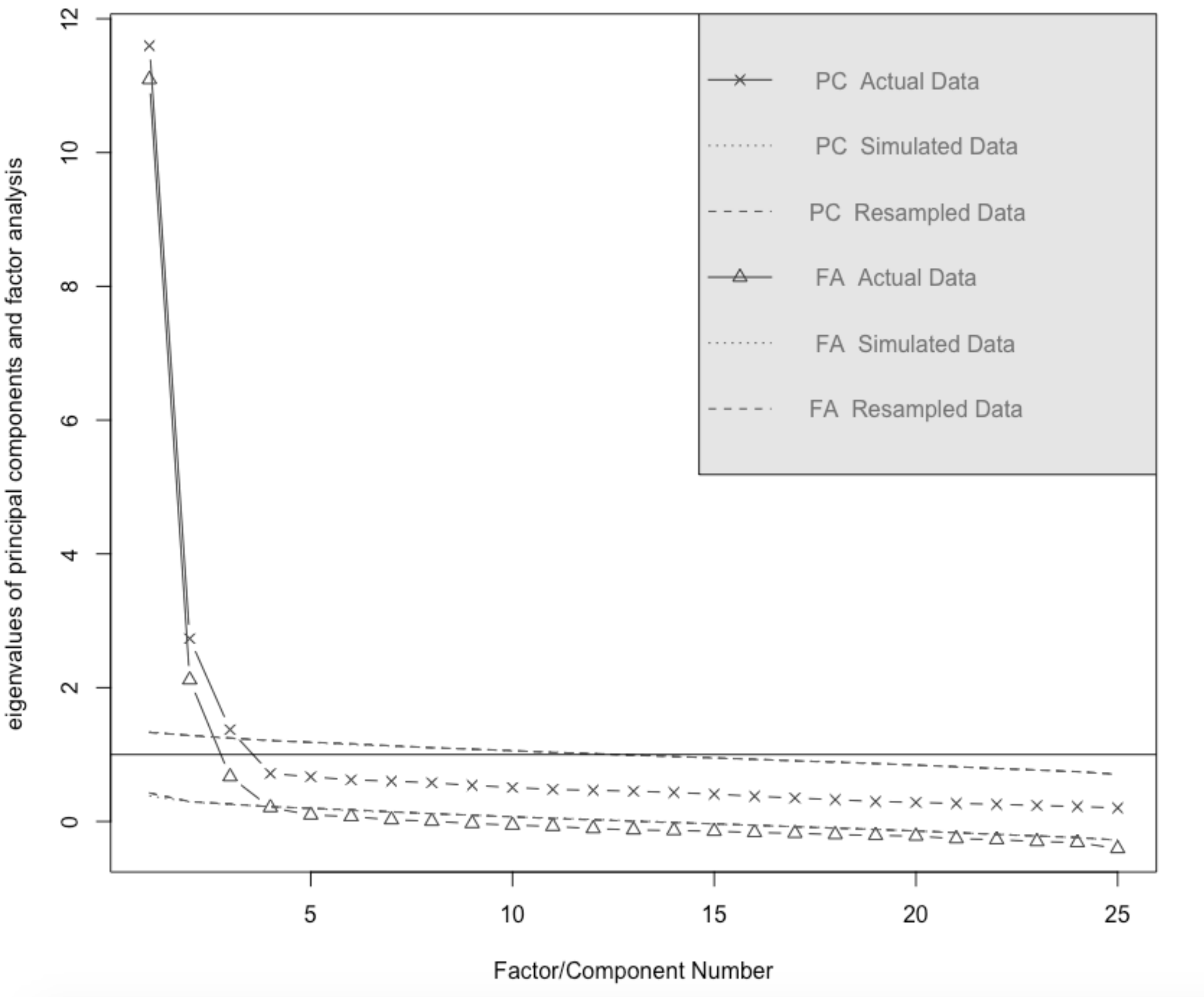

Abbildung 1. Screeplot der Parallelanalyse der PBI-dt Items zur Beurteilung des Erziehungsstils der Mutter, vorgeschlagene Anzahl an Faktoren = 3, vorgeschlagene Anzahl an Komponenten = 3.

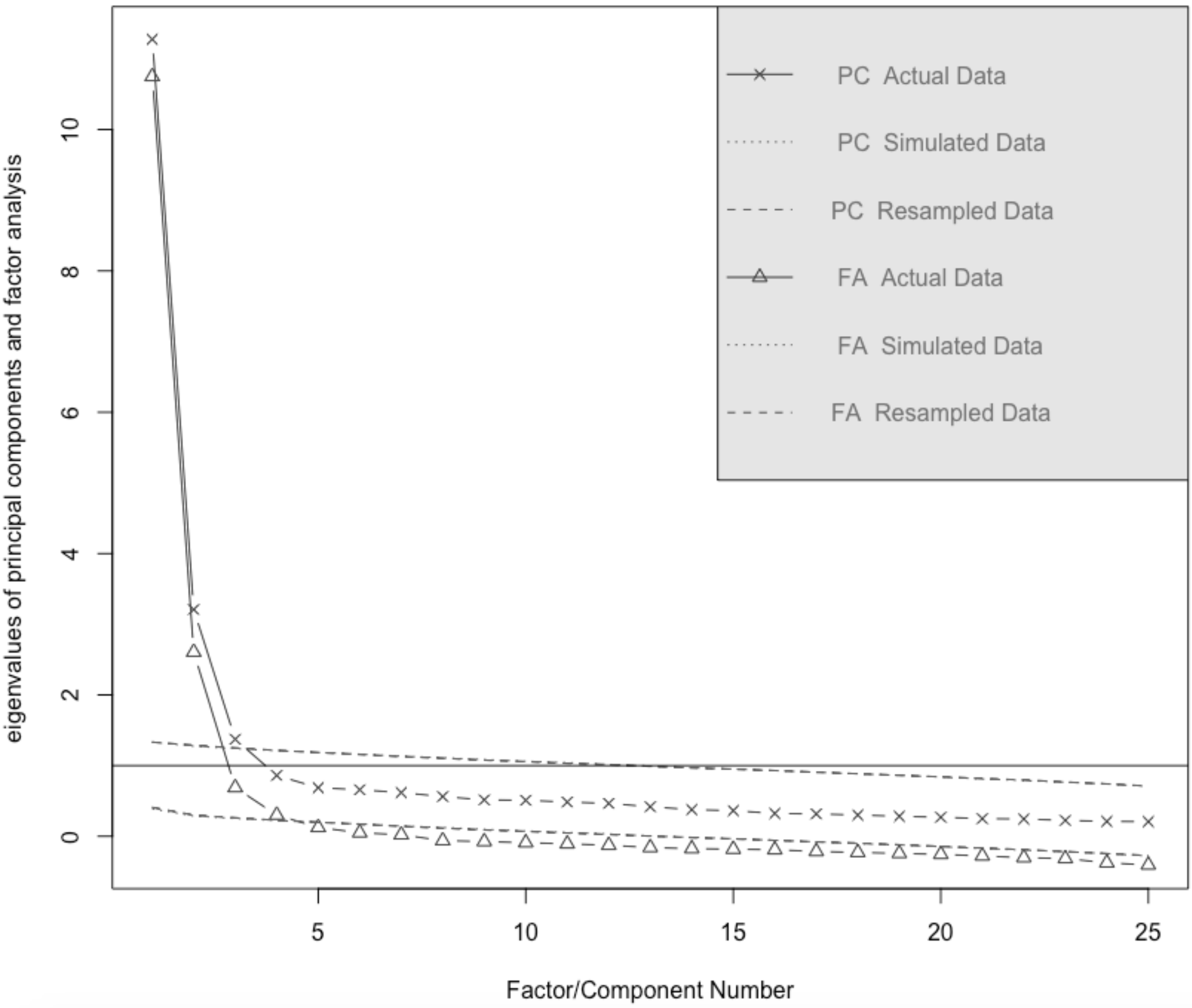

Abbildung 2. Screeplot der Parallelanalyse der PBI-dt Items zur Beurteilung des Erziehungsstils des Vaters, vorgeschlagene Anzahl an Faktoren = 4, vorgeschlagene Anzahl an Komponenten = 3.

3) Exploratorische Faktoranalyse

Berechnung in R Studio mit der Funktion fa()

Extraktionsmethode: Maximum Likelihood, Rotationsmethode: Varimax

Tabelle Z4a: *Exploratorische Faktorenanalyse des PBI-dt: Faktorladungen bei Annahme von drei Faktoren*

	Mutter			Vater			
Item	**Faktor 1**	**Faktor 2**	**Faktor 3**	**Faktor 1**	**Faktor 2**	**Faktor 3**	**Dimension**
1	**.75**	-.20	-.23	**.79**	-.14	-.25	Fürsorge
2	**.68**	-.21	-.15	**.67**	-.19	-.13	
4	**.82**	-.12	-.12	**.79**	-.13	-.18	
5	**.74**	-.28	-.21	**.74**	-.19	-.18	
6	**.83**	-.16	-.21	**.80**	-.16	-.25	
11	**.67**	-.13	-.23	**.70**	-.14	-.15	
12	**.78**	-.01	-.21	**.79**	-.07	-.19	
14	**.67**	**-.40**	-.23	**.72**	-.36	-.13	
16	**.70**	-.14	-.19	**.64**	-.21	-.15	
17	**.65**	-.23	-.17	**.72**	-.11	-.16	
18	**.73**	-.08	-.17	**.77**	-.13	-.06	
24	**.73**	-.20	-.16	**.76**	-.19	-.13	
8	-.13	**.65**	.09	-.12	**.58**	.13	Verweigerung psychologischer Autonomie
9	-.32	**.60**	.38	-.27	**.57**	**.48**	
10	**-.42**	**.53**	.35	-.32	**.48**	**.41**	
13	-.21	**.67**	.20	-.27	**.69**	.18	
19	-.31	**.55**	.11	-.23	**.55**	.19	
20	-.29	**.68**	.22	-.31	**.69**	.21	
23	.13	**.63**	.26	.13	**.57**	.28	
3	-.25	.23	**.65**	-.28	.28	**.73**	Einschränkung der Verhaltens-freiheit
7	-.38	**.45**	**.47**	-.37	**.47**	**.48**	
15	**-.41**	**.45**	**.56**	-.27	**.48**	**.59**	
21	**-.40**	.38	**.64**	-.32	.39	**.72**	
22	-.11	.15	**.65**	-.12	.17	**.75**	
25	-.18	.19	**.55**	-.11	.18	**.59**	
Erklärte Varianz (Proportional)	.30	.15	.12	.30	.14	.14	
Erklärte Varianz (Kumulativ)	.30	.46	.57	.30	.44	.58	
Chi² (*df*)			12,989.31 (300)			13,489.65 (300)	
TLI			.947			.925	
RMSEA			.054 [.049; .057]			.065 [.06; .069]	
BIC			-785.54			-546.41	

Anmerkung: Faktorladungen ≥ .40 sind fett gedruckt. TLI = Tucker-Lewis-Index der Faktorreliabilität; RMSEA = Root Mean Square of Error Approximation (angegeben mit 90% Konfidenzintervall); BIC = Bayesian Information Criterium.

Tabelle Z4b: *Exploratorische Faktorenanalyse des PBI-dt: Faktorladungen bei Annahme von zwei Faktoren*

	Mutter		Vater		
Item	**Faktor 1**	**Faktor 2**	**Faktor 1**	**Faktor 2**	**Dimension**
1	**.75**	-.29	**.79**	-.27	Fürsorge
2	**.67**	-.25	**.67**	-.22	
4	**.82**	-.16	**.80**	-.21	
5	**.74**	-.34	**.75**	-.25	
6	**.84**	-.24	**.80**	-.29	
11	**.68**	-.24	**.71**	-.20	
12	**.79**	-.24	**.79**	-.18	
14	**.67**	-.45	**.73**	-.32	
16	**.71**	-.22	**.64**	-.25	
17	**.65**	-.28	**.72**	-.19	
18	**.74**	-.15	**.78**	-.12	
24	**.73**	-.25	**.76**	-.21	
3	-.29	**.56**	-.29	**.71**	Kontrolle
7	-.39	**.64**	-.28	**.68**	
8	-.12	**.57**	-.13	**.48**	
9	-.32	**.71**	-.28	**.74**	
10	-.42	**.63**	-.33	**.63**	
13	-.19	**.65**	-.28	**.58**	
15	**-.43**	**.68**	-.28	**.76**	
19	-.30	**.50**	-.24	**.51**	
20	-.28	**.67**	-.33	**.60**	
21	**-.44**	**.67**	-.33	**.78**	
22	-.16	**.48**	-.13	**.65**	
23	.14	**.66**	.12	**.58**	
25	-.21	**.46**	-.12	**.55**	
Erklärte Varianz (Proportional)	.31	.23	-30	.24	
Erklärte Varianz (Kumulativ)	.31	.54	.30	.54	
Chi^2 (*df*)	12,989.31 (300)		13,489.65 (300)		
TLI	.909		.878		
RMSEA	.071 [.066; .074]		.083 [.078; .086]		
BIC	-454.29		-85.31		

Anmerkung: Faktorladungen ≥ .40 sind fett gedruckt. TLI = Tucker-Lewis-Index der Faktorreliabilität; RMSEA = Root Mean Square of Error Approximation (angegeben mit 90% Konfidenzintervall); BIC = Bayesian Information Criterium.

Tabelle Z5. *Inter-Faktorkorrelationen der drei untersuchten Faktorenmodelle*

	2-FM-Parker		**3-FM-Mohr**		**4-FM-Uji**	
	Mutter	Vater	Mutter	Vater	Mutter	Vater
F1 & F2	-.72	-.63	-.71	-.60	**-.99**	**-.98**
F1 & F3	-	-	-.65	-.60	-.64	-.58
F2 & F3	-	-	.83	.83	.65	.61
F1 & F4	-	-	-	-	.72	.62
F2 & F4	-	-	-	-	-.69	-.57
F3 & F4	-	-	-	-	-.83	-.83

Anmerkungen. Im Rahmen der Konfirmatorischen Faktorenanalyse (CFA) ermittelte, standardisierte Inter-Faktorkorrelationen der drei untersuchten Faktorenmodelle, angegeben für die PBI Version Mutter / PBI Version Vater. Die Faktorenbezeichnungen sind dem Manuskript sowie den Originalpublikationen zu entnehmen. In Fettdruck sind die Werte hervorgehoben, die über dem empfohlenen Wert von ≤ .90 (Bagozzi & Foxall, 1996; Hesse, 2014) liegen.

Tabelle Z6a. *Reliabilitätskennwerte*

	Skala Fürsorge		**Skala Einschränkung der Verhaltensfreiheit**		**Skala Verweigerung psychologischer Autonomie**	
	Mutter	**Vater**	**Mutter**	**Vater**	**Mutter**	**Vater**
Indikatorebene						
Korrigierte Trennschärfe r_{it}	.70 - .83	.66 - .82	.56 - .76	.58 - .80	.54 - .71	.51 - .71
Indikatorreliabilität	.51 - .74	.47 - .73	.33 - .73	.36 - .78	.29 - .66	.27 - .69
Konstruktebene						
Cronbach's α	.95	.95	.86	.89	.87	.86
McDonald's Omega	.95	.95	.87	.88	.85	.85
Inter-Item-Korrelation (MIC)	.60	.61	.52	.58	.48	.46
Faktorreliabilität	.95	.95	.86	.89	.86	.85
Durchschnittlich erfasste Varianz (DEV)	.61	.61	.52	.58	.47	.45

Anmerkungen. Auf Indikatorebene ist jeweils der Range angegeben, in der die korrigierten Trennschärfen sowie Indikatorreliabilitäten der Items liegen.

Tabelle Z6b. *Indikatorreliabilitäten, Cronbach's α und α ohne Item-Werte 3-FM-Mohr*

	Mutter			**Vater**		
Item	Indikator-reliabilität	Cronbach's *α* ohne dieses Item	Cronbach's *α*	Indikator-reliabilität	Cronbach's *α* ohne dieses Item	Cronbach's *α*
Skala Fürsorge						
1	.65	.94	.95	.70	.94	.95
2	.53	.94		.50	.95	
4	.67	.94		.68	.94	
5	.68	.94		.62	.94	
6	.74	.94		.73	.94	
11	.51	.94		.52	.94	
12	.68	.94		.66	.94	
14	.63	.94		.63	.94	
16	.53	.94		.47	.95	
17	.52	.94		.56	.94	
18	.54	.94		.58	.94	
24	.59	.94		.62	.94	
Skala Einschränkung der Verhaltensfreiheit						
3	.49	.84	.86	.67	.86	.89
7	.55	.84		.55	.88	
15	.68	.82		.63	.87	
21	.73	.82		.78	.86	
22	.33	.86		.51	.88	
25	.33	.86		.36	.89	
Skala Verweigerung der psychologischen Autonomie						
8	.33	.85	.87	.27	.85	.86
9	.66	.84		.69	.82	
10	.62	.84		.56	.84	
13	.46	.84		.46	.83	
19	.39	.85		.38	.84	
20	.55	.84		.56	.82	
23	.29	.86		.27	.85	

Tabelle Z7a. *Faktorladungen im 2-FM-Parker*

	Mutter		Vater	
	r_{it}	**Faktor-ladung**	**r_{it}**	**Faktor-ladung**
Item				
Skala Fürsorge				
1. „Sprach mit einer warmen und freundlichen Stimme zu mir."	.77	.81**	.80	.84**
2. „Half mir nicht so sehr, wie ich es gebraucht hätte." (R)	.71	.73**	.69	.70**
4. „Wirkte mir gegenüber gefühlskalt." (R)	.79	.82**	.79	.82**
5. „Schien meine Probleme und Sorgen zu verstehen."	.80	.82**	.78	.79**
6. „War liebevoll zu mir."	.83	.86**	.82	.86**
11. „Besprach gern Dinge mit mir."	.70	.72**	.72	.72**
12. „Lächelte mich häufig an."	.80	.82**	.78	.81**
14. „Schien nicht zu verstehen, was ich brauchte oder wollte." (R)	.77	.80**	.78	.80**
16. „Gab mir das Gefühl, nicht erwünscht zu sein." (R)	.71	.73**	.66	.69**
17. „Konnte mich beruhigen, wenn ich aufgebracht war."	.70	.72**	.73	.75**
18. „Redete nicht sehr viel mit mir." (R)	.72	.73**	.76	.76**
24. „Lobte mich nicht." (R)	.75	.77**	.76	.79**
Skala Kontrolle				
3. „Ließ mich die Dinge tun, auf die ich Lust hatte." (R)	.60	.65**	.71	.77**
7. „Mochte es, wenn ich meine eigenen Entscheidungen traf." (R)	.70	.73**	.73	.76**
8. „Wollte nicht, dass ich erwachsen werde."	.54	.53**	.50	.48**
9. „Versuchte alles, was ich tat, zu kontrollieren."	.74	.78**	.76	.79**
10. „Drang in meine Privatsphäre ein."	.70	.77**	.67	.72**
13. „Neigte dazu, mich wie ein kleines Kind zu behandeln."	.64	.64**	.64	.63**
15. „Ließ mich meine eigenen Entscheidungen treffen." (R)	.76	.81**	.77	.80**
19. „Versuchte, dass ich mich abhängig von ihr/ihm fühlte."	.55	.59**	.55	.56**
20. „Glaubte, dass ich ohne sie/ihn nicht zurechtkommen würde."	.69	.70**	.67	.68**
21. „Gab mir so viel Freiraum, wie ich brauchte." (R)	.76	.81**	.79	.85**
22. „Ließ mich ausgehen, so oft ich wollte." (R)	.49	.52**	.59	.66**
23. „War überbehütend."	.51	.48**	.50	.48**
25. „Ließ mich anziehen, was mir gefiel." (R)	.50	.53**	.52	.56**

Anmerkungen. r_{it} = korrigierte Trennschärfekoeffizienten. ** signifikant von Null verschieden auf dem 1% Niveau.

Tabelle Z7b. *Reliabilitätskennwerte des 2-FM-Parker*

	Skala Fürsorge		Skala Kontrolle	
	Mutter	**Vater**	**Mutter**	**Vater**
Indikatorebene				
Korrigierte Trennschärfe r_{it}	.70 - .83	.66 - .82	.49 - .76	.50 - .79
Indikatorreliabilität	.51 - .74	.47 - .73	.23 - .66	.23 - .73
Konstruktebene				
Cronbach's α	.95	.95	.91	.92
McDonald's Omega	.95	.95	.90	.92
Inter-Item-Korrelation (MIC)	.60	.61	.44	.46
Faktorreliabilität	.95	.95	.91	.92
Durchschnittlich erfasste Varianz (DEV)	.61	.61	.44	.47

Anmerkungen. Auf Indikatorebene ist jeweils der Range angegeben, in der die korrigierten Trennschärfen sowie Indikatorreliabilitäten der Items liegen.

Tabelle Z7c. *Indikatorreliabilitäten, Cronbachs α und α ohne Item-Werte im 2-FM-Parker*

Item	Mutter			Vater		
	Indikator-reliabilität	Cronbachs α ohne dieses Item	Cronbachs α	Indikator-reliabilität	Cronbachs α ohne dieses Item	Cronbachs α
Skala Fürsorge						
1	.65	.94	.95	.70	.94	.95
2	.53	.94		.50	.95	
4	.67	.94		.68	.94	
5	.68	.94		.62	.94	
6	.74	.94		.73	.94	
11	.51	.94		.52	.94	
12	.68	.94		.66	.94	
14	.63	.94		.63	.94	
16	.53	.94		.47	.95	
17	.52	.94		.56	.94	
18	.54	.94		.58	.94	
24	.59	.94		.62	.94	
Skala Kontrolle						
3	.42	.91	.91	.60	.91	.92
7	.54	.90		.57	.91	
8	.27	.91		.23	.92	
9	.61	.90		.63	.91	
10	.59	.90		.52	.91	
13	.40	.90		.40	.91	
15	.65	.90		.64	.91	
19	.34	.91		.31	.91	
20	.49	.90		.46	.91	
21	.66	.90		.73	.90	
22	.27	.91		.43	.91	
23	.23	.91		.23	.92	
25	.28	.91		.31	.91	

Tabelle Z8a. *Interkorrelationen der PBI-Skalen Fürsorge und Kontrolle und CTQ-SF-Skalen*

	PBI			
	Skala Fürsorge		Skala Kontrolle	
CTQ-SF	**Mutter**	**Vater**	**Mutter**	**Vater**
Emotionale Vernachlässigung	-.84**	-.68**	.58**	.49**
Emotionaler Missbrauch	-.74**	-.58**	.58**	.49**
Körperliche Vernachlässigung	-.63**	-.44**	.37**	.32**
Körperlicher Missbrauch	-.46**	-.33**	.35**	.33**
Sexueller Missbrauch	-.20**	-.16**	.20**	.18**

Anmerkungen. Angabe des Pearson-Korrelationskoeffizienten *r.* ** = Die Korrelation ist auf dem Niveau von 0.01 (2-seitig) signifikant.

Tabelle Z8b. *Interkorrelationen der Skalen Verweigerung psychologischer Autonomie und Einschränkung der Verhaltensfreiheit und CTQ-SF-Skalen*

	PBI			
	Skala Verweigerung psychologischer Autonomie		Skala Einschränkung der Verhaltensfreiheit	
CTQ-SF	**Mutter**	**Vater**	**Mutter**	**Vater**
Emotionale Vernachlässigung	.50**	.45**	.56**	.46**
Emotionaler Missbrauch	.52**	.46**	.55**	.45**
Körperliche Vernachlässigung	.30**	.28**	.37**	.32**
Körperlicher Missbrauch	.27**	.26**	.38**	.35**
Sexueller Missbrauch	.16**	.15**	.20**	.19**

Anmerkungen. Angabe des Pearson-Korrelationskoeffizienten *r.* ** = Die Korrelation ist auf dem Niveau von 0.01 (2-seitig) signifikant.