

**Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung (ADHS) im Erwachsenenalter:  
Stressreagibilität und Stressbewältigung unter Laborbedingungen  
und im Alltag**

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## **Vorbemerkung**

Bei der vorliegenden Arbeit handelt es sich um eine publikationsbasierte Dissertation. Kernelement sind zwei englischsprachige Originalartikel, von denen der erste als Beitrag in der Fachzeitschrift *Psychoneuroendocrinology* veröffentlicht wurde, während der zweite zur Veröffentlichung in der Fachzeitschrift *Journal of Clinical Psychology* eingereicht und gegenwärtig Gegenstand des dortigen *peer-review*-Verfahrens ist.

Zur inhaltlichen Zusammenführung der genannten Beiträge dienen ein Einleitungskapitel mit Kurzdarstellung des Gesamtkonzeptes der Arbeit, bestehend aus theoretisch-empirischem Hintergrund sowie Skizzierung der Zielsetzung der durchgeführten Studien. Weiterhin wird jedem Manuskript eine separate Kurzeinführung vorangestellt. Im Anschluss an die Vorstellung beider Originalarbeiten folgt eine abschließende Diskussion in Kapitel 4, welche die Ziele der Arbeit und die dargestellten Ergebnisse nochmals zusammenfasst, eine Einordnung vornimmt und Perspektiven für nachfolgende Forschung aufzeigt.

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## **Abstract**

The examination of the literature on attention-deficit/hyperactivity disorder (ADHD) in adults reveals that assumptions of an elevated vulnerability towards stressors and of deficits in functional stress-related coping in these patients are widespread and may also be derived from established theoretical models of the disorder. Because systematic empirical investigations of these hypotheses are almost completely lacking, the goal of the present dissertation is to systematically compare the subjective stress experience, physiological stress responses, and stress-related coping strategies of adult ADHD patients and healthy control subjects.

In the first chapter, a short introduction is given to epidemiological data on ADHD in adults as well as to established model assumptions on the general deficits underlying the disorder's diverse symptom manifestations. Furthermore, the goals of the present work are summarized. In the second chapter, hypotheses with regard to the subjective stress experience and physiological stress reactivity are derived from two theoretical models of ADHD. A short overview on empirical work in the field of stress reactivity in children with ADHD is also given. The lack of empirical studies in adult ADHD patients underpins the necessity for the investigation presented in chapter 2.2 which examines subjective stress as well as various physiological stress measures in these subjects when confronted with a standardized psychosocial stressor under laboratory conditions (Trier Social Stress Test; Kirschbaum, Pirke, & Hellhammer, 1993). In the following chapter, questions regarding the relevance of these results for the experience of real life stressors in adults with ADHD are highlighted. After outlining the empirical data available so far, a study is presented (chapter 3.2) which investigates potential differences in chronic stress and coping with daily life stressors in adult ADHD patients as compared to healthy controls. Furthermore, associations of these parameters with attentional variables as well as



self-reported quality of life and satisfaction with life were explored. The dissertation concludes with a general discussion of its implications and limitations (chapter 4), as well as recommendations for future research.

## **Zusammenfassung**

In der wissenschaftlichen wie populärwissenschaftlichen Literatur zum Störungsbild der Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung (ADHS) bei erwachsenen Patienten werden vielfach eine erhöhte Stressreagibilität und ein defizitäres stressbezogenes Coping bei den Betroffenen postuliert. Eine systematische empirische Überprüfung dieser Hypothesen, die auch aus etablierten Modellen der Störung theoretisch gut ableitbar sind, steht jedoch noch weitgehend aus. Vor diesem Hintergrund ist das Ziel der hier vorgelegten Arbeiten die Gegenüberstellung des subjektiven Stresserlebens, der physiologischen Stressantwort und der in der Konfrontation mit Alltagsstressoren angewandten Copingstrategien erwachsener ADHS-Patienten und gesunder Kontrollprobanden.

Im ersten Kapitel der Arbeit wird eine kurze Einführung in epidemiologische Daten zur ADHS bei Erwachsenen sowie in allgemeine theoretische Annahmen zu den der Störung zugrundeliegenden Defiziten gegeben. Anknüpfend wird die Zielsetzung der hier präsentierten empirischen Studien formuliert. Das zweite Kapitel widmet sich zunächst der Ableitung von Annahmen zum subjektiven Stresserleben und zur physiologischen Stressreagibilität aus Modellen der ADHS. Im Anschluss wird ein kurzer Überblick über bisherige empirische Befunde zur Stressreagibilität vorrangig bei Kindern mit ADHS gegeben. Das Fehlen empirischer Studien, die sich mit erwachsenen Patienten mit diesem Störungsbild auseinander setzen, unterstreicht die Notwendigkeit der in Kapitel 2.2 vorgestellten eigenen Arbeit, die das subjektive Stresserleben und verschiedene physiologische Stressparameter dieser Patienten unter Laborbedingungen, d.h. bei Konfrontation mit einem standardisierten psychosozialen Stressor (Trier Social Stress Test; Kirschbaum, Pirke, & Hellhammer, 1993), untersucht. Das dritte Kapitel befasst sich mit der Frage der Relevanz der Laborbefunde zum Stresserleben für die Begegnung mit und

Wahrnehmung von Alltagsstressoren bei erwachsenen ADHS-Patienten. Nach einem Überblick über die bisherige Datenlage bei Kindern und Erwachsenen mit ADHS wird eine weitere Originalarbeit präsentiert (Kapitel 3.2), die potenzielle Unterschiede im chronischen Stresserleben und im selbstberichteten stressbezogenen Coping bei Erwachsenen mit ADHS gegenüber gesunden Kontrollprobanden sowie Zusammenhänge der genannten Variablen mit Maßen spezifischer Aufmerksamkeitsfunktionen und mit der selbstberichteten Lebensqualität und –zufriedenheit untersucht. Die Arbeit schließt ab mit einer zusammenfassenden Diskussion (Kapitel 4), die die vorgestellten Ergebnisse einer kritischen Reflexion unterzieht und Empfehlungen für künftige Studien formuliert.

## **1. Einleitung**

### **1.1. Theoretischer und empirischer Hintergrund: Die Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung im Erwachsenenalter**

Die Aufmerksamkeitsdefizit-/Hyperaktivitätsstörung (ADHS) mit ihren zentralen Symptommmerkmalen Unaufmerksamkeit, Hyperaktivität und Impulsivität wurde noch lange nach dem Beginn der systematischen wissenschaftlichen Erforschung zu Anfang des 20. Jahrhunderts vornehmlich als Störungsbild des Kindes- und Jugendalters verstanden (Barkley, 1990). Diese Konzeption wandelte sich grundlegend erst in den 1970er Jahren, als die Befunde erster empirischer Längsschnittstudien zum Störungsverlauf bei einem bedeutsamen Anteil mit ADHS diagnostizierter Kinder und Jugendlicher eine Persistenz der Symptome mit erheblichen daraus folgenden Beeinträchtigungen bis weit ins Erwachsenenalter hinein verdeutlichten (Borland & Heckman, 1976; Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1998; Menkes, Rowe, & Menkes, 1967). Diesen Ergebnissen zufolge ist damit zu rechnen, dass bei bis zu 30% der Patienten das Vollbild der Störung auch nach der Adoleszenz fort besteht. Werden lediglich subsyndromale Ausprägungen beeinträchtigender Kernsymptome der ADHS als Kriterium definiert, so sind diese sogar bei bis zu 60% der Betroffenen noch im Erwachsenenalter zu beobachten (Retz, Pajonk, & Rösler, 2003). Eine nachfolgende internationale epidemiologische Untersuchung erbrachte über zehn Länder hinweg hohe Prävalenzschätzungen von durchschnittlich 3.4% der erwachsenen Allgemeinbevölkerung (Fayyad et al., 2007). Für Deutschland wurde in dieser Studie eine Prävalenzrate von 3.1% ermittelt.

Die genannten Zahlen weisen auf eine beträchtliche Relevanz von ADHS-Beschwerden bei Erwachsenen in der Allgemeinbevölkerung hin und regten ein

hohes Ausmaß an internationaler Forschungsaktivität im jungen Themenfeld der ADHS bei Erwachsenen an. Wichtige Fragestellungen beziehen sich dabei u.a. auf die Ausgestaltung der Symptomatik im Erwachsenenalter, wie auch auf typische, mit der Störung assoziierte Probleme und Charakteristika sowie auf das psychosoziale Funktionsniveau erwachsener ADHS-Patienten. Die Bedeutsamkeit dieser Aspekte ergibt sich unter anderem aus der Problematik, dass die aktuell gültigen Störungskriterien sowohl des DSM-IV als auch der ICD-10 zwar eine ADHS-Diagnose im Erwachsenenalter grundsätzlich zulassen, sofern das Vorliegen der Störung (ICD-10) bzw. zumindest einiger beeinträchtigender Symptome (DSM-IV) für die Zeit vor dem 7. Lebensjahr ggf. retrospektiv objektiviert bzw. rekonstruiert werden kann. Allerdings sind etwa die Diagnosekriterien des DSM-IV (American Psychiatric Association, 1994) ausschließlich anhand von Felduntersuchungen an Kindern und Jugendlichen entwickelt worden, wohingegen Validierungsstudien an erwachsenen Patienten nach wie vor ausstehen (Belendiuk, Clarke, Chronis, & Raggi, 2007).

Aktuelle Modelle der ADHS nehmen als der Störung zugrunde liegend ein Defizit wesentlicher neuropsychologischer Exekutivfunktionen im zentralen Nervensystem an. Diese Kontrollprozesse sind dafür zuständig, untergeordnete kognitive Funktionen miteinander zu koordinieren, zu priorisieren und zu integrieren (Brown, 2006). Sie sind somit letztlich auch zentrale Voraussetzung für das Selbstmanagement und die Selbstregulation des Individuums (Barkley, 1997). Da mit fortschreitendem Lebensalter und insbesondere mit dem Übergang vom Kind und Jugendlichen zum Erwachsenen die Anforderungen an die Selbstregulation und damit an die exekutiven Funktionen ansteigen, kann vermutet werden, dass sich das klinische Bild der ADHS im Erwachsenenalter wie auch die assoziierten Charakteristika und Folgeprobleme vom Phänotyp der Störung bei Kindern und Jugendlichen mit ADHS-Diagnose abheben.

Zur Frage des Verlaufes und der Ausgestaltung der Symptomatik bei erwachsenen Patienten bemerkten auch Ramsay und Rostain (2003): „Rather than ‘growing out’ of ADHD, the symptoms seem to ‘grow with’ the individual” (p. 320). Entsprechend bemühten sich verschiedene Autoren um die Zusammenstellung heuristischer Übersichten zu typischen, mit der ADHS im Erwachsenenalter verbundenen Merkmalen sowie teils von abgewandelten, an das Erwachsenenalter angepassten Störungskriterien, aus denen wiederum Hinweise für psychosoziale Interventionen abgeleitet werden (Faraone, Biederman, Spencer, Mick, Murray, et al., 2006; Kordon & Kahl, 2004; Krause, Krause, & Trott, 1998; McGough & McCracken, 2006; Weiss & Murray, 2003). So übernehmen die Utah-Kriterien der ADHS im Erwachsenenalter (Wender, 1995) mit Unaufmerksamkeit und Hyperaktivität als Kernkriterien zwei der drei zentralen Symptomcluster der ADHS, wie sie das DSM-IV definiert. Überdies jedoch ist das Vorliegen von mindestens zwei weiteren Symptomen aus den Bereichen Affektlabilität, desorganisiertes Verhalten, Impulsivität, Stressintoleranz und emotionale Hyperreagibilität sowie fehlende Affektkontrolle für die Diagnosestellung im Erwachsenenalter gefordert. Die Postulierung einer verminderten Stresstoleranz bzw. einer erhöhten Stressreagibilität insbesondere bei erwachsenen ADHS-Patienten findet sich wiederholt in der wissenschaftlichen und populärwissenschaftlichen Literatur zum Störungsbild, wie auch in unsystematischen Selbstberichten Betroffener (Adler & Chua, 2002; Kordon & Kahl, 2004; Krause, Krause, & Trott, 1998; Ramsay & Rostain, 2008; Resnick, 2004). Der hohe zugemessene Stellenwert dieses angeblichen Charakteristikums erschließt sich auch aus der Tatsache, dass multimodale kognitiv-verhaltenstherapeutische Interventionsansätze der ADHS im Erwachsenenalter in jüngerer Zeit zunehmend Stressmanagementelemente integrieren (z.B. Hesslinger, Philipsen, & Richter, 2004). Umso mehr mag es erstaunen, dass nach derzeitiger

Literaturübersicht eine systematische empirische Überprüfung von Hypothesen zu Abweichungen im Stresserleben und in der Stressreagibilität erwachsener ADHS-Patienten bislang kaum stattgefunden hat. Ein Ziel der vorliegenden Arbeiten ist es, einen Beitrag zur Schließung dieser Lücke zu leisten.

## **1.2. Ziel der durchgeführten Studien**

Im Rahmen der in den beiden Originalartikeln dieser Dissertation vorgestellten Studien wurden Stressreaktionsmuster erwachsener ADHS-Patienten mittels verschiedener Messmethoden erhoben und mit denen gesunder Kontrollprobanden verglichen. Die erste Arbeit (Kapitel 2) befasst sich zunächst mit dem Vergleich physiologischer Stressparameter erwachsener Patienten mit ADHS-Diagnose nach DSM-IV mit denen gesunder Kontrollprobanden unter Laborbedingungen. Zur Anwendung kam ein etabliertes Paradigma der Stressforschung mit einem standardisierten psychosozialen Stressor als Stimulusbedingung. Bislang lagen in der wissenschaftlichen Literatur keinerlei Befunde zu physiologischen Maßen der beiden wesentlichen körperlichen Stresssysteme (Sympathikus-Nebennierenmark-Achse und Hypophysen-Hypothalamus-Nebennierenrinden- (HPA-) Achse) bei erwachsenen ADHS-Patienten in akuten Stresssituationen vor. Diese wurden in der beschriebenen Untersuchung simultan jeweils unter Ruhe-, Stress- und Erholungsbedingungen betrachtet. Überdies wurde in der Laborstudie das subjektive Stresserleben bei Konfrontation mit dem Stressor untersucht. Die Ergebnisse der Studie verdeutlichen, dass bei der Gruppe der ADHS-Patienten bezüglich des subjektiven Stresserlebens und teils in den autonomen Maßen Abweichungen von

der Kontrollgruppe zu verzeichnen sind, während im Hinblick auf die Aktivität der HPA-Achse lediglich ein Trend beobachtet wurde.

Um die Relevanz der genannten Laborbefunde zur psychologischen Ebene der Stressreaktion für die Konfrontation mit realen Stressoren zu prüfen, wurde in der zweiten Studie (Kapitel 3) das subjektive Stresserleben von Erwachsenen mit ADHS in einer Vielzahl potenziell belastender Alltagssituationen per Fragebogen erhoben, wiederum im Vergleich zu einer gesunden Kontrollgruppe. Gleichzeitig erfolgte die Messung von typischen stressbezogenen Copingstrategien, Lebensqualität und Aufmerksamkeitsleistung in den beiden Gruppen. Ein weiteres vorrangiges Ziel der Studie war es, Informationen über mögliche Defizite und Kompetenzen im Bereich des stressbezogenen Copings bei erwachsenen ADHS-Patienten zu erhalten, diese Daten in Beziehung zu setzen zu potenziellen Defiziten in spezifischen Aufmerksamkeitsfunktionen und schließlich erste mögliche Hinweise für die Gestaltung von Interventionen abzuleiten, die auf eine Verbesserung des Stressmanagements dieser Patientenklientel ausgerichtet sind.



## **2. Eine quasi-experimentelle Untersuchung physiologischer und psychologischer Stressreaktionen bei erwachsenen ADHS-Patienten unter Laborbedingungen**

### **2.1. Einführung in die Fragestellung**

Theoretische Modelle der ADHS lassen Abweichungen des Stresserlebens betroffener Patienten gegenüber vergleichbaren Personen ohne Störung erwarten. So nimmt Barkley (1997) als den unterschiedlichen klinischen Manifestationen der ADHS zugrundeliegend ein primäres Inhibitionsdefizit an, welches sekundär zu Beeinträchtigungen der zentralen exekutiven Funktionen Arbeitsgedächtnis, Selbstregulation des affektiv-motivationalen Arousals, Internalisierung von Sprache und Rekonstruktion führt. Diese wiederum haben eine hohe Bedeutung für die Selbstregulation des Individuums und für sein adaptives Funktionsniveau. Das neuroanatomische Korrelat der genannten exekutiven Funktionen findet sich im präfrontalen Cortex sowie in fronto-cortico-striatalen Netzwerken. Hinsichtlich dieser bzw. der zugehörigen monoaminergen Neurotransmittersysteme wird im Falle von ADHS-Patienten eine Dysfunktion angenommen, die die klinische Symptomatik mitbedingt. Gegenüber gesunden Personen sind bei ADHS-Patienten entsprechend unter Belastungsbedingungen Unterschiede hinsichtlich physiologischer Marker wahrscheinlich. Aufgrund der defizitären Selbstregulation von Affekten kann überdies ein erhöhtes subjektives Belastungserleben erwartet werden.

Eine ähnliche Hypothese ist aus dem ADHS-Modell von Herbert C. Quay (1997) ableitbar, das sich auf der Theorie der Angststörungen von Gray (1987) beruft. Gray unterscheidet als wesentliche, primäre physiologische Systeme ein aktivierendes Verhaltenssystem (behavioral approach system; BAS), ein

inhibierendes Verhaltenssystem (behavioral inhibition system; BIS) sowie ein Kampf-Flucht-System. Das BIS koordiniert die Antwort auf Reize, die unbekannt sind oder Bestrafung oder Nichtbelohnung signalisieren (angeborene und erlernte Furchtreize). Werden derartige Signale wahrgenommen, so reagiert das BIS mit einer Erhöhung des nonspezifischen physiologischen Arousals, einer Fokussierung der Aufmerksamkeit auf relevante Umweltreize sowie einer Hemmung des aktuellen Verhaltens. Für ADHS-Patienten nimmt Quay (1997) eine Unterfunktion (Hyporeagibilität) des BIS und somit ein Defizit der Verhaltensinhibition an. Neuroanatomisch ist das BIS im septo-hippocampalen System und dessen Projektionen zum frontalen Cortex lokalisiert. Da es sich um ein zentralnervöses monoaminerg modulierte Verhaltenssystem handelt, lassen sich für eine postulierte Dysfunktion Hypothesen hinsichtlich des physiologischen Arousals bzw. damit assoziierter Parameter ableiten. Konkret ist für den Fall der Wahrnehmung von Stressoren (entweder in Form neuer oder aber angeborener oder gelernter furchtauslösender Stimuli) eine abgeschwächte physiologische Reizantwort zu erwarten.

Mit der Ableitung und Überprüfung dieser theoretischen Annahmen haben sich bisher nur wenige empirische Studien beschäftigt, die zudem fast ausschließlich einzelne physiologische Parameter bei Kindern und Jugendlichen mit ADHS untersuchten, während die psychologische Dimension unberücksichtigt blieb. Ein solches Vorgehen muss angesichts der Komplexität der Stressreaktion und der Vielzahl an ihr beteiligter Parameter als unbefriedigend bewertet werden. Zudem bleibt die Übertragbarkeit der wenigen an Kindern und Jugendlichen gewonnenen Ergebnisse auf Erwachsene mit ADHS unklar. Hinsichtlich physiologischer Indikatoren der HPA-Achse beobachteten einige Autoren eine verminderte Cortisolausschüttung als Reaktion auf die Konfrontation mit Stressoren bei Kindern

mit ADHS (Hong, Shin, Lee, Oh, & Noh, 2003; King, Barkley, & Barrett, 1998) bzw. Abweichungen im diurnalen Rhythmus der Cortisolsekretion (Kaneko, Hoshino, Hashimoto, Okano, & Kumashiro, 1993). Aus methodischer Sicht problematisch ist das Fehlen adäquater Kontrollgruppen wie auch die Diagnosestellung der ADHS unter Heranziehung unterschiedlicher Diagnosekriterien (z.B. nach DSM-III-R) in den einzelnen Studien. Teils wurde ausschließlich anhand von Kurzfragebögen, d.h. unter Verzicht auf strukturierte klinische Interviews, diagnostiziert. Publierte Studien mit erwachsenen ADHS-Patienten zur Funktion und Reagibilität der HPA-Achse liegen bislang nicht vor.

Ähnlich stellt sich die Datenlage hinsichtlich der autonomen Stressreagibilität von ADHS-Patienten dar. Es wurden wiederum vorrangig Kinder und Jugendliche untersucht, wobei die methodischen Probleme der oben genannten Studien hier teilweise ebenfalls zu verzeichnen sind. Überdies wurden in einzelne Untersuchungen auch Kinder einbezogen, die als Medikation der Störung Stimulanzien erhielten, was sicherlich vor dem Hintergrund des stimulierenden Effektes auf den Sympathikotonus als äußerst problematisch einzustufen ist. Als Befund wurde dennoch mehrfach eine verminderte autonome Reaktion auf Stressoren beschrieben (Boyce & Quas, 2001; Hanna, Ornitz, & Hariharan, 1996; Van Lang, Tulen, Kallen, Rosbergen, Dieleman, et al., 2007). Bei erwachsenen Frauen mit ADHS fanden Hermens et al. (2004) ein vermindertes autonomes Arousal unter Ruhebedingungen, erfasst über den Hautwiderstand. In keiner der genannten Studien wurde das subjektive Stresserleben mit erfasst.

Die hier vorliegende Originalarbeit beschreibt die simultane Untersuchung von subjektivem Stresserleben sowie von physiologischen Indikatoren der autonomen sympathischen und parasympathischen Aktivierung und der HPA-Achse an erwachsenen ADHS-Patienten im Vergleich mit gesunden, nach

soziodemographischen Variablen gematchten Kontrollprobanden unter Laborbedingungen. Als zu untersuchende abhängige Variablen wurden die wahrgenommene aktuelle Beanspruchung, der Cortisolspiegel im Speichel, die Herzrate sowie verschiedene Zeit- und Frequenzbereichsparameter der Herzratenvariabilität zu fünf definierten Zeitpunkten des experimentellen Ablaufes erfasst, um so Aussagen über deren Ausprägung im Gruppenvergleich und unter verschiedenen Bedingungen (Ruhe, Stressantizipation, Stress, zwei Erholungsphasen) treffen zu können. Eine weitere, explorative Fragestellung betraf das Ausmaß der Konkordanz bzw. der Enge des statistischen Zusammenhanges dieser Indikatoren unterschiedlicher Ebenen der Stressreaktion. Mit dem Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993) wurde ein etabliertes Paradigma der psychophysiologischen Stressforschung gewählt, innerhalb dessen ein standardisierter psychosozialer Stressor eingesetzt wird. Dieser besteht aus einem simulierten Vorstellungsgespräch und einer Kopfrechenaufgabe, die die Probanden für die Dauer von 10 Minuten vor einem dreiköpfigen Beurteilergremium absolvieren müssen, während gleichzeitig eine angebliche Video- und Audioaufnahme erstellt wird.

Bei der Rekrutierung der Patientenstichprobe kam ein aufwändiges diagnostisches Procedere zur Anwendung, das nach einem zweistufigen Fragebogenscreening allgemeine strukturierte klinische Interviews für DSM-IV (SKID; Wittchen, Zaudig, & Fydrich, 1997) sowie ein spezifisches strukturiertes Interview für ADHS im Erwachsenenalter (Brown, 1996) vorsah. Durch dieses diagnostisch genaue Vorgehen, das sich im Hinblick auf die Störungskriterien streng an das DSM-IV hielt, reduzierte sich die Gruppe der ursprünglichen Interessenten von 109 auf 27 Personen, von denen zum Zeitpunkt der Experimente n=18 Personen zur Teilnahme bereit waren und keines der Ausschlusskriterien erfüllten.

Die Auswertung ergab eine Vergleichbarkeit beider Gruppen hinsichtlich aller abhängigen Variablen während der anfänglichen Ruhemessung (Baseline).

Bezüglich des subjektiven Stresserlebens zeigten sich jedoch Gruppenunterschiede während der folgenden vier Phasen des Laborexperimentes (Stressantizipation; Stress; Erholung 1; Erholung 2). In jeder dieser Phasen gab die Patientenstichprobe ein höheres Ausmaß an empfundenem Stress an. Für die autonomen Maße fanden sich in der MANOVA ein signifikanter Zeit- und Interaktionseffekt (Zeitpunkt x Gruppe), jedoch kein signifikanter Gruppeneffekt. Nachfolgende univariate Analysen erbrachten lediglich einen signifikanten Interaktionseffekt für die Herzrate sowie einen entsprechenden Trend für die LF/HF-Ratio der Herzratenvariabilität.

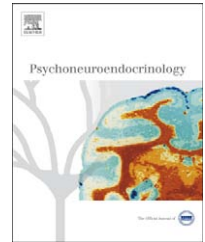
Hinsichtlich letzterer zeigte sich in der ADHS-Gruppe gegenüber der Kontrollgruppe während der Stressphase eine Verschiebung in Richtung des Parasympathikus, während in der anfänglichen Ruhephase wie auch in der zweiten Erholungsphase eine im Vergleich zur Kontrollgruppe stärkere Dominanz des Sympathikus bei den Patienten beobachtet wurde. Die Herzratenaktivität erwies sich in der Stressphase in der ADHS-Gruppe signifikant niedriger als bei den Kontrollprobanden. Kein signifikanter Gruppenunterschied zeigte sich beim Cortisolspiegel, obwohl auch hier ein statistischer Trend zu beobachten war, der auf niedrigere Werte in der Patientengruppe hindeutete.

Zusammenfassend zeigen die Ergebnisse der Studie erstmals signifikante Abweichungen der Stressantwort bei erwachsenen Patienten mit ADHS gegenüber gesunden Kontrollpersonen. Die deutlichsten Unterschiede wurden hinsichtlich der psychologischen Ebene der Stressreaktion beobachtet: Hier schätzten sich die Patienten als signifikant stärker beansprucht ein, ein Befund, der nicht auf die eigentliche Konfrontation mit dem Stressor beschränkt war, sondern sich bereits bei dessen Antizipation sowie nach seiner Beendigung während der Erholungsphasen

zeigte. Überdies fanden sich phasenabhängige Abweichungen weniger physiologischer Maße, die allerdings überwiegend keine statistische Signifikanz erreichten. Die gefundenen Trends lassen jedoch eine Erhebung der physiologischen Maße an einer größeren Stichprobe als vielversprechend erscheinen.

## **2.2. Originalartikel 1**

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# Physiological and psychological stress responses in adults with attention-deficit/hyperactivity disorder (ADHD)

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## Summary

According to self-report and unsystematic observational data adult patients with attention-deficit/hyperactivity disorder suffer from increased vulnerability to daily life stressors. The present study examined psychological and physiological stress responses in adult ADHD subjects in comparison to healthy controls under laboratory conditions. Thirty-six subjects (18 patients with DSM-IV ADHD diagnosis, 18 sex- and age-matched healthy controls) underwent the Trier Social Stress Test (TSST; Kirschbaum, C., Pirke, K.-M., Hellhammer, D.H., 1993). The “Trier Social Stress Test”—a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology* 28, 76–81), a standardized psychosocial stress protocol which contains a stress anticipation phase and a stress phase with a free speech assignment and subsequent performance of a mental arithmetic. Physiological stress measures were salivary cortisol as an indicator of the HPA axis, heart rate (HR), and time- and frequency-domain heart rate variability (HRV) parameters. Subjective stress experience was measured via self-report repeatedly throughout the experimental session. In line with previous theoretical and empirical work in the field of childhood ADHD, it was hypothesized that the ADHD and control group would exhibit comparable baseline levels in all dependent variables. For ADHD subjects, we expected attenuated responses of the physiological parameters during anticipation and presence of the standardized stressor, but elevated subjective stress ratings. Hypotheses were confirmed for the baseline condition. Consistent with our assumptions in regard to the psychological stress response, the ADHD group experienced significantly greater subjective stress. The results for the physiological variables were mixed.

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While ADHD subjects revealed an attenuated HR during the stress phase, no significant group differences were found for the other parameters, although a trend was observed for both the low frequency/high frequency (LF/HF) ratio of the HRV power spectral analysis and salivary cortisol (the latter possibly indicating generally lower cortisol levels in ADHD subjects). In summary, the present findings are the first to demonstrate a significant alteration of a specific physiological stress measure (HR) and, more clearly, of psychological aspects of the stress response in adults suffering from ADHD. In regard to the physiological stress response, it is recommended that future studies employ larger sample sizes and a more comprehensive range of physiological stress parameters. Additionally, the issue of transferability of laboratory results to real life stressors needs to be addressed.

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## 1. Introduction

Although attention-deficit/hyperactivity disorder (ADHD) was initially conceptualized as a disorder of childhood and adolescence, it is acknowledged today that for many patients, the syndrome persists into adulthood. A recent large-scale epidemiological study carried out in 10 countries reported an average prevalence estimate for DSM-IV adult ADHD of 3.4% (range 1.2–7.3%) (Fayyad et al., 2007); other authors found prevalence rates of current adult ADHD of 2.9% (Faraone and Biederman, 2005) and 4.4% (Kessler et al., 2006) for the United States. As ADHD patients often suffer from serious educational, occupational and interpersonal role impairments, and negative consequences in various areas of their lives (see Weiss and Hechtman, 1993; Barkley, 1996; Wilens et al., 1998; Mannuzza and Klein, 2000) an improved understanding of the disorder's underlying mechanisms is of great importance, particularly as it may facilitate advancements in therapeutic intervention.

The three main symptom clusters of the disorder are inattention, hyperactivity, and impulsivity (American Psychiatric Association, 1994). The symptoms must emerge before the age of 7 years and cause significant impairments in more than one setting. The DSM-IV subdivides ADHD into a predominantly inattentive, a predominantly hyperactive-impulsive, and a combined diagnostic subtype. According to several theorists and researchers, poor behavioral or response inhibition is the central characteristic of ADHD (Schachar et al., 1993; Barkley, 1997a; Quay, 1997), and vast amount of supporting empirical evidence has been reported (Barkley, 1997b; Quay, 1997). In reference to Gray's (1987) theory of anxiety disorders, Quay (1988, 1997) postulated an underreactive behavioral inhibition system (BIS) in individuals with ADHD symptoms. The BIS is monoaminergically mediated and activated by conditioned stimuli for punishment, nonreward and novelty, resulting in response inhibition, an enhanced focusing of attention to relevant environmental cues, and an increase in nonspecific arousal which leads to an elevated level of cortisol (Ryan, 1998) and heightened autonomic arousal (Rogeness et al., 1990). A potential dysfunction of the BIS in ADHD patients should thus be measurable not only via behavioral observations but also by examination of various physiological indicators of the stress response. In fact, a number of studies on children with ADHD reported abnormalities in function and reactivity of the hypothalamic–pituitary–adrenal (HPA) axis. Kaneko

et al. (1993) found dysfunctions in diurnal cortisol release in ADHD children, compared to autistic children and healthy adult controls, as well as nonsuppression in the dexamethasone suppression test (DST) in 46.7% of the ADHD subjects. Children with ADHD who retained their diagnosis over 2 years showed blunted cortisol responses to mental stressors compared to children with a more transient form of the disorder (King et al., 1998). Kariyawasam et al. (2002) observed significantly reduced single-point salivary cortisol levels in children with ADHD and comorbid oppositional-defiant disorder (ODD), compared to healthy controls of similar age. In seeming contradiction to these results, Snoek et al. (2004) found similar cortisol levels in ADHD children and normal controls not only under baseline, but also under stressful conditions. However, most children in the ADHD group were on stimulant (methylphenidate) medication which may have altered the cortisol response (Kariyawasam et al., 2002).

Hong et al. (2003) found an association between HPA axis underreactivity and impulsivity in a sample of ADHD boys after a computerized Continuous Performance Test (CPT), although it should be noted that ADHD diagnoses were not made via structured clinical interviews in the study. In a survey by Schulz et al. (1997), the hypothesized inverse relationship between basal plasma cortisol levels and aggression in prepubertal boys with DSM-III-R ADHD was not confirmed. The authors did not test possible associations between cortisol and separate ADHD symptom clusters (inattention, impulsivity). Also, since no healthy control subjects were included in the study, it is unclear whether ADHD boys, as a group, showed diminished basal cortisol levels.

While all these studies examined ADHD children, so far no investigations have been conducted on HPA axis function or reactivity in adults with ADHD. Drawing on the results of King et al. (1998), it can be assumed that adult subjects with disorder persistence since childhood display an attenuated cortisol response to mental stress when compared to healthy controls.

With regard to autonomic arousal, several studies indicated abnormal patterns in children with ADHD symptoms. Typically, skin conductance (SCL), blood pressure (BP), HRV or HR levels were measured and comparisons drawn between children with different psychopathology or between ADHD children and healthy controls. Boyce and Quas (2001) found reduced autonomic arousal in the

sympathetic and parasympathetic branch of the autonomic nervous system (ANS) in children with externalizing problems and attention deficits when responding to standard psychological stressors. In a study examining epinephrine excretion, an endocrine marker of the sympathetic nervous system, Hanna et al. (1996) discovered significantly (at least 40%) lower urinary epinephrine levels in response to a standardized intelligence test in ADHD boys than in normal controls. Electrodermal activity, which is an indicator of sympathetic nervous activity, was consistently attenuated in ADHD subjects compared to normal controls in a number of studies (Shibagaki et al., 1993; Zahn and Kruesi, 1993; Mangina et al., 2000; Beauchaine et al., 2001; O'Connell et al., 2004). In contrast, Van Lang et al. (2007) found comparable SCL, but lower HR reactivity to a stress task in ADHD children than in children with anxiety disorders. No group of normal controls was included in the study. Since HR levels are influenced by both sympathetic and parasympathetic activity, while SCL is determined by sympathetic modulation alone, the authors hypothesized a stronger parasympathetic than sympathetic activation during stress in children with ADHD than in children with anxiety disorders. However, no exclusively parasympathetic parameter was included in the study design. It is noteworthy that the expectation of an attenuated HR stress response in ADHD children is in line with Lacey (1967) and Lacey and Lacey (1970, 1974), whose theoretical and empirical work relates changes in cardiovascular function with different modes of information processing. The authors found sensory intake of external stimuli to be associated with HR deceleration, whereas environmental rejection, a process of filtering out distracting stimuli and selectively focusing relevant cues to enhance cognitive performance, was related to HR acceleration. Changes in cardiovascular function may facilitate or impair cortical information processing. It seems plausible to expect less pronounced HR increases during psychosocial and mental stress in ADHD patients with symptoms of inattentiveness than in healthy individuals.

HRV is increasingly being used as a noninvasive tool to gain detailed insight into the balance between the sympathetic and the parasympathetic branch or division of the ANS. This is relevant as there is evidence indicating that this balance may be affected by various psychiatric conditions as well as by the presence of stressful stimuli (Berntson and Cacioppo, 2004). Behaviorally inhibited children have repeatedly been shown to be under enhanced sympathetic influence when exposed to stressful tasks (Kagan et al., 1987, 1988). Börger et al. (1999) found a significantly greater 0.10-Hz component of the HRV in ADHD children than in healthy children during a CPT, designed to measure sustained attention. The 0.10-Hz component is parasympathetically determined and considered to be a psychophysiological index of effort allocation. In another study, preschool children with ADHD and ODD exhibited comparable parasympathetically influenced cardiac activity, but attenuated sympathetically influenced cardiac activity in comparison to normal controls during baseline conditions and a reward task (Crowell et al., 2006). Although the cited results on stress reactivity in ADHD patients may seem contradictory, it must be taken into account that neuroendocrine stress response patterns are known to be influenced by type of stressor (stimulus-response-specificity) and con-

textual factors of the experiment (Garralda et al., 1991; Zahn and Kruesi, 1993; Biondi and Picardi, 1999; Berntson and Cacioppo, 2004). Berntson and Cacioppo (2004) pointed out that laboratory tasks involving active cognitive processing and response, such as mental arithmetics or reaction time, lead to parasympathetic withdrawal and sympathetic activation, whereas more passive cognitive tasks (e.g. focused attention, response inhibition) are associated with either parasympathetic activation or coactivation of both ANS branches. In an extensive meta-analysis covering 208 original studies on HPA axis response to acute stressors in laboratory settings, Dickerson and Kemeny (2004) found public speaking/cognitive task combinations to elicit significantly greater cortisol changes than all other laboratory task types (cognitive tasks, public speaking/verbal interaction tasks, emotion induction procedures, or noise exposure). The empirical evidence supported the authors' social self-preservation theory insofar as performance tasks characterized by social-evaluative threat and/or uncontrollability reliably elicited significant cortisol increases. Social-evaluative threat is present when a core aspect of the self-identity (e.g. intelligence, competence) is or could be negatively judged by other persons. Uncontrollability occurs in situations of forced failure where participants cannot succeed, despite their best efforts. The largest cortisol effects were found for performance tasks that contained both elements. It can be concluded that implementing an appropriate stressor is a crucial factor in laboratory stress experiments. An established standardized laboratory stress paradigm that includes both social-evaluative threat and uncontrollability, but has not yet been employed in adult ADHD patients, is the Trier Social Stress Test (TSST; Kirschbaum et al., 1993).

So far, few studies have investigated autonomic arousal in adults with ADHD. Hermens et al. (2004) reported reduced SCL in ADHD adults compared to normal controls under resting conditions. A detailed data analysis showed, however, that only ADHD females, but not males, were autonomically hypo-aroused (although males, but not females, showed enhanced global theta EEG activity). In a pilot study, Schubiner et al. (2006) explored ANS function in ADHD adults who were receiving stimulant medication. Compared with a normal control group, ADHD patients showed significantly higher resting HRs. However, since stimulants may increase HR, and the study did not include medication-free ADHD adults, the results cannot be easily interpreted. To date, not a single study examining HRV in ADHD adults in order to determinate the relative contributions of the two ANS branches under various conditions has been conducted.

To our knowledge, the psychological dimension of the stress response in ADHD adults has also not yet been investigated systematically. Nevertheless, it seems noteworthy that many authors mention an elevation in perceived or subjective stress in adult patients with ADHD, compared to healthy subjects (e.g. Krause et al., 1998; Resnick, 2000; Kordon and Kahl, 2004). Stress intolerance is even postulated as an additional characteristic of the disorder in the Wender Utah criteria for adult ADHD (Wender, 1995). Moreover, cognitive-behavioral treatments for adult patients with ADHD often include stress management techniques (e.g. Hesslinger et al., 2002). However, it is still

uncertain whether the subjective stress experience in ADHD adults is significantly different from healthy subjects. Knowledge of associations between psychological and physiological stress measures in ADHD is also lacking.

The aim of the present study was to investigate physiological aspects of the stress response (salivary cortisol, HR, HRV) as well as the subjective stress experience in adult ADHD patients compared to healthy controls under laboratory conditions. In accordance with the majority of the cited theoretical and empirical work, it was hypothesized that ADHD adults and healthy controls would show comparable baseline levels of HPA and ANS activity, as well as similar subjective stress ratings. In response to a laboratory psychosocial stressor, however, an attenuated HPA and HR reaction and an elevated subjective stress experience were expected in the patient group. For HRV, significant differences between the ADHD and the control group were proposed regarding the relative influence of the two divisions of the ANS.

## 2. Method

### 2.1. Design of study

To test the hypotheses that ADHD patients may exhibit altered reactivity in physiological and psychological stress parameters, a quasi-experimental research design was deemed appropriate, with a sample consisting of a clinical group of adult ADHD patients and a control group of healthy adults. Subjects were matched in regard to age, gender, and educational background.

### 2.2. Subjects

Eighteen adult subjects (10 females, 8 males) who met the DSM-IV diagnosis of ADHD and ranged in age from 20 to 57 years and 18 matched healthy controls completed the laboratory session. Mean age of the whole sample was 35.97 years (*S.D.* = 10.08; mean age ADHD group = 36.00, *S.D.* = 10.62; mean age control group = 35.94, *S.D.* = 11.30). In regard to DSM-IV ADHD diagnostic subtypes, 7 subjects fulfilled criteria for the predominantly inattentive subtype, 1 subject fulfilled criteria for the predominantly hyperactive/impulsive subtype, and 10 subjects fulfilled criteria for the combined subtype.

Subjects were recruited through articles in local newspapers and the Internet. In a stepwise diagnostic process, potential ADHD subjects first completed a 30-min structured telephone screening interview, administered by a graduate student in clinical psychology (first author) and four trained undergraduate students majoring in psychology. For assessment of current ADHD symptoms, we included German versions of the six-item screener of the World Health Organization Adult ADHD Self-Report Scale (ASRS-v1.1) (Kessler et al., 2005), the Brown Attention-Deficit Disorder Rating Scale for Adults (Brown, 1996; Ruhl et al., *in press*) and the Attention Deficit Hyperactivity Disorder—Self Report Scale (ADHD-SR, Rösler et al., 2004, 2006), which contains the 18 DSM-IV symptoms of inattention, hyperactivity, and impulsivity. Childhood ADHD symptoms were retrospectively rated through the short form of the Wender

Utah Rating Scale (Ward et al., 1993; German version by Retz-Junginger et al., 2002). In cases with positive screening results, an appointment was made in order to administrate an extensive semi-structured clinical interview for adult ADHD (Brown, 1996; Ruhl et al., *in press*). Comorbid DSM-IV disorders were diagnosed through the Structured Clinical Interview for DSM-IV (SCID). All clinical interviews were audio-taped. To assess inter-rater reliability of symptom assessments via interview, a random sample of 12 interviews was rated independently by two trained research psychologists. Pearson correlations were calculated for inattention and hyperactivity/impulsivity symptom clusters, for both current and retrospective childhood assessment. Results showed high levels of inter-rater reliability (current inattention symptoms:  $r = 0.95$ ,  $p < 0.001$ ; current hyperactivity/impulsivity symptoms:  $r = 0.97$ ,  $p < 0.001$ ; childhood inattention symptoms:  $r = 0.96$ ,  $p < 0.001$ ; childhood hyperactivity/impulsivity symptoms:  $r = 0.95$ ,  $p < 0.001$ ).

To be included in the study, subjects in the ADHD group had to have both a current and a retrospective childhood diagnosis of DSM-IV ADHD. Exclusion criteria for the patient group were any neurological disorder, a lifetime history of psychotic symptoms, a current comorbid diagnosis of post-traumatic stress disorder (PTSD), regular or acute medication (including stimulants and oral contraceptives), an acute or chronic somatic disorder, and current psychotherapy. Current comorbid diagnoses of DSM-IV axis I disorders other than PTSD were allowed in the patient group, and single or multiple comorbid conditions were found in five patients (depression ( $n = 2$ ), panic disorder with agoraphobia ( $n = 1$ ), agoraphobia without panic disorder ( $n = 1$ ), social phobia ( $n = 1$ ), specific phobia ( $n = 3$ ), obsessive-compulsive disorder ( $n = 1$ )). Subjects in the control group did not have any current psychiatric diagnoses.

All subjects gave written informed consent prior to entering the study. Since the salivary cortisol response to a laboratory psychosocial stressor has been shown to be significantly lower in women during the follicular phase of the menstrual cycle as compared to men (Kirschbaum et al., 1999), laboratory sessions for female subjects were scheduled to be conducted during the luteal phase. Subjects had to abstain from alcoholic beverages, caffeine and physical exercise at least 12 h and from smoking, meals, juices and soft drinks at least 2 h before the test.

### 2.3. Experimental protocol

All subjects underwent the TSST (Kirschbaum et al., 1993), a procedure developed to induce moderate psychosocial stress under standardized laboratory conditions. TSST sessions lasted approximately 70 min, consisting of a 15 min baseline phase (phase 1), a 10 min anticipation phase (phase 2), a 10 min stress induction phase (phase 3), and two 15 min recovery phases (phases 4 and 5). The stress task contained a simulated job interview (5 min) and a mental arithmetic task (5 min) in front of a committee. Upon arrival at the laboratory, subjects were equipped with a chest belt and wrist receiver of the ECG wireless signal transmission device for continuous measurement of HR throughout the session. After each phase of the TSST (i.e. 15, 25, 35, 50, and 65 min after arrival at the laboratory), subjects were

given a questionnaire assessing the subjective stress experience, and saliva samples were taken.

## 2.4. Dependent variables

### 2.4.1. Subjective stress experience

Current subjective stress experience was measured five times during the laboratory session. At each point, subjects were given the German *Kurzfragebogen zur aktuellen Beanspruchung* (short questionnaire of current stress; KAB; Müller and Basler, 1993). The questionnaire is highly sensitive to short-term or situational changes in subjective stress experience. It is composed of six items of paired positive and negative adjectives, referring to perceptions of current stress and strain or relaxation (e.g. “tense–calm”, “uneasy–relaxed”). Subjects give their ratings on a six-point scale. The range for total item means is 1–6, with higher values indicating an increased subjective stress experience. Because of the composition of the questionnaire, it is usually not possible to remember the previous ratings, thus preventing carryover effects.

### 2.4.2. Heart rate measurement

Beat-to-beat HR was monitored continuously throughout the session by a wireless signal transmission device with electrocardiogram (ECG) precision (Polar S810i, Polar Electro GmbH, Germany) and a sampling rate of 1000 Hz. The device permits automatic storage of consecutive inter-beat (RR) intervals; inaccuracy of the RR interval measurements is less than 3 ms (Ruha et al., 1997). A separate data file was saved for each of the five phases of the laboratory session.

Polar Precision Performance Software 4.03.040 (Polar Electro Oy, Kempele, Finland) was used to process the collected data. The RR interval series were edited by careful examination and elimination of measurement artifacts (defined as a difference between consecutive RR intervals of >500 ms or >30%), which were replaced with the interpolation of the five previous RR intervals. In regard to HR, means (beats per minute (bpm)) and S.D. were calculated for every TSST phase. HRV analysis was carried out using the advanced HRV Analysis 1.1 software, developed by The Biomedical Signal Analysis Group, University of Kuopio, Finland (Niskanen et al., 2004). For this purpose, the RR time series had to be converted into ASCII text files and subsequently imported into the HRV Analysis software. Time-domain measures, which are calculated from the raw RR interval series, included the standard deviation of all normal RR intervals (SDNN, describing the overall variation of RR intervals and interpreted as an estimate of overall HRV), and the root mean square of the differences between successive RR intervals (RMSSD, for estimation of short-term components of HRV). Nonparametric frequency-domain methods based on fast Fourier transformations (FFT) were employed for calculation of power spectral density (PSD) of the RR series. PSD delivers insight in the total power (variance) distribution as a function of frequency (Task Force of The European Society of Cardiology and The North American Society of Pacing and Electrophysiology, 1996). Frequency-domain analysis also provides more detailed information on the relative power of underlying intrinsic

rhythms involved in the regulation of HR, which are represented in different frequency bands. The high frequency (HF) band (0.15–0.4 Hz) is known to represent parasympathetic activity; in contrast, the low frequency (LF) band (0.04–0.15 Hz) is more difficult to interpret. While some authors claim it to be determined by both the sympathetic and parasympathetic division of the ANS, others have stated that it mirrors solely sympathetic activity, especially when expressed in normalized units (nu) (Task Force, 1996), which indicate the relative power of both frequency bands in proportion to the total power minus the very low frequency (VLF) band (0.003–0.04 Hz). As the LF/HF ratio is interpreted as an index of sympathicovagal balance, an increase reflects a dominance of sympathetic over parasympathetic activity, and vice versa. For the present study, LF and HF bands expressed in nu were calculated. In addition to that, the LF/HF ratio was determined.

Since the RR interval series is an irregularly time-sampled signal, it was interpolated at a sampling rate of 4 Hz before computation of the spectral analysis. Data were detrended by use of the smoothness priors method (Tarvainen et al., 2002). The HRV Analysis 1.1 software employs the Welch's periodogram method in FFT spectral analysis.

### 2.4.3. Salivary cortisol

Salivary free cortisol has been shown to be a reliable and valid measure of the biologically active plasma unbound cortisol, with correlations of  $r \geq 0.90$  (Kirschbaum and Hellhammer, 1989; Lac, 2001). Five saliva samples were collected from each participant throughout the laboratory session (see above) using the “Salivette” device (Sarstedt, Nümbrecht, Germany), which consists of a cotton swab in a capped plastic tube. Subjects were instructed to chew the cotton swab for 1 min and to put the saturated swab into the plastic tube, which was stored at  $-20^\circ\text{C}$  until biochemical analysis. After thawing, samples were centrifuged at 2700 rpm for 5 min. Salivary free cortisol levels were measured by use of a radioimmunoassay (RIA) with a scintillation proximity assay (SPA; Amersham Biosciences Europe, Freiburg, Germany). The lower detection limit of the assay is 150 pg/ml. Inter-assay and intra-assay coefficients of variance were <5%. Test–retest reliability of the assay was assessed on 25 randomly selected saliva samples, using Pearson correlation coefficients ( $r = 0.98$ , d.f. = 24,  $p \leq 0.001$ ).

## 2.5. Data analyses

Possible baseline differences between the two groups in regard to the physiological parameters (ANS measures, cortisol) were explored using independent *t*-tests. Baseline subjective stress ratings were compared with the Mann–Whitney test. For a global analysis of possible between- and within-subjects effects in the psychological stress parameters a rank-based method for factorial designs was applied with the Statistical Analysis System for Windows MIXED procedure (SAS, version 9), using the macro F1-LD-F1 program (provided by Prof. Brunner, Department of Medical Statistics, Georg-August University of Göttingen; [www.ams.med.uni-goettingen.de/de/sof/ld/F1\\_LD\\_F1.SAS](http://www.ams.med.uni-goettingen.de/de/sof/ld/F1_LD_F1.SAS); Brunner



and Munzel, 2002; Brunner et al., 2002). This specific macro allows for the nonparametric analysis of longitudinal ordinal data. It was developed on the basis of the unified theory for rank statistics by Brunner and co-workers (e.g. Akritas and Brunner, 1997) and provides a more appropriate alternative to the common, but problematic use of parametric methods for ordinal data (Shah and Madden, 2004). In our design, group was used as a between-subjects factor and time as a within-subjects factor. Following the significant global test, separate Mann–Whitney tests were computed for every time point in order to test in detail for possible group differences.

A repeated-measures MANOVA with time (TSST phase) as within-subjects factor and group (ADHD vs. control) as between-subjects factor was calculated for ANS parameters. For salivary cortisol, a two-way mixed-design ANOVA was performed. Greenhouse–Geisser corrections of degrees of freedom were used when the assumption of sphericity was violated. In cases of significant main (time) or interaction (time  $\times$  group) effects, separate univariate ANOVAs were conducted for each time point in order to determine group differences in stress response patterns. Also, within-subjects contrast tests were applied when appropriate. For cortisol, an additional area under the response curve analysis was computed following the trapezoid rule with reference to zero (“area under the curve with respect to ground”, AUCg; Pruessner et al., 2003). The results of this analysis are interpreted as indicators of the total cortisol output during the experimental session.

All data were tested for homogeneity of variance and normal distribution before statistical analysis. Raw cortisol data for each experimental phase was converted by logarithmic transformation in order to correct for non-normal distributions (however, for the purpose of clarity, Figure 3 in Section 3 shows the raw cortisol data).

For further exploration of the relationships between psychological and physiological stress variables, Pearson product–moment correlations between subjective stress experience, HR, and cortisol were computed separately for the ADHD and the control group for each TSST phase. For all tests, the level of significance was set at  $p \leq 0.05$ , two-tailed. All parametric analyses were run on SPSS version 12.0 for Windows.

### 3. Results

#### 3.1. Pre-stress baselines

Means and S.D.s for age as well as baseline levels for physiological and self-report data for both study groups are presented in Table 1. There were no significant group differences in regard to mean age and pre-TSST subjective stress experience, ANS parameters, or cortisol levels.

#### 3.2. Stress responses

##### 3.2.1. Subjective stress experience

The nonparametric analysis with the F1\_LD\_F1 macro with group as between-subjects factor and time as within-subjects factor revealed a significant main effect of time, indicating significant increases in subjective stress ratings in response to the anticipation and stress phases and significant declines in perceived stress during the recovery phases (post-stress 1 and 2) ( $\chi^2(3.32) = 52.65$ ,  $p < 0.001$ ). Also, a significant main effect of group ( $\chi^2(1) = 14.7$ ,  $p < 0.001$ ) and a significant time  $\times$  group interaction ( $\chi^2(3.32) = 2.78$ ,  $p = 0.03$ ) were revealed (see Figure 1). Mann–Whitney tests subsequently showed significant group differences for each of the four experimental phases after baseline (anticipation:  $U = 91.50$ ,  $p = 0.02$ ,  $r = 0.37$ ; stress:  $U = 41.00$ ,  $p \leq 0.001$ ,  $r = 0.64$ ; post-stress 1:  $U = 89.50$ ,  $p = 0.02$ ,  $r = 0.38$ ; post-stress 2:  $U = 72.50$ ,  $p = 0.004$ ,  $r = 0.47$ ), all indicating elevated subjective stress levels in the ADHD as compared to the control group.

##### 3.2.2. ANS measures

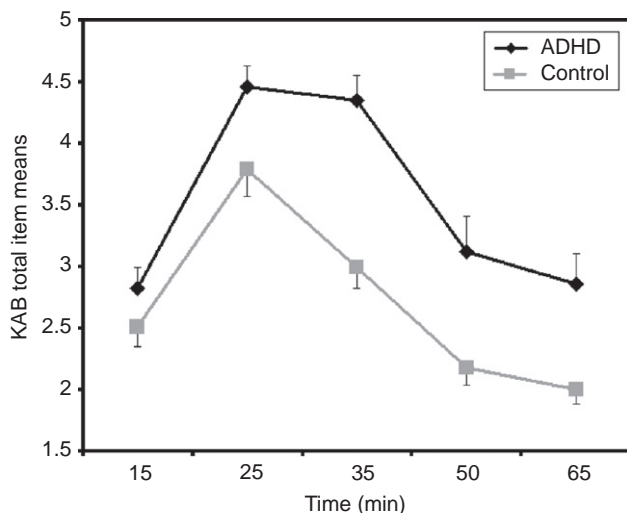
A repeated-measures MANOVA for ANS parameters (HR, SDNN, RMSSD, LF nu, HF nu, LF/HF ratio) run over all five phases of the experimental session revealed a significant main effect of time ( $F(25, 10) = 33.82$ ,  $p < 0.001$ ,  $\eta^2 = 0.98$ ) and a significant time  $\times$  group interaction ( $F(25, 10) = 3.99$ ,  $p = 0.01$ ,  $\eta^2 = 0.91$ ), whereas no significant main effect of group was found.

Subsequent univariate ANOVAs (see Figure 2a–f) yielded significant time effects for all ANS measures (HR:  $F(2.17$ ,

**Table 1** Baseline levels of age and physiological (mean  $\pm$  S.D.) and psychological (median, 25th/75th percentile) variables in the ADHD and control group.

Variable	ADHD ( $n = 18$ )	Control ( $n = 18$ )	d.f.	Test statistic	$p$
Age	36.00 $\pm$ 10.62	35.94 $\pm$ 11.30	34	$t = 0.02$	0.99
Cortisol (ng/ml)	4.69 $\pm$ 2.44	6.09 $\pm$ 3.28	34	$t = 1.46$	0.16
HR (bpm)	74.22 $\pm$ 10.15	72.89 $\pm$ 13.81	34	$t = 0.33$	0.74
SDNN (s)	0.07 $\pm$ 0.03	0.07 $\pm$ 0.02	34	$t = -0.44$	0.66
RMSSD (ms)	36.85 $\pm$ 19.61	35.70 $\pm$ 14.29	34	$t = 0.20$	0.84
LF nu	69.23 $\pm$ 18.24	68.77 $\pm$ 8.59	24.20	$t = 0.10$	0.92
HF nu	30.78 $\pm$ 18.24	31.23 $\pm$ 8.59	24.20	$t = 0.10$	0.92
LF/HF ratio	4.30 $\pm$ 3.92	2.51 $\pm$ 1.26	20.46	$t = 1.32$	0.08
KAB	2.83 (2.13–3.42)	2.50 (1.96–3.04)	–	$U = 126$	0.27

HR: heart rate; SDNN: standard deviation of all normal RR intervals; RMSSD: root mean square of differences between successive RR intervals; LF nu: low frequency band, expressed in normalized units; HF nu: high frequency band, expressed in normalized units; KAB: Kurzfragebogen zur aktuellen Beanspruchung (short questionnaire of current stress).



**Figure 1** Subjective stress ratings during baseline (15 min), anticipation phase (25 min), stress phase (35 min), post-stress 1 (50 min), and post-stress 2 phase (65 min) of the test session in the ADHD and control group (means and S.E.M.).

73.71) = 133.80,  $p < 0.001$ ,  $\eta^2 = 0.80$ ; SDNN:  $F(3.09, 105.17) = 8.28$ ,  $p < 0.001$ ,  $\eta^2 = 0.20$ ; RMSSD:  $F(1.60, 54.29) = 7.58$ ,  $p = 0.003$ ,  $\eta^2 = 0.18$ ; LF nu:  $F(4, 136) = 13.75$ ,  $p < 0.001$ ,  $\eta^2 = 0.29$ ; HF nu:  $F(4, 136) = 13.75$ ,  $p < 0.001$ ,  $\eta^2 = 0.29$ ; LF/HF ratio:  $F(1.86, 63.25) = 13.44$ ,  $p < 0.001$ ,  $\eta^2 = 0.28$ ). A significant interaction effect was found for HR ( $F(2.17, 73.71) = 8.90$ ,  $p < 0.001$ ,  $\eta^2 = 0.21$ ), but not for the other ANS parameters; however, a trend was observed for the LF/HF ratio ( $F(1.86, 63.25) = 2.38$ ,  $p = 0.10$ ,  $\eta^2 = 0.07$ ).

Regarding the significant time  $\times$  group interaction found for HR, independent  $t$ -tests conducted for every TSST phase were nonsignificant for anticipation, post-stress 1, and post-stress 2, but HR was significantly higher in the control group during the stress phase ( $t(34) = -2.47$ ,  $p = 0.02$ ,  $d = 0.84$ ). Within-subject contrasts showed a significantly larger increase between anticipation and stress ( $F(1, 34) = 10.97$ ,  $p = 0.002$ ,  $\eta^2 = 0.24$ ) and a significantly larger decline from stress to post-stress 1 ( $F(1, 34) = 14.35$ ,  $p = 0.001$ ,  $\eta^2 = 0.30$ ) for the control group.

Dependent  $t$ -tests were applied for further analysis of the main effects of time found in the other ANS measures. The results are shown in Table 2.

### 3.2.3. Salivary cortisol

Results of the two-way mixed-design ANOVA showed a significant main effect of time ( $F(1.62, 55.03) = 15.44$ ,  $p < 0.001$ ,  $\eta^2 = 0.31$ ), implying a significant activation of the

HPA axis in response to the TSST, but no significant main effect of group, although a trend towards lower cortisol levels was found for ADHD subjects ( $F(1, 34) = 2.53$ ,  $p = 0.10$ ,  $\eta^2 = 0.07$ ) (see Figure 3). The group comparison in regard to AUCg yielded a similar outcome ( $t(34) = 1.53$ ,  $p = 0.13$ ). The data did not reveal a significant time  $\times$  group interaction. Additional dependent  $t$ -tests conducted for further analysis of the main time effect found significant differences between anticipation and stress ( $t(35) = -4.76$ ,  $p < 0.001$ ), between stress and post-stress 1 ( $t(35) = -3.25$ ,  $p = 0.003$ ), and between post-stress 1 and post-stress 2 ( $t(35) = 7.43$ ,  $p < 0.001$ ).

## 3.3. Associations between selected physiological and psychological stress measures

### 3.3.1. HR and subjective stress experience

For both groups Pearson's correlations were calculated between HR and subjective stress ratings for each phase. Whereas correlation coefficients at baseline were positive and significant for ADHD ( $r = 0.57$ ,  $p = 0.02$ ) and control subjects ( $r = 0.49$ ,  $p = 0.04$ ), group differences were revealed for the anticipation phase: while the ADHD group exhibited only a small nonsignificant correlation, the same correlation was significant and positive in control subjects ( $r = 0.52$ ,  $p = 0.03$ ). Correlations were statistically insignificant for both groups during the stress phase and the first post-stress phase. Finally, the ADHD group showed a significant positive correlation for the second post-stress phase ( $r = 0.57$ ,  $p = 0.01$ ). In contrast, the correlation in the control group was approximately zero.

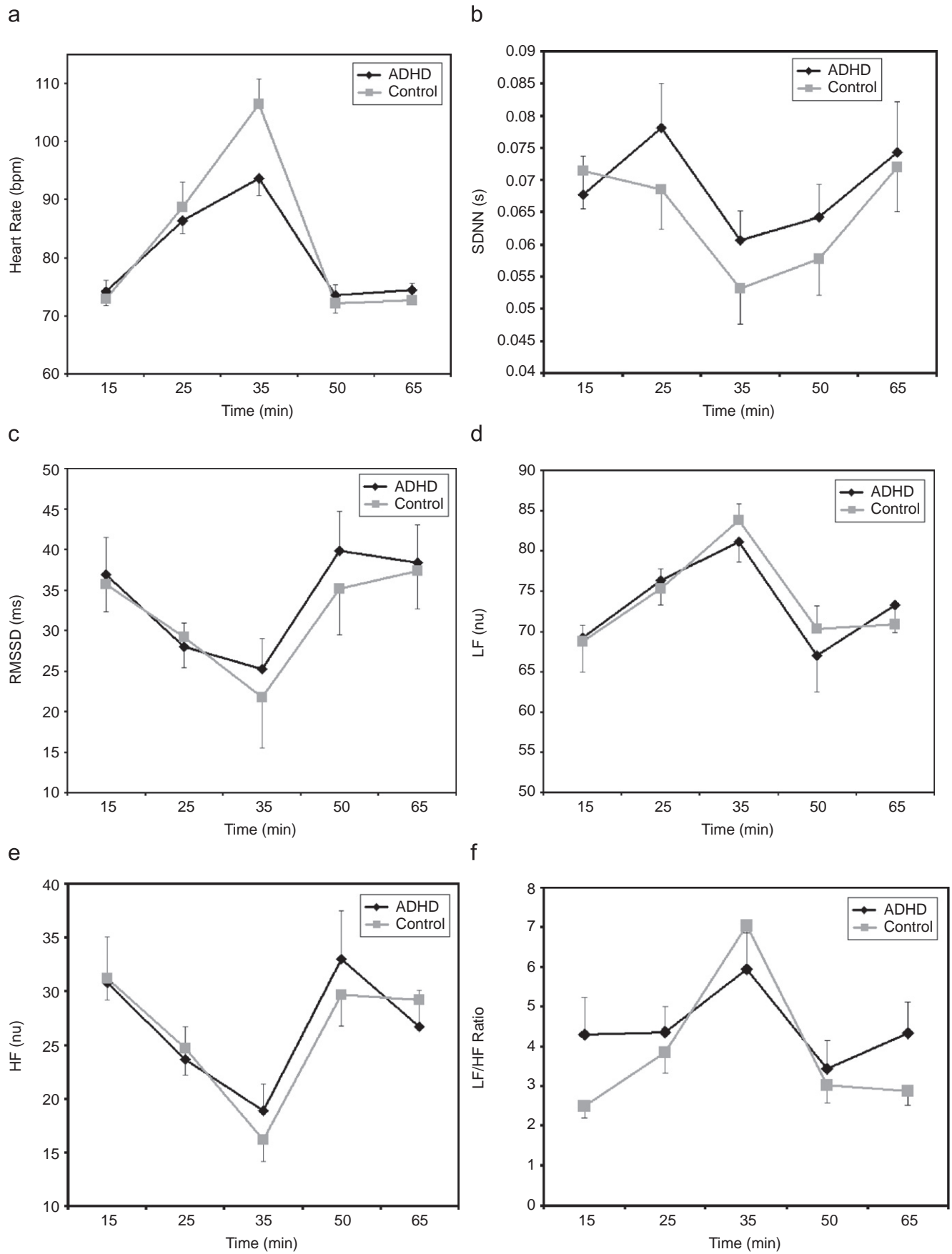
### 3.3.2. Salivary cortisol and subjective stress experience

Since the latency of the HPA axis response had to be taken into account (Kirschbaum and Hellhammer, 1999; Scheidt et al., 2000), correlation coefficients were calculated between subjective stress values of one TSST phase and cortisol levels of the following experimental phase (e.g. subjective stress during baseline and cortisol during anticipation phase). No significant correlations were found in the ADHD or control group for any experimental phase.

### 3.3.3. HR and salivary cortisol

For the ANS parameter HR and the endocrine parameter salivary cortisol correlation coefficients were again calculated using the HR and cortisol data of successive experimental phases (see above). At baseline, correlations in both groups were nonsignificant. Noteworthy is that the ADHD group shows negative, although statistically insignificant associations for the anticipation, stress, and post-stress phases, while correlations in the control group are positive

**Figure 2** (a) Heart rate (beats per minute) during baseline (15 min), anticipation phase (25 min), stress phase (35 min), post-stress 1 (50 min), and post-stress 2 phase (65 min) in the ADHD and control group (means and S.E.M.). (b) Standard deviation of all normal RR intervals (SDNN) during the laboratory session in the ADHD and control group (means and S.E.M.). (c) Root mean square of differences between successive RR intervals (RMSSD) during the laboratory session in the ADHD and control group (means and S.E.M.). (d) Changes in the low frequency band (expressed in normalized units; LF nu) during the laboratory session in the ADHD and control group (means and S.E.M.). (e) Changes in the high frequency band (expressed in normalized units; HF nu) during the laboratory session in the ADHD and control group (means and S.E.M.). (f) Ratio of the low frequency and the high frequency band (expressed in normalized units; LF/HF ratio) during the laboratory session in the ADHD and control group (means and S.E.M.).



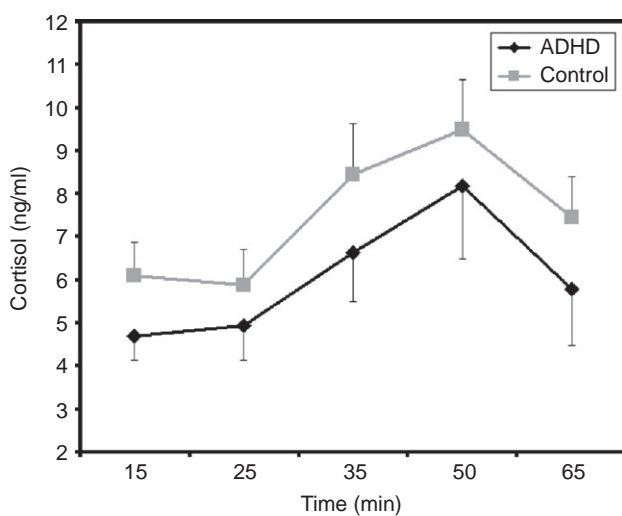
**Table 2** Results (*p*-values) of post hoc analyses of the main effect of time for heart rate variability parameters.

Variable	Baseline–anticipation	Anticipation–stress	Stress–post-stress 1	Post-stress 1–post-stress 2
SDNN	0.22	<0.001**	0.32	<0.001**
RMSSD	0.001**	0.17	0.008*	0.83
LF nu	0.002*	0.001**	<0.001**	0.09
HF nu	0.002*	0.001**	<0.001**	0.09
LF/HF ratio	0.15	<0.001**	<0.001**	0.24

SDNN: standard deviation of all normal RR intervals; RMSSD: root mean square of differences between successive RR intervals; LF nu: low frequency band, expressed in normalized units; HF nu: high frequency band, expressed in normalized units.

\* $p \leq 0.05$ .

\*\* $p \leq 0.001$ .



**Figure 3** Salivary cortisol levels (ng/ml) during baseline (15 min), anticipation phase (25 min), stress phase (35 min), post-stress 1 (50 min), and post-stress 2 phase (65 min) of the test session in the ADHD and control group (means and S.E.M.).

and, for the stress phase, significant (stress:  $r = 0.62$ ,  $p = 0.01$ ).

#### 4. Discussion

The current study is the first report on psychological and physiological stress responses to a standardized psychosocial stressor (TSST) in adult ADHD patients and healthy controls. Special emphasis was placed on the careful selection of subjects for the ADHD group. Potential subjects underwent an elaborate stepwise diagnostic process prior to the laboratory session to ensure a high reliability of the ADHD diagnoses. The experimental results show considerably elevated subjective stress levels for the ADHD group during the laboratory stress (anticipation and stress) and recovery (post-stress 1 and 2) phases, thereby confirming a multitude of previous unsystematic self-reports provided by adult ADHD patients regarding a heightened susceptibility to various stressors. The largest difference between both groups was detected during the actual stress phase.

Interestingly and congruent with our hypotheses, no group differences were found during the baseline condition. This implies that ADHD subjects are more intensely affected by the psychological dimension of the stress response, not only during the actual presence of the stressor but also while anticipating it. Importantly, they also perceive greater difficulties in psychological recovery after cessation of the stressor, as the heightened subjective stress experience during the post-stress phases suggests. However, the vast majority of the results regarding the physiological stress responses were inconsistent with this observed anomaly in perceived stress.

In line with our expectations, similar group baseline levels were found for all ANS parameters as well as for salivary cortisol. These results seem to contradict the theoretical assumption that ADHD patients demonstrate tonically low levels of physiological arousal and may be driven to their inattentive, hyperactive, or impulsive behavior by stimulation-seeking motives in order to raise their arousal to an optimal level (Zuckerman, 1979). Our study suggests that adults with ADHD do not suffer from a general hypoactivity of the ANS or HPA axis. Nevertheless, the results must be interpreted with caution since it is also possible that ADHD subtypes have different physiological patterns. Such systematic differences could not, however, be tested here because of the small sample size.

In regard to possible group differences in ANS measures during stress, our assumptions were only partially corroborated by the data. For HR, a significantly attenuated response was found during the stress phase for the ADHD group, which corresponds with the results of previous studies in ADHD children (Boyce and Quas, 2001; Van Lang et al., 2007). No group differences were found for the anticipation or post-stress experimental phases. Expectations in regard to group differences for the HRV time- and frequency-domain parameters could not be confirmed, although a trend was observed for LF/HF ratio time  $\times$  group interaction, suggesting higher values in the ADHD group during baseline and post-stress 2. Since the results did not reach significance, they need to be corroborated using a larger sample before any conclusions can be drawn.

The results of a diminished HR during the stress tasks for the ADHD group are consistent with Quay's (1988, 1997) theory of an underreactive BIS in ADHD patients and also with Lacey's (1967) theoretical distinction between the



state of sensory intake, which is accompanied by HR deceleration, and the state of environmental rejection, which elicits increased HR, thereby facilitating selective attention and cortical processing. Worthy of mention is that the finding of an elevated subjective stress experience and a simultaneously attenuated HR in ADHD subjects during the stress phase contradicts the assumption that a diminished HR could originate from an elevated threshold for the detection of stressful stimuli in these subjects (Kariyawasam et al., 2002). Insofar as results from previous investigations of ANS measures in ADHD children were only partially confirmed for adults with the disorder, the findings from the present study add to the growing body of theoretical and empirical work on similarities and differences between the manifestations of the disorder during childhood versus adulthood.

In regard to the endocrine stress response, no statistically significant differences between both groups were detected, although ADHD subjects as a group showed a trend towards lower cortisol levels. A replication of the experiment with a sample allowing for subtype analyses would be interesting, as several authors have reported a blunted cortisol stress response particularly in children with predominantly hyperactive-impulsive ADHD (Kaneko et al., 1993; Hong et al., 2003). Future studies could aim at determining whether HPA axis reactivity could even be used as a discriminant physiological measure for ADHD subtype diagnosis.

The correlations between the selected physiological stress measures (HR, salivary cortisol) and the subjective stress experience are heterogeneous and difficult to interpret. In general, the pattern for the ADHD group seems to mirror the common finding of inconsistent activation (dissociation) of the different stress response systems (Engert et al., 2004). Still, it is noteworthy that ADHD subjects in this study showed positive, partially significant associations between subjective stress and HR for all non-stress experimental phases (baseline, post-stress 1 and 2), whereas near zero correlations were observed during the stressful experimental phases (anticipation and stress). This might be cautiously interpreted as a trend, again needing investigation and corroboration in larger samples before interpretations can be offered safely. Similarly, the inconsistent relationships between subjective stress and cortisol levels in the ADHD group for the stressful TSST phases, but also during the post-stress 1 period, warrant further investigation.

Several limitations of the study need to be addressed. First, since the small sample size limited the statistical power to detect differences between the patient and the control group considerably, future studies in the field should employ larger samples. Also, it seems desirable to conduct separate analyses for the DSM-IV ADHD diagnostic subtypes, which was not possible in the present study due to small sample size and absence of subjects with the predominantly hyperactive-impulsive subtype. Another limitation can be seen in the sampling procedure used to recruit the patient sample. Since subjects were self-referred and self-selected, they might not be representative of all ADHD adults in the general population, thus limiting generalizability of the results to other than self-referred ADHD subjects.

A third issue is the limited range of physiological stress measures which were selected to test the hypotheses. To

account for the complexity of the investigated biological stress response systems, future surveys should not only include measurement of other ANS parameters (e.g. electrodermal activity), but also and more importantly additional HPA axis measures (e.g. adrenocorticotrophic hormone). The latter may also allow for a more detailed exploration of possible central or peripheral (adrenal) alterations in the HPA axis stress response in adult ADHD patients.

Fourth, we did not assess basal cortisol activity. In the interpretation of our baseline cortisol measurements, it must be taken into account that they may very well already mirror anticipatory stress, since subjects were informed about the general stress nature of the laboratory session (although not about the details of the stressor).

For practical reasons and since comorbidity is known to be common in adult ADHD patients (Kordon and Kahl, 2004; Kessler et al., 2006; Fayyad et al., 2007), subjects with comorbid DSM-IV disorders were included in the ADHD group. Although no systematic differences were found between ADHD subjects with and without comorbid conditions, the tolerance of disorders other than ADHD reduces the internal validity of the study, as differences between the ADHD and the control group may in part originate from these comorbid conditions. Again, future studies are advised to employ sample sizes large enough to control for these potential moderator variables.

While it may seem premature to draw clinical implications from the present study, it should be noted that current multimodal treatment programs for adult ADHD patients already incorporate stress management techniques, although empirical evidence for the specific importance and usefulness of these techniques is lacking. The present results regarding the psychological response to a psychosocial laboratory stressor may be seen as indicating that cognitive-behavioral stress management techniques, which aim to alleviate perceived stress, are of relevance for treatment. Still, before sound and meaningful recommendations can be made, it is essential to not only replicate the findings in larger and more heterogeneous ADHD samples, but also to examine their relevance in regard to daily life stressors. Also, a more elaborate understanding of the determinants of the psychological stress response would be helpful for the conceptualization of appropriate cognitive-behavioral interventions. In this respect, stress-related cognitive appraisal styles as well as typical coping strategies (Lazarus and Folkman, 1984) in ADHD patients should be examined.

In summary, the present study demonstrated significant differences in the psychological stress response of adults with ADHD and healthy controls under laboratory conditions. The results of the intergroup comparisons of the physiological parameters were mixed, with clear group differences for HR during the stress conditions and a trend towards lower cortisol levels in the ADHD group. While the study's strengths lie in the thoroughness of the diagnostic process and the use of a standardized laboratory stress paradigm known to elicit pronounced psychological and physiological stress responses, limitations are seen in the small sample size and the restricted range of stress parameters. Furthermore, the relevance of the results for real life stressors remains unclear. Future studies need to address these

aspects, as well as the question of possible ADHD subtype differences in stress responses and of mechanisms of the psychological stress response in ADHD subjects.

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No funding was received for this study.

## Conflict of interest

All authors declare that they have no conflicts of interest related to this work.

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### **3. Stressreagibilität, stressbezogene Copingstile, Aufmerksamkeitsleistung und Lebensqualität bei erwachsenen ADHS-Patienten**

#### **3.1. Einführung in die Fragestellung**

Im Anschluss an die Befunde der ersten durchgeführten Studie (Kapitel 2) wurde der Fragestellung nachgegangen, inwieweit die Laborergebnisse des erhöhten subjektiven Stresserlebens erwachsener ADHS-Patienten gegenüber gesunden Kontrollprobanden die Wahrnehmung von Alltagsstressoren valide abbilden. Eine herabgesetzte Stresstoleranz im Alltag wurde von Wender und Kollegen (Wender, 1995) als zusätzliches diagnostisches Merkmal der ADHS speziell bei erwachsenen Patienten postuliert. Danach sind Erwachsene mit ADHS nicht in der Lage, mit Stressoren im Alltag bedächtig und konstruktiv umzugehen, sondern reagieren stattdessen überschießend oder unangemessen mit negativen Emotionen. Diese emotionalen Reaktionen interferieren oftmals mit angemessenen Problemlöseversuchen, weshalb es wiederholt zu krisenartigen Zuspitzungen im Erleben von und Verhalten gegenüber stressreichen Alltagssituationen komme (Wender, Wolf, & Wasserstein, 2001). Auch andere Autoren beschreiben eine erhöhte emotionale Labilität erwachsener ADHS-Patienten, insbesondere in Belastungssituationen (Conners, Ehrhard, & Sparrow, 1999). Nadeau (1995) sah entsprechend den Grund für ein angenommenes erhöhtes subjektives Stressniveau bei erwachsenen ADHS-Patienten in deren herabgesetzten Möglichkeiten der Filterung von (distrahierenden) Stimuli. Wiederum eignet sich zur theoretischen Einbettung das Störungsmodell von Barkley (1997), das ein allgemeines Inhibitionsdefizit annimmt, welches zu Beeinträchtigungen der Selbstregulation in verschiedensten Bereichen und Settings führt. Die Konsequenz sind u.a. eine

emotionale Hyperreagibilität, geringe Frustrationstoleranz und mangelnde emotionale Selbstkontrollkompetenzen. Da stressbezogenes Coping sinnvoll als eine Domäne der Selbstregulation des Individuums konzipiert werden kann (Eisenberg, Fabes, & Guthrie, 1997; Eisenberg et al., 1996), können hier allgemeine Hypothesen zu Stresserleben und stressbezogenem Coping im Alltag von ADHS-Patienten formuliert werden. Im Hinblick auf das subjektive Stresserleben wird erwartet, dass ADHS-Patienten gegenüber gesunden Kontrollpersonen ein erhöhtes Niveau aufweisen. Für das stressbezogene Coping ist die emotionale Hyperreagibilität wesentlich, die höhere Anforderungen an den versierten Einsatz funktionaler emotionsfokussierter (palliativer) wie problemlöseorientierter Copingstrategien stellt. Überdies mag die Beeinträchtigung spezifischer Aufmerksamkeitsfunktionen bei ADHS-Patienten eine weitere wesentliche Rolle spielen, da etwa selektive (fokussierte) Aufmerksamkeit wie auch geteilte Aufmerksamkeit (kognitive Flexibilität) wichtige Komponenten bei der Stressor-Wahrnehmung und beim Einsatz nachfolgender Coping-Strategien sind (Compas & Boyer, 2001). Zusammenhänge zwischen einer verminderten Kapazität der selektiven Aufmerksamkeit und Beeinträchtigungen der emotionalen Selbstregulation bzw. des palliativen Copings wurden bei Kindern und Erwachsenen beobachtet (Balaban, Snidman, & Kagan, 1997; Gotlib & MacLeod, 1997; Rothbart, Posner, & Boylan, 1990). Defizite in der geteilten Aufmerksamkeit wurden ebenfalls als mit einer schlechteren emotionalen Selbstregulation in Verbindung stehend beschrieben (Eisenberg et al., 1993), wodurch das subjektive Stressniveau sich in entsprechenden Situationen nochmals erhöhen könnte. Zusammengefasst wird für erwachsene ADHS-Patienten erwartet, dass ein postuliertes generelles Selbstregulationsdefizit sich auch im Bereich der Wahrnehmung von Alltagsstressoren und der Anwendung von stressbezogenen Copingstrategien ungünstig auswirken sollte, d.h. mit erhöhtem subjektiven Stress und weniger

funktionalem Coping einhergehen sollte. Dies wiederum sollte sich negativ auf Wohlbefinden und Lebensqualität dieser Individuen auswirken.

Empirische Studien, die sich mit dem subjektiven Stresserleben und Coping von ADHS-Patienten im Alltag befasst haben, liegen bislang nur sehr vereinzelt vor. Bei Kindern wurden eine schlechtere Selbstregulation negativer Emotionen sowie generell mehr maladaptive und weniger adaptive Copingstrategien berichtet (Braaten & Rosén, 2000; Hampel & Desman, 2006). Erwachsene Probanden mit einem hohen Ausmaß an ADHS-Symptomen zeigten in spezifischen Stresssituationen ein vermehrtes Ausmaß an Ärger (Richards, Deffenbacher, & Rosén, 2002), wobei hier zu berücksichtigen ist, dass von den DSM-IV-Kriterien der ADHS abgewichen wurde. Für Frauen mit ADHS berichteten Rucklidge und Kaplan (1997) gegenüber gesunden Probandinnen erhöhte Werte im emotionsfokussierten Coping sowie ein höheres allgemeines Stressniveau, erhoben per Selbstbericht-Kurzfragebogen für die vergangene Woche. Aussagen über die differenzielle Stressbelastung in unterschiedlichen Bereichen des täglichen Lebens lassen sich jedoch aus den Studienergebnissen nicht ableiten. Lediglich das stressbezogene Coping erwachsener ADHS-Patienten erhob Young (2005). Hier zeigte die Patientengruppe gegenüber der gesunden Kontrollgruppe mehr konfrontatives Coping, Flucht-Vermeidung, jedoch auch positive Neubewertung, sowie weniger zielorientiertes Problemlösen.

In der Zusammenschau der empirischen Literatur fällt neben dem allgemeinen Mangel an Studien zu alltäglichem subjektivem Stresserleben und stressbezogenem Coping bei (erwachsenen) ADHS-Patienten ein völliges Fehlen an Untersuchungen ins Auge, die sich mit Fragen der Bereichsspezifität eines möglichen erhöhten Stressniveaus beschäftigen haben. Ebenso sind empirisch basierte Aussagen hinsichtlich strategiespezifischer Defizite, jedoch auch möglicher Kompetenzen im

stressbezogenen Coping rar und zusätzlich durch Einschränkungen in der Wahl der Stichprobe belastet (Rucklidge & Kaplan, 1997). Eine gleichzeitige Erhebung von alltagsbezogenem Stresserleben und Coping steht noch aus. Das Anliegen der zweiten hier vorgelegten Originalarbeit war es deshalb, beides simultan an einer Stichprobe erwachsener ADHS-Patienten zu erfassen und die Daten denen einer gematchten Gruppe von Kontrollprobanden ohne Störung gegenüber zu stellen. Zusätzliche abhängige Variablen waren vor dem Hintergrund der weiter oben beschriebenen angenommenen Zusammenhänge Maße der Lebensqualität sowie die Kapazität der selektiven und geteilten Aufmerksamkeit. Explorativ sollten auch die korrelativen Zusammenhänge zwischen den abhängigen Variablen untersucht werden.

Subjektives Stresserleben, kritische Lebensereignisse der letzten 12 Monate, aktuelle psychische Symptombelastungen und stressbezogenes Coping wurden jeweils per Selbstbericht-Fragebogen erhoben, ebenso die allgemeine Lebenszufriedenheit und die globale und bereichsspezifische Lebensqualität. Die Aufmerksamkeitsfunktionen wurden mittels etablierter neuropsychologischer Tests untersucht, von denen frühere Studien gezeigt hatten, dass sie in der Lage sind, zwischen ADHS-Patienten und gesunden Personen zu differenzieren (Murphy, 2002; Young, Bramham, Tyson, & Morris, 2006). Die Stichprobe setzte sich aus 27 erwachsenen Personen mit ADHS-Diagnose nach DSM-IV (zum diagnostischen Vorgehen siehe auch Kapitel 2.1) sowie 27 nach soziodemographischen Variablen gematchten Kontrollprobanden ohne aktuelle psychische Störung zusammen; Gründe für die gegenüber der ersten Studie (vgl. Kapitel 2) höhere Anzahl teilnehmender ADHS-Patienten liegen zum einen in den durch die dortige Cortisolerhebung zusätzlich notwendigen Ausschlusskriterien (akute körperliche Erkrankung, wie z.B. Grippe, Erkältung; Einnahme von Kontrazeptiva;



Schwangerschaft), zum anderen waren einige Patienten im Anschluss an die Diagnostik nicht zur Teilnahme am Laborexperiment bereit, wohl aber zum Ausfüllen der Fragebögen für die zweite Studie. Fragebogeninstrumente und Aufmerksamkeitstests wurden während eines mehrstündigen Aufenthaltes im Institut für Psychologie der Universität Göttingen bearbeitet.

Die Datenanalyse erbrachte erhöhte Werte hinsichtlich der psychischen Symptombelastung, des generellen Stresserlebens sowie spezifischer chronischer Alltagsstressoren in der Patientengruppe, jedoch eine Vergleichbarkeit der Gruppen hinsichtlich kritischer Lebensereignisse. Erwartungskonform berichteten die Patienten, weniger funktionale (emotionsfokussierte sowie aktiv-problemlösende) und mehr dysfunktionale stressbezogene Copingstrategien im Alltag zu verwenden. Beides war signifikant korreliert mit einem erhöhten Stresserleben. Allerdings zeigte sich bei den Patienten kein generalisiertes Defizit hinsichtlich des funktionalen Copings. Vielmehr zeigten sie sich hinsichtlich der (funktionalen) Strategien Schuldabwehr, Bagatellisierung, Ersatzbefriedigung und Bedürfnis nach sozialer Unterstützung als den Kontrollprobanden vergleichbar, ebenso in der selbstberichteten Anwendung der (dysfunktionalen) Verhaltensweisen sozialer Rückzug und Selbstmitleid.

Lebenszufriedenheit und bereichsspezifische Lebensqualität erwiesen sich als signifikant vermindert in der ADHS-Gruppe. Es fanden sich hier überdies signifikante positive Korrelationen zwischen Lebensqualität und einigen funktionalen Copingstrategien (Situationskontrolle, Reaktionskontrolle, positive Selbstinstruktionen), von denen die Patienten gleichzeitig berichteten, sie nur in einem geringen Ausmaß einzusetzen. Weiterhin war aggressives Coping bei diesen Probanden signifikant negativ mit der Lebensqualität assoziiert. Zusammengefasst fiel somit auf, dass die untersuchten Patienten nach eigener Aussage

Alltagsstressoren in vermindertem Ausmaß mit genau solchen Strategien begegnen, welche in einem positiven Zusammenhang mit ihrer Lebensqualität stehen, und andererseits in erhöhtem Umfang auf Strategien zurückgreifen, die teilweise negativ mit der Lebensqualität korrelieren.

Gruppenunterschiede fanden sich wie erwartet auch hinsichtlich der verwendeten Aufmerksamkeitsmaße. Allerdings erwiesen sich die ermittelten Korrelationen mit den weiteren abhängigen Variablen erwartungskonträr als überwiegend insignifikant. Eine genauere Inspektion zeigte, dass es sich hierbei teilweise um kleine Effekte handelte, die mit dem untersuchten Stichprobenumfang nicht statistisch abgesichert werden konnten.

Zusammenfassend lässt sich feststellen, dass die Befunde der vorliegenden Studie die aus theoretischen Modellen der ADHS abgeleitete Annahme eines erhöhten subjektiven Stresserlebens wie auch von Defiziten hinsichtlich funktionaler emotionsfokussierter und problemlöseorientierter Copingstrategien bei diesen Patienten untermauern. Die postulierten Zusammenhänge zwischen Defiziten der selektiven und geteilten Aufmerksamkeit, Stresserleben und Copingverhalten ließen sich jedoch mit der hier untersuchten Stichprobe von erwachsenen Patienten mit ADHS-Diagnose nach DSM-IV weitgehend nicht objektivieren.

### **3.2. Originalartikel 2**

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Chronic stress, coping styles, attentional functioning and quality of life in adults with  
ADHD

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## **Abstract**

The present study examined perceived daily life stress, psychopathological symptoms, and coping via self-report questionnaires in 27 adults with ADHD and 27 matched healthy controls and explored associations with attentional and quality of life variables. Attentional capacity was assessed with the Stroop Test and the Trail Making Test. Patients showed elevated global and domain-specific stress, lower quality of life, and deficits in adaptive coping. Chronic stress was negatively associated with functional coping, whereas a positive relationship was found between functional coping and quality of life. In contrast, specific dysfunctional strategies were associated with diminished quality of life. Patients demonstrated significantly lower attentional capacity, but correlations with coping strategies remained largely insignificant. Implications for psychosocial treatments are discussed.

Keywords: ADHD, adults, chronic stress, coping, quality of life, attention

Attention-deficit/hyperactivity disorder is today widely acknowledged as a potentially chronic condition which affects not only many children and adolescents, but also a large percentage of adults who continue to experience ADHD symptoms long after childhood and adolescence. In longitudinal studies on patients who received their diagnosis during childhood, between 30% and 50% of the participants still presented clinically relevant symptoms after adolescence (Mannuzza, Klein, Bessler, Malloy, & LaPadula, 1993; Weiss, Hechtman, Milroy, & Perlman, 1985). ADHD patients show increased rates of comorbid DSM-IV axis I and II disorders (Miller, Nigg, & Faraone, 2007), and the disorder has been empirically linked to a wide array of psychosocial problems, including higher rates of marital problems,

separation and divorce, more educational and employment problems, more driving accidents, lower academic achievement, poor interpersonal relations, and lower global functioning estimates (Barkley, 1997; Barkley, Guevremont, Anastopoulos, DuPaul, & Shelton, 1993; Biederman et al., 1993; Murphy & Barkley, 1996).

Whereas DSM-IV and ICD-10 describe three core symptom clusters – inattention, hyperactivity, and impulsivity – there is an ongoing scientific debate, focusing on the adequacy of the established ADHD diagnostic criteria for adult patients, because they have been developed based on the disorder's manifestation in childhood (Lahey et al., 1994). There is a lack of validation studies in adults, and some authors have proposed additional criteria, designed specifically for ADHD in adulthood. For example, the Utah criteria (Wender, 1995) see hyperactivity and poor concentration as the central features of adult ADHD, but define five additional symptoms – affective lability, hot temper, inability to complete tasks and disorganization, stress intolerance, and impulsivity – out of which two must be fulfilled in order to confirm the diagnosis. Especially affective lability, hot temper, and stress intolerance are described as typical psychopathological features of the disorder's appearance in adult patients (Wender, 1987; 1995). According to this view, patients should feel easily “hassled” or “stressed out”, have marked difficulties dealing with stressors in daily life, and often experience emotional overreactivity when faced with routine life troubles (Wender, Wolf, & Wasserstein, 2001). Similarly, the ADHD model by Conners, Ehrhard, and Sparrow (1999) incorporates symptoms of emotional lability in adult patients. Barkley's (1997) influential theory of ADHD offers a possible explanation for additional emotional problems in ADHD patients by conceptualising the disorder as comprising a general deficit in behavioral inhibition which leads simultaneously to impairments in various executive functions, among them the self-regulation of affect, motivation, and arousal. This self-regulative

deficiency is proposed to lead to emotional hyperreactivity, irritability, low frustration tolerance, and loss of emotional self-control. Interestingly, modern theories on stress reactivity and coping behavior have conceptualized stress-related coping as a subarea of the domain of self-regulation (Eisenberg, Fabes, & Guthrie, 1997a; Eisenberg et al., 1996), containing self-regulative activities that specifically occur under conditions of psychological stress.

Lazarus and Folkman (1984), in their transactional model of the psychological stress experience and coping, define stress as a relational concept, characterized by an imbalance between environmental demands and personal resources. Active or problem-focused coping efforts aim at remediating or changing the stressor, whereas palliative or emotion-focused strategies are employed to master negative affective reactions to stress (Lazarus, 1993). Because there is no single coping technique which allows for successful management of all types of stressors, effective coping is characterized by the flexible use of a wide array of functional coping strategies, rather than adherence to a small selection of behavioral patterns (Kaluza, 2000). Compas, Connor-Smith, Saltzman, Thomasen, and Wadsworth (2001) point at the dependency of regulatory coping efforts on the individual's biological, cognitive, social, and emotional developmental level which puts constraint on the range of available coping strategies. Especially attentional processes, e.g. attentional focus and attentional shift, are important factors not only during the perception of a stressor, but also in the execution of coping strategies (Compas & Boyer, 2001). A diminished capacity to exercise focused or selective attention has been found to obstruct the self-regulation of arousal and negative emotions in children as well as adults (Balaban, Snidman, & Kagan, 1997; Gotlib & MacLeod, 1997; Rothbart, Posner, & Boylan, 1990). To employ active problem-solving coping behavior, focusing attention is also essential. Furthermore, the ability to control and actively shift attention away from the source of

stress is of importance not only for an effective emotion-focused coping, but for the execution of any kind of coping behavior because the individual has to rededicate a portion of the attentional capacity to finding ways to deal with the stressor and engaging in these strategies, as well as to simultaneous assessment of the stressor and the adequacy of the coping behavior during the process (Mathews & Wells, 1996). Congruently, deficiencies in attentional shift have been found to be associated with negative emotionality and diminished self-regulation competencies in children (Eisenberg et al., 1993; Eisenberg et al., 1997b). Especially if a stressor is perceived as intense, harmful or potentially overwhelming, it is more likely for the individual to almost exclusively direct attentional capacity to the stressor, implying that little attentional resources are available for coping efforts. The result may well be a heightened perceived emotional arousal, passivity, and ultimately avoidance behavior.

ADHD patients are expected to experience difficulties with coping because the emotional hyperreactivity poses higher demands on emotion-focused coping techniques and might also interfere with appropriate problem-solving behavior, as it puts a strain on the individual's attentional capacity. An absence of mechanisms to effectively regulate the stress experience should, in turn, lead to even higher levels of perceived stress in daily life activities. In sum, ADHD patients are hypothesized to demonstrate deficiencies in self-regulation which should have an impact on their experience of and behavior towards stressors in daily life. Because stress and coping have been shown to be relevant factors for psychological adaptation and adjustment of the individual (Compas et al., 2001) and also for symptoms of psychopathology (Karel, 1997; Matheson & Anisman, 2003; Sigmon et al., 2006), deficiencies in coping with stressors may also contribute to an increased risk for impairment through



psychopathological symptoms in ADHD patients and reduce overall and domain-specific quality of life.

So far, empirical research in the area of stress experience and stress-related coping in ADHD patients is surprisingly sparse. Braaten and Rosén (2000) found inferior emotional self-control of specific negative emotions (anger, sadness, and guilt) in ADHD boys compared to healthy controls. Female adolescents with ADHD not only reported significantly more negative life events than a non-ADHD control group, but also perceived a greater impact of these incidents on their lives than both healthy controls and male ADHD adolescents (Rucklidge & Tannock, 2001). Hampel and Desman (2006) found increases in maladaptive coping strategies in younger ADHD boys compared to normative data. Self-reported interpersonal coping in boys with ADHD as compared to healthy controls was found to be characterized by more passive avoidance and resignation, as well as diminished use of distraction and of problem-focused coping strategies (Hampel, Manhal, Roos, & Desman, 2008). Data on perceived stress were not collected.

Despite anecdotal reports of heightened levels of perceived stress in the daily life of adult ADHD patients, very few studies have systematically examined their stress experience and coping strategies. Consistent with Barkley's (1997) theoretical assumptions, Rapport, Friedman, Tzelepis, and van Voorhis (2002) observed heightened emotional responsiveness in adult ADHD patients compared to healthy controls, pointing at a possibly elevated intensity of experienced emotion in the experimental group. Richards, Deffenbacher, and Rosén (2002) found higher levels of general trait anger and anger in the context of driving in a group of college students high in current and childhood ADHD symptoms, compared to a low-symptom control group. Individuals high in ADHD symptoms also displayed driving-related anger more aggressively and showed a general tendency to express anger in

more socially unacceptable ways. Female adult ADHD patients reported more emotion-oriented and less task-oriented coping behavior than healthy women in a study by Rucklidge and Kaplan (1997). General stress levels during the previous week were measured via a short self-report questionnaire, indicating significantly elevated subjective stress in the patient subgroup. However, the data do not allow for conclusions about group differences in subjective stress in regard to specific domains (e.g. interpersonal relationships, work). Also, because no male ADHD patients were included in the study, generalizability of the findings is uncertain. In a study by Young (2005), ADHD adults reported significantly more confrontative, escape-avoidant, and, surprisingly, positive reappraisal coping strategies in the Ways of Coping Scale than healthy controls, whereas goal-oriented problem solving was significantly lower in the patient group and no differences were found in regard to the other four coping subscales. Subjective stress levels were not measured in this study. In a recent laboratory study (Lackschewitz, Hüther, & Kröner-Herwig, 2008), adult ADHD patients experienced significantly greater subjective stress during anticipation and presence of a standardized psychosocial stressor, and also perceived increased difficulties in psychological recovery during the post-stress phases of the experiment. One target of the present study was to investigate the relevance of these laboratory results for adult ADHD patients' stress experience in daily life.

For a meaningful and customized conceptualization of multimodal psychotherapeutic intervention programs it is desirable not only to investigate differences in the level of general perceived stress, but also to gather information about possible domain-specific aberrations of the stress experience of adults with ADHD when compared to healthy controls. Furthermore, knowledge about specific deficits of ADHD patients in regard to coping strategies is essential. The aim of our study was to simultaneously investigate self-reported chronic psychosocial stress,

coping strategies, and quality of life in a sample of adults with a DSM-IV ADHD diagnosis and a group of healthy matched controls. Additionally, we planned to compare selective and divided attentional functioning in the two groups, and to explore possible relationships of the attentional parameters with functional, emotion-focused and problem-solving coping strategies in the patient subgroup. In accordance with the cited theoretical literature, we expected the patient group to show significantly higher levels of chronic stress and strain in daily life, a higher degree of psychopathological symptomatology, as well as less positive (functional) and more negative (dysfunctional) coping strategies. A positive correlation in the ADHD subsample between chronic stress and dysfunctional coping strategies, as well as a negative correlation between chronic stress and functional coping behavior, was hypothesized. Moreover, satisfaction with and quality of life was expected to be lower in the ADHD subgroup, and negatively associated with chronic stress and dysfunctional coping. In regard to the cognitive parameters, ADHD patients were expected to show inferior focused and divided attention capacities, and significant negative correlations were hypothesized between these parameters and functional, active problem-solving and emotion-focused coping behavior.

## **Method**

### **Design of study**

To test our hypotheses on systematic differences between ADHD patients and healthy controls in regard to chronic stress, coping strategies, attentional functioning, and quality of life, a quasi-experimental between-subjects research design was used, with a sample consisting of a clinical group of adult ADHD patients and a control group of healthy adults. The study was part of a larger project on stress responses in

adult ADHD patients. Participants were matched in regard to age, gender, and educational background.

### **Participants and procedure**

The final study sample consisted of 27 adults with a DSM-IV ADHD diagnosis and 27 matched adults without psychopathology. Participants were recruited through articles in local newspapers and the internet. ADHD diagnoses required a positive history of ADHD during childhood and adolescence as well as current ADHD symptomatology and were made by a graduate student in clinical psychology (first author) and four trained undergraduate students majoring in psychology, using DSM-IV (American Psychiatric Association, 1994) criteria for ADHD. In a first step, a 30-min structured telephone screening interview was administered, containing German versions of the World Health Organization Adult ADHD Self-Report Scale (ASRS-v1.1; Kessler et al., 2005), the Brown Attention-Deficit Disorder Rating Scale for Adults (Brown, 1996; Ruhl, Schmid, & Hach, in press) and the Attention Deficit Hyperactivity Disorder – Self Report Scale (ADHD-SB, Rösler et al., 2006), which lists the 18 DSM-IV symptoms of inattention, hyperactivity, and impulsivity. Interview partners were asked for retrospective rating of childhood ADHD symptoms by administration of the Wender Utah Rating Scale (short form; Ward, Wender, & Reimherr, 1993; German version by Retz-Junginger et al., 2002).

Individuals with positive screening results underwent extensive structured clinical interviews at the university's Department of Clinical Psychology and Psychotherapy, including the Structured Clinical Interview for DSM-IV (SCID; German version by Wittchen, Zaudig, & Fydrich, 1997) and a semi-structured clinical interview on childhood and current symptoms of ADHD (Brown, 1996; Ruhl et al., in press). For calculation of inter-rater reliability of ADHD symptom assessment, all

clinical interviews were audio-taped, and a random sample of 12 interviews was independently evaluated by two trained research psychologists. Pearson correlation coefficients for inattention and hyperactivity/impulsivity symptom clusters were generally high, both for assessment of current and childhood symptoms (current inattention symptoms  $r = .95$ ,  $p < .001$ ; current hyperactivity/impulsivity symptoms  $r = .97$ ,  $p < .001$ ; childhood inattention symptoms  $r = .96$ ,  $p < .001$ ; childhood hyperactivity/impulsivity symptoms  $r = .95$ ,  $p < .001$ ).

Inclusion criteria for the ADHD group were both current and childhood fulfillment of DSM-IV diagnostic criteria for ADHD. Exclusion criteria for the patient group were a history of significant neurological disorder, a lifetime history of psychotic symptoms, a current comorbid diagnosis of post-traumatic stress disorder (PTSD) or substance dependency, any current medication (including stimulants), and current psychotherapy. Because psychiatric comorbidity has been found to be common in adult ADHD patients (Kessler et al., 2006; Kordon & Kahl, 2004; Fayyad et al., 2007), current comorbid diagnoses of DSM-IV disorders other than PTSD and substance dependency were allowed in the patient group. Single or multiple comorbid axis I conditions were found in 12 patients (major depression ( $n = 3$ ), dysthymia ( $n = 4$ ), cannabis abuse ( $n = 3$ ), panic disorder with agoraphobia ( $n = 1$ ), agoraphobia without panic disorder ( $n = 1$ ), social phobia ( $n = 3$ ), specific phobia ( $n = 4$ ), obsessive-compulsive disorder ( $n = 2$ )). Additionally, 4 patients were diagnosed with axis II personality disorder (borderline personality disorder:  $n = 2$ , antisocial personality disorder:  $n = 2$ ). Individuals in the control group were required not to have any current psychiatric diagnoses.

Participants ranged in age from 20 to 57 years, with a mean age of 36.69 years ( $SD = 10.02$ ). 28 individuals (51.9% of the sample) were male, 26 (48.1%) were female. The ADHD and control group were matched for age, gender distribution, and

years of school education ( $M=10.85$  years,  $SD=1.59$ ). In regard to DSM-IV ADHD diagnostic subtypes, 13 individuals (48.1%) in the patient group fulfilled criteria for the predominantly inattentive subtype, 1 individual (3.7%) fulfilled criteria for the predominantly hyperactive/impulsive subtype, and 13 individuals (48.1%) fulfilled criteria for the combined subtype.

Participants' written informed consent was obtained after oral and written information on the study had been provided. To assess possible differences in perceived daily life stress, self-reported coping behavior, and quality of life between adult ADHD patients and healthy controls, participants completed a set of psychometric questionnaires and neuropsychological tests (see below) during an appointment at the university's Department of Clinical Psychology and Psychotherapy.

### **Dependent Variables**

*Subjective stress.* Perceived chronic stress in daily life was measured with the Trier Inventory for the Assessment of Chronic Stress (TICS; Schulz, Schlotz, & Becker, 2004), a 57-item self-report questionnaire. Respondents are asked to indicate the experienced frequency of various stressful situations and events during the last three months on five-point Likert scales (0 = never; 4 = very often). The TICS consists of ten subscales: work overload, social overload, pressure to succeed, dissatisfaction with work, excessive demands at work, lack of social recognition, social tension, social isolation, chronic worry (Cronbach's  $\alpha = .84-.90$ ), and an additional chronic stress screening scale (Cronbach's  $\alpha = .91$ ). Subscale scores are computed through addition of the scale's single items, with larger values indicating a higher degree of chronic stress.

Number and impact of life events during the last year were assessed with a 14-item German short form of the Life Experiences Survey (Sarason, Johnson, & Siegel, 1978; German version by Schwarzer, 2000). Respondents have to indicate for every listed event whether it occurred during the previous twelve months (seperately for months 1-6 and 7-12) and to which degree they were negatively affected by it (0 = event did not occur, or was perceived as positive or irrelevant; 4 = event caused extreme psychological strain). The sum of the single items forms the total score. Separate total scores are computed for months 1-6 and 7-12.

*Psychopathological symptoms.* For assessment of perceived strain and impairment through psychological problems and symptoms of psychopathology, the German version of the Symptom Checklist-90-Revised (SCL-90-R; Derogatis, 1994; Franke, 2002) was used. Participants are asked to indicate to which degree they felt impaired by the listed symptoms during the last week on a 5-point Likert scale (0 = not at all; 4 = extremely). The questionnaire comprises nine subscales (somatization, obsessive-compulsive symptoms, interpersonal sensitivity, depression, anxiety, hostility, phobic anxiety, paranoid ideation, and psychoticism). Satisfactory reliability (Cronbach's  $\alpha = .75-.87$ ) and validity have been reported (Franke, 2002). In addition to subscale scores, the Global Severity Index (GSI) indicates overall psychological strain and is computed by first summing the scores of the nine dimensions and the additional items, then dividing by the total number of responded items.

*Coping.* Coping strategies were assessed by administration of the German "Stressverarbeitungsfragebogen" (stress-coping questionnaire, SVF120; Janke & Erdmann, 1997), a 120-item self-rating instrument. The questionnaire consists of 20 coping subscales, with scales 1-10 describing positive (i.e. functional or stress-reducing) coping strategies (trivialization; attitude of downplaying own stress; denial of guilt; distraction; substitute gratification; self-affirmation; relaxation; situational

control; response control; positive self-instructions) and scales 13-18 listing negative, or dysfunctional strategies (escape; social withdrawal; rumination; resignation; self-pity; self-blame). The four remaining scales are need for social support, avoidance, aggression, and drug use (i.e. taking of medication, alcohol, or nicotine).

Respondents are asked to rate for each item on five-point Likert scales the probability with which they would react as described when faced with stress (0 = not at all; 4 = very likely). Subscale scores are the sum of each subscale's single item scores.

Additionally, it is possible to compute total scores for positive and negative coping strategies by summation of the respective subscales' scores and subsequent division through the number of subscales (10 for positive strategies, 6 for negative strategies).

*Quality of life.* Participants were asked to complete the German version of the self-report World Health Organization Quality of Life instrument (WHOQOL-BREF; WHOQOL Group, 1998; Angermeyer, Kilian, & Matschinger, 2000). The 26-item questionnaire measures generic quality of life. It is an abbreviated version of the 100-item WHOQOL-100 and covers four quality of life domains (physical health, psychological health, social relationships, environment; Cronbach's  $\alpha = .66-.80$ ), with higher domain scores representing higher quality of life. Additionally, two single items measure overall perceived quality of life and general health satisfaction.

Respondents rate items on 5-point Likert scales (1= very poor / very dissatisfied / not at all; 5 = very good / very satisfied / extremely). For calculation of domain scores the mean score of items within each domain is used. Validation studies confirmed good validity and test-retest reliability (Skevington, Lotfy, & O'Connell, 2004; WHOQOL Group, 1998).

In addition, participants completed the life satisfaction scale of the Freiburg Personality Inventory (FPI-R; Fahrenberg, Hampel, & Selg, 2001). The scale consists



of twelve dichotomous items (“true” vs. “false”), addressing feelings of contentment and satisfaction with life, self, job, marriage/relationship, and attitudes towards one’s past and future. The internal consistency (Cronbach’s  $\alpha$ ) of the scale is .76.

*Attentional measures.* For investigation of focused and divided attention, study participants completed the German version of the Stroop Color Word Interference Test (Bäumler, 1985) and the Trail Making Test (Reitan & Wolfson, 1985). The Stroop Test consists of three sections: reading of columns of color words printed in black ink (“color word” subtest), naming of colors of horizontal color bars (“color” subtest), and naming the ink color of printed color words, with the ink color being incongruent with the written color word (interference condition). The latter subtest is an established measure of focused or selective attention, because it is necessary to pay attention to the relevant dimension of the stimulus (the ink color) while simultaneously ignoring the task-irrelevant but distracting dimension (the written word). Participants are asked to complete each subtest as quickly as possible. The dependent variables in the present study were the reaction times in the three test sections (the interference subtest being of special interest), as well as the Stroop interference effect, computed by subtraction of the latencies in the interference condition from the latencies found in the “color” subtest.

The TMT is composed of two subtests. TMT part A requires participants to draw lines to connect 25 printed numbers on a sheet of paper in correct numerical sequence as quickly as possible and is a simple measure of visual search and motor speed. In TMT part B, the test person is asked to draw lines to connect alternately numbers (1-13) and letters (A-L) in ascending order, making it necessary to repeatedly switch attention between the two types of items. Accordingly, this subtest is commonly used as a measure of divided attention or cognitive flexibility. For both parts of the TMT, the time needed for task completion was measured.

## Data Analyses

Data analyses were conducted by use of the SPSS statistical package (version 12.0). Prior to the main statistical analysis, we inspected skewness and kurtosis of all single parameters. To additionally test the data for normality of distribution, Kolmogorov-Smirnov tests were calculated for all dependent variables. Because the majority of the psychometric variables within the domains of subjective stress, psychopathological symptoms, coping strategies, and quality of life turned out to be non-normally distributed and could not be transformed to normal, all variables from these domains were analyzed by use of non-parametric Mann-Whitney tests. The global level of significance was established at  $p \leq .05$  (two-tailed), and Bonferroni corrections were applied to the results of the analyses within each domain (i.e. according to the number of tests computed within the respective domain). In addition, non-parametric effect sizes were calculated from the z scores, with  $r$  values  $< .3$  classified as small effects and  $r > .5$  assessed as large effects (Cohen, 1988; 1992).

The attentional parameters were measured at interval level and showed normal distribution. Hence, a one-way multivariate analysis of variance (MANOVA) by group (ADHD vs. control) was calculated, subsequently followed by univariate ANOVAs in case of a significant overall group effect.

To further explore the relationships between chronic stress, positive as well as negative coping strategies (total scores), and global quality of life, correlational analyses with calculation of Spearman rank correlation ( $\rho$ ) coefficients were conducted. For the patient subsample we also examined correlational patterns between single coping strategies and the attentional parameters and psychopathological symptoms, as well as relationships with the global indices of stress and quality of life.

## Results

### Subjective Stress

Separate Mann-Whitney tests for the ten TICS subscales revealed significant group differences for the following dimensions: work overload, pressure to succeed, excessive demands at work, lack of social recognition, social tension, and chronic worry ( $p \leq .004$  after Bonferroni correction for multiple testing). ADHD patients scored significantly higher than healthy controls on all of these subscales as well as on the TICS global chronic stress screening scale (see Table 1), with effect sizes in the moderate to high range. In contrast, no group differences were found for social overload, dissatisfaction with work, and social isolation. Also, both groups were comparable in regard to the occurrence and impact of life events in the preceding year (total scores of the LES, calculated separately for months 1-6 and 7-12).

**Table 1**

**Subjective stress, psychopathological symptoms, coping strategies, and quality of life variables in the ADHD and control group**

Dependent Variable	M (SD)		Test Statistic			Effect Size
	ADHD (n=27)	Control (n=27)	U	Z	p	r
<b>Subjective stress</b>						
<i>Work overload</i>	20.4 (4.16)	16.48 (4.85)	198.50	-2.88	<b>.004</b>	<b>-.39</b>
<i>Social overload</i>	10.56 (4.01)	9.70 (3.59)	340.50	-.42	.68	-.06
<i>Pressure to succeed</i>	22.63 (3.84)	11.56 (3.29)	15.50	-6.06	<b>&lt;.001</b>	<b>-.82</b>
<i>Dissatisfaction with work</i>	14.11 (4.07)	11.81 (4.31)	262.50	-1.78	.076	-.24
<i>Excessive demands at work</i>	12.96 (4.58)	9.00 (3.79)	170.50	-3.37	<b>.001</b>	<b>-.46</b>
<i>Lack of social recognition</i>	11.22 (3.19)	5.22 (1.93)	68.00	-5.16	<b>&lt;.001</b>	<b>-.70</b>
<i>Social tension</i>	13.63 (4.59)	8.85 (4.25)	155.00	-3.63	<b>&lt;.001</b>	<b>-.49</b>
<i>Social isolation</i>	9.00 (4.47)	9.70 (3.37)	310.00	-.95	.34	-.13
<i>Chronic worry</i>	10.30 (2.43)	6.56 (2.04)	83.50	-4.90	<b>&lt;.001</b>	<b>-.67</b>
<i>Chronic stress screening scale</i>	29.26 (5.62)	20.74 (6.02)	113.00	-4.36	<b>&lt;.001</b>	<b>-.59</b>
<i>Impact of life events (months 1-6)</i>	.44 (.31)	.60 (.43)	306.50	-1.01	.31	-.14
<i>Impact of life events (months 7-12)</i>	.14 (.22)	.09 (.25)	289.00	-1.46	.15	-.20
<b>Psychopathological symptoms</b>						
<i>Somatization</i>	.96 (.69)	.21 (.17)	103.50	-4.56	<b>&lt;.001</b>	<b>-.62</b>
<i>Obsessive-compulsive symptoms</i>	1.97 (.64)	.27 (.21)	.00	-6.33	<b>&lt;.001</b>	<b>-.86</b>
<i>Interpersonal sensitivity</i>	1.38 (.77)	.19 (.16)	18.50	-6.02	<b>&lt;.001</b>	<b>-.82</b>
<i>Depression</i>	1.42 (.65)	.24 (.19)	21.50	-5.96	<b>&lt;.001</b>	<b>-.81</b>
<i>Anxiety</i>	.91 (.65)	.20 (.18)	95.00	-4.68	<b>&lt;.001</b>	<b>-.64</b>
<i>Hostility</i>	1.20 (.42)	.17 (.24)	44.50	-5.61	<b>&lt;.001</b>	<b>-.76</b>
<i>Phobic anxiety</i>	.39 (.42)	.03 (.06)	124.50	-4.54	<b>&lt;.001</b>	<b>-.62</b>
<i>Paranoid ideation</i>	.91 (.59)	.12 (.15)	40.00	-5.70	<b>&lt;.001</b>	<b>-.78</b>
<i>Psychoticism</i>	.63 (.50)	.10 (.16)	95.50	-4.76	<b>&lt;.001</b>	<b>-.65</b>
<i>Global Severity Index</i>	1.03 (.09)	.17 (.02)	2.00	-6.28	<b>&lt;.001</b>	<b>-.85</b>
<b>Coping</b>						
<i>Trivialization</i>	13.59 (3.36)	14.63 (3.19)	309.00	-.97	.33	-.13
<i>Downplaying own stress</i>	6.48 (3.11)	14.33 (2.90)	21.00	-5.96	<b>&lt;.001</b>	<b>-.81</b>
<i>Denial of guilt</i>	11.41 (3.50)	13.26 (2.03)	217.50	-2.57	.01	-.35
<i>Distraction</i>	8.78 (2.64)	12.67 (2.52)	109.00	-4.46	<b>.001</b>	<b>-.61</b>
<i>Substitute gratification</i>	13.19 (3.23)	13.74 (3.24)	339.50	-.44	.66	-.06
<i>Self-affirmation</i>	8.37 (3.26)	16.11 (2.52)	25.00	-5.89	<b>&lt;.001</b>	<b>-.80</b>
<i>Relaxation</i>	7.48 (3.67)	13.22 (2.74)	83.50	-4.87	<b>&lt;.001</b>	<b>-.66</b>
<i>Situational control</i>	8.52 (3.59)	16.04 (2.63)	46.00	-5.53	<b>&lt;.001</b>	<b>-.75</b>
<i>Response control</i>	8.63 (3.95)	15.19 (3.85)	81.00	4.92	<b>&lt;.001</b>	<b>-.67</b>
<i>Positive self-instructions</i>	8.74 (3.17)	15.78 (3.48)	51.00	-5.44	<b>&lt;.001</b>	<b>-.74</b>
<i>Need for social support</i>	12.30 (3.27)	13.07 (3.61)	298.50	-1.15	.25	-.16
<i>Avoidance</i>	15.78 (4.26)	11.11 (2.94)	100.00	-4.61	<b>&lt;.001</b>	<b>-.63</b>
<i>Escape</i>	16.93 (3.68)	8.59 (3.19)	34.50	-6.72	<b>&lt;.001</b>	<b>-.78</b>
<i>Social withdrawal</i>	8.81 (2.94)	8.07 (3.01)	330.00	-.60	.55	-.08
<i>Rumination</i>	18.07 (3.46)	11.11 (2.85)	19.00	-6.00	<b>&lt;.001</b>	<b>-.82</b>
<i>Resignation</i>	17.26 (3.48)	7.44 (2.92)	23.00	-5.93	<b>&lt;.001</b>	<b>-.81</b>
<i>Self-pity</i>	9.67 (2.89)	9.96 (2.30)	359.00	-.10	.92	-.01
<i>Self-blame</i>	18.00 (4.47)	9.48 (3.79)	67.00	-5.16	<b>&lt;.001</b>	<b>-.70</b>
<i>Aggression</i>	17.30 (4.33)	9.81 (2.83)	70.50	-5.10	<b>&lt;.001</b>	<b>-.69</b>
<i>Drug use</i>	5.22 (2.08)	1.70 (1.75)	85.50	-4.88	<b>&lt;.001</b>	<b>-.66</b>
<i>Positive strategies (total score)</i>	9.52 (2.21)	14.50 (2.34)	10.50	-6.13	<b>&lt;.001</b>	<b>-.83</b>
<i>Negative strategies (total score)</i>	14.79 (2.88)	9.11 (2.95)	1.00	-6.29	<b>&lt;.001</b>	<b>-.86</b>
<b>Quality of life</b>						
<i>Global</i>	14.44 (2.17)	15.63 (1.84)	254.00	-2.02	.044	-.27
<i>Physical health</i>	14.75 (2.84)	16.40 (2.41)	180.00	-3.21	<b>.001</b>	<b>-.44</b>
<i>Psychological health</i>	13.19 (3.82)	15.63 (2.21)	95.00	-4.71	<b>&lt;.001</b>	<b>-.64</b>
<i>Social relationships</i>	13.33 (2.77)	13.98 (1.97)	312.50	-.92	.36	-.13
<i>Environment</i>	14.81 (2.08)	15.65 (3.32)	284.00	-1.40	.16	-.19
<i>Life satisfaction</i>	4.37 (2.27)	7.52 (2.15)	116.50	-4.32	<b>&lt;.001</b>	<b>-.59</b>

Note. The tests remaining significant after Bonferroni correction appear in boldface.

## Psychopathological Symptoms

Significantly higher scores for ADHD patients as compared to the control group were found in all nine subscales of the SCL-90-R questionnaire (see Table 1), with effect sizes in the high range ( $r=.62-.86$ ). Additionally, a large significant group effect was calculated for the SCL-90-R Global Severity Index (GSI), again with ADHD patients showing elevated scores ( $p \leq .005$  after Bonferroni correction).

### *Coping*

In regard to the SVF, Mann-Whitney tests on the composite scores for positive and negative strategies yielded large group effects, with the healthy control group revealing higher levels of self-reported functional stress coping strategies and ADHD patients exhibiting higher scores of self-reported dysfunctional stress coping strategies (Bonferroni-corrected  $p \leq .002$ ; see Table 1). Further Mann-Whitney tests for each of the single SVF subscales revealed significant group differences on the functional strategies of downplaying own stress, distraction, self-affirmation, relaxation, situational control, response control, and positive self-instructions, in all of which the healthy control group showed significantly higher values (see Table 1). All effects were of high magnitude ( $r > .5$ ).

In contrast, ADHD patients scored significantly higher on the dysfunctional strategies of escape, rumination, resignation, and self-blame (large effects,  $r=.70-.82$ ). In regard to the four remaining subscales ADHD patients showed higher self-report levels of avoidance, aggression, and drug use (large effects,  $r=.63-.69$ ), whereas the groups did not differ in need for social support. No group differences were also detected for trivialization, denial of guilt, and substitute gratification (functional strategies) and for social withdrawal and self-pity (dysfunctional strategies).

## Quality of Life

ADHD patients reported significantly lower quality of life in the domains of psychological health (large effect) and physical health (moderate effect) of the WHOQOL-BREF, whereas both groups proved comparable with respect to quality of life in social relationships, environment, and, after Bonferroni correction of significance level ( $p \leq .008$ ), global quality of life (see Table 1). In contrast, a large group effect was found for the FPI-R life satisfaction scale, with ADHD patients reporting significantly lower satisfaction with life.

### *Attentional Measures*

The one-way MANOVA on Stroop and TMT measures yielded a significant group effect,  $F(5,48)=2.47$ ,  $p=.046$ ,  $\eta^2=.204$ . Follow-up univariate ANOVAs indicated significant group effects for the three Stroop conditions as well as for the Stroop interference effect and part B of the TMT, whereas no group differences were detected for TMT part A (see Table 2).

**Table 2**

**Attentional measures (reaction latencies in seconds,  $M \pm SD$ ) in the ADHD and control group**

Dependent Variable	M (SD)		Test Statistic			Effect Size
	ADHD (n=27)	Control (n=27)	F	df	p	$\eta^2$
Stroop color word subtest	30.33 (4.10)	28.19 (3.60)	4.15	1, 52	.047	.07
Stroop color subtest	47.74 (9.59)	42.07 (5.52)	7.08	1, 52	.01	.12
Stroop interference subtest	75.59 (13.98)	65.04 (7.36)	12.05	1, 52	.001	.19
Stroop interference effect	27.00 (.07)	22.00 (.05)	37.42	1, 52	.089	.06
TMT A	24.07 (5.02)	22.00 (3.67)	3.00	1, 52	.046	.08
TMT B	46.78 (10.71)	41.19 (9.30)	4.19	1, 52	.009	.13

**Note.** Significant univariate tests ( $p \leq .05$ ) appear in boldface.

## Exploration of Correlative Relationships Between Dependent Variables

In both groups significant positive correlations were found between the TICS chronic stress screening score and the total score for negative (dysfunctional) coping strategies as measured by the SVF (ADHD group:  $\rho=.59$ ,  $p=.001$ ; control group:  $\rho=.55$ ,  $p=.003$ ). Also, total scores for functional and dysfunctional coping strategies were significantly negatively correlated in both ADHD patients ( $\rho=-.48$ ,  $p=.012$ ) and healthy control participants ( $\rho=-.40$ ,  $p=.038$ ). Only ADHD patients showed a significant negative relationship between functional coping strategies and overall chronic stress,  $\rho=-.75$ ,  $p<.001$ .

Next, we explored the relationships between single coping strategies and global quality of life, satisfaction with life, and overall chronic stress in the patient subsample. The functional coping strategies found to be significantly correlated with global quality of life were situational control ( $\rho=.39$ ,  $p=.043$ ) and positive self-instructions ( $\rho=.38$ ,  $p=.05$ ), whereas aggression (a dysfunctional coping behavior) was negatively correlated with global quality of life ( $\rho=-.43$ ,  $p=.025$ ). A significant positive relationship was again found between response control and life satisfaction ( $\rho=.56$ ,  $p=.003$ ). On the other hand, substitute gratification turned out to be significantly and negatively correlated with life satisfaction ( $\rho=-.39$ ,  $p=.46$ ) in ADHD patients.

The following functional coping strategies showed strong inverse relationships with the TICS chronic stress screening subscale: attitude of downplaying own stress ( $\rho=-.57$ ,  $p=.002$ ), denial of guilt ( $\rho=-.44$ ,  $p=.022$ ), distraction ( $\rho=-.71$ ,  $p<.001$ ), self-affirmation ( $\rho=-.39$ ,  $p=.04$ ), relaxation ( $\rho=-.65$ ,  $p<.001$ ), situational control ( $\rho=-.56$ ,  $p=.002$ ), response control ( $\rho=-.72$ ,  $p<.001$ ), and positive self-instructions ( $\rho=-.60$ ,  $p=.001$ ). Furthermore, the coping strategy of avoidance also showed a significant



inverse relationship with chronic stress ( $\rho = -.42$ ,  $p = .032$ ). In contrast, only the dysfunctional coping strategies of resignation ( $\rho = .45$ ,  $p = .019$ ) and self-blame ( $\rho = .51$ ,  $p = .007$ ) proved to be significantly and positively correlated with chronic stress in the patient subsample. Additionally, ADHD patients with higher levels in self-reported aggressive coping behavior also showed higher values in the TICS chronic stress screening scale ( $\rho = .51$ ,  $p = .007$ ).

For the attentional measures, only the avoidance coping strategy had a significant positive relationship with the Stroop interference subtest reaction time ( $\rho = .39$ ,  $p = .047$ ). Furthermore, a statistical trend ( $p < .10$ ) was observed for the positive correlation between avoidance and the Stroop interference effect ( $\rho = .33$ ,  $p = .098$ ). Other correlations did not reach significance.

## Discussion

The present study investigated self-reported chronic stress, psychopathological symptoms, stress-coping behavior and quality of life as well as objective measures of selective and divided attention in adult ADHD patients in comparison with a healthy control group. Correlational patterns between the dependent variables were also examined. In line with our hypotheses, the ADHD subgroup experienced higher global levels of chronic stress in everyday life, a pattern that was also evident in the specific domains of work overload, excessive demands at work, pressure to succeed, lack of social recognition, social tension, and chronic worry. As expected, group differences were also found for everyday impairment through psychopathological symptoms, with ADHD patients again reporting higher levels, whereas both groups did not differ in regard to recent life events. In line with our assumptions, ADHD patients used less positive (functional) and more negative

(dysfunctional) coping strategies when faced with everyday stressors, both being associated with higher levels of perceived chronic stress. A more detailed inspection of group differences in specific coping techniques revealed deficits of the ADHD subgroup in regard to several functional, emotion-focused and problem-solving coping strategies, among them distraction, relaxation, situational control, response control, and positive self-instructions. In contrast, these individuals reported high degrees of dysfunctional rumination, resignation, escape, and self-blame in response to stressful situations. Interestingly, chronic stress was significantly higher in those ADHD patients who reported even lower levels of downplaying of own stress, denial of guilt, distraction, self-affirmation, relaxation, situational and response control, and positive self-instructions, and higher levels of resignation, aggressive coping behavior, and self-blame.

Our data also confirmed reduced domain-specific quality of life (psychological and physical health) in the patient subsample, as well as attenuated life satisfaction. Contrary to our assumptions, no significant group differences were found for global quality of life after significance level correction. However, functional coping strategies in general were significantly associated with both quality of life and life satisfaction. Specifically, ADHD patients with higher self-reported situational control, positive self-instructions, and response control perceived higher levels of global quality of life and life satisfaction. In regard to dysfunctional coping, increased levels of aggressive behavior were associated with lower global quality of life in the patient subsample.

As assumed, both subgroups also differed with respect to measures of selective and divided attention, although in subsequent correlational analyses our hypotheses remained largely unsupported, which may be due to the small sample size and the resulting lack of statistical power to detect small effects in the study sample. Alternatively, the attentional tests used in this study may have been

inappropriate to measure the specific cognitive deficits which are associated with heightened levels of dysfunctional coping behavior.

The presented results indicate that adult ADHD patients experience elevated levels of impairment due to specific everyday stressors, but that they do not differ from the control group with regard to number and impact of life events during the past year. These findings are consistent with anecdotal reports and theoretical models of ADHD (Barkley, 1997; Wender, 1995). They are also in line with the previous finding of significantly elevated perceived stress in adult ADHD patients in response to a standardized laboratory stress paradigm (Lackschewitz et al., 2008), thus corroborating the relevance of these earlier experimental findings for real-life stressors. Furthermore, the general study outcome of heightened dysfunctional coping and simultaneous deficits in functional, stress-reducing coping behavior in ADHD patients mirror the findings of previous investigations in ADHD children (e.g., Braaten and Rosén, 2000; Hampel and Desman, 2006; Hampel et al., 2008). They are also seemingly in line with the elevated degree of aggressive coping behavior found in college students with ADHD in specific stressful situations (Richards et al., 2002) and the deficiency in functional task-oriented coping in a sample of female ADHD patients reported by Rucklidge and Kaplan (1997). However, to our knowledge the present study is the first to simultaneously investigate self-reported stress and coping behavior towards a wide range of everyday stressors in a sample of male and female ADHD patients in comparison with a healthy control group, and to connect the results with attentional measures and quality of life measures. To enhance the validity of the results, we employed an elaborate stepwise diagnostic procedure, including DSM-IV axis I and II differential diagnoses, as well as strict adherence to DSM-IV criteria for ADHD.

With regard to clinical implications, the present study provides preliminary support for the incorporation of stress management techniques in multimodal psychosocial interventions for adult ADHD patients. Special clinical relevance stems from the finding of associations between specific coping techniques, quality of life, and life satisfaction in the ADHD subsample. It was particularly striking that ADHD patients reported using those functional coping strategies that appeared to be positively associated with their quality of and satisfaction with life, only to a small degree. In general, the present results indicate that adult ADHD patients, in comparison with healthy controls, not only have a narrower range of functional strategies available for coping with stressful situations, but they also use them less frequently. Instead, they largely rely on specific potentially stress-aggravating responses to everyday stressors, e.g. aggressive behavior, resignation, or self-blame. Because successful and adaptive coping is characterized by the ability to choose from a broad variety of stress-reducing strategies of different modes and functions and to apply these techniques in a flexible manner to varying situational demands (Kaluza, 2000; Young, 2005), the present results indicate that interventions targeted at expanding the functional emotion-focused and task-oriented coping repertoire of adult ADHD patients are of particular importance, as is the practice of employing these new techniques meaningfully and flexibly under stressful conditions. Faced with real-life stressors, ADHD patients may often need to reduce their emotional hyperreactivity as a prerequisite to accessing and applying active problem-directed coping strategies, such as information seeking, planning, and taking action towards the stressor. Interestingly, a recent feasibility study with adult ADHD patients (Zylowska et al., 2008) showed improvements in self-reported ADHD symptoms after completion of an 8-week mindfulness training program, as well as better attentional test performance, although measures of perceived stress and coping were not

included. Other authors have included mindfulness strategies as well as stress management elements in a comprehensive group therapy program for adults with ADHD (Hesslinger et al., 2002).

It should be noted, however, that the ADHD patients in our study did not exhibit a generalized deficiency in functional coping strategies. In contrast, they were comparable to healthy controls with respect to denial of guilt, trivialization, substitute gratification, and need for social support. Although a self-report bias cannot be completely excluded, e.g. in regard to social support, adult ADHD patients may very well have developed some functional coping competencies over the course of their disorder. These should be identified and used as valuable resources in the context of intervention. In this sense, a meaningful treatment should aim at balancing ADHD patients' initial coping profiles and at compensating their specific deficits while building on their strengths.

The findings need to be considered in the light of several limitations of the study. As already mentioned, the sample size was small, thereby reducing statistical power to detect small effects. Nevertheless, we were able to discover several (moderate to large) group effects in the dependent variables. An analysis differentiating ADHD subtypes would have been desirable but was not possible, again because of the small sample size, in which only one participant was diagnosed with ADHD of the predominantly hyperactive/impulsive subtype. Second, the study's self-referred and self-selected ADHD subsample may not be representative of all ADHD adults in the community or in clinical settings. It also must be taken into account that all patients received their diagnosis during adulthood, necessitating a childhood retrospective diagnosis which relied heavily on recall of ADHD symptoms and impairment during childhood. Because comorbid conditions have been shown to be common in adult ADHD patients (e.g. Fayyad et al., 2007), we allowed for

comorbid disorders in the patient subgroup, thereby increasing the results' external validity. However, the internal validity of the study was simultaneously reduced, because it cannot be ruled out that the demonstrated effects may be partially attributable to other psychiatric conditions than ADHD. Again because of the small sample size an inclusion of covariates or testing for mediational effects was not feasible, but should be considered for future research. Furthermore, the study did not include a psychiatric control group, which would have allowed for conclusions about the specificity of the observed effects for adult ADHD patients. As the stress experience and coping patterns of adults with ADHD, although an important topic in theoretical models of the disorder as well as in unsystematic self-reports from ADHD patients, have been widely neglected in empirical research, the present investigation aimed solely at the assessment of chronic stress and coping in adult ADHD patients, without the pretension for the results to apply exclusively to patients with this specific psychiatric disorder. However, the replication of the reported results and comparison with other psychiatric disorders is clearly a necessary step for future research.

With regard to study design, it must also be pointed out that, given the cross-sectional nature of the investigation, it is not possible to establish causal relationships between the dependent variables. Finally, the results are largely based on self-report questionnaires. Especially with respect to daily life subjective stress experiences and coping behavior, it seems desirable to complement these measures and validate their accuracy, e.g. through diary methods or in-the-moment assessments of stress level and coping efforts (Knouse et al., 2008). It should be noted, however, that previous studies have shown the stress-coping questionnaire (SVF120) to be predictive of coping with naturally occurring stressors in healthy individuals (e.g. Trempa, Janke, & Weyers, 2002).

## **Conclusion**

In summary, the present study reaffirms the clinical relevance and practical importance of addressing issues of stress and coping in ADHD research as well as in the treatment of adult ADHD patients. The reported findings provide support for the assumption of heightened subjective stress in everyday life and impairments in functional coping competencies in adult ADHD patients, thereby corroborating the theoretical model of general deficits in behavioral inhibition and self-regulation presented by Barkley (1997). At the same time, the presented empirical evidence raises interesting questions, pointing at a potentially deleterious impact of chronic stress on life satisfaction of adults with ADHD, a potentially stress-reducing or stress-buffering effect of functional coping strategies on chronic stress, and the importance of specific stress-reducing strategies for subjective quality of life, thus emphasizing the relevance of tailored psychosocial interventions based on the specific deficits and competencies in coping behavior found in adult ADHD patients. Future studies are advised to investigate larger patient samples, analyse potential differences with regard to DSM-IV ADHD subtypes, and control for comorbid psychiatric disorders in ADHD patients, as well as investigate the specificity of the presented results through comparison with other psychiatric patient groups. Furthermore, associations of stress and coping variables with attentional deficits should be explored more comprehensively, and implementation of methodological designs for the testing of causal relationships between subjective stress, coping strategies, and quality of life is recommended.

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#### **4. Diskussion**

Insgesamt konnte mit den hier vorgestellten Originalarbeiten gezeigt werden, dass Erwachsene mit einer nach DSM-IV-Kriterien gestellten ADHS-Diagnose sowohl gegenüber einem standardisierten psychosozialen Laborstressor als auch hinsichtlich der Begegnung mit Alltagsstressoren mit einem im Vergleich zu gesunden Kontrollpersonen signifikant erhöhten subjektiven Stresserleben reagieren. Während der erste Artikel überdies einige Abweichungen in physiologischen Stressparametern in der Patientenstichprobe beschreibt, konnten in der zweiten Originalarbeit Unterschiede im selbstberichteten Coping mit Alltagsstressoren sowie Unterschiede hinsichtlich Lebenszufriedenheit, Lebensqualität und Maßen der selektiven und geteilten Aufmerksamkeit zwischen erwachsenen ADHS-Patienten und gesunden Kontrollprobanden objektiviert werden.

Die Ergebnisse der Laborstudie zeigten erstmals für eine gemischtgeschlechtliche Stichprobe erwachsener ADHS-Patienten ein erhöhtes Stresserleben bei gleichzeitig verminderter Ausprägung autonomer Stressmaße in der Stresssituation selbst. Überdies nahmen diese Patienten bereits die Antizipation des Stressors als belastender wahr, und sie hatten größere Schwierigkeiten, sich von der Stressexposition psychisch zu erholen. Hinsichtlich der Reagibilität der HPA-Achse (Cortisolspiegel im Speichel) wurde lediglich ein Trend beobachtet, dessen Prüfung an einer größeren Stichprobe wünschenswert erscheint. Die aus den Theoriemodellen von Barkley (1997) und Quay (1997) abgeleiteten Annahmen konnten mit diesen Befunden in weiten Teilen bestätigt werden.

In der zweiten Arbeit wurde der Frage nachgegangen, inwieweit die zuvor im Labor beobachteten höheren Ausprägungen im subjektiven Stresserleben von

ADHS-Patienten als relevant für die Stresswahrnehmung im Alltag angesehen werden können. Es fanden sich in ausgewählten Stressorendomänen wiederum erhöhte Werte in der Patientengruppe, wie auch ein verminderter Umfang funktionalen Copings und ein vermehrtes dysfunktionales Coping im Umgang mit Alltagsstressoren. Überdies wurden ungünstige Assoziationen der bei den ADHS-Patienten gefundenen Stresserlebensmuster und Copingstrategien mit Maßen der Lebenszufriedenheit und –qualität gefunden. Hinsichtlich der verwendeten Aufmerksamkeitsmaße fanden sich zwar überwiegend signifikante Gruppenunterschiede, jedoch kaum signifikante Korrelationen mit dem selbstberichteten Copingverhalten. Hier wäre ein möglicher Grund in der Stichprobengröße zu sehen. Alternativ besteht die Möglichkeit, dass die verwendeten Aufmerksamkeitstests nicht die spezifischen Defizite erfasst haben, die eine Relevanz für das Copingverhalten aufweisen.

Der ebenfalls in dieser Studie berichtete Befund, wonach ADHS-Patienten gegenüber gesunden Kontrollprobanden keine generalisierten Coping-Defizite zeigen, sondern beispielsweise im Bedürfnis nach sozialer Unterstützung Letzteren vergleichbar sind, könnte interessante Hinweise für ressourcenorientierte psychosoziale Behandlungsansätze bieten, sollte er sich in Replikationsstudien bestätigen. Gleichzeitig ist zu beachten, dass die hier rekrutierte Stichprobe selbstselektierter ADHS-Patienten möglicherweise über mehr soziale Ressourcen verfügt, d.h. sich für die Untersuchung vorrangig solche Patienten interessiert und gemeldet haben könnten, die vergleichsweise gute soziale Ressourcen besitzen. Auch vor diesem Hintergrund kann aus den Ergebnissen zunächst keine generelle Aussage zu Copingressourcen von Erwachsenen mit ADHS in der Allgemeinbevölkerung abgeleitet werden.

Zusammenfassend betrachtet untermauern die dargestellten Befunde einen Großteil der aus der Theorie der ADHS von Barkley (1997) und den korrespondierenden theoretischen Annahmen von Quay (1997) ableitbaren Hypothesen zu Stressempfinden und –reagibilität bei ADHS-Patienten wie auch die anekdotischen und unsystematischen Selbstberichte dieser Patientengruppe aus der Literatur. Überdies erscheint in der Zusammenschau das von Wender (1995) zusätzlich postulierte Störungskriterium der Stressintoleranz an Relevanz zu gewinnen: Da nach Barkley (1997) von einem allgemeinen Defizit der Inhibition und in der Folge der Selbstregulation bei Patienten mit ADHS auszugehen ist, welches die Kernpathologie der Störung darstellt und ihren diversen klinischen Symptommanifestationen zugrunde liegt, erscheint es sinnvoll, für die Merkmale einer verminderten Stresstoleranz und eines dysfunktionalen stressbezogenen Copings den Status zusätzlicher Symptomkriterien in Erwägung zu ziehen. Bei der Ableitung entsprechender Aussagen aus den hier präsentierten Ergebnissen ist jedoch wiederum zu berücksichtigen, dass der untersuchte Stichprobenumfang und damit die statistische Power der Studie gering war. Eine Replikation an einer größeren und repräsentativen Stichprobe von ADHS-Patienten, die auch eine Analyse möglicher Unterschiede zwischen den Subtypen der ADHS erlaubt, erscheint in diesem Lichte wünschenswert. Ein weiterer wichtiger Schritt ist die Gegenüberstellung nicht nur mit einer Kontrollgruppe gesunder Probanden, sondern zusätzlich mit Patienten mit anderen psychischen Störungen, um so Hinweise zur Spezifität der beobachteten Abweichungen zu gewinnen. Unabhängig von einer möglichen Spezifität sollte jedoch berücksichtigt werden, dass ein verstärktes Stresserleben und verminderte Copingkompetenzen von erwachsenen ADHS-Patienten eine Relevanz für die Konzeption von Behandlungsprogrammen haben können, sollten sie sich in nachfolgenden Studien bestätigen. Um diesbezüglich

weitere Erkenntnisse zu gewinnen, sollten künftige Studien zusätzliche Untersuchungsmethoden hinzuziehen, etwa die Erhebung von Stresserleben und Coping im Alltag mittels Tagebuchmethoden (z.B. computergestützte Experience-Sampling-Verfahren, vgl. Knouse et al., 2008). Auch aus theoretischer Sicht wäre die Messung physiologischer Stressparameter in alltäglichen Stresssituationen interessant, wiewohl hier der Einfluss potenzieller Störfaktoren (z.B. Bewegungsartefakte bei autonomen Parametern) erhebliche methodische Probleme aufwerfen dürfte.

Der oftmals anzutreffenden (und häufig impliziten) Auffassung, wonach Stressbewältigung per se ein sinnvoller Behandlungsbaustein für Patienten mit psychischen Störungen und insbesondere für erwachsene ADHS-Patienten sei (Hesslinger, van Elst, Nyberg, Dykieriek, Richter, et al., 2002; Ramsay & Rostain, 2007; Zylowska, Ackerman, Yang, Futrell, Horton, et al., 2008), setzen die vorliegenden Untersuchungen erste Ergebnisse entgegen, mit der die Vermutung eines erhöhten subjektiven Stresserlebens und dysfunktionalen Copings dieser Patienten Klientel auf eine empirische Grundlage gestellt werden kann. Eine zusätzliche Bedeutung erhalten diese Daten durch die gefundenen Zusammenhänge mit der Lebenszufriedenheit und –qualität. Für die Diagnostik wurde in den Studien ein sorgfältiges Vorgehen mit strenger Orientierung an den DSM-IV-Kriterien bei Verwendung umfassender strukturierter klinischer Interviews sowie ergänzender Fragebogeninstrumente gewählt. Die Diagnosestellung entsprach damit in wesentlichen Teilen den Leitlinien der Deutschen Gesellschaft für Psychiatrie, Psychotherapie und Nervenheilkunde (DGPPN; Ebert, Krause, & Roth-Sackenheim, 2003) und ist hierin vielen früheren und aktuellen Studien zur ADHS im Erwachsenenalter überlegen. Hinsichtlich einer möglichen Relevanz für klinische Behandlungsansätze müssen die Befunde aufgrund der beschriebenen

Einschränkungen als vorläufig betrachtet werden. Zukünftige Studien sollten hier anknüpfen, um auf diese Weise nicht nur die theoretischen Modelle zum Störungsbild einer weiteren Prüfung zu unterziehen. Gleichzeitig sind hierdurch potenziell Hinweise für die Ausgestaltung von psychosozialen Behandlungsmaßnahmen zum Stressmanagement bei dieser Patientenklientel zu gewinnen. Diese wiederum wären in einem nächsten Schritt einer systematischen Evaluation zu unterziehen, um den Betroffenen langfristig eine Perspektive auf ein angepasstes und empirisch begründetes Interventionsangebot im Bereich des stressbezogenen Copings zu eröffnen.

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