



Psychophysiologische und subjektive Korrelate aversiver und appetitiver Reizverarbeitung im Menschen und die Rolle interindividueller Unterschiede

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Zusammenfassung

Die vorliegende Dissertation befasst sich mit interindividuellen Unterschieden in der Verarbeitung aversiver und appetitiver Reize. Durch die Zusammenhänge zwischen Abweichungen in der Reizverarbeitung und psychischer Gesundheit können Ansätze für klinische Interventionen erarbeitet werden. Im Rahmen dieser Dissertation wurden drei zentrale Prozesse der Reizverarbeitung untersucht: die kognitive Verarbeitung emotionaler Reize, deren Verzerrungen mit der Entwicklung von Depressionen assoziiert werden, das affektive Lernen, das oftmals als Störungsmodell für Suchterkrankungen herangezogen wird und die Reaktion auf akute Stressreize als relevanten Einflussfaktor für die Entstehung vieler klinischer Krankheitsbilder. Besondere Berücksichtigung fand hierbei die Betrachtung der Rolle der habituellen Angstbewältigung, da ein repressiver Bewältigungsstil mit einer erhöhten Prävalenz zahlreicher stressbedingter Erkrankungen assoziiert wird. Zur Untersuchung dieser Faktoren wurden drei aufwendige Studien durchgeführt, bei denen verschiedene physiologische Maße, wie elektrodermale Aktivität und Herzaktivität, subjektive Ratings, sowie implizite Maße zur Erfassung kognitiver Verzerrungen zum Einsatz kamen. Die Ergebnisse der Studien deuten darauf hin, dass interindividuelle Unterschiede in allen betrachteten Prozessen der Reizverarbeitung eine Rolle spielen. In Studie I zeigte sich, dass habituelle Angstbewältigung die automatischen Handlungstendenzen gegenüber positiven Reizen beeinflussen kann, wobei Represser eine verstärkte Annäherungstendenz beobachten ließen. Dies deutet darauf hin, dass kognitive Verzerrungen möglicherweise prinzipiell und nicht nur gegenüber negativen Reizen maladaptiv sein könnten. Studie II konnte zeigen, dass appetitive Konditionierung zu vergleichbaren kardialen CRs führen kann, wie aversive Konditionierung und liefert damit ein neues peripherphysiologisches Maß für CRs in appetitiven Konditionierungsparadigmen. Darüber hinaus lieferte die Studie Hinweise auf einen Zusammenhang zwischen appetitiven und aversiven CRs auf subjektiver, jedoch nicht auf physiologischer Ebene. In Studie III konnte unter nicht-sozialem Stress keine von Repressern bekannte veränderte Stressreaktion in Form einer abgeschwächten subjektiven Stresswahrnehmung und einer verstärkten physiologischen Stressreaktion beobachtet werden. Dies deutet darauf hin, dass diese Reaktion möglicherweise vorrangig durch sozialen Stress ausgelöst werden könnte. Insgesamt liefern die Ergebnisse Hinweise darauf, dass interindividuelle Unterschiede eine Rolle bei der emotionalen Reizverarbeitung spielen könnten. Implikationen für Theorie und Praxis werden diskutiert.

Inhalt

Abkürzungsverzeichnis	1
I PRÄAMBEL.....	2
II THEORETISCHE EINFÜHRUNG	4
1 Grundlagen emotionaler Reizverarbeitung.....	4
1.1 Kognitive Verarbeitung	4
1.2 Affektives Lernen.....	5
1.3 Stressverarbeitung	7
1.4 Die Rolle interindividueller Unterschiede.....	8
2 Ziele und Forschungsfragen.....	10
2.1 Fragestellung I: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und kognitiven Verzerrungen bei der Verarbeitung emotionaler Stimuli?.....	10
2.2 Fragestellung II: Welcher Zusammenhang besteht zwischen konditionierten Reaktionen bei aversiver und appetitiver Konditionierung?.....	11
2.3 Fragestellung III: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und akuten Stress- und Entspannungsreaktionen?.....	12
III ZUSAMMENFASSUNG DER STUDIEN.....	13
3 Studie I: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und kognitiven Verzerrungen bei der Verarbeitung emotionaler Stimuli? (Exner, Machulska et al., 2023)	13
3.1 Methode.....	13
3.2 Ergebnisse	14
3.3 Konklusion	15
4 Studie II: Welcher Zusammenhang besteht zwischen konditionierten Reaktionen bei aversiver und appetitiver Konditionierung? (Exner et al., 2021)	15
4.1 Methode.....	15
4.2 Ergebnisse	16
4.3 Konklusion	17
5 Studie III: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und den Reaktionen auf akuten Stress und anschließende Entspannung? (Exner, Kampa et al., 2023)....	18

5.1 Methode.....	18
5.2 Ergebnisse	19
5.3 Konklusion	20
IV ZUSAMMENFASSENDE DISKUSSION	21
6 Zusammenfassung der Ergebnisse	21
7 Implikationen für Theorie und Praxis	22
8 Limitationen und Ausblick.....	24
9 Konklusion.....	26
Literaturverzeichnis.....	27
Anhang	
Anhang A	
Anhang B	
Anhang C	
Anlage zur Dissertationsschrift	

Abkürzungsverzeichnis

AAT	Approach-Avoidance-Task
CR	konditionierte Reaktion
CS	konditionierter Stimulus
CS+	konditionierter Stimulus, der mit dem Auftreten des UCS gepaart wird
CS-	konditionierter Stimulus, der mit dem Ausbleiben des UCS gepaart wird
EDA	elektrodermale Aktivität
EKG	Elektrokardiogramm
engl.	Englisch
HP	Herzperiode
HR	Herzrate
HRV	Herzratenvariabilität
ABI	Angstbewältigungsinventar
MMST	Mannheimer Multikomponenten-Stresstest
Non-UCS	neutraler Kontrollreiz zu dem unkonditionierten Stimuli
SCR	Hautleitfähigkeitsreaktion; engl. skin conductance response
SAM	Self-Assessment Manikin
SD	Standardabweichung; engl. standard deviation
SEM	Standardfehler des Mittelwertes; engl. standard error of the mean
UCR	unkonditionierte Reaktion
UCS	unkonditionierter Stimulus

I PRÄAMBEL

Die Prozesse, die der Wahrnehmung und der Verarbeitung emotionaler Reize, sowie den Reaktionen auf diese Reize zugrunde liegen, sind seit langer Zeit Gegenstand psychologischer Grundlagenforschung. Sie sind nicht nur elementar für das alltägliche menschliche Leben, sondern auch von Bedeutung für die psychische Gesundheit. Das gesamte Reizverarbeitungssystem sowohl aversiver als auch appetitiver Reize ist dabei von interindividuellen Unterschieden geprägt. Kognitive Verzerrungen gegenüber bestimmten emotionalen Reizen (Loijen et al., 2020), maladaptives Verhalten auf Stressreize (O'Connor et al., 2021) und Veränderungen affektiver Lernprozesse (Martin-Soelch et al., 2007; Schweckendiek et al., 2011) wurden als zentrale Faktoren bei der Entstehung, Aufrechterhaltung und Behandlung psychischer Störungen wie beispielweise Angststörungen, Sucht und Depression identifiziert.

Psychotherapeutische Behandlungsansätze zielen oft darauf ab, diesen maladaptiven Komponenten in der Reizverarbeitung entgegenzuwirken. Sowohl das gezielte Einsetzen von Konditionierungsprozessen (Lewinsohn, 1974), die Veränderung kognitiver Verzerrungen (Beard, 2011; MacLeod & Mathews, 2012) als auch das Erlernen von Entspannungstechniken zur Stressreduktion (Dharmawardene et al., 2016; Khoury et al., 2015) stellen bewährte Therapieansätze dar. Neuere Ansätze der Psychotherapie zielen zudem auf individualisierte Behandlungen ab, um den Besonderheiten einzelner Personen(gruppen) optimal gerecht werden zu können (Cuijpers et al., 2016). Eine repressive Angstbewältigung (z. B. gekennzeichnet durch das Vermeiden negativer Gedanken) hat sich als ein möglicher Vulnerabilitätsfaktor für die Entwicklung stressbedingter Erkrankungen herausgestellt (Mund & Mitte, 2012; Myers, 2010) und charakterisiert damit eine Personengruppe die therapeutisch von besonderer Bedeutung ist.

Im Rahmen dieser Dissertation werden drei zentrale Prozesse der aversiven und appetitiven Reizverarbeitung untersucht: Es werden (1) interindividuelle Unterschiede in der kognitiven Verarbeitung emotionaler Reize (Exner, Machulska et al., 2023) und (2) in der Reaktion auf Stress (Exner, Kampa et al., 2023), sowie (3) die Reaktion auf Hinweisreize für aversive und appetitive Stimuli (Exner et al., 2021) betrachtet. Im Rahmen dieser drei aufwendigen Studien kamen verschiedene Maße peripherphysiologischer Reaktionen (Elektrodermale Aktivität, Herzaktivität, Blutdruck), subjektiver Ratings, sowie impliziter Maße kognitiver Verarbeitung (Approach-Avoidance-Task, Dot-Probe-Task) zum Einsatz, um die verschiedenen Schritte in der Verarbeitungskette emotionaler Reize zu untersuchen.

Nach einer grundlegenden Einleitung in das Themengebiet der Verarbeitung motivational-affektiver Reize folgt eine Darstellung der theoretischen Hintergründe der drei in der Dissertation bearbeiteten Fragestellungen. Im Anschluss folgt eine methodische Darstellung der Studien und der zentralen Ergebnisse. Die Dissertation schließt mit einer einordnenden und zusammenführenden Diskussion der Befunde in den Forschungskontext, einer Erörterung von Implikationen für die Grundlagenforschung und die klinische Praxis und einem Ausblick auf zukünftige Forschung.

II THEORETISCHE EINFÜHRUNG

1 Grundlagen emotionaler Reizverarbeitung

Viele Modelle zur Emotionsverarbeitung gehen davon aus, dass bedeutsame Reize durch eines von zwei gegenläufig arbeitenden Motivationssystemen verarbeitet werden (Lang, 1995; Lang & Bradley, 2010; Lang et al., 1998): Während das appetitive System auf angenehme Reize (z. B. Nahrung) reagiert und Annäherungsverhalten (z. B. Nahrungsaufnahme) auslöst, reagiert das defensive System auf aversive Reize (z. B. Raubtiere) und steuert Vermeidungsverhalten (z. B. Flucht). Lang und Kollegen (1995; 1998) nehmen an, dass die beiden Motivationssysteme von zwei sequentiellen Prozessen gesteuert werden. Der erste Prozess beschreibt die Ausrichtung der Aufmerksamkeit auf einen aversiv oder appetitiv bedeutsamen Hinweisreiz (Bradley, 2009), gesteuert durch die physiologische und psychologische Erregung, die er hervorruft (Lang & Bradley, 2010; Russell et al., 1989). Der zweite Prozess beinhaltet die Vorbereitung eines expliziten, dem spezifischen Reiz angemessenen Verhaltens und entscheidet damit, welches der Systeme aktiviert wird (Löw et al., 2008; Löw et al., 2015).

Im Rahmen dieser Dissertation werden drei zentrale Prozesse aus diesem System herausgegriffen und untersucht: (1) die kognitive Verarbeitung, (2) das affektive Lernen, sowie (3) die Stressverarbeitung.

1.1 Kognitive Verarbeitung

Die Tendenz, eine bestimmte Art von Informationen bevorzugt zu verarbeiten, variiert stark von Person zu Person (Broeren & Lester, 2013). Während die bevorzugte Verarbeitung positiver Informationen als Resilienzfaktor für das psychische Wohlbefinden gilt (Heuer et al., 2007; Joormann & Gotlib, 2007; Joormann et al., 2007; Rinck & Becker, 2007), gibt es Hinweise darauf, dass die bevorzugte Verarbeitung negativer Stimuli die Entwicklung psychischer Erkrankungen wie Depressionen begünstigen könnte (Radke et al., 2014; Struijs et al., 2017; Trew, 2011).

Die Aufmerksamkeit wird heute als ein Schlüsselprozess der menschlichen Reizverarbeitung betrachtet, durch den das Gehirn das Denken, Verhalten und Handeln steuert (Mishra, 2015). Die Tendenz, bestimmten Reizen bevorzugt Aufmerksamkeit zu schenken, scheint dabei einen starken Einfluss auf die psychische Gesundheit zu haben: Es gibt Hinweise darauf, dass Suchterkrankungen mit einer Aufmerksamkeitsverzerrung für suchtbezogene Hinweisreize (Begh et al., 2016; Marissen et al., 2006) und Angststörungen mit einer Aufmerksamkeitsverzerrung für furchtinduzierende Stimuli einhergehen könnten (Pfabigan & Tran, 2015; Sagliano

et al., 2014). Eines der wichtigsten Paradigmen zur Messung von Aufmerksamkeitsverzerrungen ist die Dot-Probe-Task (MacLeod et al., 1986), die auch im Rahmen dieser Dissertation Verwendung findet. Bei dieser Aufgabe wird die Aufmerksamkeit für bestimmte Reizkategorien gemessen, indem wiederholt zwei Stimuli (ein Zielreiz, z. B. ein aversives Bild und ein Referenzreiz, z. B. ein neutrales Bild) für eine kurze Zeit nebeneinander präsentiert werden. Anschließend verschwinden beide Stimuli, und ein Testreiz wird anstelle eines Reizes präsentiert. Die Reaktionszeit für das Erkennen der Position des Testreizes soll Aufschluss über Aufmerksamkeitspräferenzen geben. Schnellere Reaktionszeiten für Testreize, die eine bestimmte Kategorie von Reizen (z. B. bedrohungsbezogene Stimuli) ersetzen, deuten dabei auf eine erhöhte Aufmerksamkeit für diese Reizkategorien hin (MacLeod et al., 1986).

Automatische Handlungstendenzen in Form von Annäherungs- oder Vermeidungstendenzen gegenüber bestimmten Reizkategorien sind ein weiterer wichtiger Schritt in der Reizverarbeitung. Auch kognitive Verzerrungen in diesem Prozess könnten laut aktueller Studien einen Einfluss auf die Entwicklung und Aufrechterhaltung verschiedener psychischer Störungen haben (Loijen et al., 2020; Mogg et al., 2005; Rinck & Becker, 2007). Beispielsweise gibt es Hinweise darauf, dass das Vorhandensein einer Annäherungsverzerrung für substanzbezogene Stimuli in subklinischen Populationen ein Risikofaktor für einen erhöhten zukünftigen Substanzkonsum sein könnte, während bei Depressionen teilweise eine verringerte Annäherung an positive Stimuli und eine verringerte Vermeidung negativer Stimuli beobachtet wurde (Loijen et al., 2020). Ein zentrales Maß zur Erfassung dieser impliziten Handlungstendenzen ist der Approach-Avoidance-Task (AAT; Rinck & Becker, 2007), der in dieser Dissertation Verwendung findet. Der AAT misst Annäherungs- und Vermeidungstendenzen, indem die Versuchspersonen angewiesen werden, eine Annäherungsbewegung (z. B. Ziehen eines Joysticks) oder eine Vermeidungsbewegung (z. B. Wegdrücken eines Joysticks) als Reaktion auf leicht gedrehte Bilder auszuführen, die nacheinander auf einem Computerbildschirm präsentiert werden (z. B. Ziehen bei Rechtsdrehung, Schieben bei Linksdrehung). Im Allgemeinen gilt eine kürzere Reaktionszeit beim Ziehen oder Schieben bestimmter Bilde als Hinweis auf eine Annäherungs- bzw. Vermeidungstendenz gegenüber der entsprechenden Bildkategorie (Strack & Deutsch, 2004).

1.2 Affektives Lernen

Das Vorhersagen von Gefahren oder belohnenden Reizen, und damit das Erkennen von Hinweisreizen stellt evolutionär betrachtet einen entscheidenden Vorteil für das Überleben von

Individuen dar. Diese Art des affektiven Lernens kann als klassische Konditionierung beschrieben werden: Ein vormals neutraler Reiz erlangt durch wiederholte Paarung mit einem affektiv bedeutsamen Reiz (unkonditionierter Reiz, UCS) eine gewisse Vorhersagekraft für das Auftreten dieses UCS und damit selbst eine affektive Bedeutung (Cox et al., 2005; Delgado et al., 2006; Fendt & Fanselow, 1999; Lipp et al., 1994; O'Doherty et al., 2004; Phelps et al., 2001). Konditionierungsprozesse scheinen darüber hinaus eine große Bedeutung für die psychische Gesundheit zu haben: Während sich bei Angstpatienten teilweise verstärkte Konditionierungsprozesse auf Furchtreize beobachtet wurden (Lissek et al., 2005), kann das Auslösen des Bedürfnisses nach Suchtmittelkonsum durch vormals neutrale Reize bei Suchterkrankungen durch appetitive Konditionierungsprozesse erklärt werden (Martin-Soelch et al., 2007). Ein etabliertes Verfahren zur Untersuchung klassischer Konditionierungsprozesse stellen differenzielle Konditionierungsparadigmen dar, die auch in dieser Dissertation Verwendung finden. Dabei wird ein konditionierter Reiz (CS+) mit dem UCS gepaart, während ein anderer CS (CS-) die Abwesenheit des UCS voraussagt. Der CS+ löst somit anschließend eine ähnliche Reaktion wie der UCS aus (konditionierte Reaktion; CR) (Bechara et al., 1995; Büchel et al., 1998; Cohen et al., 2009; Cox et al., 2005; Delgado, 2007; Labar et al., 1998; Rolls, 2000), anhand derer das Erlernen einer Assoziation analysiert werden kann. Etabliert ist die Analyse auf zwei Ebenen: Auf der subjektiven Ebene auf den Dimensionen Valenz und Arousal unter Verwendung von non-verbalen Bildskalen (Bradley & Lang, 1994) und auf der physiologischen Ebene z. B. anhand von Veränderungen in der elektrodermalen Aktivität (EDA) oder der Herzaktivität. Während der CS+ bei der Verwendung von furchtinduzierenden UCS üblicherweise eine stärkere elektrodermale Reaktion (engl. skin conductance response, SCR) hervorruft als der CS- (Lonsdorf et al., 2017), finden nur einige Studien ohne Furchtinduktion Hinweise auf differentielle CRs (Andreatta & Pauli, 2015; Austin & Duka, 2010; Ebrahimi et al., 2019; Hermann et al., 2000; Klucken, Kagerer et al., 2009; Klucken, Schweckendiek et al., 2009; Klucken, Wehrum et al., 2013; Kruse et al., 2017; Stussi et al., 2018; Wardle et al., 2018). Als CR in der Herzaktivität lässt sich bei der Furchtkonditionierung während des typischen dreiphasigen Reaktionsmusters bestehend aus Verlangsamung, Beschleunigung und erneuter Verlangsamung (Bull & Lang, 1972) auf den CS+ typischerweise ein verstärkte zweiten Verlangsamung der Herzrate beobachten (Furchtbradikardie; Bradley et al., 2005; Castegnetti et al., 2016; De Leon, 1964; Hugdahl, 1979; Panitz et al., 2015), während die wenigen Studien zu kardialen Reaktionen bei appetitiver Konditionierung meist keine differentiellen CRs berichten (Ebrahimi et al., 2019; Hermann et al., 2000; Prévost et al., 2012; Wardle et al., 2018). Jedoch wurden oft auch keine differentielle CR im Valenzempfinden beobachtet, wodurch die

Eignung der UCS für die appetitive Konditionierung in Frage gestellt werden könnte. Da die kardialen Reaktionen als Indikator für eine erhöhte Aufmerksamkeit gegenüber der Umwelt interpretiert werden (Bull & Lang, 1972; Lang & Bradley, 2010; Löw et al., 2008) und angenommen wird, dass ihre Stärke mit einem höheren Erregungsniveau verbunden ist (Bradley et al., 1999; Wardle et al., 2018), ist es naheliegend, dass prinzipiell auch Hinweisreize für appetitive Stimuli kardiale CRs hervorrufen können.

Entscheidend für die Untersuchung von Konditionierungsprozessen ist die Auswahl des UCS. Bei der aversiven Konditionierung werden meist elektrotaktile Stimulationen oder laute Geräusche verwendet (Lonsdorf et al., 2017), während bei der appetitiven Konditionierung meist Geldgewinne (Kirsch et al., 2003; Knutson et al., 2001; Kruse et al., 2017; Tapia León et al., 2018) oder erotische Bilder (Klucken, Schweckendiek et al., 2009; Klucken, Wehrum et al., 2013) als UCS dienen. Olfaktorische Reize bieten dagegen die einmalige Möglichkeit sowohl als aversive als auch als appetitive UCS einsetzbar zu sein (Gottfried, 2011; Gottfried et al., 2002; Hermann et al., 2000) und werden auch im Rahmen dieser Dissertation verwendet.

1.3 Stressverarbeitung

Stress ist ein physiologischer und psychologischer Zustand, der als Reaktion auf eine Herausforderung, eine Belastung oder eine Bedrohung auftritt (Lazarus & Baker, 1956). Es handelt sich um eine komplexe Reaktion des Körpers und des Geistes auf bestimmte externe oder interne, physische oder psychische Reize, die als Stressoren bezeichnet werden. Es gibt verschiedene Faktoren, die dazu beitragen können, dass ein Reiz für eine bestimmte Person zu einem Stressor wird: die individuelle Wahrnehmung, die subjektive Bedeutung, die wahrgenommene Kontrollierbarkeit des Reizes, sowie die Ressourcen und Bewältigungsfähigkeiten einer Person (Lazarus, 2006; Schneiderman et al., 2005). Der menschliche Körper reagiert mit einer Stressreaktion auf belastende Situationen, die eine Anpassungsreaktion des Organismus darstellt, um die gegebene Situation zu bewältigen und gilt daher als kurzfristig adaptiv. In zahlreichen Studien wurde längerfristiger Stress jedoch mit schlechter körperlicher und geistiger Gesundheit in Verbindung gebracht (O'Connor et al., 2021; Schneiderman et al., 2005). Stressoren lassen sich grundlegend in physische und psychosoziale Stressoren untergliedern: Während physische Stressoren physische Einflüsse, wie z. B. Lärm, umfassen, entstehen psychosoziale Stressoren im Kontext belastender sozialer Interaktionen. Eine gut etablierte Methode zur Induktion von akutem Stress stellt der Mannheimer Multikomponenten-Stresstest dar (MMST; Kolotylova et al., 2010), der eine Vielzahl von Stressoren miteinander kombiniert: akustische und emotionale Stressoren, eine kognitiven Belastungsaufgabe unter Zeitdruck,

sowie eine eher geringe sozial-evaluative Komponente in Form eines Feedbacks durch ein Computerprogramm. Etabliert ist die multi-methodale Erfassung der Stressreaktion in Form einer kombinierten Analyse physiologischer und subjektiver Reaktionen. Während sich physiologische Reaktion hauptsächlich durch Veränderungen der kardialen Aktivität (Herzrate, Herzratenvariabilität) und des Blutdrucks zeigen (Kim et al., 2018; Vrijkotte et al., 2000), wird das subjektive Stresserleben durch eine Likert-Skala abgefragt.

Die Nachbearbeitung von Stresserfahrungen (Finke et al., 2022) und die Fähigkeit, sich aktiv von wahrgenommenem Stress zu entspannen (Dharmawardene et al., 2016; Khoury et al., 2015), könnten wichtige Faktoren zur Verringerung schädlicher stressbedingter Auswirkungen darstellen, wobei Menschen sich in der Art und Weise, wie sie mit Stress und Ängsten umgehen stark unterscheiden (Krohne, 2003; Weinberger et al., 1979). Gängige Entspannungsverfahren, wie achtsamkeitsbasierte Stressreduktion und Meditationstechniken, erzielen dabei geringe bis mäßige Wirksamkeitsraten (Dharmawardene et al., 2016; Khoury et al., 2015). Es gibt neuere psychologische Interventionen, die sich die digitalen Möglichkeiten einer virtuellen Realität (VR) zu Nutze machen (Navarro-Haro et al., 2017; Riva et al., 2019; Seabrook et al., 2020), um die Entspannungsprozesse z. B. durch die Unterstützung der Achtsamkeitspraxis (Kabat-Zinn, 2005; Seabrook et al., 2020) oder durch ein Feedback zu physiologischen Reaktionen (Blum et al., 2019; Bossenbroek et al., 2020; Tinga et al., 2019; van Rooij et al., 2016), zu unterstützen. Besonders etabliert sind dabei eine VR mit Naturszenen, die in vorangegangenen Studien das subjektive Stressempfinden und negative Affekte verringern konnten (Anderson et al., 2017; Seabrook et al., 2020; Tinga et al., 2019). Die in dieser Dissertation verwendete Entspannungsintervention kombiniert all diese Komponenten in einer VR-Intervention, in der eine Naturszene von einer Anleitung zu Entspannung und Atmung begleitet wird.

1.4 Die Rolle interindividueller Unterschiede

Aus den bisherigen Ausführungen wird klar, dass die einzelnen Reizverarbeitungsprozesse eine hohe Varianz aufweisen, die systematisch auf spezifische Einflussfaktoren zurückzuführen ist. Von besonderer Relevanz für die Verarbeitung emotionaler Reize sind dabei interindividuelle Unterschiede in der habituellen Angstbewältigung.

Es können verschiedene Angstbewältigungsstile unterschieden werden, welche die dispositionelle Präferenz für bestimmte Kategorien von Bewältigungsstrategien beschreiben (Anshel, 2012). Zur Klassifizierung verschiedener Bewältigungsstile gilt das Modell der Bewältigungsmodi von Krohne (1993), das eine Kategorisierung entlang der Dimensionen kognitive Vermeidung und Vigilanz vornimmt, als besonders einflussreich. Während kognitive

Vermeidung mit einem Rückzug der Aufmerksamkeit von bedrohungsbezogenen Merkmalen einer Situation verbunden ist, beschreibt Vigilanz die verstärkte Aufmerksamkeit dieser situativen Merkmale (Krohne, 1993; Weinberger, 1995). Auf der Grundlage dieses Modells können Personen mit Hilfe des Angstbewältigungsinventars (ABI; Krohne et al., 2000) in vier Gruppen eingeteilt werden: Represser (hohe kognitive Vermeidung, niedrige Vigilanz), Sensitizer (niedrige kognitive Vermeidung, hohe Vigilanz), Fluktuierende (hoch auf beiden Dimensionen) und Nicht-defensive (niedrig auf beiden Dimensionen) (Krohne et al., 2000). Im Vergleich zu allen anderen Bewältigungsstilen gibt es Hinweise darauf, dass repressive Angstbewältigung mit einer starken Diskrepanz zwischen physiologischen und subjektiven Stressreaktionen einhergehen könnte: Die selbstberichtete Angst wird oftmals als gering berichtet, während die physiologische Reaktion verstärkt ausfällt (Derakshan & Eysenck, 1997; Derakshan et al., 2007; Kohlmann et al., 1996; Newton & Contrada, 1992). Es gibt Studien, welche die gleiche Diskrepanz bei Betrachtung der psychischen Gesundheit nahelegen: Eine erhöhte Prävalenz stressbedingter Erkrankungen (Denollet et al., 2008; Frasure-Smith et al., 2002; Giese-Davis et al., 2006; Mund & Mitte, 2012; Myers, 2010; Schwerdtfeger et al., 2006) scheint mit einer eher positiven Einschätzung der eigenen psychischen Gesundheit im Selbstbericht einherzugehen (Coifman et al., 2007; Myers & Derakshan, 2015; Phipps & Srivastava, 1997). Als Erklärungen für diese Befunde werden oft ein vermindertes Bewusstsein für den eigenen körperlichen Zustand (Myers, 2010; Schwerdtfeger et al., 2006) und eine insgesamt veränderte Reizverarbeitung angeführt (Myers, 2010). Kognitive Verzerrungen könnten dabei eine entscheidende Rolle spielen (Derakshan & Eysenck, 1997), die sich teilweise in einer geringeren Aufmerksamkeit für negative Reize zeigten (Fox, 1993; Mogg et al., 2000; Schwerdtfeger & Derakshan, 2010), wobei auch gegenteilige Befunde existieren (Brosschot et al., 1999; Ioannou et al., 2004; Mogg et al., 2000). Bisher wurde die beschriebene Diskrepanz in der Stressreaktion vor allem bei sozialen Stressoren beobachtet (Derakshan & Eysenck, 1997; Derakshan et al., 2007; Kohlmann et al., 1996; Myers, 2010; Newton & Contrada, 1992; Paul et al., 2012; Rohrmann et al., 2002; Schwerdtfeger & Kohlmann, 2004), während für physische Stressoren Untersuchungen zu invasiven medizinischen Eingriffen erste Hinweise liefern könnten. Sensitizer zeigten in einigen Studien mehr subjektive Angst vor den Eingriffen als Patienten mit anderen Bewältigungsstilen (Krohne et al., 1989; Schwenkmezger et al., 1996; Slangen et al., 1993), während die Ergebnisse zu Unterschieden in physiologischen Stressparametern bisher uneinheitlich waren (Krohne et al., 1989; Schwenkmezger et al., 1996; Slangen et al., 1993). Zu Unterschieden in der Entspannungsfähigkeit könnten Studien zu kognitiver Belastung erste

Hinweise liefern: Während Sensitizer in einer Studie bei geringer kognitiver Belastung, weniger angstbezogene Informationen vergaßen als andere Bewältigungsgruppen (Peters et al., 2012), erfuhren Patienten, die zu kognitiver Vermeidung neigen, in einigen Studien die größte Reduktion ihres Stressniveaus durch aktive Entspannung vor medizinischen Eingriffen (Gattuso et al., 1992; Krohne & El-Giamal, 2008; Lerman et al., 1990).

2 Ziele und Forschungsfragen

Jede Fragestellung dieses Dissertationsprojekts widmet sich einem Prozess der emotionalen Reizverarbeitung: (1) kognitive Verarbeitung (2), affektives Lernen und (3) Stressverarbeitung. Ein besonderer Schwerpunkt liegt dabei auf möglichen Einflüssen unterschiedlicher Angstbewältigungsstile.

2.1 Fragestellung I: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und kognitiven Verzerrungen bei der Verarbeitung emotionaler Stimuli?

Die erste Fragestellung beschäftigt sich mit interindividuellen Unterschieden in der Aufmerksamkeit für und der automatischen Annäherung an emotionale Reize bei verschiedenen habituellen Angstbewältigungsstilen. Wie oben beschrieben wird angenommen, dass das Zusammenspiel verschiedener kognitiver Verzerrungen in der Reizverarbeitung eine wichtige Rolle bei der Entwicklung und Aufrechterhaltung psychischer Störungen spielen (Garner et al., 2006; Hirsch & Mathews, 2000) und bei Personen mit einer repressiven Angstbewältigung auch als Erklärung für die Diskrepanz zwischen einer erhöhten Prävalenz stressbedingter Erkrankungen und einer positiven Selbsteinschätzung ihrer psychischen Gesundheit herangezogen werden (Derakshan & Eysenck, 1997). Bisherige Ergebnisse zu Aufmerksamkeitsverzerrungen sind heterogen: Teils zeigte sich, dass Represser negativen Stimuli weniger und positiven Stimuli mehr Aufmerksamkeit schenkten, teils zeigten sich keine Verzerrungen (Brosschot et al., 1999; Fox, 1993; Franklin et al., 2016; Ioannou et al., 2004; Mogg et al., 2000). Automatische Handlungstendenzen wurden in diesem Zusammenhang bisher nicht untersucht, obwohl diese einen wichtigen Baustein für das Verständnis für die Entstehung und Aufrechterhaltung von Suchterkrankungen darstellen (Loijen et al., 2020).

In Fragestellung 1 werden entsprechend Unterschiede in verschiedenen kognitiven Verzerrungen in Abhängigkeit der Angstbewältigungsstile untersucht. Zu diesem Zweck wird eine Dot-Probe-Task zur Messung der Aufmerksamkeitsverzerrung verwendet, während der AAT zur Messung der Annäherungs-/Vermeidungstendenzen eingesetzt wird. Die Stimuli für beide Paradigmen sind positive und negative Bilder. Es wird erwartet, dass Represser eine erhöhte

Aufmerksamkeit für und eine verstärkte Annäherungstendenz an positive Stimuli und eine geringere Aufmerksamkeit für und eine verstärkte Vermeidung von negativen Stimuli zeigen.

2.2 Fragestellung II: Welcher Zusammenhang besteht zwischen konditionierten Reaktionen bei aversiver und appetitiver Konditionierung?

Die zweite Fragestellung dieses Dissertationsprojektes beschäftigt sich mit dem Erlernen von Hinweisreizen durch Konditionierungsprozesse. Das Erlernen negativer Assoziationen wird als wichtiger Prozess bei der Entstehung von Angststörungen (Lissek et al., 2005) eingestuft, während das Erlernen positiver Assoziationen mit Suchterkrankungen (Martin-Soelch et al., 2007) in Verbindung gebracht wird. Um die häufigen Komorbiditäten zwischen diesen Erkrankungen (Burns & Teesson, 2002; Grant et al., 2004; Kessler et al., 2005) besser zu verstehen, ist es wichtig, zu untersuchen, ob es eine gemeinsame Empfindlichkeit für aversives und appetitives affektives Lernen gibt. Die Untersuchung von Konditionierungsprozessen anhand der gut etablierten SCRs birgt das Problem, dass diese bei weniger erregenden UCS oft keine differentiellen CRs zeigen (Andreatta & Pauli, 2015; Austin & Duka, 2010; Ebrahimi et al., 2019; Hermann et al., 2000; Klucken, Kagerer et al., 2009; Klucken, Schweckendiek et al., 2009; Klucken, Wehrum et al., 2013; Kruse et al., 2017; Stussi et al., 2018; Wardle et al., 2018). In der Furchtkonditionierung ist daneben die Verlangsamung der Herzfrequenz nach dem CS+ im Vergleich zum CS- ein gut untersuchtes Maß für Konditionierungsprozesse (Bradley et al., 2005; De Leon, 1964; Hugdahl, 1979; López et al., 2009; Panitz et al., 2018; Sperl et al., 2016). Für die appetitive Konditionierung konnten bisher keine differentiellen CRs nachgewiesen werden (Ebrahimi et al., 2019; Hermann et al., 2000; Prévost et al., 2012; Wardle et al., 2018), jedoch fehlt eine Untersuchung unter Verwendung von UCS, die das Potenzial haben gleiche physiologische Erregung auszulösen, wie aversive UCS (Martin-Soelch et al., 2007).

Fragestellung II untersucht Zusammenhänge zwischen kardialen Reaktionen bei der aversiven und der appetitiven Konditionierung. Als UCS kamen olfaktorische Reize mit gleichem Erregungs- und Valenzniveau zwischen aversiver und appetitiver Konditionierung zum Einsatz. Es wurde angenommen, dass aversive Konditionierung stärkere CRs hervorrufen würde als appetitive Konditionierung, während sich die Reaktionsmuster grundlegend ähneln. Weiter wurde ein positiver Zusammenhang zwischen appetitiven und aversiven CRs erwartet.

2.3 Fragestellung III: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und akuten Stress- und Entspannungsreaktionen?

Die dritte Fragestellung beschäftigt sich mit interindividuellen Unterschieden in der Reaktion auf stress-induzierende Stimuli und anschließende Entspannung für verschiedene Angstbewältigungsstile. Besonders Personen mit repressiver Angstbewältigung scheinen verstärkt von stressbedingten Erkrankungen betroffen zu sein (Denollet et al., 2008; Frasure-Smith et al., 2002; Giese-Davis et al., 2006; Mund & Mitte, 2012; Myers, 2010; Schwerdtfeger et al., 2006), was mit einer erhöhten physiologischen und einer verminderten subjektiv wahrgenommenen Stressreaktion in Zusammenhang gesehen wird (Derakshan & Eysenck, 1997; Derakshan et al., 2007; Kohlmann et al., 1996; Myers, 2010; Newton & Contrada, 1992; Paul et al., 2012; Rohrman et al., 2002; Schwerdtfeger & Kohlmann, 2004). Die vertiefte Untersuchung interindividueller Unterschiede in der Stressreaktion und gleichzeitig der Entspannungsfähigkeit verschiedener Angstbewältigungsgruppen ist damit ein wichtiger Baustein hin zu einer individualisierten Diagnostik und Therapie. Vorangegangene Studien konzentrierten sich auf soziale Stressoren, während Stressreaktionen auf nicht-soziale Stressoren für verschiedene Angstbewältigungsstile bisher nicht untersucht wurden. Offen bleibt darüber hinaus die Fragestellung, inwieweit die Entspannungsfähigkeiten nach einem stressigen Ereignis zwischen den Angstbewältigungsstilen variieren, was von großer Bedeutung ist, da die Fähigkeit sich nach einem stressigen Ereignis zu entspannen als wichtiger Resilienzfaktor bezogen auf die schädlichen Auswirkungen von Stress angesehen wird (Dharmawardene et al., 2016; Khoury et al., 2015).

Fragestellung III untersucht Unterschiede in wahrgenommener und physiologischer Stress- und Entspannungsreaktion für die unterschiedlichen Angstbewältigungsstile unter Verwendung einer Stressaufgabe ohne direkte soziale Bewertung. Es wurde angenommen, dass Sensitizer den größten selbstberichteten Stress aufweisen, während Represser den größten physiologischen Stress erleben. Hinsichtlich der Entspannung wurde erwartet, dass Sensitizer eine geringere Reduktion des subjektiv und physiologisch empfundenen Stresses zeigen als Represser.

III ZUSAMMENFASSUNG DER STUDIEN

3 Studie I: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und kognitiven Verzerrungen bei der Verarbeitung emotionaler Stimuli? (Exner, Machulska et al., 2023)

3.1 Methode

3.1.1 Stichprobe

Es nahmen 73 Studierende (55 weiblich; Alter: $M = 21.19$ Jahre; $SD = 3.57$ Jahre), mit normaler oder korrigierter Sicht und ohne psychische oder neurologische Vorerkrankungen an dieser Studie teil. Sie erhielten für die Teilnahme eine Aufwandsentschädigung in Höhe von 10.00 €/Stunde oder Versuchspersonenstunden.

3.1.2 Studiendesign

Die Studie umfasste die Messung zweier kognitiver Verzerrungen, die von den Teilnehmern nacheinander absolviert wurden: eine visuelle Dot-Probe-Task zur Messung von Aufmerksamkeitsverzerrungen und eine Approach-Avoidance-Task (AAT) zur Messung von automatischen Handlungstendenzen.

Dot-Probe-Task. In jedem der 50 Trials wurden ein positives und ein negatives Bild gleichzeitig nebeneinander präsentiert. Anschließend verschwanden beide Bilder und der Testreiz (engl.: Probe; ein "X") erschien und ersetzte entweder das positive oder das negative Bild (MacLeod et al., 1986). Die Teilnehmer wurden angewiesen, die Position des Testreizes (rechts oder links) so schnell und genau wie möglich durch Drücken einer Taste anzugeben. Um den Wert für die Aufmerksamkeitsverzerrung zu berechnen, wurden die mittleren Reaktionszeiten für Testreize, die positive Bilder ersetzen, von den mittleren Reaktionszeiten für Testreize, die negative Bilder ersetzen, subtrahiert (Becker et al., 2016).

Approach-Avoidance-Task. Automatische Handlungstendenzen wurden mit dem AAT gemessen. In jedem der 200 Trials wurde ein positives oder ein negatives Bild präsentiert, das entweder nach links oder nach rechts geneigt war. Die Teilnehmer wurden angewiesen, einen Joystick zu sich heranzuziehen, wenn das Bild nach links, und den Joystick von sich wegzuschieben, wenn das Bild nach rechts geneigt war. Der Wert für die Annäherungs-/Vermeidungstendenz wurde für positive und negative Bilder getrennt berechnet, indem die mittlere Reaktionszeit für Ziehbewegungen von der mittleren Reaktionszeit für Drückbewegungen abgezogen wurde (Rinck & Becker, 2007).

3.1.3 Angstbewältigung

Zur Messung des Bewältigungsstils wurde das ABI (Krohne et al., 2000) verwendet. Die Teilnehmer wurden mittels Median-Splits der beiden Dimensionen kognitive Vermeidung und Vigilanz auf der Subskala für selbstwertbedrohliche Situationen in die vier Gruppen an Bewältigungsstilen eingeordnet.

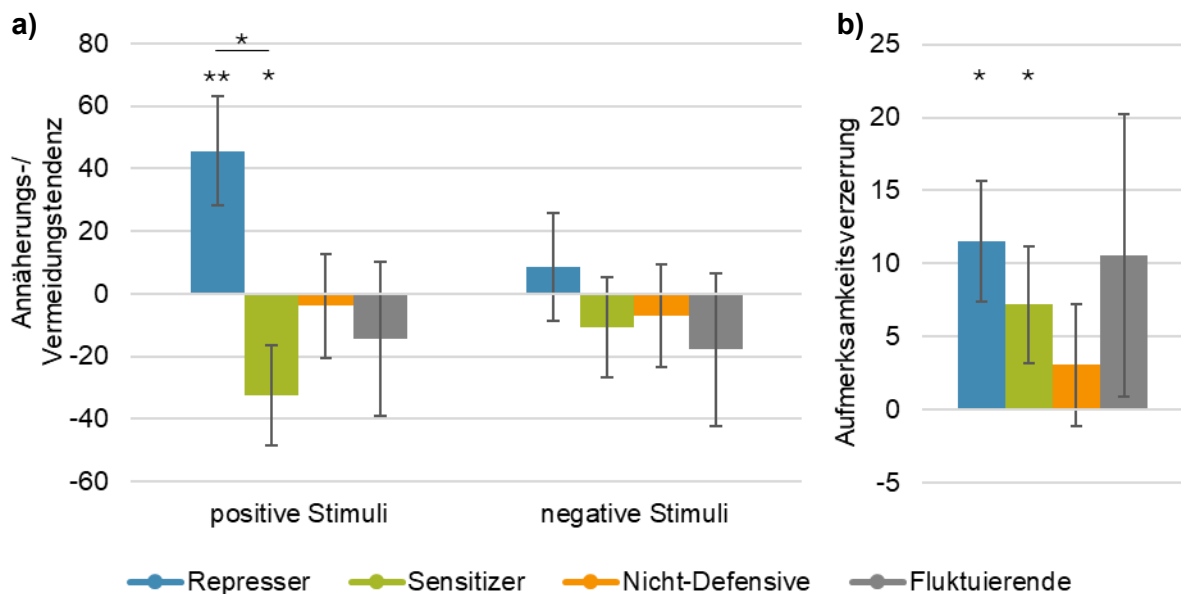
3.2 Ergebnisse

3.2.1 Dot-Probe-Task

Die Analysen der Aufmerksamkeitspräferenzen zeigten eine signifikant erhöhte Aufmerksamkeit gegenüber positiven Stimuli bei Repressern und Sensitizern ohne signifikanten Unterschied zwischen diesen Gruppen. Nicht-defensive und fluktuierende Personen zeigten keine Aufmerksamkeitsverzerrungen (Abb. 1).

Abbildung 1

Schätzungen der a) Annäherungs-/Vermeidungstendenz abgeleitet aus der AAT und der b) Aufmerksamkeitsverzerrung abgeleitet aus der Dot-Probe-Task für verschiedene Bewältigungsstile.



Anmerkungen: Die Fehlerbalken zeigen den SEM. ** $p < .01$, * $p < .05$. a) Positive Werte stellen eine Annäherungstendenz, negative Werte eine Vermeidungstendenz dar. b) Positive Werte stellen eine Aufmerksamkeitspräferenz für positive Stimuli, negative Werte für negative Stimuli dar.

3.2.2 Approach-Avoidance-Task

Bei der Analyse der automatischen Handlungstendenzen konnte eine signifikante Annäherungstendenz bei Repressern und eine signifikante Vermeidungstendenz bei Sensitizern für

positive Stimuli und keine Verzerrungen für negative Stimuli beobachtet werden. Nicht-defensive und fluktuierende Personen zeigten keine Annäherungs- oder Vermeidungstendenzen (Abb. 1).

3.3 Konklusion

Zusammenfassend konnte gezeigt werden, dass sich Represser und Sensitizer in ihrer kognitiven Verarbeitung unterscheiden. Die Studie liefert erste Hinweise für die Annahme, dass besonders im Umgang mit positiven Stimuli entscheidende Unterschiede bestehen könnten, wobei Represser eine verstärkte Hinwendung zu positiven Reizen zeigten. Es konnte gezeigt werden, dass Angstbewältigungsstile nicht nur Aufmerksamkeitspräferenzen, sondern auch automatische Handlungstendenzen und damit verschiedene Ebenen der kognitiven Reizverarbeitung beeinflussen könnten (für eine ausführliche Diskussion siehe Anhang A).

4 Studie II: Welcher Zusammenhang besteht zwischen konditionierten Reaktionen bei aversiver und appetitiver Konditionierung? (Exner et al., 2021)

4.1 Methode

4.1.1 Stichprobe

An der Studie nahmen insgesamt 86 Studierende (61 weiblich; Alter: $M = 23.8$ Jahre; $SD = 5.24$ Jahre) mit normaler oder korrigierter Sicht, normaler Riechfähigkeit und ohne psychische, neurologische oder kardiovaskuläre Vorerkrankungen teil. Sie erhielten für die Teilnahme eine Aufwandsentschädigung in Höhe von 10.00 €/Stunde oder Versuchspersonenstunden.

4.1.2 Studiendesign

Die Studie bestand aus zwei nacheinander durchgeführten differenziellen Konditionierungsaufgaben, die sich nur in der Valenz des verwendeten olfaktorischen UCS (appetitiv vs. aversiv) unterschieden. Zwei Paare geometrischer Figuren dienten als CS+ und CS-, während die Gerüche "Tier" (aversive Aufgabe) und "heißer Apfelkuchen" (appetitive Aufgabe) (Scent 5-pack for SDS100, BIOPAC Systems Inc., Santa Barbara, CA, USA) als UCS dienten. Jede Konditionierungsaufgabe bestand aus 20 CS+ und 20 CS- Trials, wobei 75 % der CS+-Trials verstärkt wurden. In den verstärkten Trials wurde der Geruchs-UCS, in den nicht verstärkten Trials neutrale Luft (Non-UCS) während der letzten 2,5 s der CS-Präsentationszeit mittels Olfaktometer (Multistimulator OG001, Burghart Messtechnik GmbH, Wedel, Deutschland) dargeboten.

4.1.3 Subjektive Ratings

Die Teilnehmer bewerteten die subjektive Valenz und Erregung aller Reize (CS+, CS-, UCS, Non-UCS) direkt vor und nach der appetitiven und der aversiven Konditionierungsaufgabe.

4.1.4 Physiologische Maße

Die physiologischen Signale wurden während aller Phasen des Experimentes aufgezeichnet und jeweils für beide Konditionierungsaufgaben über die erste bzw. zweite Hälfte der CS+ bzw. CS-Trials gemittelt. Es wurde eine EDA-Messung an Mittel- und Zeigefinger der nicht-dominanten Hand vorgenommen. Die SCR wurde als größte Differenz zwischen einem Minimum und einem nachfolgenden Maximum innerhalb des Analysefensters von 1s bis 5,5s nach Beginn des CS berechnet (Benedek & Kaernbach, 2010). Kardiale Aktivität wurde mittels EKG in der Ableitungskonfiguration II mittels am Rumpf des Teilnehmers platzierter Elektroden erfasst. Aus den Zeitpunkten der R-Zacken wurde ein kontinuierliches Herzperiodensignal (HP-Signal) berechnet, wobei jeder Abtastpunkt die Dauer zwischen der vorangehenden und der nachfolgenden R-Zacke darstellt. Für jeden Trial wurde das HP-Signal für das Zeitfenster von 0s bis 8s nach Beginn der CS segmentiert und die kardiale Reaktion anhand von Amplituden und Latenzen (Bradley, 2009) entsprechend des erwarteten dreiphasigen Reaktionsmusters quantifiziert (Bull & Lang, 1972).

4.2 Ergebnisse

4.2.1 Subjektive Ratings

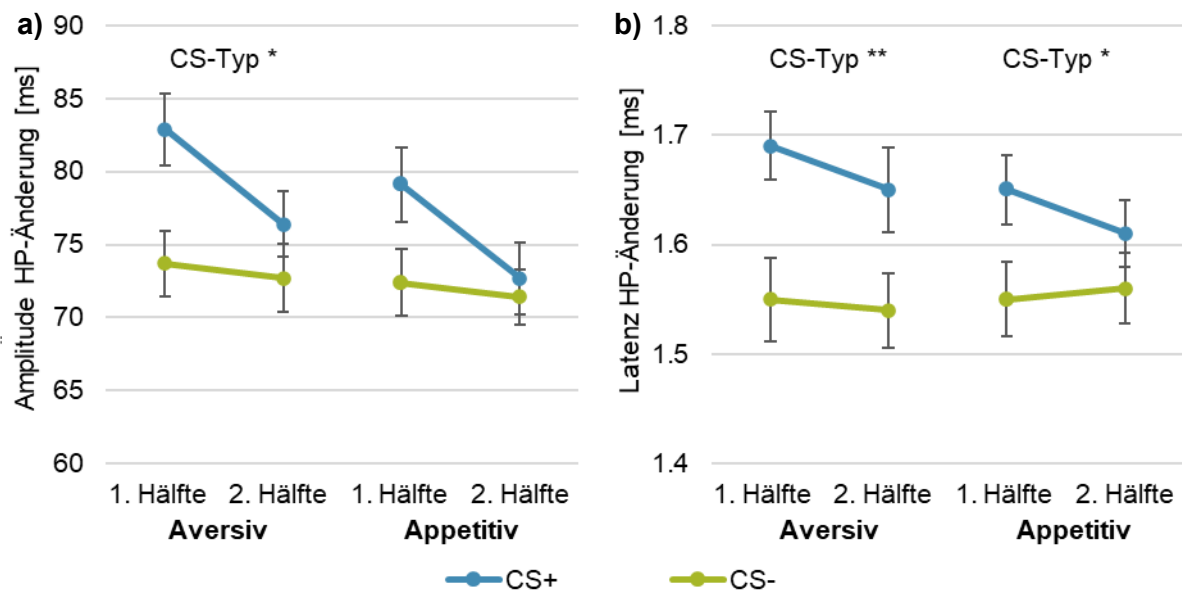
Die Analyse der subjektiven Ratings zeigte, dass der CS+ für die appetitive Konditionierung als aufregender und angenehmer und für das aversive Paradigma als aufregender und unangenehmer empfunden wurde als der CS- mit einer jeweils stärkeren Ausprägung der CR bei der aversiven Konditionierung.

4.2.2 Physiologische Maße

Die Analyse der EDA zeigte, dass die SCR des CS+ bei der aversiven Konditionierung in der ersten Hälfte der Trials höher war als des CS-, während sich bei der appetitiven Konditionierung keine differentiellen SCRs zeigten. Die Analysen der Herzaktivität zeigten das typische drei-phasige Muster aus Verlangsamung, Beschleunigung und Verlangsamung der Herzfrequenz für beide Konditionierungsaufgaben. Die zweite Verlangsamung zeigte sich jeweils mit längerer Dauer und bei der aversiven Konditionierung zusätzlich mit stärkerer Amplitude für den CS+ als für den CS-.

Abbildung 2

Veränderungen in der zweiten Verlangsamung der Herzrate für CS+ und CS- für beide Konditionierungsaufgaben (a) in der Amplitude und (b) in der Latenz für die erste und die zweite Hälfte der Trials.



Anmerkungen: Die Fehlerbalken zeigen den SEM. ** $p < .01$, * $p < .05$.

4.2.4 Korrelationen

Für die subjektiven Maße wurden signifikante Korrelationen zwischen den CRs in beiden Konditionierungsaufgaben gefunden, während sich für die physiologischen Maße kein signifikanter Zusammenhang zeigte.

4.3 Konklusion

Es konnte gezeigt werden, dass sich unter Verwendung von UCSs der gleichen Modalität und mit vergleichbarem Valenz- und Arousal-Niveau, vergleichbare CRs bei der aversiven und der appetitiven Konditionierung zeigen. Die Dauer der zweiten Verlangsamung der Herzrate könnte vor allem unter Verwendung weniger erregender UCS ein sensibles Maß für CRs darstellen. Die Studie liefert erste Hinweise auf Zusammenhänge in der Konditionierungssensitivität für aversive und appetitive Reize bezogen auf subjektive Ratings, nicht jedoch bei physiologischen Maßen (für eine ausführliche Diskussion siehe Anhang B).

5 Studie III: Welcher Zusammenhang besteht zwischen habitueller Angstbewältigung und den Reaktionen auf akuten Stress und anschließende Entspannung? (Exner, Kampa et al., 2023)

5.1 Methode

5.1.1 Stichprobe

An der Studie nahmen 96 Studierende (83 weiblich; Alter: $M = 21.42$ Jahre; $SD = 2.89$ Jahre) mit normaler oder korrigierter Sicht, normaler Hörfähigkeit und ohne psychische, neurologische oder kardiovaskuläre Vorerkrankungen teil. Sie erhielten für die Studienteilnahme eine Aufwandsentschädigung in Höhe von 10.00 €/Stunde oder Versuchspersonenstunden.

5.1.2 Studiendesign

Die Teilnehmer absolvierten eine 5,5-minütige Stressinduktion und eine anschließende 15-minütige Entspannungsintervention. Die Stressinduktion erfolgte mit dem MMST (Kolotylova et al., 2010). Die Teilnehmer wurden zufällig einer von zwei Entspannungsinterventionen zugeteilt. Die eine Gruppe nahm an einer geführten Intervention mittels VR-Headset (HTC Vive pro HMD, HTC Corporation, ViveTM) teil, die eine Landschaft, beruhigende Musik, Naturgeräusche und einen Sprecher, der über Kopfhörer Anweisungen zu Entspannung und Atmung gab, beinhaltete. Die andere Gruppe führte eine selbst gewählte Entspannungsmethode im Sitzen durch.

5.1.3 Subjektive Ratings

Subjektive Bewertungen von Stress und Entspannung wurden zu Beginn (Baseline), während der Stressinduktion, nach der Entspannung, sowie am Abend der Untersuchung erhoben.

5.1.4 Physiologische Maße

Kardiale Aktivität wurde mittels EKG in der Ableitungskonfiguration II mit am Rumpf des Teilnehmers platzierten Elektroden erfasst. Nach einer Vorverarbeitung wurde die Herzrate über das gesamte Zeitintervall jeder Phase des Experimentes (Baseline, Stress, Entspannung) gemittelt. Hieraus wurde die Herzratenvariabilität geschätzt (Shaffer & Ginsberg, 2017). Der Blutdruck wurde zur Baseline, während der Stressinduktion und während der Entspannung mittels Blutdruckmanschette (Dinamap Pro 300, General Electric Deutschland Holding GmbH, Frankfurt am Main, Deutschland) am nicht-dominanten Oberarm der Teilnehmer gemessen.

5.1.5 Angstbewältigung

Zur Erfassung der Angstbewältigungsstile wurde das ABI (Krohne et al., 2000) verwendet. Durch die Verwendung des nicht-sozialen Stressors wurde zur Berechnung von kognitiver Vermeidung und Vigilanz, wie von den Autoren empfohlen, die Sub-Skala für physische Bedrohung verwendet (Krohne, 1993). Die Teilnehmer wurden durch Dichotomisierung der beiden Dimensionen mittels Median-Splits in die vier Bewältigungsstile eingeteilt.

5.2 Ergebnisse

5.2.1 Subjektive Ratings

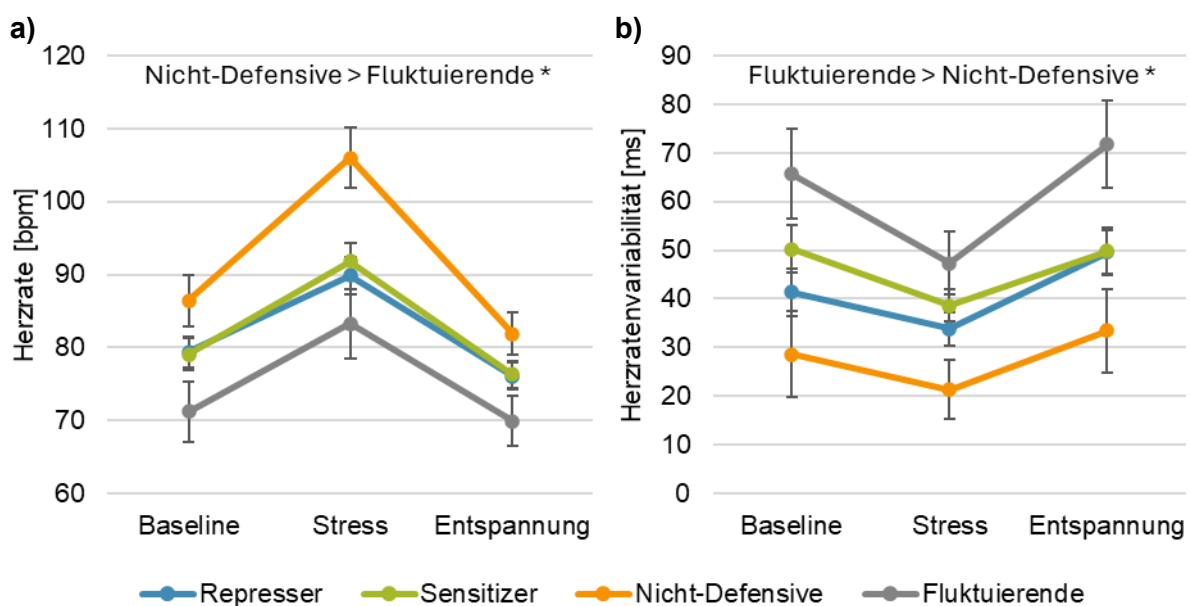
Für die subjektiven Ratings wurden niedrigere Stress- und höhere Entspannungsratings für Represser als für Sensitizer während der gesamten Testsituation, jedoch nicht für den Abend der Testung beobachtet.

5.2.2 Physiologische Maße

Für Herzrate und Herzratenvariabilität zeigten sich keine Unterschiede zwischen Repressern und Sensitizern, jedoch für die anderen Angstbewältigungsstile: Nicht-defensive wiesen eine höhere Herzrate und eine niedrigere Herzratenvariabilität auf als Fluktuierende (Abb. 3). Die Analyse der Blutdruckwerte zeigte keine signifikanten Unterschiede zwischen den Angstbewältigungsgruppen.

Abbildung 3

Physiologische Reaktionen: a) Herzrate und b) Herzratenvariabilität während Baseline, Stress und Entspannung für verschiedene Bewältigungsstile.



Anmerkungen: Fehlerbalken zeigen den SEM. ** $p < .01$, * $p < .05$.

5.3 Konklusion

Die Dissoziation zwischen subjektiven Einschätzungen und physiologischen Reaktionen bei Repressern in Form einer geringeren subjektiven Stresswahrnehmung wurde während des gesamten Experiments, jedoch nicht in der Stressreaktion und nicht am Abend der Testung, bestätigt. Die Studie stützt die Annahme, dass sich die Unterschiede in der Stressreaktion zwischen Repressern und Sensitizern möglicherweise nur unter sozialem Stress zeigen. Die Unterschiede zwischen Nicht-defensiven und Fluktuierenden während des gesamten Experiments zeigen die Wichtigkeit der Betrachtung aller vier Bewältigungsgruppen (für eine ausführliche Diskussion siehe Anhang C).

IV ZUSAMMENFASSENDE DISKUSSION

Über die drei Studien hinweg konnten Hinweise dafür geliefert werden, dass interindividuelle Unterschiede in der Verarbeitung aversiver und appetitiver Reize eine große Bedeutung besitzen und es wichtig ist, neue Maße für Reaktionen auf diese Reize zu identifizieren. Die Ergebnisse liefern wichtige Implikationen für theoretische Modelle und auf diesen basierenden psychotherapeutischen Ansätzen.

6 Zusammenfassung der Ergebnisse

In Studie I wurden interindividuelle Unterschiede in der kognitiven Verarbeitung positiver und negativer Reize bei unterschiedlichen Angstbewältigungsstilen untersucht. Die Ergebnisse deuten darauf hin, dass ein repressiver Bewältigungsstil mit einer automatischen Annäherungstendenz gegenüber positiven Stimuli im Zusammenhang stehen könnte, während sich für Represser und Sensitizer eine Aufmerksamkeitsverzerrung hin zu positiven Stimuli beobachten ließ. In Studie II wurden kardiale CRs auf Hinweisreize für aversive und appetitive Stimuli untersucht und verglichen. Aversive als auch appetitive Konditionierungsprozesse führten dabei zu vergleichbaren Reaktionen in der Herzaktivität. Die Studie liefert damit Hinweise dafür, dass die Verlangsamung der Herzrate eher die Erregung als die Valenz des UCS widerspiegeln könnte. Ein weiteres interessantes Ergebnis ist, dass aversive und appetitive CRs auf intraindividuelle Ebene für subjektive Bewertungen korreliert waren, während für physiologische Maße kein Zusammenhang festgestellt werden konnte. In Studie III wurden interindividuelle Unterschiede in der Stressreaktion auf nicht-soziale Stressoren und die anschließende Entspannungsfähigkeit bei unterschiedlichen Angstbewältigungsstilen untersucht. Es konnte bezogen auf interindividuelle Unterschiede im Stresserleben eine Dissoziation zwischen subjektiven Einschätzungen und der Physiologie bei Repressern bestätigt werden. Der Einsatz eines nicht-sozialen Stressors führte dagegen nicht zu Unterschieden in der Stressreaktivität. Somit wurden Hinweise dafür geliefert, dass die typische Dissoziation in der Stressreaktion bei Repressern eher bei Stressinduktionen mit ausgeprägter sozialer Bedrohung auftreten könnten. Unterschiede in der Entspannungsfähigkeit wurden nicht festgestellt. Nicht-defensive Personen zeigten im Laufe der gesamten Testung erhöhte physiologische Reaktionen, was einen wichtigen Impuls für zukünftige Forschungen liefert.

7 Implikationen für Theorie und Praxis

Studie I liefert Hinweise darauf, dass eine verstärkte Annäherung an positive Reize zu der verzerrten Stressreaktion (Derakshan & Eysenck, 1997; Derakshan et al., 2007; Kohlmann et al., 1996; Newton & Contrada, 1992) und der höheren Prävalenz stressbedingter Erkrankungen (Denollet et al., 2008; Frasurre-Smith et al., 2002; Giese-Davis et al., 2006; Mund & Mitte, 2012; Myers, 2010) bei Repressern beitragen könnten. Für neuere Therapieansätze, die zum Ziel haben, kognitive Verzerrungen zu modifizieren (Beard, 2011; MacLeod & Mathews, 2012), lassen sich daraus wichtige Erkenntnisse ableiten. Diese Ansätze streben einen Abbau negativer und einen Aufbau positiver Verzerrungen an unter der Annahme, dass eine Präferenz für positive Stimuli positive Folgen hat (Becker et al., 2019; Becker et al., 2016). Die in Studie I vorgestellten Befunde sind für solche Interventionen von hoher Relevanz, da sie darauf hindeuten, dass eine verzerrte Informationsverarbeitung per se - ob gegenüber positiven oder negativen Reizen - mit dysfunktionalem Coping zusammenhängen könnte. In diesem Fall müsste eine hilfreiche Intervention nicht notwendigerweise darauf abzielen, die positiven Verzerrungen in der Informationsverarbeitung zu erhöhen, sondern sollte eher eine flexible Verarbeitung trainieren. Unterstützende Belege liefern Studien mit PTBS-Patienten, in denen ein Training zur Modifikation der Aufmerksamkeitsverzerrung in Richtung positiver Stimuli weniger wirksam war als ein Training zur Aufmerksamkeitskontrolle in beide Richtungen (Badura-Brack et al., 2015; Lazarov et al., 2019). Auch existieren erste Hinweise darauf, dass kognitive Vermeidung ein Risikofaktor für die Entstehung und Aufrechterhaltung von Suchterkrankungen sein könnte (Shakeri et al., 2021; Vadar et al., 2019), die wiederum mit stärkerer Annäherung an suchtbezogene Reize einhergehen könnten (Loijen et al., 2020). Studie I deutet darauf hin, dass diese Annäherungsverzerrung möglicherweise für positive Reize im Allgemeinen existieren könnte. Dadurch könnte es sinnvoll sein, durch AAT-basierte Therapieansätze auch kognitive Verzerrungen gegenüber einer Vielzahl appetitiver und nicht ausschließlich gegenüber Sucht-assoziierten Reizen zu modifizieren. Translationale Studien sind nötig, um diesen Ansatz in der Praxis zu untersuchen.

Studie II liefert wichtige Implikationen für die Konditionierungsforschung: Die Ergebnisse legen nahe, dass die bei der Furchtkonditionierung zuverlässig beobachtete "Furcht-Bradykardie" (Campbell et al., 1997) möglicherweise nicht angstspezifisch ist, sondern eher eine allgemeine CS-induzierte Bradykardie darstellt. Insgesamt deuten die Ergebnisse darauf hin, dass die CS-induzierte Bradykardie ein nützliches physiologisches Maß zur Messung appetitiver und aversiver CRs mit nicht-furchterregenden UCSs darstellen könnten. Damit könnten sie in

zukünftigen Studien eine Ergänzung zu SCRs darstellen, die bei mildereren UCS nur gelegentlich differentielle CRs zeigen (Andreatta & Pauli, 2015; Austin & Duka, 2010; Ebrahimi et al., 2019; Hermann et al., 2000; Klucken, Kagerer et al., 2009; Klucken, Schweckendiek et al., 2009; Klucken, Wehrum et al., 2013; Kruse et al., 2017; Stussi et al., 2018; Wardle et al., 2018). Da leicht aversive und appetitive Reize im Alltag verglichen mit furchterregenden Reizen (z. B. elektrotaktile Stimulationen) deutlich häufiger auftreten, ist diese Möglichkeit für die lebensnahe Messung von CRs und damit auch für die Untersuchung der Konditionierungssensitivität bei verschiedenen psychischen Störungen von großer Bedeutung. Der Zusammenhang der CRs auf der Ebene subjektiver Bewertungen könnte als Bestätigung für den Einfluss interindividueller Unterschiede auf die Evaluation von aversiven als auch appetitiven Hinweisreizen gewertet werden: Beispielsweise liefern neuere Studien Hinweise darauf, dass Neurotizismus zu einem stärkeren Fokus auf valente Reize im Allgemeinen und damit auch zu stärkeren CRs in Paradigmen der aversiven und appetitiven evaluativen Konditionierung führen könnte (Ingendahl & Vogel, 2022; Vogel et al., 2019). Da unterschiedliche kognitive und damit neuronale Prozesse für die Auslösung physiologischer und evaluativer CRs verantwortlich sind, ist der abweichende Befund auf der Ebene der Physiologie nicht überraschend. Die fehlende Beziehung auf der Ebene der Verlangsamung der Herzrate steht in Einklang mit der Erkenntnis, dass aversive und appetitive Reize neuronal unterschiedlich verarbeitet werden (Hayes et al., 2014) und damit mit der Theorie zweier unabhängiger Motivationssysteme – dem appetitiven und dem defensiven System –, die durch unterschiedliche Lernerfahrungen ausgebildet und deren Sensitivität in letzter Konsequenz sehr unterschiedlich ausfallen kann (Löw et al., 2008; Löw et al., 2015). Prinzipiell gibt es Hinweise darauf, dass Personen mit dem 5-HTTLPR-Genotyp – einem potentiellen Risikofaktor für die Entwicklung von Angststörungen – eine erhöhte physiologische CR für aversive als auch appetitive Konditionierung aufweisen könnten (Klucken, Alexander et al., 2013; Klucken et al., 2015; Klucken, Wehrum et al., 2013), wodurch eine weitere Untersuchung in psychiatrischen Stichproben weitere Erkenntnisse in dieser Fragestellung liefern können.

Studie III deutet darauf hin, dass gerade sozial bedrohliche Situationen und nicht physisch bedrohliche Situationen das abweichende Stressreaktionsmuster bei Repressern auslösen. Eine Untersuchung der genauen Umstände, unter denen Represser dieses Muster zeigen, ist besonders relevant, um zu verstehen, wie die hohe Prävalenz stressbezogener Erkrankungen entsteht und wie man ihr in individualisierten Behandlungsansätzen entgegenwirken kann. Studie I stützt diese Annahme, durch den fehlenden Hinweis auf Aufmerksamkeitsverzerrungen gegen-

über allgemein aversiven Reize, die in anderen Studien für selbstwertbedrohliche Reize teilweise berichtet wurden (Fox, 1993; Mogg et al., 2000; Schwerdtfeger & Derakshan, 2010). Die Unterschiede in der subjektiven Bewertung des eigenen Stresslevels in der gesamten Testsituation trotz gleicher physiologischer Stressparameter untermauern die Annahme, dass Represser möglicherweise ein geringeres Bewusstsein für den eigenen körperlichen Zustand haben könnten (Myers, 2010; Schwerdtfeger et al., 2006). Für Behandlungsansätze stressbezogener Erkrankungen könnte es daher hilfreich sein, neben der Psychoedukation zu diesen Mechanismen die Wahrnehmungsfähigkeit für körperliche Stressreaktionen in sozial bedrohlichen Situationen zu trainieren, während nicht zu erwarten ist, dass Entspannungsinterventionen einen zusätzlichen Nutzen bringen. Zukünftige Interventionsstudien müssen diese Ansätze bestätigen und für die Praxis nutzbar machen. Für die Theorie der Bewältigungsmodi liefert Studie III interessante Hinweise in Bezug auf die selten untersuchten Gruppen der Nicht-defensiven und Fluktuierenden. Die erhöhte HRV der Fluktuierenden im Vergleich zu Nicht-defensiven in Ruhe könnte auf eine effektivere Emotionsregulation fluktuierender Personen hindeuten (Balzarotti et al., 2017; Park & Thayer, 2014; Thayer & Lane, 2009). Unterstützung für diese Theorie findet sich in einer latenten Klassenanalyse von Schmukle et al. (2000), in der fluktuierende Personen als Personen identifiziert werden, die ihre Bewältigungsstrategie je nach Situation anpassen können. Da eine dysfunktionale Emotionsregulation häufig mit der Entwicklung und Aufrechterhaltung psychischer Gesundheitsprobleme in Verbindung gebracht wird (Sheppes et al., 2015) könnte zukünftige Forschung zur Emotionsregulation fluktuierender und nicht-defensive Personen neue Erkenntnisse zur Adaptivität verschiedener Bewältigungsstile und damit für Therapieansätze, die auf die Vermittlung von Angstbewältigungsstrategien abzielen, liefern.

8 Limitationen und Ausblick

Im Folgenden werden Limitationen der drei durchgeführten Studien dargestellt und Hinweise für mögliche zukünftige Forschung gegeben.

Eine Limitation der Studien I und III betrifft die Klassifizierung der Angstbewältigungsstile nach Krohne (1993). Diese Klassifizierung ist theoretisch fundiert und gut etabliert, jedoch existieren auch andere Klassifizierungsansätze, die Angstbewältigungsstile beispielsweise entlang der Dimensionen Defensivität und Ängstlichkeit unterscheiden (Weinberger et al., 1979). Zwar gibt es Hinweise darauf, dass die Gruppenzuordnung zwischen den beiden Methoden für Represser und Sensitizer weitgehend übereinstimmt (Krohne et al., 2000), jedoch könnte eine

parallele Klassifizierung zusätzliche Erkenntnisse für die beiden übrigen Bewältigungsstile liefern. Bei der Interpretation der Ergebnisse aus Studien I und III ist zudem zu berücksichtigen, dass die Gruppen, vor allem der Fluktuierenden und der Nicht-defensiven, eher klein sind, auch wenn die verwendeten Gruppengrößen, denen in früheren Untersuchungen entsprechen (Brosschot et al., 1999; Fox, 1993; Klucken et al., 2010; Mogg et al., 2000; Peters et al., 2012). Zukünftige Forschung sollte die präsentierten Ergebnisse in größeren Stichproben bestätigen und durch eine gezieltere Rekrutierung homogene Gruppengrößen anstreben.

Weitere Limitationen können in der konkreten Auswahl der verwendeten Paradigmen gesehen werden. Beispielsweise zeigen neuere Studien sehr niedrige Werte für die interne Konsistenz und die Retest-Reliabilität der Dot-Probe-Task (Chapman et al., 2019; Kappenman et al., 2014; Machulska et al., 2022; Rodebaugh et al., 2016). Die Verwendung alternativer Methoden zur Messung von Aufmerksamkeitsverzerrungen könnte entsprechend für zukünftige Forschung von Interesse sein. In Studie III wurde im Gegensatz zu früheren Studien ein nicht-sozialer Stressor verwendet. Da sich Bewältigungsgruppen in früheren Arbeiten häufig in ihrer Reaktion auf sozialen Stress unterschieden, wäre es für zukünftige Studien interessant, die Fähigkeit zur Entspannung zusätzlich nach einer sozialen Stressinduktion zu untersuchen, um tiefere Erkenntnisse zu Unterschieden in der Entspannungsfähigkeit zwischen den Bewältigungsgruppen zu erlangen. In Studie III wurden olfaktorische Stimuli als UCS verwendet. Zukünftige Studien müssen zeigen, inwieweit die CS-induzierte Bradykardie auf Stimuli anderer Modalitäten, anderer Valenz- und Erregungslevel generalisierbar ist.

Weitere mögliche Einschränkungen ergeben sich aus potentiellen konfundierenden Variablen. Beispielsweise wurde in Studie I nicht für die durch die Bilder ausgelöste Erregung kontrolliert, was einen Einfluss auf die visuelle Aufmerksamkeit haben könnte (Sutton & Lutz, 2019). Zukünftige Studien könnten ein Matching der Bildreize anhand bekannter Erregungswerte durchführen, um die Vergleichbarkeit der Bildkategorien zu erhöhen. In Studie II wurde nicht für das Atemverhalten während der Präsentation von CS und UCS kontrolliert. Es ist bekannt, dass die Herzfrequenz durch die Atmung beeinflusst wird (Brownley et al., 2000), jedoch weisen die kardialen CRs bei der aversiven und der appetitiven Konditionierungsaufgabe keine qualitativen Unterschiede auf, wodurch es unwahrscheinlich ist, dass dies einen größeren Einfluss auf die vorliegenden Ergebnisse hatte. Eine Berücksichtigung der Atmung könnte dennoch in zukünftigen Studien interessant sein.

Eine weitere Limitation der vorgestellten Studien besteht darin, dass es sich bei den Stichproben um gesunde Studierendenstichproben handelte. Zukünftige Forschung sollte die vorgestellten Befunde an psychiatrischen Stichproben replizieren und weiter integrieren, um die Rolle interindividueller Unterschiede in der Verarbeitung emotionaler Reize für die Entstehung psychischer Störungen näher zu erforschen und sie als Ansatzpunkte für psychotherapeutische Interventionen nutzbar zu machen. Für die Studien I und III könnte dieser Ansatz die Frage beantworten, ob eine größere Varianz auf den Dimensionen des ABI zu Unterschieden in den automatischen Handlungstendenzen gegenüber negativen Stimuli oder zu differentiellen physiologischen Stressreaktionen führen kann. Für Studie II könnte eine Replikation in einer psychiatrischen Stichprobe zu höheren CRs führen, wie sie bei Suchtstörungen oder Angststörungen bereits beobachtet wurden (Lissek et al., 2005; Martin-Soelch et al., 2007), wodurch es wahrscheinlicher sein könnte, Beziehungen zwischen diesen Messungen zu finden und damit einen gemeinsamen Risikofaktor für beide Arten von Störungen identifizieren zu können.

9 Konklusion

Im Rahmen dieser Dissertation wurde ein relevanter Beitrag zum Forschungsfeld der emotionalen Reizverarbeitung beim Menschen geleistet. Insgesamt zeigen die drei Studien und die Diskussion ihrer möglichen Implikationen auf, dass interindividuelle Unterschiede bei der Verarbeitung von und Reaktion auf appetitive und aversive Reize eine hohe Relevanz für die Entstehung psychischer Störungen und stressbezogener Erkrankungen haben. Es wurden drei unabhängige Aspekte der Reizverarbeitung untersucht und auf ihrer Basis Implikationen für die Entwicklung und Evaluation individualisierter Therapieelemente dargestellt. Die Reizverarbeitungsprozesse verschiedener Psychopathologien besser zu verstehen und hierbei nicht nur interindividuelle Unterschiede zu betrachten, sondern auch neue Maße zu entwickeln, die eine bessere Messung dieser Prozesse ermöglichen, bereitet den Weg für zukünftige Therapiefor-schung. Weitere Studien sind nötig, um die Generalisierbarkeit der dargestellten Befunde zu untersuchen und ein umfassenderes Bild des gesamten menschlichen Reizverarbeitungssystems mit all seinen Varianzen zu erlangen.

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Anhang A

Exner, A.*, Machulska, A.*, Stalder, T., & Klucken, T. (2023). Biased information processing and emotional coping: Differences in attentional and approach patterns towards positive cues in repressors and sensitizers. *Current Psychology*, 42(34), 30412–30421. <https://doi.org/10.1007/s12144-022-04087-7>.



Biased information processing and anxiety coping: differences in attentional and approach patterns towards positive cues in repressors

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Abstract

Individual differences in emotional coping styles are likely to affect information processing on different stages. Repressive coping is assumed to be related to an attentional bias away from threatening information. Possible links to biases in later stages of information processing have not been investigated to date. In the current study, 82 participants completed the visual dot-probe task as a measure of attentional bias and the Approach-Avoidance Task (AAT) as a measure of approach/avoidance bias and classified into coping groups via the Mainz Coping Inventory (MCI). Prevalence of attention bias and approach/avoidance bias were compared between groups. Main results revealed a strong approach tendency toward positive stimuli for repressors and a strong avoidance tendency for sensitizers. No group differences were found for approach bias to negative stimuli or for attention bias. The present findings of strong preferential processing of positive stimuli in repressors may be part of broader information processing alterations, which may also be linked to alterations in emotion processing.

Keywords Repressors · Sensitizers · Dot-probe task · Cognitive bias · Approach-Avoidance Task · Emotional coping · Cognitive coping

Introduction

The way people cope with anxiety or stress provoking situations varies highly between individuals and is assumed to influence responses to threatening situations or valenced stimuli. Whereas coping strategies refer to the situational use of emotional, cognitive, or behavioral techniques to reduce anxiety, coping styles refer to a dispositional preference for specific categories of coping strategies that characterize the person's reactions to anxiety or stress across different situations (Anshel, 2012). Several approaches have been undertaken to provide a meaningful classification of different coping styles, with the model of coping modes by Krohne (1993) being particularly influential. This model postulates a categorization based on the dimensions of cognitive avoidance (CAV) and vigilance (VIG), each of which encompasses

different emotional, as well as cognitive coping strategies. These dimensions of coping behavior refer to attentional orienting and information processing in the face of threatening events and have been identified as relevant by numerous studies (e.g., Derakshan et al., 2007; Krohne, 1993; Miller, 1980).

The dimension of CAV involves cognitive processes leading to a withdrawal of attention from threat-related features of a situation, e.g., by applying coping strategies like distracting, trivializing, and/or focusing on positive aspects. It is assumed that a major goal of using CAV is to attenuate aversive internal arousal triggered by the perception of threat-associated stimuli (e.g., Krohne, 1993; Weinberger, 1995). The dimension of VIG, on the other hand, involves attending to threat-related features of a situation and leads to an intense processing of such stimuli, e.g., by applying coping strategies like actively seeking information and/or anticipating possible negative outcomes. An essential goal for using VIG is the reduction of uncertainty, which is a defining characteristic of threatening situations (Krohne, 1993; Krohne et al., 2000). Based on this model, people can be classified into four groups: repressors (high CAV, low VIG), sensitizers (low CAV, high VIG), fluctuating copers (high on both dimensions), and non-defensive copers (low on both dimensions) (Krohne et al., 2000).

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Compared with all other coping styles, repressive coping has repeatedly been associated with a decreased awareness of their own physical states (e.g., Myers, 2010; Schwerdtfeger et al., 2006). This assumption is supported by ample evidence indicating that repressors exhibit greater avoidance of internal arousal states, as indicated by a discrepancy between physiological and subjective stress responses: self-reported anxiety is low, whereas the physiological response is strong, compared to the other coping groups (Derakshan & Eysenck, 1997; Derakshan et al., 2007; Kohlmann et al., 1996; Newton & Contrada, 1992). This decreased awareness of their own physical condition is often taken as an explanation for the higher prevalence of stress-related illnesses among repressors (Denollet et al., 2008; Frasure-Smith et al., 2002; Giese-Davis et al., 2006; Mund & Mitte, 2012; Myers, 2010; Schwerdtfeger et al., 2006), which contrasts the tendency toward positive ratings in mental health questionnaires (e.g. coping with bereavement: Coifman et al., 2007; alexithymia: Myers & Derakshan, 2015; adjustment to severe illness: Phipps & Srivastava, 1997).

Several explanations for this discrepancy have been proposed. The four-factor theory by Derakshan and Eysenck (1997) might be the most influential conception and holds that repressors are characterized by cognitive biases in response to threatening information, which may originate from four different sources: (i) the environment as well as the individuals' (ii) physiological state, (iii) behavior, and (iv) long-term memory. If threatening information is perceived in any of these areas, repressors exhibit cognitively biased processing which serves to mitigate the conscious perception of fear. There is a whole range of cognitive biases that can have this effect, including attentional biases (i.e., increased attention to positive stimuli or attenuated attention to negative stimuli), approach/avoidance biases (i.e., approaching positive stimuli and avoiding negative ones), association biases (i.e., increased association of stimuli with positive than with negative associations), and many others. Moreover, according to the combined cognitive biases hypothesis presented by Hirsch et al. (2006), different cognitive biases influence each other and interact. Therefore, it is proposed that cognitive biases should not be examined in isolation, but rather in combination to assess how they work together to maintain psychological effects or even dysfunctions. The investigation of cognitive biases in different coping styles offers a promising opportunity to understand the background of the dissociation between subjective experience and physiology. This, in turn, might be of relevance with regard to understanding the development of physical as well as mental health issues in repressors and thus represents a valuable starting point to improve therapeutic interventions for this group.

Coping style is suspected to influence different points in time in the chain of steps in information processing: From the very early stage of perception of the stimulus and

subsequent attentional orienting to behavioral tendencies of approaching or avoiding the stimulus. Previous research into the relationship between coping style and cognitive biases has particularly focused on attentional biases, whereas we are not aware of any study investigating approach/avoidance tendencies on the behavioral level. Results on attention have suggested that repressors first automatically direct their attention toward threatening stimuli in a very short window of time, and then subsequently divert their attention away from these stimuli (see Vigilance Avoidance Theory of Repressive Coping, Derakshan et al., 2007). However, respective results are heterogeneous for certain measures including neural processing (Brosschot et al., 1999; Fox, 1993; Ioannou et al., 2004; Klucken et al., 2010, 2015; Mogg et al., 2000; Schwerdtfeger & Derakshan, 2010). Several studies have utilized the dot-probe task as a measure of attention. During this task, attention to specific stimuli is measured by presenting two stimuli (a target and a reference stimulus) side-by-side for a short duration of time. Thereafter, both stimuli disappear, and a probe is presented in the location of one of the pictures. The reaction times for detecting the position of the probe are supposed to provide information about participants' attentional preferences, i.e., faster reaction times for probes replacing specific stimuli (e.g., threat-related cues) indicating increased attention toward such stimulus categories (MacLeod et al., 1986). Research using the dot-probe task to assess attention toward negative stimuli has yielded mixed results, with some studies reporting a greater diversion of attention away from negative or threatening stimuli in repressors (Fox, 1993; Mogg et al., 2000; Schwerdtfeger & Derakshan, 2010), while others did not (Brosschot et al., 1999; Ioannou et al., 2004; Mogg et al., 2000). Sensitizers have been found to show a different pattern in their attention to negative stimuli, however, the evidence is equally mixed: Some research suggests increased attention to threatening stimuli (Ioannou et al., 2004), whereas other research does not (Franklin et al., 2016; Mogg et al., 2000). To our knowledge only one study analyzed attentional biases towards positive stimuli in relation to coping style, with results suggesting that repressors show more attention for positive stimuli while sensitizers do not show an attentional bias (Franklin et al., 2016).

The absence of studies on approach or avoidance tendencies is surprising as they have been shown to be important in the development and maintenance of several mental disorders (for a review see Loijen et al., 2020; Mogg et al., 2005; Rinck & Becker, 2007): Specifically, there is evidence that in addictive disorders, the presence of an approach bias to substance-related stimuli might be a risk factor for increased future substance use (Loijen et al., 2020), whereas depression has been associated with lower approach to positive stimuli and lower avoidance of negative stimuli (Loijen et al., 2020). In addition, anxiety disorders have been

associated with avoidance tendencies toward threat-related stimuli (Loijen et al., 2020). These implicit action tendencies can be assessed with the Approach-Avoidance Task (AAT; Rinck & Becker, 2007). The AAT measures approach and avoidance tendencies by instructing subjects (in the classic PC-based version) to perform an approach movement (pulling a joystick) or an avoidance movement (pushing away a joystick) in response to pictures presented successively on a computer screen. In general, a shorter reaction time for pulling or pushing a particular image is indicative of an approach or avoidance tendency, respectively, towards this image (Strack & Deutsch, 2004).

The aim of the current study was to assess preferential information processing on different levels of the processing chain for the different coping styles. For this purpose, a dot-probe task is used to measure attentional bias whereas the AAT is employed to measure approach/avoidance bias. Stimuli for both paradigms are general positive and general negative pictures. We hypothesize that repressors show increased attention to positive compared to negative stimuli, whereas sensitizers show a reverse pattern of attention allocation. Further, we expect that repressors show a greater approach tendency to positive stimuli and increased avoidance of negative stimuli, whereas sensitizers would show increased avoidance of positive stimuli and increased approach to negative stimuli. No specific hypotheses are raised concerning the fluctuating and non-defensive groups due to the absence of previous research. However, based on the assumptions from Krohne's (1993) definition of coping styles, it can be suggested that no cognitive biases will be observed in either group. In the fluctuating individuals, the alternating use of vigilant and cognitive avoidant coping might involve an alternating turning towards and away from negative and positive stimuli, whereas in the non-defensive individuals, the tolerance for uncertainty and internal arousal might lead to none of the stimulus categories being avoided or approached intensively. Respective results are reported to ensure that the observed effects for repressors and sensitizers were exclusive to these groups.

Method

Participants

A total of 82 healthy participants took part in the study (18 males; age: $M = 21.19$, $SD = 3.57$). Exclusion criteria were insufficient German language skills, uncorrected visual or auditory impairment. In addition, subjects were asked in self-report format if they had currently or previously suffered from mental illnesses, if they were undergoing psychological or psychiatric treatment, or were taking perception-altering medications, which also resulted in exclusion

from the study. Nine participants were excluded because of missing information in the coping questionnaire, leaving 73 study participants. Participants received either monetary reimbursement (10€/h) or course credits for participation. The study protocol was approved by the local ethics committee and was conducted in accordance with the Declaration of Helsinki. Participation was voluntary and participants had the right to withdraw their consent to participate at any time.

Procedure

The experiment was part of a larger study on psychometric properties of influential experimental tasks for cognitive bias assessment (Machulska et al., 2022) and conducted in the laboratory of the Department of Clinical Psychology and Psychotherapy at the University of Siegen, Germany. It included three measurements of cognitive bias, which were passed by the participants successively: a visual dot-probe task, an Approach-Avoidance Task (AAT), and an Implicit Association Test (IAT; data not shown here). The order of experimental tasks was counterbalanced across participants. The experiment took place in groups of up to four participants in the same room and lasted for about 60 min. After the laboratory session, participants completed a set of questionnaires, including the German version of the Mainz Coping Inventory (MCI; Krohne et al., 2000), scales on wellbeing (Positive Mental Health, PMH; Lukat et al., 2016), personality traits Neuroticism-Extraversion-Openness-Five-Factor Inventory, NEO-FFI, German version: Borkenau & Ostendorf, 2008; Affective Neuroscience Personality Scales, ANPS, German version: Reuter et al., 2017), and trait anxiety (State-Trait Anxiety Inventory, STAI; German version: Laux et al., 1981; Anxiety Sensitivity Index, ASI-4, German version: Kemper et al., 2010).

Measures

Experimental paradigms

The dot-probe task was programmed and operated in Inquisit 5 Lab software, while the AAT was programmed in Microsoft VisualBasic. For task presentation, a desktop computer (Dell Version 1903) and a 23.8-inch computer monitor with a resolution of 1920×1080 pixels were used.

Visual Dot-Probe Task (DPT) The visual dot-probe task measures attentional biases by comparing reaction times to a probe that replaces a positive or a negative picture, after both pictures have been presented simultaneously side-by-side (MacLeod et al., 1986). Each trial started with a fixation cross (500 ms) in the center of the screen. Afterwards, a positive and a negative picture with dimensions of 640×479 pixels, gathered from the Geneva Affective Picture Database (GAPED; Dan-Glauser & Scherer, 2011), were presented

simultaneously for 1000 ms in the left and right halves of the screen. Subsequently, both pictures disappeared, and an "X" (the probe) appeared on one side of the screen, replacing either the positive or the negative picture, respectively. Participants were instructed to indicate the position of the probe (right vs. left) as fast and accurately as possible by pressing a key on a response pad (Cedrus Response Pad RB844). 40 pairs of images were presented successively in a random order. In addition, 40 filler trials with 10 different neutral image pairs were presented to avoid habituation effects (Miller & Fillmore, 2010). To calculate the attentional bias score, median reaction times for probes replacing positive pictures were subtracted from median reaction times for probes replacing negative pictures (Becker et al., 2016). Accordingly, a positive attentional bias score can be interpreted as enhanced attention to positive pictures, whereas a negative score can be interpreted as enhanced attention to negative pictures.

Approach-Avoidance Task (AAT) The AAT measures automatic action tendencies for positive and negative stimuli by contrasting reaction times in milliseconds for pull (approach) or push (avoidance) motor movements in response to positive and negative stimuli (Rinck & Becker, 2007). For this purpose, 50 positive and 50 negative pictures depicting people, animals, and nature scenes were selected from the Geneva Affective Picture Database (GAPED; Dan-Glauser & Scherer, 2011) and were presented with dimensions of 332 × 262 pixels one after the other on a computer screen. To avoid training effects, pictures used in the AAT were not identical to those presented in the dot-probe task. In each trial, pictures were either tilted 3° to the left or 3° to the right. Participants were instructed to pull a joystick attached to the computer (Logitech Extreme 3D) towards themselves when the image was tilted to the left. As a result, the image enlarged to 977 × 768 pixels, creating a sense of approaching the image. For images tilted to the right, participants were asked to push the joystick away from them, causing the image to shrink to 111 × 89 pixels and therefore creating a sense of avoiding the image. At the beginning of the experiment, 12 practice trials were performed with neutral images, which were not included into the analyses. Thereafter, each positive and each negative image were presented once in a pull (tilted to the left) and once in a push format (tilted to the right), resulting in 200 trials in total. The approach/avoidance bias score was calculated for each image category by subtracting the median reaction time for pull movements from the median reaction time for push movements (Rinck & Becker, 2007). By doing so, a positive bias score is indicative of an approach bias for a particular image category (i.e., positive, or negative stimuli), whereas a negative bias score implies an avoidance bias for a particular images category. Here,

Table 1 Descriptive statistics of the four coping style groups

Coping style	N	Age	Cognitive avoidance	Vigilance
Repressors	19	21.83 (3.67)	14.84 (1.50)	8.12 (2.47)
Sensitizers	21	20.10 (2.04)	8.43 (1.94)	14.33 (1.68)
Non-defensive	23	20.91 (2.92)	10.30 (1.89)	7.78 (2.28)
Fluctuating	10	22.80 (6.48)	14.50 (1.65)	14.20 (2.39)

Mean (standard deviation) of age, COV and VIG scores

reaction time was defined as the total time from the onset of the response to the execution of the entire movement.

Coping style

The German version of the Mainz Coping Inventory (MCI; Krohne et al., 2000) was used to measure coping style. The MCI measures habituated anxiety coping on the two independent dimensions of cognitive avoidance and vigilance. To determine a subject's personal expression of these coping styles, eight different stressful situations with different levels of threat and controllability were described (e.g., 'Imagine that you will have an important examination the next morning'), to each of which five response items with cognitive avoidant behavior and five response items with vigilant behavior were presented. Participants were instructed to rate in a true-false format whether they would exhibit this behavior in the corresponding situation or not (in a public speech scenario e.g., 'I think about what questions might be asked after the speech.' for vigilant coping; 'I don't think about the speech anymore.' for cognitive avoidant coping). Habitual tendencies to cognitive avoidance and vigilance were calculated using the subscale for ego-threatening situations as a sum score across the associated items of these situations (true = 1; false = 0), in order to ensure comparability with other studies (Krohne et al., 2000). 15 missing item values were replaced according to the manual by using the rounded-up or rounded-down mean of the specific item reported in the normalization sample (separated by gender of the subjects). Sum scores were used to classify participants into the four coping style categories by dichotomizing the two dimensions of CAV and VIG by median splits ('low': percentile rank below 50% in the current sample; 'high': percentile rank above 50% in the current sample) resulting in the four groups further described in Table 1. There were no significant differences between coping style groups in terms of gender distribution ($\chi^2(3) = 1.64, p = 0.651$) or average age of group members (Welch's $F(3, 27.42) = 78.53, p = 0.243$).

Statistical analyses

Extreme values were defined as scores that are more than 3 times the interquartile range and excluded them from further analysis (DPT: $n = 1$, AAT: $n = 2$). In addition, technical

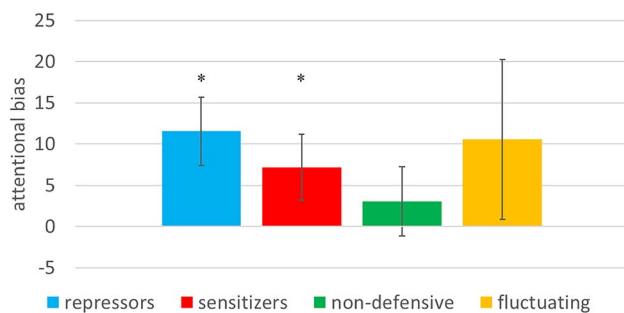


Fig. 1 Estimates of attentional bias derived from the dot-probe task shown for different coping styles. Error bars indicate the SEM. ** $p < 0.01$, * $p < 0.05$

difficulties resulted in the loss of reaction time data for some subjects (DPT: $n = 1$, AAT: $n = 6$). To examine cognitive biases for each coping style, different analyses were conducted: For the DPT a one-way ANOVA was conducted with coping style (repressors vs. sensitizers vs. fluctuating vs. non-defensive) as between-subject factor. Additionally, one-sided one-sample t-tests were conducted separately for each coping style separately to examine the extent to which scores differed from zero, i.e., to test whether attentional biases were present. For the AAT, a 2×4 ANOVA was conducted with stimulus category (positive vs. negative) as within-subject factor and coping style (repressors vs. sensitizers vs. fluctuating vs. non-defensive) as between-subject factor. Post-hoc tests were run when necessary. SPSS 28 (SPSS 28.0 for Windows, SPSS Inc, Chicago, IL) with an alpha (α)-level of 0.05 was used for all analyses.

Results

Visual Dot-Probe Task (DPT)

Regarding attentional preferences, the one-way ANOVA revealed no significant differences between coping styles ($F(3, 68) = 0.66$, $p = 0.583$, $\eta^2 = 0.028$). One-sample t-tests showed that attentional biases significantly deviated from zero, for both repressors ($t(17) = 2.79$, $p = 0.006$, $d = 0.66$) and sensitizers ($t(20) = 1.79$, $p = 0.044$, $d = 0.39$; Fig. 1), indicating a significant attentional bias towards positive stimuli. The other two groups did not display a significant attention bias towards or away from valenced pictures (non-defensive: $t(22) = 0.73$, $p = 0.237$, $d = 0.15$; fluctuating: $t(9) = 1.09$, $p = 0.153$, $d = 0.34$).

Approach-Avoidance Task (AAT)

Regarding approach/avoidance tendencies, the ANOVA revealed a significant valence $\times$ coping style interaction ($F(1, 64) = 2.84$, $p = 0.045$, $\eta_p^2 = 0.118$). No main effects reached significance. Bonferroni-adjusted post-hoc analysis showed a

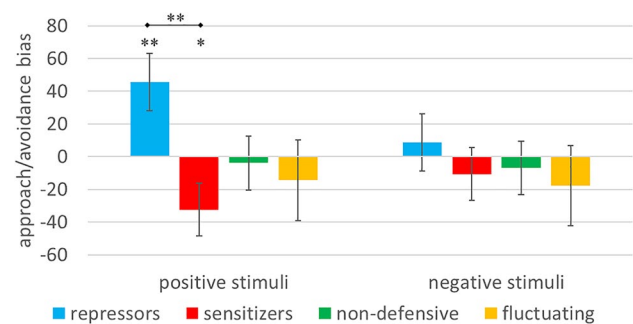


Fig. 2 Estimates of approach/avoidance bias derived from the Approach-Avoidance Task shown for different coping styles. Error bars indicate the SEM. ** $p < 0.01$, * $p < 0.05$

significant difference in bias scores between repressors and sensitizers for positive stimuli only (positive stimuli: $M_{diff} = 78.16$, $p = 0.010$; negative stimuli: $M_{diff} = 19.29$, $p = 1.000$) with an approach tendency for repressors and an avoidance tendency for sensitizers (see Fig. 2). One-sample t-tests confirmed a significant approach tendency towards positive images for repressors (positive stimuli: $t(15) = 3.08$, $p = 0.004$, $d = 0.77$; negative stimuli: $t(18) = 0.43$, $p = 0.336$, $d = 0.10$) and a significant avoidance tendency for sensitizers (positive stimuli: $t(20) = -2.00$, $p = 0.029$, $d = 0.44$; negative stimuli: $t(20) = -0.54$, $p = 0.297$, $d = 0.12$). The remaining two groups did not display a significant approach/avoidance bias towards or away from valenced pictures (positive stimuli: non-defensive: $t(20) = -0.37$, $p = 0.359$, $d = 0.08$; fluctuating: $t(9) = -0.69$, $p = 0.253$, $d = 0.22$; negative stimuli: non-defensive: $t(19) = -0.53$, $p = 0.303$, $d = 0.12$; fluctuating: $t(8) = -0.57$, $p = 0.293$, $d = 0.19$).

Discussion

The present study was the first to examine the presence of cognitive biases on different stages of the information processing chain from the direction of attention to action tendencies in individuals of different habitual coping styles. Our results revealed evidence for a significant attentional bias in both repressors and sensitizers characterized by increased attention towards positive stimuli, but no group differences in the magnitude of attention bias. With respect to the automatic action tendencies, we were able to reveal a significant approach tendency for repressors and a significant avoidance tendency for sensitizers for positive stimuli, whereas no significant approach/avoidance bias for negative stimuli emerged for any of the coping groups.

When contrasting positive and negative images in the dot-probe task, our results showed a preferential processing of positive stimuli as opposed to negative ones for repressors as well as for sensitizers. For repressors, these results are in line with current research: a decreased attention for negative stimuli

(Fox, 1993; Franklin et al., 2016; Mogg et al., 2000) and an increased attention for positive stimuli have previously been observed (Franklin et al., 2016). Nevertheless, there are also studies that were unable to find such effects, both for negative (Brosschot et al., 1999; Fox, 1993; Ioannou et al., 2004; Mogg et al., 2000) as well as positive stimuli (Brosschot et al., 1999; Ioannou et al., 2004). The reason why the present study did find attentional biases toward positively valenced cues while others did not may be multifaceted. Since the only other study using general valenced pictures instead of words or faces also reports a significant effect (Franklin et al., 2016), it could be supposed that complex visual cues cause a stronger attentional bias in repressors or at least make it more visible. In addition, it is conceivable that the chosen contrast between positively and negatively-valenced stimuli may have contributed to the present pattern of results. This approach differs from the majority of previous studies, which have contrasted valenced stimuli with neutral stimuli (Fox, 1993; Franklin et al., 2016; Ioannou et al., 2004; Mogg et al., 2000).

For sensitizers, the preferential attention toward positive over negative stimuli that was observed in the present study does not seem to be entirely consistent with the current literature, since most previous evidence of significant attentional biases suggested effects in the opposite direction, i.e., a preferential attention allocation toward negative stimuli (Brosschot et al., 1999; Fox, 1993; Ioannou et al., 2004; Klucken et al., 2010) and an avoidance of positive stimuli (Franklin et al., 2016; Ioannou et al., 2004; Klucken et al., 2010). The evidence is equally inconsistent as for repressors, with a majority of studies reporting null-findings (Brosschot et al., 1999; Fox, 1993; Franklin et al., 2016; Mogg et al., 2000). The present study used picture stimuli, which are known to allow a faster categorization than words (Guenther et al., 1980; Potter & Faulconer, 1975; Seifert, 1997). This may have left the present participants more time after initial categorization to turn their attention to the respective stimulus, which may make it possible to observe a stronger attentional bias than with text stimuli and thereby generating larger effects in attentional bias. Another explanation relates to the selection of positive and negative stimuli. In most studies, preferential processing of negative stimuli was exclusively found for socially threatening stimuli, whereas no attentional bias was observed for physically threatening stimuli in most cases (Brosschot et al., 1999; Fox, 1993). Thus, in contrast to the generally negative images that were used as negative stimuli in the present study, it might be necessary to also include socially threatening stimuli in order to observe preferential processing of negative stimuli.

In terms of behavioral approach/avoidance biases measured by AAT, repressors showed an approach tendency and sensitizers an avoidance tendency towards positive stimuli. These results are in line with previous evidence showing repressors to exhibit an increased attention (Franklin et al., 2016) and sensitizers a

decreased attention (Franklin et al., 2016; Ioannou et al., 2004) towards positive stimuli. In contrast to these results, neither repressors nor sensitizers showed a significant approach-avoidance bias for negative stimuli. These results are partly consistent with the literature: While repressors often show less attention (Fox, 1993; Franklin et al., 2016; Mogg et al., 2000) and sensitizers often show more attention (Brosschot et al., 1999; Fox, 1993; Ioannou et al., 2004) for negative stimuli, there are also many studies that did not find these effects (Brosschot et al., 1999; Fox, 1993; Mogg et al., 2000). However, it must be noted that the studies reviewed above focused on attentional biases rather than action tendencies or motor movements. Even though these biases (if present) are frequently interpreted as approach or avoidance tendencies, the possibility to generalize attentional preferences to a preferential processing in terms of action tendencies remains unclear. Thus, it is possible that the early phase of stimulus processing, in which attention is directed toward or away from a stimulus, is less (or less consistently) influenced by coping style than the later behavioral tendency to approach or avoid that stimulus. By using the AAT, we were able to show that it may not be the negative stimuli that make the difference between repressors and sensitizers, but that these groups most strongly differ from each other in terms of their behavioral tendencies towards positive stimuli.

The current finding of no cognitive biases in fluctuating and non-defensive individuals corresponds with assumptions derived from Krohne's (1993) model of coping modes: Fluctuating individuals are expected to exhibit an intolerance to internal arousal and uncertainty, which leads them to employ a fluctuating use of vigilant and cognitive-avoidant coping in dealing with anxiety-evoking situations. This switching between these coping styles might thus result in neither a stable cognitive bias toward nor away from positive or negative stimuli being observable. In future research, these dynamics might be investigated in fluctuating individuals, for example, by manipulating cue-response time intervals in the AAT to assess immediate as well as delayed approach/avoidance biases (Wei et al., 2020). In contrast, the non-defensive individuals are tolerant of uncertainty as well as internal arousal. Thus, there is no reason for these individuals to turn away from certain stimuli or towards others.

There are some limitations in this study that need to be mentioned. The classification according to Krohne (1993) is theoretically sound and commonly used, but previous research in this context has also adapted a coping classification based on individual 'defensiveness' (measured with the Marlowe-Crowne Social Desirability Scale; MCSDS, Crowne & Marlowe, 1960) and 'trait anxiety' (measured with the State-Trait Anxiety Inventory; STAI, Spielberger et al., 1983) with repressors showing low anxiety and high defensiveness and sensitizers showing high anxiety but low defensiveness (Weinberger et al., 1979). Although it has been shown that the group assignment converges between the two methods for repressors and sensitizers

(Krohne et al., 2000), it could be argued that a parallel classification of the sample according to the Weinberger method would have brought additional gain for the remaining two coping styles. It might be interesting for future research to study approach/avoidance biases additionally using this classification to confirm the unique character of repressors' and sensitizers' results. Another limitation might be, that recent research casted doubts regarding the psychometric properties of the dot-probe task, since internal consistency and retest reliability are usually very low (Chapman et al., 2019; Kappenman et al., 2014; Machulska et al., 2022; Rodebaugh et al., 2016). The presented study is in line with these findings, showing a very low internal consistency for the dot-probe task (Spearman-Brown corrected split-half correlation $r = -0.31$; Machulska et al., 2022). The AAT on the other hand has been found to show moderate to good internal consistency and retest reliability (Machulska et al., 2022). Beyond that, it has to be considered that we did not control for arousal in our study, which might be important since arousal can influence visual attention when using picture stimuli (e.g., Sutton & Lutz, 2019). A comparison of the arousal values for the positive and negative stimuli (see Table 2 in the appendix) shows that the negative pictures elicit a significantly higher arousal than the positive pictures. In future research, it might therefore be interesting to match the arousal ratings for the individual pictures to ensure a better comparability of picture categories. Furthermore, when interpreting the results, it is important to consider that the groups used are rather small. However, the group sizes used here correspond to the group sizes used in previous research and should thus be sufficient to find similar effect sizes (Brosschot et al., 1999; Fox, 1993; Klucken et al., 2010; Mogg et al., 2000). Since we only used diagnostic screening questions rather than not a full diagnostic interview, we cannot fully rule out the possibility that some individuals suffering from mental illnesses may have been included in the present sample. However, self-report measures concerning positive wellbeing, personality traits, and trait anxiety indicated that mean scores and standard deviations were comparable to those reported for healthy young samples (Machulska et al., 2022). Nevertheless, future studies should consider more comprehensive assessment of mental health. Finally, it has to be noted that gender was unequally distributed, with more female participants being included in the current sample. However, since the gender distribution does not differ significantly across coping styles, it is not expected that this would substantially bias the results. Nevertheless, a more precise investigation of gender differences of approach/avoidance biases for repressors and sensitizers could be interesting for future research.

In summary, the results of this study mildly suggest that the difference between repressors and sensitizers in their preference for certain stimuli is considerably more intense for positive stimuli than for negative stimuli. The higher prevalence of stress-related illnesses in repressors (Denollet et al., 2008;

Frasure-Smith et al., 2002; Giese-Davis et al., 2006; Mund & Mitte, 2012; Myers, 2010), which is often attributed to their decreased awareness of their own physical states (e.g., Myers, 2010; Schwerdtfeger et al., 2006), could therefore also be related to this information processing bias towards positive stimuli. In recent years, a new branch of research has developed that not only measures cognitive biases, but seeks to modify them (e.g., Beard, 2011; MacLeod & Mathews, 2012). These attempts of cognitive bias modification are mostly based on reducing negative biases and developing positive biases. The findings presented in this study are highly relevant to such interventions, as they aim to increase positive information processing under the assumption that this would have positive consequences in any case (e.g., positivity approach training: Becker et al., 2016, 2019). The results of the present study suggest that biased information processing per se—whether towards positive or towards negative stimuli—might be related to dysfunctional coping. In this case, a helpful intervention does not necessarily have to be aimed at increasing information processing biases, even if the increase is focused on positive stimuli, but should train a flexible and unbiased processing. Supportive evidence for this account is provided, for example, in PTSD research: Attentional bias modification training towards positive stimuli (even though the bias modification was successful), is frequently found to be less effective than attention control trainings that apply the instruction to direct attention towards threat in 50% and away from threat in the remaining 50% of trials (e.g., Badura-Brack et al., 2015; Lazarov et al., 2019). Moreover, meta-analyses show that the effects reached by cognitive bias modification trainings are at most very small, if not non-significant (Cristea et al., 2015). These results suggest that principled reinforcement of approach to positive stimuli is not beneficial in all cases. Moreover, the present study provides first hints that this might be due to differences in coping behavior. In light of our results, it seems reasonable to assume that it could be important for cognitive bias modification training to determine individual coping styles beforehand and to tailor the training correspondingly. Future studies will have to show whether (1) cognitive biases toward positive stimuli can also be dysfunctional and (2) cognitive bias modification training involving an approach training to negative and an avoidance training of positive stimuli could be useful for repressors.

Methodologically, the divergent results across cognitive bias measures highlight the importance of using multiple procedures in individual studies to reveal possible inconsistencies in the results. Moreover, they underscore the need to examine the entire information processing chain, as biases may arise at many stages besides attentional, which may be significantly more relevant in the context of coping styles. We demonstrated that the AAT is one way to examine behavioral approach or avoidance tendencies toward positive and negative stimuli, and that this consideration of different stages of information processing leads to other findings—the potentially strong importance of positive stimuli.

Appendix

Table 2 Mean (standard deviation) of valence and arousal ratings of the presented picture stimuli according to the Geneva Affective Picture Database (GAPED; Dan-Glauser & Scherer, 2011)

	DPT		AAT	
	Positive	Negative	Positive	Negative
Valence	91.96 (4.14)	14.01 (4.93)	91.62 (3.57)	13.10 (5.81)
Arousal	19.49 (8.33)	64.60 (8.95)	20.33 (9.37)	67.70 (6.21)

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Data availability The data that support the findings of this study are available from the corresponding author upon request.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the local Ethics Committee of the University of Siegen.

Consent to participate/publish Informed consent was obtained from all individual participants included in the study. Participants signed informed consent regarding publishing their data.

Competing interests The authors have no conflicts of interests to declare.

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Anhang B

Exner, A., Tapia León, I., Mueller, E. M., & Klucken, T. (2021). Cardiac response in aversive and appetitive olfactory conditioning: Evidence for a valence independent CS-elicited bradycardia. *Psychophysiology*, 58(11), e13912. <https://doi.org/10.1111/psyp.13912>.

Cardiac response in aversive and appetitive olfactory conditioning: Evidence for a valence-independent CS-elicited bradycardia

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Abstract

While the examination of conditioned cardiac responses is well established in human fear conditioning research, comparable studies using less-aversive or rather appetitive unconditioned stimuli (UCS) are sparse and results are mixed. Therefore, the aim of this study was a systematic analysis of cardiac reactions in aversive and appetitive conditioning. Olfactory stimuli were used as unconditioned stimuli as they are suitable reinforcers in both an aversive and an appetitive conditioning offering the opportunity for a comparison between conditioned responses. In total, $n = 86$ participants took part in both an aversive and an appetitive differential conditioning task with a counterbalanced order across participants. Aversive or appetitive odors, respectively, served as UCS and neutral geometrical figures as CS. Subjective ratings, skin conductance response (SCRs), and evoked cardiac reactions were analyzed and compared between tasks. Conditioned responses in subjective ratings could be observed in both aversive conditioning and appetitive conditioning, while SCRs discriminated between CS+ and CS− in aversive conditioning only. Regarding conditioned cardiac responses, the deceleration for the CS+ was longer than for the CS− in both tasks. In addition, a higher deceleration magnitude and a shorter acceleration for the CS+ as compared to the CS− were found in aversive but not in appetitive conditioning. There were medium-size correlations between aversive and appetitive CRs for subjective ratings and none for physiological responses. The results suggest similarities between cardiac response patterns in aversive and appetitive conditioning, which implies that bradycardia in conditioning might not be fear-specific but presents a valence-independent CS-elicited bradycardia.

KEYWORDS

autonomic, cardiovascular, emotion, fear bradycardia, learning, odor

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1 | INTRODUCTION

Aversive as well as appetitive conditioning play an important role in the development and maintenance of anxiety disorders, addiction, and eating disorders (Lissek et al., 2005; Martin-Soelch et al., 2007). Differential conditioning describes the process of associative learning between a neutral stimulus (CS+) and a stimulus with a high aversive or appetitive value (unconditioned stimulus, UCS), while a second neutral stimulus (CS−) is not associated with the presence of this UCS.

Aversive as well as appetitive conditioning is extensively analyzed in animal models, while studies on human subjects focus more frequently on aversive conditioning. This is surprising since both processes are similarly important for mental health (Lissek et al., 2005; Martin-Soelch et al., 2007). Regarding human subjects, one of the most commonly used measures of conditioned responses apart from subjective ratings of valence or arousal is the differential skin conductance response (SCR): The CS+ commonly evokes stronger SCRs than the CS− in aversive (for a review see Lonsdorf et al., 2017) as well as appetitive conditioning (e.g., Andreatta & Pauli, 2015; Kruse et al., 2017). However, while SCRs reliably differ between CS+ and CS− during conditioning, this response system is not sensitive for differentiating between appetitive and aversive CRs, i.e., SCRs show the same increase to appetitive and to aversive CS+s if non-fear stimuli are used (e.g., Hermann et al., 2000; Klucken, Alexander, et al., 2013; Klucken, Kagerer, et al., 2009).

Beside the SCR as a measure of emotional reactions, cardiac responses play an important role in the processing of aversive or appetitive events (e.g., preparation for fighting or ingestion) by controlling central physiological processes (Löw et al., 2008, 2015; Obrist, 1976; Veen et al., 2000). Furthermore and in contrast to SCRs, cardiac responses might offer the opportunity to differentiate between aversive and appetitive responses. Previous research has shown a tri-phasic pattern of cardiac responses to emotional stimuli in general: An initial short deceleration (after CS onset), followed by an acceleration and a further late deceleration (Bohlin & Kjellberg, 1979; Bradley et al., 2001; Bull & Lang, 1972). In contrast, the changes within this response pattern might be different in aversive compared to appetitive conditioning. In studies investigating aversive conditioning of cardiac responses, a stronger deceleration following the CS+ compared to the CS− is typically observed in a certain time window after CS onset (2–6 s after CS onset for humans) in human (Bradley et al., 2005; De Leon, 1964; Hugdahl, 1979; López et al., 2009; Panitz et al., 2018; Sperl et al., 2016; but also see Hodes et al., 1985) and non-human subjects (Applegate et al., 1982; Burhans et al., 2010; Holdstock & Schwartzbaum, 1965; Kuniecki et al., 2002;

Pascoe & Kapp, 1985). Since this deceleration is reliably observed towards fear-eliciting stimuli, it is often termed “fear bradycardia” (Campbell et al., 1997; De Leon, 1964; Hugdahl, 1979; López et al., 2009). It has been interpreted as an index of increased attention to the environment (Bull & Lang, 1972; Lang & Bradley, 2010; Löw et al., 2008) and its strength is assumed to be associated with a higher level of arousal (Bradley et al., 1999; Wardle et al., 2018). By contrast, conditioned cardiac responses in appetitive conditioning have frequently been analyzed in animal models with many studies showing a conditioned acceleration in heart rate (e.g., Boivin, 1986; Braesicke et al., 2005; Gantt, 1960; Obrist & Webb, 1967; Randall et al., 1975; Wenzel, 1961) and others showing a conditioned deceleration in heart rate (e.g., Goldstein et al., 1970; Hunt & Campbell, 1997; McLaughlin & Powell, 1999; Powell et al., 1993). Regarding human subjects, only few studies have examined appetitive conditioning of cardiac reactions (Ebrahimi et al., 2019; Hermann et al., 2000; Prévost et al., 2012; Wardle et al., 2018) with mostly no differential responses between CS+ and CS−. However, most studies reported no differential CRs in valence ratings either, which might lead to the conclusion that the used UCSs were not of a sufficient potency for conditioning. To our knowledge, only one study found differential responses to CS+ versus CS− (Prévost et al., 2012) with a more pronounced deceleration towards the CS− trials. Since these authors describe to simply compare the number of heart beats in a certain time window, this finding might be interpreted as an acceleration for CS+ trials. In summary, aversive CS+s have consistently been found to induce a heart rate deceleration, while results on appetitive CS+s have been mixed.

Surprisingly, most studies on human subjects have investigated aversive conditioning or appetitive conditioning separately, although the underlying neural processes are assumed to be comparable between both forms of conditioning (Klucken et al., 2015; Klucken, Alexander, et al., 2013; Klucken, Wehrum, et al., 2013). However, a detailed within-subject analysis of similarities and differences between appetitive and aversive conditioning might be important due to the following reasons: Appetitive and aversive conditioning are assumed to be crucial processes for understanding mental illnesses, like anxiety disorders or addictive disorders (Lissek et al., 2005; Martin-Soelch et al., 2007). For example, increased CRs in fear conditioning tasks have been found for patients suffering from anxiety compared to healthy controls (for a review see Lissek et al., 2005). Additionally, there is some evidence suggesting enhanced CRs in appetitive conditioning tasks in patients suffering from addiction compared to healthy controls (e.g., Klucken et al., 2016). As comorbidities between addiction and anxiety disorders are common (e.g., Burns & Teesson, 2002; Grant et al., 2004; Kessler et al., 2005), it might be expected

that individuals exhibit a common sensitivity to both aversive and appetitive conditioning. In other words, a raised sensitivity to appetitive as well as aversive conditioning might be a risk factor for a comorbidity of anxiety and addiction. This hypothesis is indirectly supported by previous data showing that specific genotypic subgroups demonstrate an increased neuronal sensitivity to salient cues in general, i.e., to appetitive as well as to aversive cues—rather than specifically to appetitive or aversive cues (Klucken et al., 2015; Klucken, Alexander, et al., 2013; Klucken, Wehrum, et al., 2013). However, the mentioned studies have investigated increased sensitivity to aversive and appetitive conditioning in different samples, which thus impedes the possibility of intra-individual comparisons.

One difficulty in comparing appetitive and aversive conditioning is the choice of appetitive stimuli that elicit physiological responses comparable to those elicited by aversive stimuli (Martin-Soelch et al., 2007). This has often led to the use of reinforcers of entirely different modalities in aversive and appetitive conditioning. In aversive conditioning, mostly tactile or auditory fear-inducing reinforcers, like electro-tactile stimulations or loud noise, are used (for a review see Lonsdorf et al., 2017). In human appetitive conditioning, money (Kirsch et al., 2003; Knutson et al., 2001; Kruse et al., 2017; Tapia León et al., 2018) or erotic pictures (e.g., Klucken, Schweckendiek, et al., 2009; Klucken, Wehrum, et al., 2013), are commonly used as reinforcers. However, given that partially distinct brain regions are activated if UCSs of different modalities are used (Delgado et al., 2011; Levy & Glimcher, 2011), the comparison of aversive and appetitive conditioning would clearly profit from the use of same modality reinforcers. In summary, the studies available comparing appetitive and aversive conditioning either used a between-subject design (Austin & Duka, 2010; Hermann et al., 2000), different reinforcer modalities between tasks (Andreatta & Pauli, 2015) and/or did not examine conditioned cardiac responses (Andreatta & Pauli, 2015; Austin & Duka, 2010; Cook et al., 2015).

The present study thus sets out to investigate conditioned responses in an aversive and an appetitive differential conditioning task in a within-subject design. In order to utilize reinforcers of the same modality across both tasks, olfactory stimuli comparable in subjective ratings of valence and arousal were used as UCSs. We first sought to investigate cardiac response patterns and CS+/CS− differentiation within aversive and appetitive conditioning separately. Our main aim was then to examine differences and similarities in conditioned responses between aversive and appetitive conditioning. Concerning the latter, it was hypothesized that the aversive task would induce stronger CRs than the appetitive task. Last, an explorative analysis of intra-individual relationships between aversive and appetitive CRs was conducted.

2 | METHOD

2.1 | Sample

In total, 95 participants took part in this study. Data of five participants had to be discarded from analyses due to technical problems, another four participants were excluded due to aberrant UCS ratings (three participants rated the appetitive UCS as aversive, one participant rated the aversive UCS as appetitive), leaving a total sample of 86 study participants (61 females; age: $M = 23.80$ years; $SD = 5.24$ years).

Participants were excluded if they reported suffering from a current or chronic olfactory disorders in order to ensure an adequate perception of the UCSs. Additionally, none of the participants reported a history of mental, neurological or cardiovascular disorders. Participants were remunerated with 14.00€ or course credits for their participation. The study protocol was approved by the local ethics committee at the University of Siegen.

2.2 | Experimental paradigm

Since this study is part of a larger research project, participants filled in some trait questionnaires (NEO-FFI, BIS/BAS, Sensation Seeking Scale, Disgust Scale) before starting the experiment. The study procedure consisted of two differential conditioning tasks (with one CS+ and one CS− per task) only varying in the valence of the UCS used (appetitive vs. aversive). Participants completed the two conditioning tasks one after the other within the same study session. The task order was counterbalanced across the sample.

2.2.1 | Stimuli

Two pairs of black geometric figures (pair 1: square in normal orientation or rotated by 90°, pair 2: eclipse in vertical or horizontal orientation) served as CS+ and CS− (aversive task: avCS+, avCS−; appetitive task: appCS+, appCS−) and were presented at the center of a grey screen. The assignment of the CS pairs to aversive and appetitive conditioning as well as the CS orientation to the CS type (CS+, CS−) was counterbalanced across participants.

As UCSs, the odors “animal” (aversive task) and “hot apple pie” (appetitive task) (Scent 5-pack for SDS100, BIOPAC Systems Inc., Santa Barbara, CA, USA) were used, which were identified as most aversive and most appetitive respectively out of a set of 16 odors in a pilot study (data not reported). On non-reinforced trials, neutral air was presented as Non-UCS to ensure that the tactile stimulation (stream of air) was similar over all conditions. All three odors were presented via an olfactometer directing the odors via three

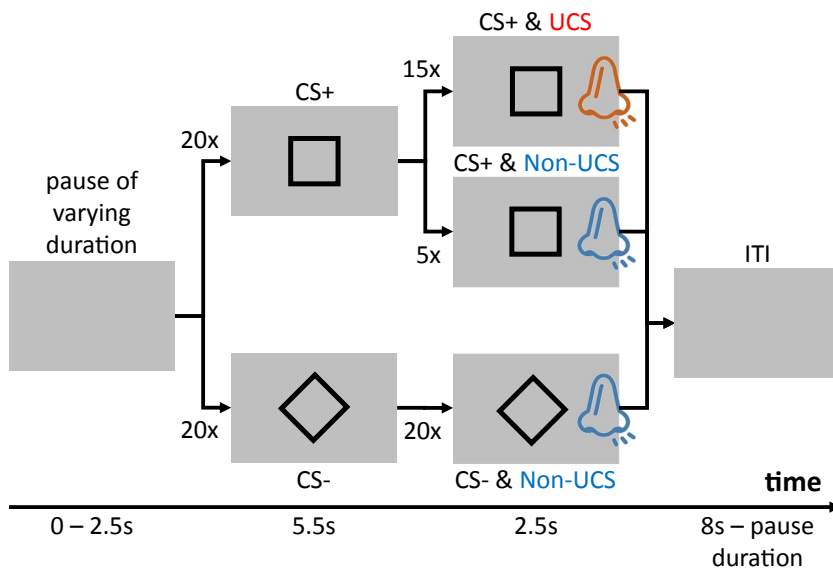


FIGURE 1 Trial design. After a pause of varying duration (0–2.5 s), in half of the 40 trials the CS+, in the other half the CS– was shown for 5.5 s. During the next phase the CS remained displayed, while the UCS (in 15 of the CS+ trials) or respectively the Non-UCS (in all other trials) was presented for 2.5s. Every trial ended with a ITI lasting for 5.5–8 s depending on the length of the preceding pause to ensure an overall trial length of 16 s

different PTFE tubes connected to a mask directly to the participant's nose (Multistimulator OG001 with two odorant modules type 2, Burghart Messtechnik GmbH, Wedel, Germany).

2.2.2 | Conditioning tasks

The study included two separate experimental tasks, i.e., (1) an aversive conditioning task and (2) an appetitive conditioning task. It was counterbalanced across participants which task was passed first or second. The following design and stimuli parameters were used in both the appetitive and the aversive conditioning task to ensure comparability: In each task, 20 CS+ and 20 CS– trials were conducted (aversive task: avCS+/avCS–; appetitive task: appCS+/appCS–). Each task started with one reinforced CS+ and one CS– trial. No more than two CS+ or two CS– were presented in succession. Each trial started with a pause of a variable duration of 0–2.5 s showing a plain grey screen (see Figure 1). This was followed by the presentation of a CS+ or a CS– for 8 s. In total, 75% of the CS+ trials were reinforced. The olfactory UCS (aversive task: avUCS; appetitive task: appUCS) was presented during the final 2.5 s of the CS+ presentation period. In the other 25% of CS+ trials and in all of the CS– trials, neutral air was presented (Non-UCS) with the same duration as the UCSs to ensure comparability between reinforced and non-reinforced trials. During the intertrial interval (ITI), a plain grey screen was displayed. The ITI varied between 5.5 and 8 s, resulting in a 16 s time lag between the CS onset of one trial and the CS onset of the next trial.

Participants were instructed to look at the center of the screen attentively and to breath regularly during the entire experiment. A semi-instructed design was used (Schweckendiek et al., 2013, 2016) to ensure that all participants acquired

contingency awareness (Klucken, Kagerer, et al., 2009; Klucken, Schweckendiek, et al., 2009). Participants were told before starting the experiment that two geometrical figures will be presented with one of them being followed by an aversive (or appetitive) odor in many cases, while the other will never be followed by the odor. Participants rated the subjective valence and arousal of all stimuli (CS+, CS–, UCS, Non-UCS) directly before and after the appetitive and the aversive task. UCS expectancy was assessed directly after each conditioning procedure to ensure that participants were aware of the relationship between CSs and UCSs.

2.3 | Subjective ratings

Subjective valence and arousal were rated with the self-assessment-manikin (SAM, Bradley & Lang, 1994) on a 9-point Likert scale. Valence could be rated from “very unpleasant” (1) to “very pleasant” (9), while arousal could be rated from “calm and relaxed” (1) to “very aroused” (9). In addition, participants rated the intensity of each UCS and Non-UCS via a 11-point Likert scale ranging from “not perceivable” (0) to “extremely strong” (10). UCS expectancy was assessed after each task by estimating the likelihood of the CS+ and CS– being followed by the aversive (or appetitive) odor on a scale from 0% (“not likely at all”) to 100% (“extremely likely”).

2.4 | Physiological recordings

All electrophysiological signals were recorded at 1 kHz using a BIOPAC MP160 System in conjunction with AcqKnowledge 5.0 software (BIOPAC Systems Inc., Santa Barbara, CA, USA) during all phases of the experiment. For

both skin conductance response (SCR) and ECG recordings, disposable Ag/AgCl electrodes pre-gelled with isotonic gel (electrolyte: 0.5% chloride salt) were used and connected to the corresponding amplifiers (BioNomadix Wireless EDA Amplifier and BioNomadix Wireless RSP with ECG Amplifier, BIOPAC Systems Inc., Santa Barbara, CA, USA), which sent the data wirelessly to the BIOPAC system.

2.4.1 | Skin conductance response

Electrodes for SCRs were placed on the intermediate phalanx of the middle and the index finger of the non-dominant hand. For preprocessing and analysis, Ledalab 3.4.9 (Benedek & Kaernbach, 2010) was used. Preprocessing involved the downsampling of data to 100 Hz and smoothing using a Gaussian kernel of a full-width at half-maximum of 32 samples. Subsequently, all data were visually screened for artifacts to ensure high data quality. Twenty of the 86 participants had to be excluded from SCR analyses due to technical failure during data acquisition resulting in incorrectly recorded data, leaving $n = 66$ participants for SCR analyses.¹

The time window from 1 to 5.5 s following CS onset was chosen for analysis. SCRs were quantified as trough to peak values—the greatest difference between a minimum that was situated within the analysis window and the corresponding maximum (Benedek & Kaernbach, 2010). If a response was smaller than 0.01 mS, it was considered to be zero. SCR values were square root-transformed to account for violations of the normal distribution assumption. Mean responses were computed for CS+ and CS− over the first and the second phase of acquisition and for aversive and appetitive conditioning separately.

2.4.2 | ECG and heart period

The ECG was collected in lead II configuration with electrodes placed on the torso of the participant (bipolar electrodes: underneath the right clavicle and above the left hip bone; ground electrode: underneath the left clavicle). For preprocessing, a custom script in MATLAB R2017a (Mathworks, Natick, MA, USA) was used, starting with bandpass-filtering the raw ECG data (1–30 Hz). R spikes were detected automatically and manually inspected for incorrect detections due to ventricular extrasystoles or severe artifacts. 90 artifact laden trials were found (0.72%) and most of consequent R spike misdetections manually corrected, 17 (0.12%) trials could not be corrected because of artifact

severity and were excluded from further analysis. From the timing of R spikes, a continuous heart period (HP) signal was computed with every sample point representing the duration between the preceding and the subsequent R spike. For each trial the HP signal was segmented for the time window of 0–8 s after CS onset. The data within this time window was divided into 500 ms time bins and all data points in each time bin were averaged.

The cardiac response was quantified in accordance with the expected tri-phasic response pattern: Typically there are four points specifying the waveform of the response of cardiac reactions in two-stimulus paradigms, as first describes by Bull and Lang (1972). The baseline (B, defined as the half second before CS onset), the peak of a first deceleration (D1, the slowest half second during the first 2 s after CS onset), the peak of a subsequent acceleration (A, the fastest half second subsequent to D1 and within the first 5 s after CS onset) and the peak of a second deceleration (D2, the slowest half second subsequent to A before UCS onset). From these points the magnitudes of the three typical HP curve components were calculated: A 1st deceleration (D1-B), a subsequent acceleration (A-D1) and a 2nd deceleration (D2-A). As some studies report a prolongation instead of a higher magnitude of decelerations in emotional contexts (e.g., Bradley, 2009), additionally the peak latencies of all three components were analyzed. We define these peak latencies (similar to the magnitudes) as the time period from a preceding peak to the current peak (e.g., D2-A for the second deceleration). As other studies on HP responses in fear conditioning often use a mean cardiac response operationalized as the mean HP change in the interval of 2 to 5.5 s relative to CS onset (Bradley et al., 2005; De Leon, 1964; Hugdahl, 1979), this measure was additionally analyzed after baseline correction by subtracting the HP value in the half second before CS onset. Results are presented in the Supporting Information. As for SCR data, HP measures were averaged across trials for each CS type and the first and the second phase of acquisition and for aversive and appetitive conditioning separately.

2.5 | Statistical analyses

For each measure of conditioned responses two separate analyses were performed: First, successful conditioning was assessed in aversive conditioning and in appetitive conditioning separately. Second, if aversive as well as appetitive conditioning showed significant CRs, differences between CRs were analyzed. All analyses were performed using SPSS 23 (SPSS 23.0 for Windows, SPSS Inc., Chicago, IL) with an alpha (α) level of 0.05.

For valence and arousal ratings, successful conditioning was analyzed via paired *t*-tests (CS+ vs. CS−) after acquisition. For SCRs and (magnitudes and peak latencies of) cardiac

¹After exclusion, the counterbalance in task order persisted ($n = 30$ participants performed the aversive, $n = 36$ the appetitive task first; $X^2(1, 65) = 0.545, p = .460$).

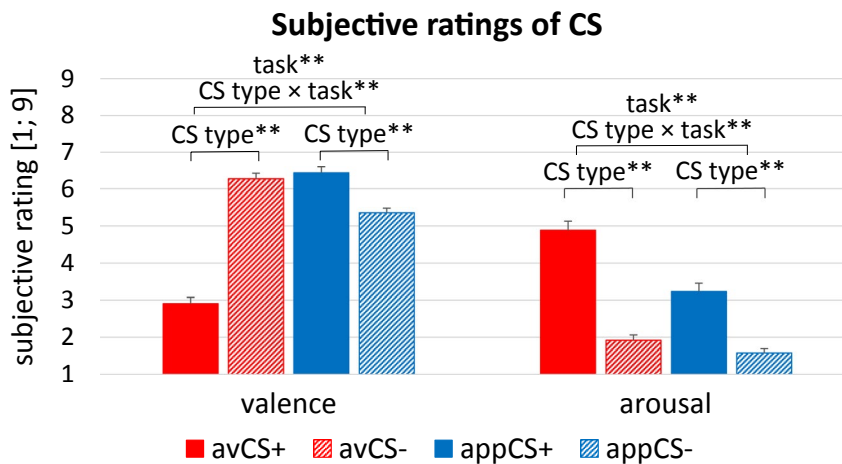


FIGURE 2 Valence and arousal ratings after acquisition for CS+ and CS− (aversive task: avCS+, avCS−, appetitive task: appCS+, appCS−). Valence ratings ranged from “very unpleasant” (1) to “very pleasant” (9), arousal ratings from “calm and relaxed” (1) to “very aroused” (9). Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008). ** $p < .01$; * $p < .05$

TABLE 1 Bivariate correlations of aversive and appetitive CRs in subjective ratings, SCRs and HP changes

CS ratings			Heart period						
Valence	Arousal	SCR	1st Deceleration			Acceleration		2nd Deceleration	
			Mean	Magnitude	Peak latency	Magnitude	Peak latency	Magnitude	Peak latency
−.508**	.434**	.188	.061	−.218*	−.078	−.096	−.097	.026	−.036
		(.094)	(.018)	(−.096)	(.051)	(.030)	(.001)	(.179)	(−.029)

Note: Subjective ratings after acquisition were used; SCRs and HP changes were averaged over all trials (over all trials of the first half of acquisition).

** $p < .01$; * $p < .05$.

response components, mean values were compared via repeated-measures analysis of variance (ANOVA) in a CS type (CS+ vs. CS−) $\times$ time (first vs. second phase of acquisition) design. Additional post-hoc tests were performed wherever necessary. UCS expectancy was compared via paired *t*-tests (CS+ vs. CS−).

If significant CRs were found in both aversive and appetitive conditioning, CRs (CS+–CS−) were compared between aversive and appetitive conditioning. Last, relationships between aversive CRs and appetitive CRs were assessed. For valence and arousal ratings, mean CRs were compared via paired *t*-tests (aversive vs. appetitive task). For physiological measures, time $\times$ task (aversive vs. appetitive task) ANOVAs were chosen.² UCS expectancy was compared via paired *t*-tests (avCS+ vs. appCS+). To examine relationships between aversive and appetitive CRs, bivariate correlations were calculated.

Additional analyses of subjective ratings of the UCSs and further analyses of cardiac responses can be found in the Supporting Information.

²One could argue that a preceding trial presenting the UCS could influence responses in the current trial differently than a preceding trial presenting the Non-UCS. Due to the pseudo-randomization and the reinforcement rate of 75% the likelihood of a CS− trial being preceded by the UCS is twice as high compared to a CS+ trial (here: CS+: 25.70%; CS−: 49.98%). Therefore, an additional CS type $\times$ task ANOVA was performed for baseline values. No effects reached significance (all $p > .131$, $\eta_p^2 < .027$).

3 | RESULTS

The experiments for aversive conditioning and appetitive conditioning were conducted independently, in counterbalanced order. However, since all major design and time parameters were kept constant between these experiments, with only UCS valence varying, the respective results will be presented alongside each other in order to allow for an easier comparison between results. Regarding presented correlations subjective ratings were used after acquisition; SCRs and HP changes were averaged over all trials of acquisition and additionally over all trials of the first part of acquisition only if habituation effects occurred in the second half of acquisition.

3.1 | Subjective CS ratings

3.1.1 | Valence

Paired *t*-tests showed significantly lower valence ratings to the CS+ compared to the CS− for aversive conditioning ($t(85) = -12.53$, $p < .001$, $d = -1.34$) and higher ratings for the CS+ compared to the CS− for appetitive conditioning ($t(85) = 4.82$, $p = .001$, $d = 0.52$) (Figure 2). The paired *t*-test comparing (absolute values of) CRs revealed stronger CRs in aversive than in appetitive conditioning ($t(85) = 7.56$,

$p = .001$, $d = 0.81$). CRs in aversive and appetitive conditioning were positively related, $r = .508$, $p = .001$ (see Table 1).

3.1.2 | Arousal

Paired t -tests revealed higher arousal ratings for the CS+ compared to the CS− for aversive and appetitive conditioning (aversive: $t(85) = 10.39$, $p = .001$, $d = 1.11$; appetitive: $t(85) = 7.17$, $p = .001$, $d = 0.77$) (Figure 2). Stronger CRs were found in aversive than in appetitive conditioning ($t(85) = 6.28$, $p = .001$, $d = 0.68$). CRs in aversive conditioning were positively related to CRs in appetitive conditioning ($r = .434$, $p = .001$; see Table 1).

3.1.3 | UCS expectancy

Ratings of the likelihood of a CS being followed by the UCS were 77.09% ($SD = 17.73\%$) for the CS+ and 15.23% ($SD = 25.19\%$) for the CS− in aversive conditioning and 74.71% ($SD = 17.34\%$) for the CS+ and 12.44% ($SD = 22.41\%$) for the CS− in appetitive conditioning. There were significant differences in these ratings between CS+ and CS− within both tasks (aversive: $t(85) = 16.54$, $p = .001$, $d = 1.72$; appetitive: $t(85) = 17.09$, $p = .001$, $d = 1.83$), but no differences between aversive and appetitive conditioning ($t(85) = 1.17$, $p = .246$, $d = 0.14$).

3.2 | Skin conductance response

For aversive conditioning as well as for appetitive conditioning, ANOVAs revealed a significant CS type $\times$ time interaction (aversive: $F(1, 64) = 4.79$, $p = .032$, $\eta_p^2 = .069$; appetitive: $F(1, 65) = 4.39$, $p = .040$, $\eta_p^2 = .063$) (Figure 3). No further effects reached significance (aversive: all $p > .130$, $\eta_p^2 < .035$; appetitive: all $p > .722$, $\eta_p^2 < .002$). For aversive conditioning, post-hoc analyses showed significantly higher SCRs for the CS+ than for the CS− in the first, but not the second phase of acquisition (first phase: $t(65) = 2.45$, $p = .017$, $d = 0.29$; second phase: $t(65) = 0.44$, $p = .665$, $d = 0.05$). For appetitive conditioning, no differences between CRs were found in the first or in the second phase of acquisition (first phase: $t(65) = 1.11$, $p = .270$, $d = 0.14$; second phase: $t(65) = -1.85$, $p = .069$, $d = -0.23$). No significant relationship between aversive and appetitive CRs was found (see Table 1).

3.3 | Heart period

Visually inspecting the mean HP change after CS onset (Figure 4), the tri-phasic pattern of cardiac responses can be

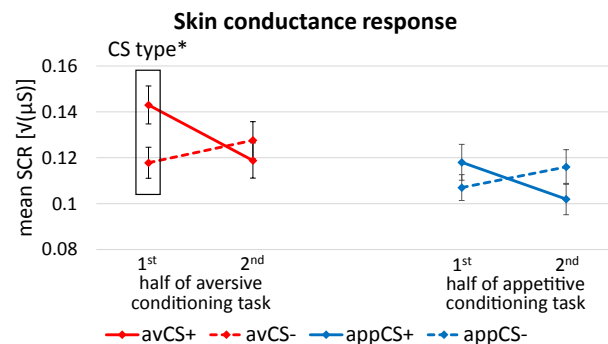


FIGURE 3 Normalized SCRs to CS+ and CS− for the first versus. second phase of acquisition (aversive task: avCS+, avCS−, appetitive task: appCS+, appCS−). The rectangle indicates a significant CR only in the first half of acquisition. Error bars indicate the SEM corrected for within-subject designs (Morey, 2008). * $p < .05$ (significant difference between response to CS+ versus CS− in the 1st half of aversive conditioning task)

identified. Significance tests confirmed a first deceleration, a subsequent acceleration and a final deceleration before UCS onset as a response pattern to all CSs. Details of analyses and additional figures for the first deceleration can be found in the Supporting Information.

3.3.1 | First deceleration

Magnitude

ANOVAs revealed a main effect of time with a higher first deceleration magnitude in the first compared to the second phase of acquisition for both aversive and appetitive conditioning (aversive: $F(1, 85) = 4.18$, $p = .044$, $\eta_p^2 = .047$; all other $p > .217$, $\eta_p^2 < .018$ appetitive: $F(1, 85) = 6.65$, $p = .012$, $\eta_p^2 = .073$; all other $p > .321$, $\eta_p^2 < .012$). Since no significant differential effects between CS+ and CS− were found, no comparison of CRs between aversive and appetitive conditioning was performed.

Peak latency

ANOVAs showed a main effect of time for aversive conditioning ($F(1, 85) = 4.45$, $p = .038$, $\eta_p^2 = .050$; all other $p > .221$, $\eta_p^2 < .018$) with a longer peak latency in the first phase of acquisition. For appetitive conditioning, no effects reached significance (all $p > .287$, $\eta_p^2 < .013$). Since no significant differential effects between CS+ and CS− were found, no comparison of CRs between aversive and appetitive conditioning was performed.

3.3.2 | Acceleration

Magnitude

ANOVAs yielded no significant effects for aversive or appetitive conditioning (aversive: all $p > .199$, $\eta_p^2 < .019$;

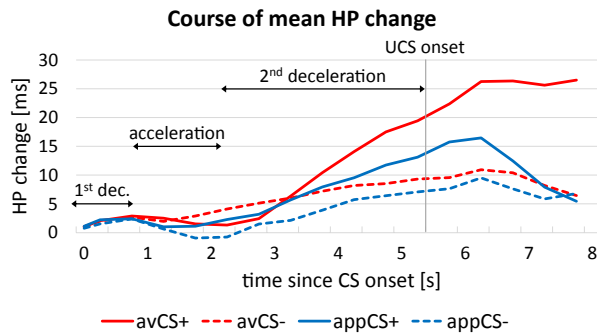


FIGURE 4 Mean evoked HP change after CS onset averaged over all trials and subjects. 1st dec. = 1st deceleration

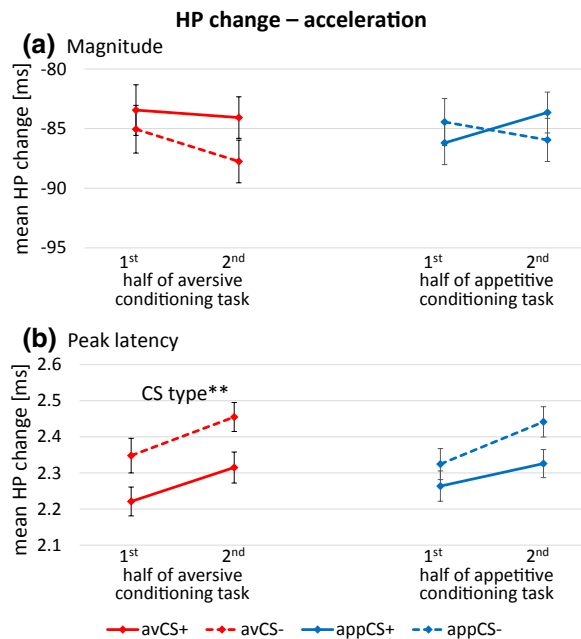


FIGURE 5 Changes in the acceleratory part of cardiac responses for CS+ and CS– (aversive task: avCS+, avCS–, appetitive task: appCS+, appCS–) (a) in magnitude and (b) peak latency for the first and second phase of acquisition. Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008). * $p < .05$ (significant main effect for the factor CS type)

appetitive: all $p > .283$, $\eta_p^2 < .013$) (Figure 5). Since no significant differential effects between CS+ and CS– were found, no comparison of CRs between aversive and appetitive conditioning was performed.

Peak latency

A main effect of time was found for both aversive and appetitive conditioning (aversive: $F(1, 85) = 6.59$, $p = .012$, $\eta_p^2 = .072$; appetitive: $F(1, 85) = 4.29$, $p = .041$, $\eta_p^2 = .048$) with a significantly longer acceleration in the second phase of acquisition. For aversive conditioning, a main effect for CS type with a longer acceleration for the CS– compared to the CS+ was also observed, while there was only a trend for the same effect

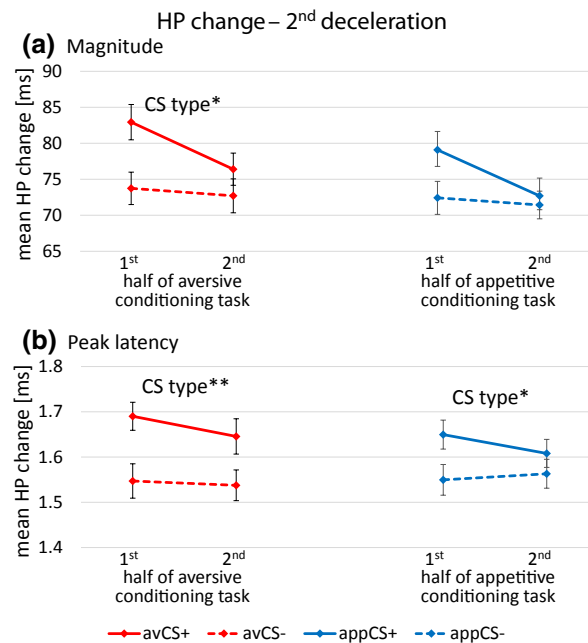


FIGURE 6 Changes in the second deceleration of cardiac responses for CS+ and CS– (aversive task: avCS+, avCS–, appetitive task: appCS+, appCS–) (a) in magnitude and (b) peak latency for the first and second phase of acquisition. Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008). ** $p < .01$; * $p < .05$ (significant main effect for the factor CS type)

in appetitive conditioning (aversive: $F(1, 85) = 7.99$, $p = .006$, $\eta_p^2 = .086$; appetitive: $F(1, 85) = 3.78$, $p = .055$, $\eta_p^2 = .043$). ANOVAs comparing CRs between aversive and appetitive conditioning showed no significant effects (all $p > .513$, $\eta_p^2 < .005$).

3.3.3 | Second deceleration

Magnitude

For aversive conditioning, ANOVAs revealed a higher magnitude for the CS+ compared to the CS–, while there was only a non-significant trend for the same effect in appetitive conditioning (aversive: $F(1, 85) = 6.89$, $p = .010$, $\eta_p^2 = .075$; all other $p > .189$, $\eta_p^2 < .020$; appetitive: $F(1, 85) = 2.78$, $p = .099$, $\eta_p^2 = .032$; all other $p > .131$, $\eta_p^2 < .027$) (see Figure 6). ANOVAs comparing CRs between aversive and appetitive conditioning showed no significant effects (all $p > .142$, $\eta_p^2 < .025$).

Peak latency

ANOVAs showed a main effect for CS type with a longer deceleration for the CS+ compared to the CS– in aversive and appetitive conditioning (aversive: $F(1, 85) = 8.81$, $p = .004$, $\eta_p^2 = .094$; all other $p > .476$, $\eta_p^2 < .006$; appetitive: $F(1, 85) = 4.48$, $p = .037$, $\eta_p^2 = .050$; all other $p > .469$, $\eta_p^2 < .050$). ANOVAs comparing CRs between aversive and

appetitive conditioning showed no significant effects (all $p > .338$, $\eta_p^2 < .011$).

3.3.4 | Correlations

Except for the first deceleration, no significant relationships between aversive and appetitive CRs were found (see Table 1). However, it has to be noted, that this component did not show a significant CR in aversive nor in appetitive conditioning. None of the CRs identified as significant were related between both conditioning tasks.

4 | DISCUSSION

The present study was the first to compare patterns of aversive and appetitive differential conditioning in a within-subject design using olfactory UCSs. Our results revealed robust CRs in valence and arousal ratings for both tasks, while differential SCRs were only observed in aversive but not in appetitive conditioning. Cardiac activation in response to all CSs showed the typical tri-phasic pattern of an initial deceleration, a mid-interval acceleration and a final deceleration. Cardiac responses showed significant CRs in both tasks in the form of a prolonged second deceleration following the CS+, with no differences between tasks. Except for subjective ratings, measures were found to be uncorrelated between tasks.

In aversive conditioning, strong valence and arousal ratings as well as differential SCRs were observed. These results are in line with previous conditioning studies (for a review see Lonsdorf et al., 2017) confirming the assumption that odors can serve as adequate UCSs in aversive conditioning. In contrast, in appetitive conditioning the current study showed strong CRs with regard to valence and arousal ratings, but no differential SCRs. Our results of valence and arousal are in line with previous findings, while the current SCR results are in conflict with some previous findings (Andreatta and Pauli, 2015; Kruse et al., 2017) but not with others (e.g., Klucken, Schweckendiek, et al., 2009). Importantly, when only considering previous studies using olfactory UCS, it can be stated that generally no differential SCRs were observed (Hermann et al., 2000; Stussi et al., 2018). As discussed by Stussi et al. (2018), this might partially be explained by the specific UCSs, as odors might generally be a less potent class of stimuli than erotic pictures or money in humans and consequently lead to smaller CRs. These results underline the necessity of identifying physiological measures which are more sensitive to appetitive conditioning.

Regarding cardiac responses, a tri-phasic response pattern was observed in aversive and appetitive conditioning for all CSs (CS+ and CS−), which is typically shown in two-stimuli

tasks (e.g., Castagnetti et al., 2016) as well as for emotional stimuli in general (Bradley et al., 2001). For aversive conditioning, differential CRs were characterized by a shortened acceleration and a prolonged as well as intensified second deceleration for the CS+ compared to the CS−. These results are in line with previous research reporting stronger decelerations (“fear bradycardia”) to the CS+ compared to the CS− (Bradley et al., 2005; De Leon, 1964; e.g., Hugdahl, 1979; Panitz et al., 2015). Interestingly, while previous studies observed a strong deceleration immediately after CS onset (e.g., Bradley et al., 2005; Panitz et al., 2015), in our data the relevant CRs showed up in the second deceleration and were not as pronounced as in studies using threat-inducing UCS (like shock stimulation: e.g., Bradley et al., 2005). Part of an explanation for these differences might be a higher variability of affective responses towards odors across individuals in contrast to shock stimuli (Ferdenzi et al., 2013), leading to a higher variance in CRs towards odors (Lissek et al., 2006) and thus limiting the power to detect significant effects. Another explanation might be that the UCS intensity of electrical shocks is typically individually calibrated, which has been shown to increase CRs (Lipp, 2006), whereas this was not done for olfactory stimuli in the present study.

For appetitive conditioning, a prolonged second deceleration after the CS+ was the only significant CR, while the magnitude and peak latency of the preceding acceleration showed only a non-significant trend for differential responses. Our results are in line with studies on appetitive stimuli in general, reporting a stronger deceleration for appetitive pictures or odors compared to neutral stimuli (Bradley et al., 2001; Delplanque et al., 2009). In contrast to the initial deceleration in picture viewing tasks, our data showed a stronger second deceleration (e.g., Bradley et al., 2001). However, respective effects for the first deceleration in previous studies have typically been found to decline after even one picture repetition (Bradley, 2009; Bradley et al., 1993). Therefore, the first deceleration might not be a good index for affective learning but rather for stimulus novelty (Bradley, 2009; Bradley et al., 1993), which is also in line with our data showing that the first deceleration declined with stimulus repetition. A comparison between the current cardiac response findings on appetitive conditioning with previous studies is limited by the fact that cardiac responses have rarely been studied in appetitive conditioning research on human subjects. However, most of the currently available studies did not report significant CRs (Ebrahimi et al., 2019; Hermann et al., 2000; Wardle et al., 2018), with only one exception (Prévost et al., 2012). Similarly, corresponding results from animal research are also mixed (Obrist & Webb, 1967; Powell et al., 1993; Wenzel, 1961). A potential explanation for the stronger CRs seen in our data compared to previous research on human subjects might be related to the potency of our appetitive olfactory UCS compared to the appetitive

olfactory and gustatory UCSs used in these previous studies. The notion that the present olfactory UCS might have had a greater potency is indicated by the present evidence for strong conditioned CRs in valence ratings, which were not seen in previous studies (Ebrahimi et al., 2019; Hermann et al., 2000; Wardle et al., 2018). To our knowledge, there is only one study reporting a significant cardiac CR in appetitive conditioning on humans (Prévost et al., 2012). This study reported a greater number of heart beats in the time window from 1.5 to 3.5 s to the CS+ compared to the CS−, which might be interpreted as an increased acceleration towards the CS+. An explanation for the difference in findings between this study and our present data might be related to the use of a conditioning training procedure before actual conditioning by Prévost et al. (2012). During the training procedure food was consumed immediately after CS+ presentation, while participants received it after completing the conditioning task in the main conditioning procedure. As a consequence, subjects were used to an immediate behavioral activation required after CS onset. Since cardiac acceleration is often associated with motor preparation (e.g., Löw et al., 2008) this provides a plausible explanation for the findings of Prévost et al. (2012). By contrast, picture viewing or olfactory stimulation (as in the present study) does not require behavioral activation, thus leading to an accentuated deceleration after CS+ presentation. In summary, our data provide preliminary evidence for the utility of olfactory appetitive UCSs for the investigation of conditioned cardiac responses.

Regarding the comparison between aversive and appetitive conditioning, the prolonged deceleration after the CS+ was similar in both tasks, while evidence for a stronger magnitude and a shortened acceleration was only observed in aversive conditioning. Hermann et al. (2000) compared aversive and appetitive conditioning using similar olfactory UCS, but they used a between-subjects design with rather small sample sizes ($n = 15$; Hermann et al., 2000) and did not report cardiac CRs in appetitive conditioning. To our knowledge there are no studies comparing differential cardiac responses between aversive and appetitive conditioning. In summary, the present data thus yield novel findings which tentatively suggest that the second deceleration is the first component of the cardiac response pattern showing differential results in affective learning if non-threatening UCSs are used. In addition, a decline in the preceding acceleration adds to CRs if a higher level of arousal is reached. This reaction seems to be independent of UCS valence, which implies, that the “fear bradycardia” reliably observed in aversive conditioning (Campbell et al., 1997) may not be fear-specific, but rather a general CS-elicited bradycardia. Further research using UCSs of different levels of arousal and valence will be needed to clarify this. Another interesting finding of the current study is that aversive and appetitive CRs were correlated on an intra-individual level for

subjective ratings, while they were entirely unrelated for physiological measures.

As the presented sample consisted of healthy participants without a history of mental disorders, further research on psychiatric samples using a comparable design might be of interest. Psychiatric samples have sometimes been found to show stronger CRs towards conditioning, e.g., addictive disorders were associated with a higher sensitivity towards appetitive conditioning (Martin-Soelch et al., 2007), while anxiety disorders were associated with a higher sensitivity towards aversive conditioning (Lissek et al., 2005). A stronger sensitivity in both aversive and appetitive conditioning might thus be found in individuals suffering from anxiety as well as addiction. Evidence for intra-individual relationships between CRs can thereby be viewed as support for a common risk factor for both types of disorders, e.g., in people showing pronounced reactions in both tasks. Further research on psychiatric samples will be needed to clarify this hypothesis.

There were several limitations to the present study which need to be considered. One limitation could have been that the within-subject design may have led to potential task order effects. Counterbalancing of the task order was applied to minimize this possibility. Still, we further ran additional analyses in which we controlled for the factor “task order” which replicated the initial result patterns for any of the CRs. Another potential limitation might be that we did not control for respiratory behavior during CS and UCS presentation, since heart rate is known to be influenced by respiration (Brownley et al., 2000), and some studies suggest that differences in physiological responses to odor stimuli are mainly due to differences in breathing behavior (Cook et al., 2015; Van Diest et al., 2009). While this might clearly be a valuable addition for future research, we consider it unlikely that this might have had a major confounding influence on the present results. Specifically, the tri-phasic pattern of cardiac activation was similar for all CSs and the same components of this response showed (at least trends for) CRs in aversive and appetitive conditioning, thus reassuring confidence in the validity of the present results. A further potential limitation relates to the high proportion of excluded participants from SCR analysis. However, although an exclusion rate of about 25% is clearly not satisfying, the fact that this was due to technical failure makes it unlikely that loss of participants induced any systematic bias on results. Additionally, differences in SCR responses between CS+ and CS− were noticeably small in both conditioning tasks and this effect was only present during the first half but abolished in the second half of the conditioning task, which suggests a process of habituation. Comparable findings of relatively small differential effects when non-fear stimuli were used (e.g., Hermann et al., 2000; Klucken, Alexander, et al., 2013; Klucken, Kagerer, et al., 2009) and similar habituation processes (e.g., Tabbert et al., 2006) have

been found in previous research. However, it is important for future research to clarify whether olfactory UCSs in general or specific aspects of the current study design in particular led to relatively small CRs and/or noticeably fast habituation effects in SCRs. Finally, a potential limitation might be that we did not explicitly control for pseudoconditioning. There is a consensus amongst the majority of human conditioning researchers that the use of a CS– condition provides an adequate control for potential non-associative effects (Lonsdorf et al., 2017). Still, it has been argued by some that a CS– condition might not always provide full control for pseudoconditioning (e.g., Burstein, 1973) and thus future research on pseudoconditioning in this context might be interesting.

In summary, both aversive and appetitive conditioning were found to yield cardiac conditioned responses. Moreover, no fundamental differences in cardiac response patterns were found between aversive and appetitive conditioning. These findings lead to the proposal that cardiac responses have the potential to function as an adequate measure of conditioning in both valence categories, with them possibly being even more sensitive to appetitive conditioning than SCRs. The striking similarity between both response patterns suggests a general affective learning response in cardiac activation, which might be dependent on arousal rather than on UCS valence. Our results thus speak for a more general phenomenon of a CS-elicited bradycardia in conditioning instead of the more specific concept of fear bradycardia.

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CONFLICT OF INTEREST

The authors have no conflicts of interests to declare.

AUTHOR CONTRIBUTIONS

Anna Exner: Conceptualization; Data curation; Formal analysis; Funding acquisition; Investigation; Methodology; Project administration; Visualization; Writing-original draft. **Isabell Tapia León:** Methodology; Writing-review & editing. **Erik Malte Mueller:** Methodology; Supervision; Writing-review & editing. **Tim Klucken:** Conceptualization; Resources; Software; Supervision; Writing-review & editing.

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SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.

FIGURE S1 Valence, arousal and intensity ratings for UCSs and Non-UCSs before acquisition (aversive task: avUCS, avNon-UCS, appetitive task: appUCS, appNon-UCS). Valence ratings ranged from “very unpleasant” (1) to “very pleasant” (9), arousal ratings from “calm and relaxed” (1) to “very aroused” (9), intensity ratings from “not perceivable” (0) to “extremely strong” (10). Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008). ** $p < .01$; * $p < .05$

FIGURE S2 Mean HP change from baseline (0.5 s before CS onset) in the time window for analysis (2–5.5 s after CS onset) for the first and second phase of acquisition (aversive task: avCS+, avCS–, appetitive task: appCS+, appCS–). Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008)

FIGURE S3 Changes in the first deceleration of cardiac responses after CS onset for CS+ and CS– (aversive task: avCS+, avCS–, appetitive task: appCS+, appCS–) (a) in magnitude (b) in peak latency for the first and second phase of acquisition. Error bars indicate the *SEM* corrected for within-subject designs (Morey, 2008)

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Anhang C

Exner, A.*, Kampa, M.*, Finke, J. B., Stalder, T., Klapperich, H., Hassenzahl, M., Kleinke, K., & Klucken, T. (2023). Repressive and vigilant coping styles in stress and relaxation: evidence for physiological and subjective differences at baseline, but not for differential stress or relaxation responses. *Frontiers Psychology*, 14:1196481. <https://doi.org/10.3389/fpsyg.2023.1196481>.



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Repressive and vigilant coping styles in stress and relaxation: evidence for physiological and subjective differences at baseline, but not for differential stress or relaxation responses

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Introduction: Previous research suggested differential stress reactivity depending on individuals' coping style, e.g., as classified by the model of coping modes. Specifically, stronger physiological reactivity and weaker subjective stress ratings were found for repressors than for sensitizers. However, it remains to be investigated (i) whether these findings, which are largely based on social stress induction protocols, also generalize to other stressors, (ii) whether repressors vs. sensitizers also exhibit differential stress recovery following the application of a relaxation method, and (iii) which stress reactivity and recovery patterns are seen for the two remaining coping styles, i.e., fluctuating, and non-defensive copers. The current study thus examines stress reactivity in physiology and subjective ratings to a non-social stressor and the subsequent ability to relax for the four coping groups of repressors, sensitizers, fluctuating, and non-defensive copers.

Methods: A total of 96 healthy participants took part in a stress induction (Mannheim Multicomponent Stress Test) and a subsequent relaxation intervention. Subjective ratings of stress and relaxation, heart rate (HR), heart rate variability (HRV), and blood pressure were assessed during the experiment. HR and blood pressure are markers of the sympathetic stress response that can be regulated by relaxation, while HRV should increase with relaxation. To investigate long-term relaxation effects, subjective ratings were also assessed on the evening of testing.

Results: Despite successful stress induction, no differential responses (baseline to stress, stress to relaxation) were observed between the different coping groups on any of the measures. In contrast, a strong baseline effect was observed that persisted throughout the experiment: In general, fluctuating copers showed lower HR and higher HRV than non-defensive copers, whereas repressors reported lower subjective stress levels and higher levels of relaxation during all study phases. No differences in subjective ratings were observed in the evening of testing.

Conclusion: Contrary to previous research, no differential stress reactivity pattern was observed between coping groups, which could be due to the non-social type of stressor employed in this study. The novel finding of physiological baseline

differences between fluctuating and non-defensive individuals is of interest and should be further investigated in other stressor types in future research.

KEYWORDS

repressors, sensitizers, heart rate variability, blood pressure, MMST, stress, relaxation

1. Introduction

Stress has been linked to poor physical and mental health in numerous studies (for detailed reviews see: [Schneiderman et al., 2005](#); [O'Connor et al., 2021](#)). The post-processing of stressful experiences ([Finke et al., 2022](#)) and the ability to actively relax from perceived stress is an important factor in reducing these harmful effects, such as depression, anxiety, poor quality of life, or burnout ([Khoury et al., 2015](#); [Dharmawardene et al., 2016](#)). For these reasons, the way we deal with stress has a significant influence on our health. People differ in the way they cope with stress and anxiety, which can be observed across different situations ([Weinberger et al., 1979](#); [Krohne, 2003](#)).

There are different approaches to classifying coping strategies. A common approach is the formation of four groups on the basis of trait anxiety and social desirability (termed 'defensiveness') ([Weinberger et al., 1979](#)). These two traits are assumed to determine coping patterns in fearful situations. According to this model, repressors are defined as individuals with low anxiety but high defensiveness, sensitizers as individuals with high anxiety and low defensiveness, defensive-anxious as individuals with high scores on both scales, and low-anxious as individuals with low scores on both scales. Despite the wide use of this approach, some problems still need to be considered. The traditional anxiety and social desirability scales neither refer to fear-eliciting situations nor explicitly assess coping behaviors ([Krohne, 2003](#); [Paul et al., 2012](#)).

The model of coping modes (MCM) ([Krohne, 1993](#)) seeks to overcome these difficulties. It is based on the assumption that people can be distinguished by their dispositional way of dealing with stressful situations. These individual differences are reflected in vigilance (VIG) and cognitive avoidance (CAV), which have been identified by several models of cognitive coping as the dominant dimensions ([Miller, 1980](#); [Krohne, 1993](#); [Derakshan et al., 2007](#)). Cognitive avoidance describes the strategy of shielding the organism from threat-related cues, whereas vigilance describes the strategy of actively focusing on such cues ([Krohne, 1993](#); [Weinberger, 1995](#)). Vigilance summarizes a class of coping strategies used to reduce uncertainty triggered by unpredictability in fearful situations. Vigilance is thus used by individuals who exhibit an intolerance for uncertainty. Thus, they try to anticipate the course of a negative situation by closely observing and analyzing all related stimuli in order not to be surprised by a negative outcome ([Krohne, 1993](#); [Krohne et al., 2000](#)). Cognitive avoidance, on the other hand, summarizes a class of coping strategies aimed at shielding the organism from stressful stimuli that evoke emotional arousal. Cognitive avoidance is thus used by individuals who exhibit an intolerance for emotional arousal and serves as strategy for the reduction of emotional arousal ([Krohne, 1993](#); [Krohne et al., 2000](#)). The MCM conceptualizes CAV and VIG as two independent dimensions with the opportunity of classification into repressors (high

CAV, low VIG), sensitizers (low CAV, high VIG), fluctuating copers (high on both dimensions), and non-defensive copers (low on both dimensions).

When screening research results for the individual coping groups, the following finding arises. Classifications of repressors and sensitizers based on the MCM and based on the approach by [Weinberger et al. \(1979\)](#), correspond to each other ([Krohne et al., 2000](#)). For categorizing fluctuating and non-defensive individuals, however, there is no significant overlap between the two classification systems ([Krohne et al., 2000](#)), allowing only studies in which the MCM was used to be considered. For repressors and sensitizers, the body of research is large; in the majority of studies there is a dissociation effect between peripheral physiological responses to stress and subjective ratings of perceived stress between repressors and sensitizers. Repressors tend to show an increased physiological stress response (e.g., heart rate, blood pressure), but lower subjectively perceived stress compared to sensitizers ([Newton and Contrada, 1992](#); [Kohlmann et al., 1996](#); [Derakshan and Eysenck, 1997](#); [Rohrmann et al., 2002](#); [Schwerdtfeger and Kohlmann, 2004](#); [Derakshan et al., 2007](#); [Myers, 2010](#); [Paul et al., 2012](#)). A small number of studies, however, has not found this dissociation but instead revealed lower subjective and physiological stress reactivity in repressors ([Jørgensen and Zachariae, 2006](#); [Oskis et al., 2019](#)).

Compared to repressors and sensitizers, fluctuating and non-defensive copers have rarely been studied in terms of their stress response. This inhomogeneity is caused by different conceptualizations of coping styles. Most studies rely on the indirect classification approach based on two separate trait questionnaires for anxiety and social desirability ([Weinberger et al., 1979](#)). Encouragingly, when group assignment was considered, convergent assignment of repressors and sensitizers could be found, but there was no overlap for the remaining two groups ([Krohne et al., 2000](#)). For this reason, only theoretical assumptions can be taken into account: Theoretically, it is assumed that fluctuating individuals show an intolerance for uncertainty as well as for emotional arousal, which leads them to try to protect themselves against both aspects simultaneously. Since this balance cannot be achieved – e.g., simultaneously seeking and avoiding fearful stimuli – it is assumed that they tend to exhibit fluctuating, unstable coping behavior without achieving the desired regulatory effect ([Krohne, 1993](#); [Hock and Krohne, 2004](#)). Non-defensive individuals, on the other hand, are understood as individuals who exhibit situation-specific coping behaviors. They are assumed to have neither an increased intolerance for uncertainty nor for emotional arousal. Thus, these individuals could meaningfully adapt their coping behavior to the demands of a given situation, for example, by applying cognitive avoidance in uncontrollable situations and vigilance in situations where controllability can be increased by collecting and monitoring certain anxiety-related information and stimuli ([Krohne, 1993](#); [Hock and Krohne, 2004](#)).

Most experimental studies have focused on social stressors, like public speaking, raising the question of whether the results are generalizable to other types of stressors, especially non-social stressors. Indirect information can be derived from data on differential reactivity to medical interventions, which tend to be predominantly physically and less socially threatening. In general, sensitizers indicate more subjective anxiety before invasive medical interventions than patients with other coping dispositions [elective facial surgery (Krohne et al., 1989; Slangen et al., 1993); endoscopic examination (Schwenkmezger et al., 1996)], whereas results on differences in physiological stress parameters are inconsistent. Krohne et al. (1989) observed that non-defensive individuals showed higher physiological stress levels (concentration of free fatty acids in blood) than all other coping groups. Slangen et al. (1993) also found that repressors and sensitizers showed a relatively low stress response (cortisol level) compared to non-defensive individuals and fluctuating copers, with the latter group exhibiting the highest stress response. Schwenkmezger et al. (1996) reported elevated levels of growth hormones in high-vigilant vs. low-vigilant patients, whereas cardiovascular parameters showed no differences between coping groups. The inconsistencies in studies of medical interventions as physiological stressors might be explained by very limited experimental control, e.g., considerable between and within-study differences in the severity of surgical procedures and individual differences in patients' previous experiences with medical situations. Thus, experimental studies are needed to integrate these results and to better understand the mechanisms underlying stress responses towards non-social stressors.

To our knowledge, there are no experimental studies that focused on the effects of avoidant and vigilant coping on the ability to relax after a stressful event. This asymmetry is surprising, as the post-stress processing and relaxation capacity can contribute significantly to the reduction of negative stress consequences (Khoury et al., 2015; Dharmawardene et al., 2016). Some transfer may be possible from research on the relationship between cognitive load and coping; there is some evidence that sensitizers tend to forget less fear-related information under low cognitive load than other coping style groups (Peters et al., 2012). There is empirical evidence that relaxation can reduce internal sources of cognitive load (for a discussion see Burgess et al., 2017). Thus, it is reasonable to assume that sensitizers might experience less stress reduction from relaxation than the other groups. These findings are partly confirmed by research results on the use of relaxation techniques before medical interventions: Patients who have a tendency towards cognitive avoidance experience the greatest reduction in their stress levels through active relaxation (Lerman et al., 1990; Gattuso et al., 1992; Krohne and El-Giamal, 2008).

The aim of the present study was to investigate group differences between repressors and sensitizers in terms of their subjectively perceived and physiological stress responses. In contrast to previous research, we included the groups of fluctuating and non-defensive individuals according to the MCM categorization scheme to investigate whether potential differences are unique to repressors and sensitizers. Heart rate and blood pressure have been chosen as physiological markers of the sympathetic stress response that can be regulated by relaxation, while heart rate variability should increase with relaxation (Van Diest et al., 2014; Blum et al., 2020). In contrast to previous research that used largely social stressors we applied a stress task without a direct social evaluation, but

multiple types of stressors including physically aversive stimuli and focused on the participant's subsequent ability to relax. In addition, as a follow-up, stress and relaxation ratings were assessed in the evening of testing to test the persistence of relaxation effects. Consistent with the empirical findings and theoretical background, we hypothesized that sensitizers show the greatest self-reported stress, while repressors experience the greatest physiological stress compared to all other groups. Regarding relaxation, we expected that sensitizers and fluctuating individuals show a smaller reduction in physiological and subjectively perceived stress than repressors and non-defensive individuals.

2. Materials and methods

2.1. Sample

Healthy undergraduates ($N=102$) were recruited via internal undergraduate mailing lists and online notice boards. Participants received either course credit ($n=98$) or monetary compensation (15.00€; $n=4$) for participation. Two participants dropped out after stress induction, and four participants were excluded because of missing information in the coping questionnaire. Thus, 96 participants (83 women; age: $M=21.42$ years, $SD=2.89$) were included in the present study. The study was approved by the local ethics committee of the University of Siegen and conducted in accordance with the Declaration of Helsinki. All participants provided written informed consent.

2.2. Study design

2.2.1. Procedure

Prior to the laboratory testing, participants completed two online surveys, which included the assessment of trait questionnaires. The actual experiment was conducted in the laboratories of the Department of Clinical Psychology and Psychotherapy at the University of Siegen and consisted of a 5-min baseline measurement, a 5.5-min stress induction, a 15-min relaxation phase, and a 5-min recovery measurement, the latter of which was not included in the present analyses. Physiological data were recorded continuously throughout the test session (see below). Subjective ratings of stress and relaxation were collected at baseline (before the start of stress induction), during stress (in the middle of stress induction), and post relaxation as well as in the evening of testing. A detailed description of all phases will be given in the following sections. For additional information on the original study, see Kampa et al. (2022).

2.2.2. Stress induction

Stress was induced using the Mannheim Multicomponent Stress Test (MMST; Kolotylova et al., 2010), a computer-based stress test that has already shown reliable stress induction on a subjective and physiological level (Reinhardt et al., 2012). The stress test includes presenting aversive sounds (60 randomly timed explosion sounds and noise from 75 to 93 dB) as an acoustic stressor and aversive pictures with fear-eliciting and disgusting scenes as an emotional stressor. Simultaneously, in the foreground, participants performed the PASAT-C (Lejuz et al., 2003), a mental arithmetic task under time

TABLE 1 Descriptive statistics of the four coping style groups within the sample.

Coping style	N	Women	Age	Cognitive avoidance	Vigilance
Repressors	36	26	21.72 (3.32)	15.83 (1.38)	6.22 (2.27)
Sensitizers	36	35	21.31 (2.73)	9.58 (2.60)	13.82 (2.74)
Non-defensive	14	13	21.36 (2.59)	10.00 (1.80)	7.21 (1.89)
Fluctuating	10	9	21.42 (2.89)	14.70 (1.34)	12.0 (2.45)

pressure, as a cognitive stressor. During the PASAT-C numbers (0–20) were briefly presented (250 ms) with a short duration in between (first half: 3 s, second half: 2 s) and participants were asked to calculate the sum of every two numbers and to enter their results via a numerical mouse keypad, while feedback on correct answers was continuously given. As an additional motivational stressor, participants are told that their reimbursement is reduced for each incorrect response. Since the arithmetic task is performed while being alone in the laboratory and feedback on correct and incorrect answers is given purely computer-aided, the MMST only entails a minor social-evaluative component of stress induction.

2.2.3. Relaxation groups

Participants were randomly assigned to one of two relaxation interventions. The first group perceived a guided virtual reality (VR) intervention, while the second group performed a self-selected relaxation method in a sitting position (e.g., listening to music, reading, breathing exercises etc.). The VR relaxation included a landscape displayed via the HTC Vive pro HMD (HTC Corporation, ViveTM), which was shown as a night scene at the beginning of the intervention and turning into daylight until the end of the intervention (see the [Supplementary material](#) for pictures of the relaxation setup and for an impression on the VR scene). Participants were able to look at different parts of the scene by moving their head. The breathing cycle was accompanied by a blue sphere in the VR environment that increased in size for inhalation and decreased in size for exhalation. Additionally, a pillow in the participant's lap vibrated in sync with the changing size of the blue sphere. A Nexus-10 MKII device (Mind Media, Herten, Netherlands) was used to monitor breathing via a breathing belt around the participant's chest. The relaxation consisted of different phases. Via headphones participants listened to soothing music, nature sounds and occasionally, a narrator gave instructions on relaxation and respiration. The relaxation started with a familiarization phase including an introduction of the narrator (3 min). Afterwards the sphere reflected a deaccelerated respiratory cycle adapted to each participant by increasing for inhalation and shrinking for exhalation (3 min). In the last phase participants were asked by the narrator to hold their breath after each inhalation and exhale long and deeply afterwards (9 min).

2.3. Coping style

The German version of the Mainz Coping Inventory (MCI) ([Krohne et al., 2000](#)) was used to assess habitual coping strategies. The MCI measures cognitive avoidance (CAV) and vigilance (VIG) as two separate dimensions of coping with eight threatening situations of varying controllability (four ego-threatening situations: e.g., public speaking; four physically threatening situations: e.g., dentist

appointment). For each situation, the MCI contains five items on cognitive avoidance behavior and five items on vigilance behavior in a dichotomous response format (avoidant strategy: e.g., 'I put on my headphones and listen to music'; vigilant strategy: e.g., 'I carefully review the topics I'm going to present'). Because we used a non-social stressor with physically threatening components, habitual CAV and VIG scores were calculated as summed scores across all physically threatening situations, as recommended by the authors ([Krohne, 1993](#)). Internal consistency was 0.82 for VIG and 0.74 for CAV (Cronbach's alpha), and there was a negative correlation between the two dimensions ($r = -0.64$, $p < 0.001$), as previously reported ([Schwerdtfeger and Rathner, 2016](#)). Eight missing item values were included as indicated in the manual. Sum scores were used to classify participants into the four coping style categories (repressors, sensitizers, non-defensive, and fluctuating copers) by dichotomizing the two dimensions of CAV and VIG by median splits ('low': percentile rank below 50% in the current sample; 'high': percentile rank above 50% in the current sample) ([Table 1](#)).

2.4. Subjective ratings

Participants rated their subjective stress and relaxation levels using a Likert scale ranging from 0 ("not stressed," "not relaxed") to 9 ("very stressed," "very relaxed"). For the analyses of subjective stress ratings, two participants had to be excluded due to missing data.

2.5. Physiological recordings and processing

Physiological data were recorded with the Biopac MP160 recording system (BIOPAC Systems Inc., Goleta, California, United States) at a sampling rate of 2000 Hz, using a 100C ECG amplifier and a Bionomadix wireless transmitter. Three pre-gelled Ag/Ag-Cl ECG electrodes were placed in lead configuration (ECG II) for electrocardiogram recording. Blood pressure was measured with the Dinamap Pro 300 (General Electric Deutschland Holding GmbH, Frankfurt am Main, Germany) via a blood pressure cuff on the participant's non-dominant upper arm. Blood pressure measurement was triggered automatically to ensure correct timing. All data were visually inspected and analyzed in Matlab 2020b (The Mathworks Inc., Natick, Massachusetts, United States).

ECG data were analyzed using the Pan-Tompkins algorithm for QRS detection ([Pan and Tompkins, 1985](#)) [Matlab implementation ([Sedghamiz, 2014](#))]. Outliers in the intervals between beats (mean $\pm$ 3 standard deviations) were excluded from the analyses. Heart rate was averaged over the entire time span of each phase (baseline, stress,

relaxation). Heart rate variability was estimated by applying the root mean square of successive differences (RMSSD) (Shaffer and Ginsberg, 2017) to the inter-beat-intervals. To ensure high data quality, 19 participants had to be excluded from the analysis of cardiac activity because of highly noisy data or serious artefacts, leaving $n=77$ participants for the analysis of HR and RMSSD (repressors: 30, sensitizers: 29, non-defensive: 10, fluctuating: 8). Two participants had to be excluded from the analysis of blood pressure because of missing recordings due to technical problems, leaving $n=94$ participants for analysis.

2.6. Statistical analyses

To examine responses to stress induction and relaxation, repeated-measures analyses of variance (ANOVA) were conducted for the subjective and physiological measures in a design of coping style (repressors vs. sensitizers vs. non-defensive vs. fluctuating) $\times$ time (baseline vs. stress vs. relaxation). We controlled for effects between relaxation groups by additionally including this factor in the analysis.¹ For post-processing in the evening, univariate ANOVAs were conducted for the stress and relaxation ratings to compare the four coping styles. Additional post-hoc tests were conducted to evaluate group differences. All analyses were conducted in SPSS 28 (SPSS 28.0 for Windows, SPSS Inc., Chicago, IL) with an alpha (α)-level of 0.05.

3. Results

3.1. Manipulation check

All ANOVAs revealed a significant main effect of time (Greenhouse–Geisser corrected; HR: $F(1.38, 101.97) = 131.23$, $p < 0.001$, $\eta_p^2 = 0.639$; RMSSD: $F(1.75, 125.65) = 33.45$, $p < 0.001$, $\eta_p^2 = 0.317$; blood pressure: $F(1.72, 152.87) = 64.69$, $p < 0.001$, $\eta_p^2 = 0.580$; stress rating: $F(1.69, 150.48) = 122.92$, $p < 0.001$, $\eta_p^2 = 0.580$; relaxation rating: $F(1.82, 165.52) = 134.91$, $p < 0.001$, $\eta_p^2 = 0.597$) (Figures 1, 2). Bonferroni-adjusted post-hoc analyses revealed significantly higher heart rate, lower heart rate variability, higher blood pressure, higher subjective ratings of stress and lower ratings of relaxation for the stress induction phase than for baseline (HR: $M_{\text{diff}} = 13.68$, $p < 0.001$; RMSSD: $M_{\text{diff}} = -11.21$, $p < 0.001$; blood pressure: $M_{\text{diff}} = 11.02$, $p < 0.001$; stress rating: $M_{\text{diff}} = 1.77$, $p < 0.001$; relaxation rating: $M_{\text{diff}} = -1.88$, $p < 0.001$). In addition, reverse effects were found between the stress and relaxation phases (HR: $M_{\text{diff}} = -16.68$, $p < 0.001$; RMSSD: $M_{\text{diff}} = 15.85$, $p < 0.001$; blood pressure: $M_{\text{diff}} = -5.37$, $p < 0.001$; stress rating: $M_{\text{diff}} = -3.04$, $p < 0.001$; relaxation rating: $M_{\text{diff}} = 3.58$, $p < 0.001$). These effects demonstrate successful stress induction and successful relaxation across the sample.

¹ To ensure that observed effects were not confounded by a random imbalance in the distribution of coping styles across the relaxation groups, a chi-square test was conducted. There was no statistically significant correlation between relaxation group and coping style, $\chi^2(3) = 4.02$, $p = 0.259$, $\phi = 0.21$.

3.2. Subjective ratings

Significant main effects of coping style were revealed for both stress ($F(3, 89) = 3.26$, $p = 0.025$, $\eta_p^2 = 0.099$) and relaxation ratings ($F(3, 91) = 3.44$, $p = 0.020$, $\eta_p^2 = 0.102$) (Figure 1). No interactive effects reached significance (all $p > 0.429$). A Bonferroni-adjusted post-hoc analysis revealed significantly higher stress and lower relaxation scores for sensitizers than for repressors (stress rating: $M_{\text{diff}} = 1.00$, $p = 0.049$; relaxation rating: $M_{\text{diff}} = -1.09$, $p = 0.016$). Univariate ANOVAs for stress and relaxation ratings on the evening of testing revealed no significant group differences (all $p > 0.230$).

3.3. Physiological measures

For HR, a significant main effect of coping style ($F(3, 74) = 3.89$, $p = 0.012$, $\eta_p^2 = 0.136$) and a significant time $\times$ coping style interaction (Greenhouse–Geisser corrected; $F(4.13, 101.97) = 2.60$, $p = 0.039$, $\eta_p^2 = 0.095$) were found (Figure 2A). Bonferroni-adjusted post-hoc analysis revealed significantly higher HR in non-defensive than in fluctuating copers ($M_{\text{diff}} = 16.34$, $p = 0.008$). As post-hoc tests for the significant interaction, univariate ANOVAs were conducted for stress response ($HR_{\text{stress}} - HR_{\text{baseline}}$) and relaxation response ($HR_{\text{relax}} - HR_{\text{stress}}$) with coping styles as the between-subject factor. No statistically significant effects were found (stress: $F(3, 45) = 1.65$, $p = 0.184$; relaxation: $F(3, 45) = 1.60$, $p = 0.196$).

Regarding HRV, the ANOVA revealed a significant main effect for coping style ($F(3, 72) = 3.57$, $p = 0.018$, $\eta_p^2 = 0.129$) (Figure 2B). Bonferroni-adjusted post-hoc analysis revealed a significantly higher RMSSD for fluctuating than for non-defensive copers ($M_{\text{diff}} = 33.77$, $p = 0.014$). Additionally, a significant time $\times$ relaxation group interaction ($F(1.75, 125.64) = 3.76$, $p = 0.031$, $\eta_p^2 = 0.050$) was found. Post-hoc analyses showed a significantly higher HRV during relaxation for the guided intervention than for the self-selected intervention ($F(1, 72) = 4.30$, $p = 0.042$, $\eta_p^2 = 0.056$), which was expected due to the guidance toward slow, regular breathing in the guided intervention.

In the ANOVA on mean arterial blood pressure, no other effects (apart from the main effect for time) reached significance (Figure 2C).

3.4. Additional analyses

Since one could argue that the classification of individuals close to the median is highly dependent on the sample, in addition to the above analyses, further analyses were conducted following a classification of the four groups based on quartile splits of the two dimensions of CAV and VIG (“low”: percentile rank below 25% in the current sample; “high”: percentile rank above 75% in the current sample) to confirm potential findings. This procedure reduced the group sizes to 18 repressors, 16 sensitizers, 3 non-defensive, and 1 fluctuating subjects. Because of the reduced size, only results between repressor and sensitizer were calculated. The results essentially confirmed the previous results between repressors and sensitizers: (1) No significant difference was found in stress or relaxation responses between repressors and sensitizers for physiological or subjectively perceived stress and (2) Sensitizers showed a higher subjective stress

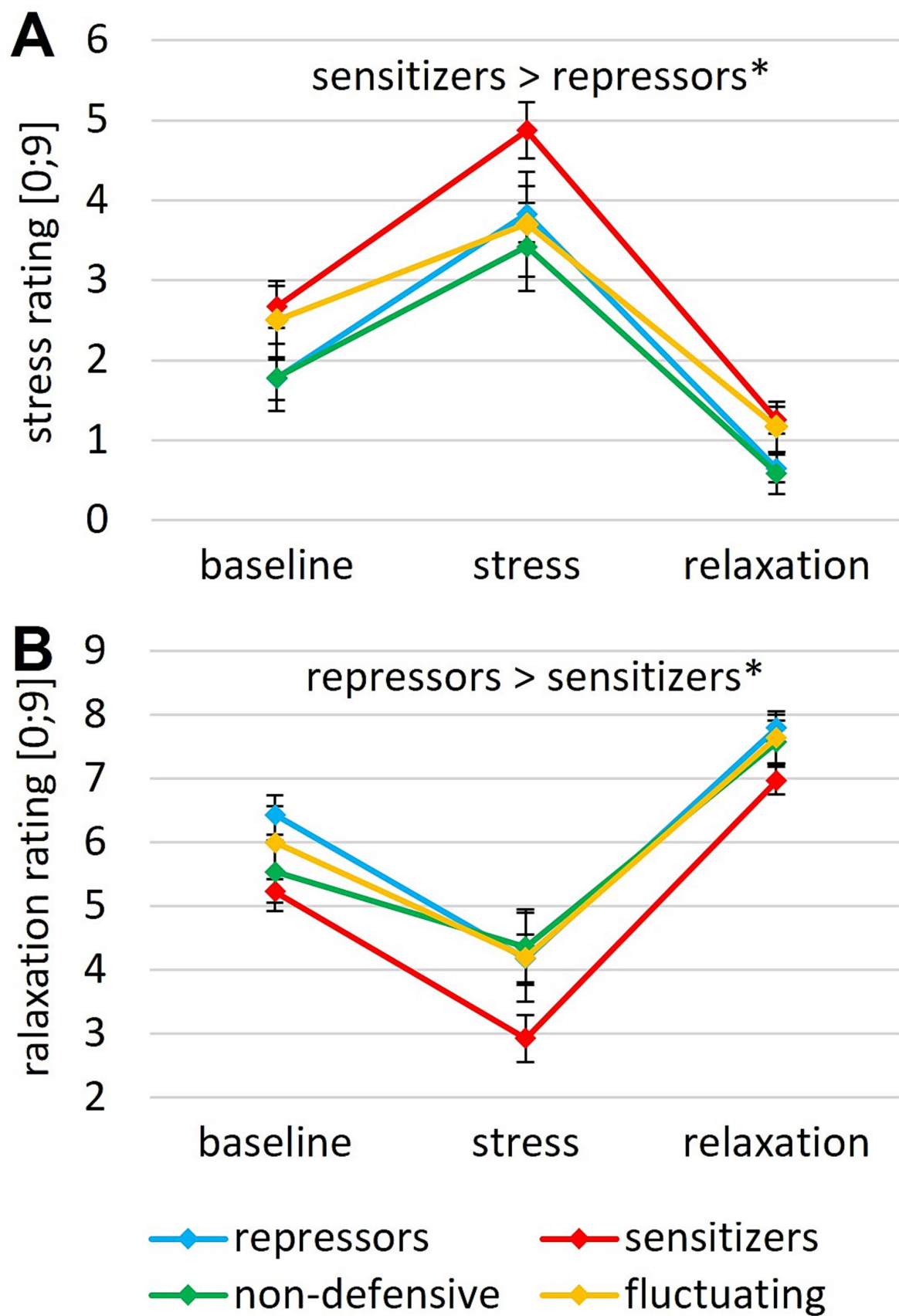


FIGURE 1

Subjective rating of perceived (A) stress and (B) relaxation after baseline, during stress induction and after relaxation for different coping styles. Error bars indicate the SEM; ** $p < 0.01$, * $p < 0.05$.

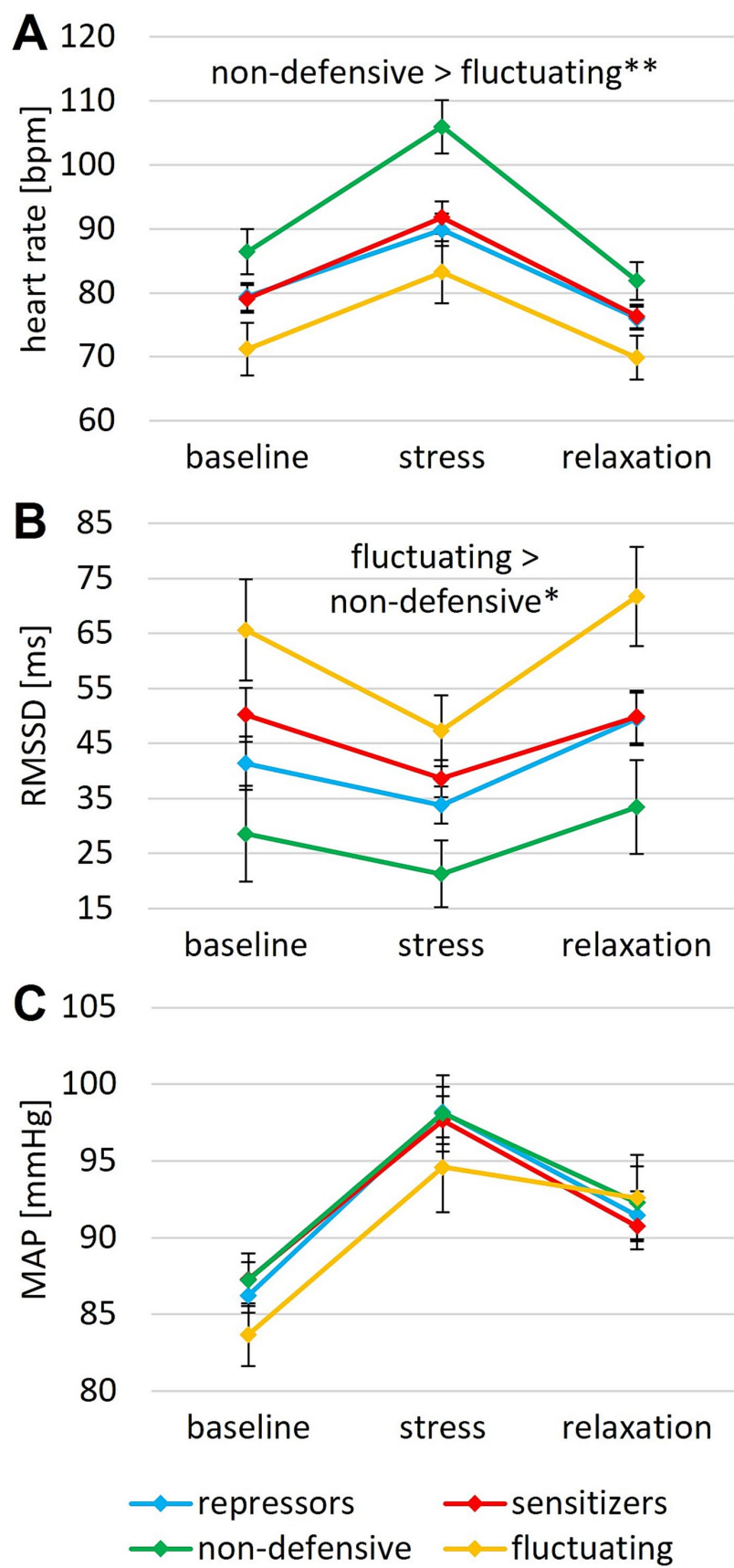


FIGURE 2 (A) Heart rate, (B) RMSSD, and (C) mean arterial blood pressure during baseline, stress and relaxation for different coping styles. Error bars indicate the SEM; ** $p < 0.01$, * $p < 0.05$.

level throughout the entire experiment as compared to repressors (stress rating: $F(1, 30) = 5.21, p = 0.030, \eta_p^2 = 0.148$).

4. Discussion

This study investigated stress reactivity to non-social stress, as well as the post-stress relaxation ability and post-processing after experiencing stress of individuals with different coping styles. Overall, results replicate the typically lower subjective stress ratings for repressors than for sensitizers. Contrary to expectation, there were no significant differences between repressors and sensitizers in the physiological stress responses. However, there was a significant difference in physiological measures between non-defensive and fluctuating copers at baseline, during stress induction and during relaxation, with non-defensive individuals overall showing a higher HR and lower HRV than fluctuating individuals. No group differences were observed in the magnitude of stress reduction neither through relaxation nor at post-processing.

4.1. Sensitizers experienced more subjective stress

Repressors reported lower stress levels than sensitizers, which is in line with data showing that sensitizers report higher subjective stress before and during experimental stress inductions (Newton and Contrada, 1992; Kohlmann et al., 1996; Derakshan and Eysenck, 1997; Rohrmann et al., 2002; Schwerdtfeger and Kohlmann, 2004; Derakshan et al., 2007; Myers, 2010; Paul et al., 2012; Oskis et al., 2019). Additional evidence can be found in research on the stress of having to undergo a medical intervention wherein sensitizers show an increased stress experience at several measurement time points before the intervention (Krohne et al., 1989; Slangen et al., 1993; Schwenkmezger et al., 1996). The stress response as defined by the change in subjective stress rating on the other hand did not differ between coping groups, which has also been reported previously (Jørgensen and Zachariae, 2006; Oskis et al., 2019).

4.2. Repressors showed no increased physiological stress responses

The majority of studies reported a dissociation between subjective ratings and physiological stress responses between repressors and sensitizers (Schwerdtfeger and Kohlmann, 2004; Myers, 2010). A dissociation was found here in the form of a lower subjective stress rating but an equally strong physiological stress response. In contrast, the physiological stress response, i.e., baseline-to-stress changes in HR, HRV and mean arterial blood pressure, did not show significant differences between repressors and sensitizers. Even though the majority of research findings point to significant differences in stress reactivity (Schwerdtfeger and Kohlmann, 2004; Myers, 2010), the same pattern has been observed by other studies before (Oskis et al., 2019). Importantly, this previous research exclusively used social stressors, such as a speech in front of an audience, which thus mainly presented threat to self-esteem. Non-socially threatening situations, i.e., also including a physically aversive element, can be assumed to

be inherently less controllable than socially threatening situations (Schmukle et al., 2000) and might thus be associated with divergent stress reactivity patterns.

4.3. Relaxation responses did not differ between coping groups

With respect to the relaxation response (i.e., the change between experienced stress during stress induction and after relaxation), no differences between coping groups were observed in this study. Consistently, no coping group differences were observed for subjective stress ratings in the evening of testing. Thus, contrary to the evidence from relaxation interventions prior to medical procedures (Lerman et al., 1990; Gattuso et al., 1992; Krohne and El-Giamal, 2008), sensitizers were shown to benefit no less from relaxation than repressors. An important difference to these studies, however, is that the relaxation techniques were applied before the medical intervention, thus they must be assumed to mainly influence baseline levels and/or the cognitive appraisal of upcoming stressors. By contrast, the focus in the present study was on inducing relaxation after a stressful experience. Here, there were no differences between the coping groups. Because coping groups often differed in their response to social stress in previous work, it would be interesting for future studies to examine the ability to relax following a social stress induction.

4.4. Fluctuating and non-defensive individuals differ in their baseline physiological stress level

Concerning the two groups of fluctuating and non-defensive individuals, we found a significant difference in physiological measures at baseline and throughout the entire experiment. Fluctuating individuals showed an increased heart rate variability and a lower HR compared to non-defensive copers. For these findings, we find supporting evidence in research on medical interventions. Krohne et al. (1989) observed that non-defensive individuals showed higher physiological stress levels (concentration of free fatty acids in blood) than all other coping groups. Slangen et al. (1993) also found that repressors and sensitizers showed a relatively low stress response (cortisol level), whereas non-defensive individuals demonstrated a significantly elevated stress response and fluctuating individuals showed the highest stress response. Relating these results to the MCM, the assumed intolerance of uncertainty and arousal as basis for the dimensions of vigilance and cognitive avoidance might lead to a differential adoption of coping resources in fluctuating vs. non-defensive copers: Since non-defensive individuals, with low scores on both the vigilance and cognitive avoidance dimensions are able to tolerate both arousal and uncertainty, they might have had to adopt few coping strategies over the course of their lives, while individuals who score high on both dimensions – the fluctuating – had to learn a huge variety of coping strategies, which could be used adaptively. Support for this theory can be found in a latent class analysis by Schmukle et al. (2000), wherein the fluctuating individuals are identified as individuals who adapt their coping strategy depending on the situation. In conclusion, the group of fluctuating individuals might consist of individuals with a variety of coping strategies, which

might be beneficial for non-socially experienced stress. Further research on the coping styles of fluctuating and non-defensive individuals is clearly needed to understand how these coping styles are used in different situations and to draw conclusions about the extent to which one style may be more adaptive than the other.

Emotion regulation and coping processes are thought to be related to a person's ability to adjust HRV in the short-term depending on the circumstances (Thayer and Lane, 2000). Higher HRV at rest has usually been associated with a more effective emotion regulation (Thayer and Lane, 2009; Park and Thayer, 2014; Balzarotti et al., 2017). Since dysfunctional emotion regulation is often associated with the development and maintenance of mental health problems (Sheppes et al., 2015) and research on fluctuating and non-defensive copers is sparse, it might be interesting for future research to further investigate these two coping styles in terms of their emotion regulation abilities.

4.5. Limitations

The presented study has some limitations that should be mentioned. The group sizes for fluctuating and non-defensive individuals are considerably smaller than for repressors and sensitizers. This underrepresentation has also been found in previous studies (Peters et al., 2012), but results in reduced power of the analyses. However, when looking at the data more closely, one can assume that the main expected effects – i.e. the differences between repressors and sensitizers in the stress response – would presumably not be found even with a larger sample. The standardized effect size in the stress rating is 0.2, which is a very small effect. In contrast, in the physiological response, exemplified by heart rate, a moderate effect of about 0.4 was found, but pointing in the opposite direction rather than the expected one. Further research is needed to determine whether the cause of the direction of this effect is due to the nature of the stress induction or to selection effects of the sample. Additionally, sexes are unequally distributed across coping groups. The high number of male participants in the repressors group might cause a bias in the results. Future studies might want to control for such biases by aiming for a recruitment of similar distributions between coping styles. Another limitation is that the differences found between the groups of fluctuating and non-defensive individuals rely on the classification by Krohne (1993). Studies based on the classification by Weinberger et al. (1979) will most likely come to different results and conclusions since group assignment hardly overlaps. It might be interesting for future research to additionally examine stress and relaxation responses using this classification to determine if there are differences according to this classification. Another limitation is that our study sample consisted of a healthy student cohort with an associated lower variance in coping styles than might be found in a clinical population. Furthermore, when interpreting HRV, it is important to keep in mind that HR and HRV are inversely correlated (Kazmi et al., 2016), making it difficult to interpret group differences in HRV independently of HR. Correspondingly, an additional ANCOVA controlling for baseline differences in HR did not reveal a significant group difference in HRV. This finding further highlights the importance of carefully evaluating the specificity of HRV effects in future research. Another limitation relates to the generalizability of the study: future studies should investigate whether the described effects can also be observed in populations other than a healthy student sample and

for other non-social stress inductions. Overall, the question arises whether there might be differential effects for the individual coping styles depending on the type of stressor. This could be addressed in future studies by looking at different stressors individually (e.g., acoustic stressors, aversive images, emotional stressors) and by also systematically varying the controllability of the stressors.

4.6. Conclusion

In summary, we found support for the dissociation between subjective ratings and physiology in repressors in the form of a lowered subjective perception of stress throughout the entire experiment. Additionally, no substantial differences in stress reactivity were observed between coping groups, neither on a physiological nor on a subjective level. As the present study involved a non-social stressor, this might be viewed as tentative indication for the notion that these inter-individual differences only arise when stress induction involves pronounced social threat. However, additional corroboration by future research is needed here. The differences at baseline that persist throughout the experiment could be interesting for future research and shows the importance of examining all four coping groups.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving humans were approved by local ethics committee of the University of Siegen. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AE: conceptualization, methodology, formal analysis, visualization, and writing – original draft. MK: conceptualization, methodology, software, formal analysis, and writing – review and editing. JF and TS: conceptualization, software, investigation, and writing – review and editing. HK: conceptualization, software, and writing – review and editing. MH and TK: conceptualization, supervision, funding acquisition, and writing – review and editing. KK: formal analysis and writing – review and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fpsyg.2023.1196481/full#supplementary-material>

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Anlage zur Dissertationsschrift

Gemäß der Promotionsordnung der Lebenswissenschaftlichen Fakultät der Universität Siegen erfolgt im Folgenden eine Angabe des Eigenanteils an Publikationen, die in Ko-Autorenschaft publiziert wurden.

Studie I:

Exner, A.*, Machulska, A.*, Stalder, T., & Klucken, T. (2023). Biased information processing and emotional coping: Differences in attentional and approach patterns towards positive cues in repressors and sensitizers. *Current Psychology*, 42(34), 30412–30421. <https://doi.org/10.1007/s12144-022-04087-7>.

Eigenanteil: Im Rahmen dieser Publikation war ich hauptverantwortlich für die Formulierung der Fragestellung, die Aufbereitung und Analyse der Daten, sowie das Verfassen des Manuskriptes.

Studie II:

Exner, A., Tapia León, I., Mueller, E. M., & Klucken, T. (2021). Cardiac response in aversive and appetitive olfactory conditioning: Evidence for a valence independent CS-elicited bradycardia. *Psychophysiology*, 58(11), e13912. <https://doi.org/10.1111/psyp.13912>.

Eigenanteil: Im Rahmen dieser Publikation war ich hauptverantwortlich für die Formulierung der Fragestellung, die Konzeption und die Durchführung der Studie, die Analyse der Daten, sowie das Verfassen des Manuskriptes.

Studie III:

Exner, A.*, Kampa, M.*, Finke, J. B., Stalder, T., Klapperich, H., Hassenzahl, M., Kleinke, K., & Klucken, T. (2023). Repressive and vigilant coping styles in stress and relaxation: evidence for physiological and subjective differences at baseline, but not for differential stress or relaxation responses. *Frontiers Psychology*, 14:1196481. <https://doi.org/10.3389/fpsyg.2023.1196481>.

Eigenanteil: Im Rahmen dieser Publikation war ich hauptverantwortlich für die Formulierung der Fragestellung, die Aufbereitung und Analyse der Daten, sowie das Verfassen des Manuskriptes.

* geteilte Erstautorenschaft