Effort-Reward Imbalance among PhD Students:

Exploring Efforts, Rewards and Coping Strategies

Inaugural-Dissertation

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„Nothing in life is to be feared, it is only to be understood.

Now is the time to understand more, so that we may fear less.“

~ Marie Curie ~

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Danksagung

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VIELEN DANK

Deutsche Zusammenfassung

Effort-Reward Imbalance im Kontext der Promotion: Untersuchung der Belastungen, Honorierungen, Motive und Copingstrategien von Promovierenden

Deutsche Zusammenfassung

Einführung

Unter dem Twitter Hashtag *#IchBinHanna* bekunden viele junge WissenschaftlerInnen ihre Unzufriedenheit am wissenschaftlichen Forschungsbetrieb und dessen Arbeitsbedingungen (Bahr et al., 2022). Kritisiert werden unter anderem die befristeten Arbeitsverträge, die geringe Vergütung, die oftmals hohe Anzahl an Überstunden sowie die Abhängigkeit zum bzw. zur Vorgesetzten (z. B. Cornwall et al., 2019; Levecque et al., 2017). Zudem stehen die fehlenden Zukunftsperspektiven, die eine langfristige Lebens- und Familienplanung erschweren und die soziale Isolation in der Kritik (z. B. Cornwall et al., 2019; Levecque et al., 2017). Daneben zeichnet sich die Promotion durch eine Doppelbelastung zwischen a) dem Promotionsprojekt an sich und b) weiteren Zusatzaufgaben aus, die für die Absicherung des Lebensunterhaltes notwendig sind, wie die Ausführung eines Zweitjobs oder einer Bewerbung auf ein Stipendium. Stresstheoretisch betrachtet, handelt es sich hierbei um zahlreiche Faktoren, die Stress bewirken (Stressoren) und ein Risiko für die Gesundheit von Promovierenden darstellen können. Interessanterweise konzentriert sich die bisherige Forschung auf Arbeitsbelastungen von DoktorandInnen, die ihre Promotion als wissenschaftliche MitarbeiterInnen erwerben, während andere Promovierende kaum in Betracht gezogen werden (z. B. Stipendiaten). Außerdem gibt es bisher kein einheitliches Konzept zur Erfassung von Stress im Kontext der Promotion und Erhebungen im deutschsprachigen Raum sind spärlich (de Vries, 2020). Daher ist es schwierig, konsistente Aussagen darüber zu treffen, wie sich Stress auf die Gesundheit von Promovierenden auswirkt und wie Promovierende Stress effektiv entgegenwirken können (z. B. durch Copingstrategien). An diese Forschungslücke knüpft die vorliegende Dissertation an, indem sie auf die Annahmen des Effort-Reward Imbalance Modells (Siegrist, 1996) sowie des Transaktionalen Stressmodells (Lazarus & Folkmann, 1984) zurückgreift. Diese Modelle zählen zu den bekanntesten Arbeitsstressmodellen und eigenen sich, um die

Gesundheitsrisiken der Stressoren sowie potenzielle Copingstrategien von Promovierenden mit unterschiedlichen Promotionsmodellen (z. B. Stipendium, Industriepromotion) systematisch zu erfassen und stellen die Ausgangsbasis für die vorliegende Forschungsarbeit dar.

Das Effort-Reward Imbalance Modell

Das Effort-Reward Imbalance Modell (dt. Modell der beruflichen Gratifikationskrisen) hat seinen Ursprung Ende der 80er Jahre und basiert auf der Norm der sozialen Reziprozität [1]. Sie besagt, dass Arbeit sich dadurch auszeichnet, etwas zu leisten (*Effort*) und im Gegenzug eine gleichwertige ökonomische, sozio-emotionale oder statusbezogene Honorierung (*Reward*) zu erhalten (Siegrist, 1996). Eine Honorierung kann dabei in Form von angemessenem Gehalt, Wertschätzung durch KollegInnen oder die Führungskraft sowie die Schaffung von Arbeitsplatzsicherheit und Aufstiegschancen im Unternehmen erfolgen (Siegrist, 1996). Wird auf Dauer ein subjektiv wahrgenommenes Ungleichgewicht zwischen hoher Verausgabung und niedriger Honorierung verspürt, kann dies zu Unzufriedenheit und Stress bis hin zu schweren gesundheitlichen Folgen wie Herz-Kreislauf-Erkrankungen führen – insbesondere dann, wenn Individuen ihre Arbeitsanstrengung trotz auftretender Symptome fortsetzen. Siegrist (1996) nennt für die Fortsetzung drei potenzielle Gründe: a) eine existenzielle Abhängigkeit; b) strategische Gründe, wie die Hoffnung auf Karrierechancen; sowie c) eine übersteigerte Verausgabungsbereitschaft, die im englischsprachigen Raum auch als *Overcommitment* bekannt ist. Personen, auf die ein oder mehrere der genannten Faktoren zutreffen, gelten als Risikogruppe für ein erhöhtes Stresserleben bis hin zu den bereits genannten gesundheitlichen Folgen (Siegrist, 1996).

[1] Das Effort-Reward Imbalance Modell wird häufig mit weiteren Theorien verglichen, wie beispielsweise der sozialen Austauschtheorie bzw. Equitytheorie von Adams oder dem psychologischen Vertrag von Rousseau. Eine ausführliche Darstellung hierzu findet sich in Ulich & Wülser (2009, S. 88 ff.).

Die Annahmen des Modells konnten mit Blick auf bezahlte und unbezahlte bzw. ehrenamtliche Arbeit in zahlreichen Studien empirisch gestützt werden (van Vegchel et al., 2005). Promovierende wurden bisher nur in einer Studie aufgegriffen, die erst während der Erhebungsphase des hier vorliegenden Forschungsprojekts veröffentlicht wurde (Kunz et al., 2021). In dieser Studie konnte ein Zusammenhang zwischen der Zufriedenheit mit der eigenen Gesundheit und der Fähigkeit zur psychischen Erholung von der Arbeit (Distanzierungsfähigkeit) von Promovierenden festgestellt werden. Allerdings muss beachtet werden, dass die Erhebung in einem Querschnittsdesign erfolgte und somit keine kausalen Aussagen möglich sind. Zudem bezog sich die Datenerhebung ausschließlich auf Promovierende der Universität Bielefeld. Erforderlich ist daher ein Längsschnittdesign sowie der Einbezug unterschiedlicher Hochschulen und Promotionsmodelle (z. B. Industriepromotion, Stipendium).

Das Transaktionale Stressmodell

Ein weiteres bekanntes Modell zur Untersuchung von Stress ist das Transaktionale Stressmodell von Lazarus und Folkmann (1984). Es betrachtet, wie Menschen mit Stress umgehen und unterscheidet zwischen problemorientierten und emotionsorientierten Copingstrategien, die Individuen zur Verfügung stehen, um mit Stress umzugehen. Strategien, die mit einer aktiven Stressbewältigung der Individuen einhergehen, werden als problemorientierte Strategien bezeichnet (z. B. Einwerbung von Drittmitteln). Emotionsorientierte Strategien beziehen sich auf Verhaltensweisen, die helfen, mit den eigenen Emotionen umzugehen (z. B. Isolation, soziale Aktivitäten). Beide Strategien wurden bereits im Rahmen der Untersuchung von Promovierenden analysiert (z. B. Byers et al., 2014; Martinez et al., 2013; McAlpine & Norton, 2006). Allerdings hauptsächlich im amerikanischen und kaum im europäischen Raum, sodass die Ergebnisse nur schwer auf die Situation von Promovierenden in Deutschland übertragen werden können (Hazell et al., 2020). Zudem gibt es keine

Untersuchung, die das Transaktionale Stressmodell mit dem Effort-Reward Imbalance Modell verknüpft. Dieser Forschungslücke widmet sich die vorliegende Arbeit.

Gegenstand der Arbeit

Ziel dieser Arbeit ist, durch das Effort-Reward Imbalance Modell und das Transaktionale Stressmodell einen Einblick in die Wahrnehmung von Promovierenden aus Deutschland hinsichtlich Belastungen, Honorierungen, Motiven und Copingstrategien zu erlangen (1) und die Effort-Reward Imbalance Skala in einer längsschnittlichen Studie zu adaptieren und zu validieren (2). Hierfür gliedert sich die Arbeit in zwei Teilbereiche: Eine qualitative Interviewstudie mit 21 Promovierenden sowie eine quantitative Studie mit 1275 Promovierenden. Beide Teile werden im Folgenden kurz vorgestellt.

Teil 1: Die berufliche Gratifikationskrise bei Promovierenden: Eine qualitative Untersuchung [Engl. The Effort-Reward Imbalance among PhD students: A Qualitative Study]

Der erste Teil der Arbeit wurde von Melanie Vilser konzipiert, durchgeführt und ausgewertet. Das Kodierschema wurde unabhängig von Sabrina Rauh auf alle Interviewdaten angewendet und auf Übereinstimmungen überprüft. Melanie Vilser hat die Erstellung des Manuskripts übernommen und Überarbeitungen anhand des Feedbacks von Sabrina Rauh, Dr. Irmgard Mausz und Prof. Dr. Dieter Frey (LMU München) vorgenommen. Das Paper wurde im September 2022 im *International Journal of Doctoral Studies* veröffentlicht und am 52. Kongress der Deutschen Gesellschaft für Psychologie in Hildesheim präsentiert.

Einleitung

Der erste Teil der Studie widmet sich, der Analyse der Belastungen, Honorierungen sowie Motiven und Copingstrategien von Promovierenden. Als theoretische Grundlage hierfür dient das Effort-Reward Imbalance Modell (Siegrist, 1996) und das Transaktionale Stressmodell (Lazarus & Folkman, 1984).

Methoden und Ergebnisse

Im Rahmen der Studie wurden 21 Promovierende aus sieben deutschen Universitäten und acht Fachrichtungen in halbstrukturierten Interviews zu ihren Belastungen, Honorierungen, Motiven und Copingstrategien während der Promotion befragt. Unter den Befragten waren 14 weibliche und sieben männliche Promovierende im Alter zwischen 25 und 51 Jahren (M = 29.52, SD = 5.49). Die Antworten wurden mithilfe von MAXQDA transkribiert und mittels der qualitativen Inhaltsanalyse nach Mayring (2003) mit deduktiv-induktiver Kategorienbildung durch zwei KodiererInnen ausgewertet. Die Studienergebnisse weisen auf zwei Hauptkategorien für Belastungen und drei Hauptkategorien für Honorierung sowie auf zahlreiche Unterkategorien hin.

Die Belastungen gliedern sich in die zwei induktiv gebildeten Hauptkategorien: 1) Belastungen, die mit dem direkten Promotionsprojekt in Verbindung stehen (z. B. Gefühle der Unsicherheit und Isolation, Probleme mit dem Feedbackprozess, Schwierigkeiten sich zu motivieren oder abzuschalten) sowie 2) weitere Belastungen, die unabhängig vom Promotionsprojekt anfallen (z. B. Lehrverpflichtungen oder soziale Aktivitäten).

Die drei Hauptkategorien der Honorierungen wurden deduktiv, in Anlehnung an das Modell von Siegrist (1996) entwickelt und umfassen die sozio-emotionale, die finanzielle bzw. materielle sowie die statusbezogene Honorierung (mit den drei Unterkategorien Arbeitsplatzsicherheit, Karriereförderung und berufliche Entwicklungsmöglichkeiten). Anschließend fanden eine induktive Erweiterung und Analyse der Kategorien statt. Es wurde beispielsweise entdeckt, dass viele der Befragten das Universitätssystem aufgrund des Wissenschaftszeitvertragsgesetzes als belastend empfanden. Im Vergleich zur Arbeit in der Privatwirtschaft wurde das Universitätssystem als weniger attraktiv beschrieben, vor allem hinsichtlich der Aufstiegsmöglichkeiten und der finanziellen Honorierung. Das Missverhältnis zwischen

Arbeitsbelastung und Gehalt wurde insbesondere von an der Universität arbeitenden Promovierenden kritisiert.

Weiterhin wurden die Promovierenden nach ihren Motiven für die Promotion befragt, um Rückschlüsse darauf zu ziehen, welche Personengruppen in einem besonders hohen Maße von einer Effort-Reward Imbalance betroffen sein könnten (z. B. Personen, die *Overcommitment* zeigen). Die Promovierenden gaben an, dass sie sich im Klaren darüber seien, dass eine Promotion nicht unbedingt zu einer sofortigen Honorierung führe. Sie konzentrierten sich eher auf intrinsische und langfristige Ziele, etwa auf ihren Beitrag zur Forschung oder ihrer Entwicklung zu einem bzw. einer ExpertIn im Forschungsfeld. Für andere waren die Verbesserung der eigenen Fähigkeiten und die fachliche Weiterbildung zentrale Motive. Weiterhin gaben die Promovierenden an, Spaß an der Forschung zu haben und schätzten es, dass sie für die Arbeit an einem Projekt bezahlt wurden, das ihren persönlichen Interessen entsprach. Auch wurden die Flexibilität und Freiheit während einer Promotion, etwa in Form von flexiblen Arbeitszeiten hervorgehoben. Gerade Promovierende, die zuvor in der Industrie gearbeitet hatten, schätzten diesen Aspekt sehr.

Die Studienergebnisse weisen außerdem auf drei problemorientierte und fünf emotionsorientierte Copingstrategien hin. Zu den problemorientierten Strategien zählen die Etablierung von Arbeitsroutinen, das aktive Setzen von Grenzen (z. B. durch Out-Off-Office Benachrichtigungen) und der Austausch (vor allem mit anderen Promovierenden). Zu den emotionsorientierten Copingstrategien zählen sportliche Aktivitäten, Kontakt zu FreundInnen und der Familie, Medienkonsum, Self-Care Routinen und das Abschalten nach der Arbeit durch Arbeitspausen am Wochenende oder im Urlaub.

Zusammenfassung und Schlussfolgerungen

Die Ergebnisse der Studie geben einen Einblick in Belastungen und Honorierungen, die Promovierende während ihres Promotionsstudiums wahrnehmen sowie Faktoren, die

Promovierende für eine Promotion motivieren. Weiterhin zeigt die Studie problemorientierte und emotionsorientierte Copingstrategien auf, die Promovierende einsetzen, um mit Stress während der Promotion umzugehen. Dadurch trägt die Arbeit nicht nur zu einem tieferen Verständnis der Effort-Reward Imbalance Beziehung und deren gesundheitlichen Konsequenzen bei Promovierenden bei, sondern nimmt gleichzeitig eine präventive Perspektive ein.

Teil 2: Die berufliche Gratifikationskrise in einer Promovierenden-Stichprobe: Anpassung und Validierung der Effort-Reward Imbalance Skala für Promovierende [Engl. Effort-Reward Imbalance within a PhD Student Population: Adaptation and Validation of the Effort-Reward Imbalance Scale for Doctoral Students]

Der zweite Teil der Arbeit wurde von Melanie Vilser konzeptualisiert, durchgeführt und ausgewertet. Dr. Irmgard Mausz, Prof. Dr. Dieter Frey (LMU München) und Prof. Dr. Johannes Siegrist (Universität Düsseldorf), der Begründer der originalen Effort-Reward Imbalance Skala, gaben daraufhin Feedback auf die Arbeit. Der entwickelte Fragebogen wurde auf der Plattform *Open Science Framework* präregistriert (OSF, 10.17605/OSF.IO/ZGH2R). Im Moment befindet sich das Manuskript im Review beim *International Journal of Stress Management* (Stand: März 2023).

Einleitung

Nachdem in der ersten Studie zahlreiche Stressoren herausgearbeitet wurden, die zum Arbeitsstress von Promovierenden beitragen, verfolgte die zweite Studie das Ziel den Effort-Reward Imbalance Fragebogen von Siegrist (1996) auf die Zielgruppe der Promovierenden zu adaptieren und entsprechend der Empfehlung von Boateng et al. (2018) durch unterschiedliche Arten zu validieren. Hierfür wurde überprüft, ob sich die Effort-Reward Imbalance Werte bei verschiedenen Gruppen von Promovierenden unterschieden, beispielsweise zwischen Frauen und Männer oder StipendiatInnen und wissenschaftlichen MitarbeiterInnen (Diskriminante Validität). Außerdem wurde der Zusammenhang der Effort-Reward Imbalance-Werte

mit dem mentalen Gesundheitszustand der Promovierenden als externes Kriterium gemessen (Kriteriumsvalidität). Um die Skala auf alle Promovierenden anwendbar zu machen, konzentriert sich die Adaption auf Belastungs- und Honorierungsfaktoren, die unabhängig von den im Teil 1 beschriebenen Zusatzaufgaben während der Promotion anfallen – also auf das reine Promotionsprojekt.

Methoden und Ergebnisse

Die Daten der zweiten Studie wurden via Onlinefragebögen zu zwei Messzeitpunkten mit einem sechswöchigen Abstand von April 2022 bis August 2022 erhoben (finale Stichprobe: n = 1294 Promovierende von 100 deutschen Universitäten und sechs großen Begabtenförderungswerken). Im Rahmen der explorativen Faktorenanalyse zeigte sich eine Vier-Faktor-Lösung mit den Faktoren *„Belastungen“, „Anerkennung/Wertschätzung“, „Karrierechancen“* und *„Übersteigerte Verausgabungsbereitschaft“.* Vier Items wurden aufgrund geringer Faktorladungen ausgeschlossen. Die konfirmatorische Faktorenanalyse bestätigte die in der explorativen Faktorenanalyse gefundene Faktorenstruktur. Ebenso konnte für die Skala die diskriminante Validität und Kriteriumsvalidität bestätigt werden. Im Ergebnis liegt ein Fragebogen zur Erfassung der Effort-Reward Imbalance von Promovierenden mit 18 Items vor (ERI-PhD).

Zusammenfassung und Schlussfolgerungen

Die Studie stellt mit dem adaptierten Effort-Reward Imbalance Fragebogen ein Instrument zur Verfügung, dass das Ungleichgewicht von hoher Arbeitsbelastung und niedriger Honorierung spezifisch während der Promotion erfassen kann. Zudem tragen die Ergebnisse des Fragebogens dazu bei, den Einfluss einer Effort-Reward Imbalance auf die Gesundheit von Promovierenden zu berücksichtigen sowie Copingstrategien zu untersuchen, welche gesundheitliche Risiken minimieren können. Gerade im Kontext der aktuellen Debatten um die prekäre Beschäftigungssituation des wissenschaftlichen Personals stellt die Studie ein wichtiges

Werkzeug bereit, um Aussagen über Arbeitsstress von Promovierenden sowie über mögliche gesundheitliche Risiken zu treffen. Zukünftige Untersuchungen sollten erfolgen, um zu überprüfen, ob die Skala für andere Länder aufgrund differenzierender struktureller und finanzieller Promotionsstrukturen adaptiert werden muss.

Abschließende Diskussion und Fazit

Die vorliegende Dissertation identifizierte Belastungen, Honorierungen, Motive sowie Copingstrategien für eine Effort-Reward Imbalance. Dieses Wissen wurde im Anschluss verwendet, um den Effort-Reward Imbalance Fragebogen an den Kontext der Promotion zu adaptieren und zu validieren.

Die Befunde ziehen theoretische und praktische Implikationen nach sich. Aus theoretischer Sicht ist es unter anderem wichtig, den angepassten und validierten Fragebogen im Rahmen weiterer und vor allem internationaler Studien zu testen. Dadurch kann der Forschungsstand erweitert und verschiedene Promotionsmodelle im nationalen und internationalen Raum verglichen werden. Aus praktischer Sicht sprechen wir uns dafür aus, dass Promovierende bereits vor Beginn ihrer Promotion über die Anforderungen informiert und darin unterstützt werden, mit Belastungsfaktoren während der Promotion umzugehen. Auf diese Weise kann ein subjektiv wahrgenommenes Ungleichgewicht zwischen hoher Arbeitsbelastung und niedriger Honorierungen reduziert werden. Auch Workshops, die persönliche Arbeits- sowie Entspannungstechniken vermitteln, sollten in den Promotionsprozess integriert werden (z. B. Zeit- und Selbstmanagement, Achtsamkeit), um die Nutzung von nicht effektiven Copingstrategien, die in unserer Studie und anderen Studien identifiziert wurden, zu reduzieren (z. B. Prokrastination). Zudem empfiehlt es sich, den Austausch unter den Promovierenden zu fördern (z. B. durch Networking-Workshops oder andere Austauschformate). Insbesondere der Austausch mit erfahrenen Promovierenden scheint laut den Ergebnissen der Interviewstudie sehr wertvoll zu sein.

Neben der individuellen Ebene sind die BetreuerInnen mit einzubeziehen. Sie sind hauptverantwortlich für die Verbesserung von Promotionsstudiengängen, für die Schaffung von Fort- und Weiterbildungsmaßnahmen sowie für eine gute Führungskultur. Die BetreuerInnen sollten über verbreitete Belastungs- und Honorierungsfaktoren, Motive zum Erwerb einer Promotion sowie Copingstrategien informiert werden, um ihr Wissen einerseits an ihre Promovierenden zu vermitteln, sowie andererseits auf ihr eigenes Verhalten zu übertragen (z. B. Verbesserung der Lob- und Anerkennungskultur, Finanzierung von Weiterbildungsveranstaltungen). Durch diese Implementierung könnte die Beziehung zur Promotionsbetreuung und damit die Honorierungskomponente des Effort-Reward Imbalance Modells verbessert werden.

Die genannten Implikationen zeigen, dass es zahlreiche Strategien gibt, um mit der Kluft zwischen hohen Arbeitsanforderungen und -erwartungen sowie den konkreten Arbeits- und Beschäftigungsbedingungen und Karriereperspektiven der Promotion umzugehen. Weitere Implikationen finden sich in den zwei vorgestellten Papieren dieser Arbeit.

Insgesamt bieten die Ergebnisse eine fundierte Ausgangslage, für zukünftige empirische Untersuchungen sowie die Ausgestaltung von Bildungsmaßnahmen, die einen präventiven Charakter zur Entstehung einer hohen Effort-Reward Imbalance haben können.

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Part I

The Effort-Reward-Imbalance among PhD students: A Qualitative Study

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THE EFFORT-REWARD-IMBALANCE AMONG PHD STUDENTS – A QUALITATIVE STUDY

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ABSTRACT

Aim/Purpose	The purpose of this paper is to examine the perceived efforts, rewards, motives, and coping strategies of a sample of PhD students in Germany based on tested stress models, the Effort-Reward-Imbalance Model and the Transactional Model of Stress and Coping.
Background	Pursuing a PhD can be challenging and stressful. Students face conflicts, isolation, and competition as well as difficulties with their supervisors. However, there is little known about how students perceive their PhD.
Methodology	Semi-structured interviews were conducted in 2021 with 21 male and female doctoral students from various fields of research. The recorded interviews were transcribed and analyzed according to Mayring's qualitative content analysis.
Contribution	Little is known about the work stress of PhD students. Most studies focus on single aspects (e.g., the relationship with the supervisor or the heavy workload) and use questionnaires that do not show all aspects causing work stress and how to prevent it. In this study, we examined the elements of work stress and coping strategies by using the Effort-Reward-Imbalance Model and the Transactional Model of Stress and Coping in a theoretical framework.
Findings	The analysis yielded two main categories for efforts and three main categories for rewards as well as several sub-categories. Participants persisted in the PhD program for five reasons: an intrinsic motivation, an interest in improving one's skills, the motivation to become an expert in one's field, the ability to contribute

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	to research, and because of the flexibility and freedom offered during a PhD. Further, the study analyzed how PhD students cope with stress. Engaging in physical activities or spending time with family and friends were the most common coping strategies used, followed by work routines (like scheduling time for deep work and breaks) and seeking assistance from other PhD students.
Recommendations for Practitioners	To decrease the stress factors and negative health outcomes, we recommend incorporating personal as well as organizational measurements in the university setting. Through kick-off events and personal development workshops, PhD students should be made aware of the potential stress factors and coping strategies. Mentoring programs with postdocs can further support the doctoral students. On an organizational level, the knowledge about the elements of work stress should be incorporated in the recruiting process and supervisor workshops.
Recommendations for Researchers	As past research has investigated the effects of stress on physiological parameters, the framework of this study proposes the incorporation of the imbalance component into biological stress research.
Impact on Society	Understanding the efforts, rewards, and motives for a doctoral degree will help to reduce work stress of PhD students and create a more positive overall workplace, for example, by improving the relationship between students and their supervisors.
Future Research	Additional work is required to explore how the Effort-Reward-Imbalance model and coping strategies could interact and influence different outcomes. As the majority of the participants pursed a PhD degree in psychology, further studies need to be conducted that include other disciplines.
Keywords	coping strategies, effort-reward-imbalance, motives, PhD students

INTRODUCTION

Doctoral students play a key role in shaping the scientific landscape and its future (Vollmar, 2019). Demographic changes such as low birth rates, a growing ageing population, and an increasing number of PhD students as well as the skilled labor shortage could shape economic growth and technical innovations. However, high efforts and low rewards at the beginning of the scientific career, the doctoral phase, have been subject to criticism. For example, PhD students feel isolated (Grady et al., 2014; Tomasz & Denicolo, 2013). They attribute their mental health problems to career and financial insecurity (El-Ghoroury et al., 2012; Lau & Pretorius, 2019), work environment dilemmas (Pyhältö et al., 2012), or the supervisor's leadership style. Many of them turn to industry due to mental health issues (Levecque et al., 2017). Some even never finish their PhD. For example, the attrition rate in North America is estimated at 40-50 % and should be of high concern, as the PhD students already have a high level of qualification and a high amount of work spent in their theses (Litalien & Guay, 2015). According to Litalien and Guay (2015) the perceived competence, supervisor relationship, and interaction with other faculties can be seen as strong predictors for attrition. Also, in comparison to a normative population of the same age, PhD students report higher levels of depression, anxiety, and stress (Barry et al., 2018). This is in line with other studies that focus on the mental health of PhD students. They state that today's PhD students are generally more stressed than previous generations and have a greater risk of having or developing mental disorders, especially depression (Levecque et al., 2017). Thirty-two percent of Belgian science and social science PhD students where at a higher risk for developing a common psychiatric disorder. They experienced two (51 %) or four (32 %)

symptoms of poor mental health (Levecque et al., 2017). Compared to a random sample of a population with a similar level of higher education, the prevalence was twice as high (Levecque et al., 2017). Some studies report the highest incidences of mental illnesses in academic work settings compared to other occupations (Lau & Pretorius, 2019). This is problematic as stress affects dropout rates and the time to accomplish a PhD degree (Groenvynck et al., 2013; van der Haert et al., 2014). For example, one study showed that one third of the 724 participants intended to drop out (Castelló et al., 2017). Consequently, studies highlight the importance of understanding how stress affects the mental well-being of PhD students and the need for interventions to address mental illnesses (Evans et al., 2018; Lau, 2019; Lau & Pretorius, 2019). Earlier research mainly focused on demographic characteristics, financial situations (Fineisen, 2011), working conditions (Lange-Vester & Teiwes-Kügler, 2013), or dropout reasons (Hauss et al., 2012). Stressors of the day-to-day work of PhD students, however, have not yet been investigated. Therefore, it is important to examine work stress of PhD students with tested and valid stress models – the Effort-Reward-Imbalance Model (Siegrist, 1996) and the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984). According to the first model, which focuses on work-related psychosocial stress, work stress can be defined as a result of a failed social reciprocity in terms of high efforts spent (e.g., high workload, working overtime) and low rewards given (e.g., job security, job promotion). This is in line with the definition of the International Labour Organization (2016, p. 2) which describes, work stress as a "harmful physical and emotional response caused by an imbalance between the perceived demands and the perceived resources and abilities of individuals to cope with those demands. Work-related stress is determined by work organization, work design, and labour relations and occurs when the demands of the job do not match or exceed the capabilities, recourses, or needs of the worker, or when the knowledge or abilities of an individual worker or group to cope are not matched with the expectations of the organizational culture of an enterprise." Nevertheless, there is no common standardizes instrument to measure work stress of PhD students. By using both models, the study will not only contribute to a deeper understanding of the relationship between efforts and rewards, but could also address illness (Waight & Giordano, 2018) by helping to identify coping strategies that PhD students can use to handle stress and a potential mismatch between high efforts and low rewards. Last, the study could indicate how to improve PhD work conditions and reduce the increasing world trend of doctoral students leaving academia (Chen, 2021) by pointing out job crafting measures (Creed et al., 2020).

LITERATURE REVIEW

PHD TRENDS IN GERMANY

In Germany, students face many challenges during their PhD. However, there is relatively little research on the situation of doctoral students and their health and well-being (Briedis et al., 2020; Schmidt & Hansson, 2018). The prevalence of mental health issues of doctoral students in Germany is alarmingly high "as 17.9% report moderate depressive symptoms and 62.7% show moderate to high state anxiety" (Max Planck Society, 2020, p. 32). Furthermore, the trend to leave academia in Germany is extremely high. Only 9% of PhD students at the largest scientific research organization in Germany want to pursue a postdoc position while the majority wants to leave academia for industry after their PhD (Degen, 2014). This may be due to fixed-term employment contracts that often end after less than one year in addition to low salaries. However, this is for PhD students working at a university. In Germany, there are a variety of options to gain a PhD degree (Federal Ministry of Education and Research, 2019). Students have the choice between an individual or structured PhD program as well as the opportunity to pursue a PhD in cooperation with a company. Due to this, there is variety of job positions (e.g., research associate at a department, in a third-party-funded project, or at a non-university research institution) and funding options (e.g., scholarship, individual funding). This study focuses on PhD students at universities as well as other PhD settings. It captures several elements that contribute to work stress while working on a PhD degree. Thus, this study draws on existing stress models.

THE EFFORT-REWARD-IMBALANCE MODEL

A well-known instrument to measure work stress is the Effort-Reward-Imbalance model (Siegrist, 1996). It is considered to be one of the most commonly tested and valid models of stress and has been used in several work-based and unpaid social contexts (e.g., household and family work). Furthermore, the Effort-Reward-Imbalance model has been applied in the academic context. Experiences of efforts and rewards of both students and predominantly teaching staff at universities have been investigated with Siegrist's framework (Hamilton, 2019; Williams et al., 2018), extending the applicability of the model to university-related settings. Based on the idea of social reciprocity, the model states that employees put efforts into their job in exchange for rewards provided by their companies, such as an appropriate salary (financial reward), job security or career opportunities (status-related reward), or esteem (socio-emotional reward). However, if individuals perceive an imbalance in the form of high efforts and low rewards, the expected reciprocity is not in place (see Figure 1). According to the Effort-Reward-Imbalance model, this can lead to strong negative emotions and physiological distress afflicting the individual's health and well-being (Siegrist, 2012). Also, studies have shown that an imbalance can increase risk for cardiovascular morbidity and mortality; high blood lipids, blood pressure, and blood coagulation or increase behavioral-related risk factors such as smoking (van Vegchel et al., 2005). In the academic sector, the Effort-Reward-Imbalance is a significant stressor contributing to burnout (Kim et al., 2017). Furthermore, Williams et al. (2018) found burnout to fully mediate the relationship between Effort-Reward-Imbalance and withdrawal intentions in Australian university students. Siegrist (2012) explains that a mismatch of high efforts and low rewards is sometimes maintained due to three motives: strategic reasons (e.g., career promotion), no alternative choices in the labor market (for unskilled, semi-skilled, or elderly employees), or a high need for approval often exhibited by excessive work-related overcommitted individuals. Those people invest more effort than required even if there is little to no reward (Siegrist, 2012.).

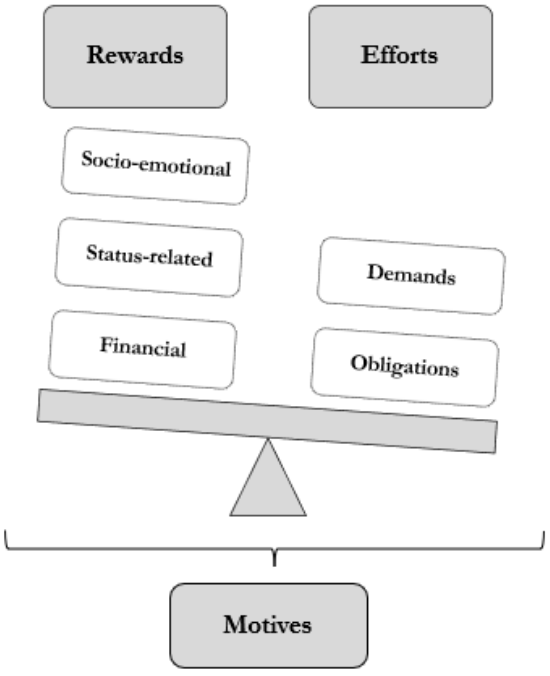

Figure 1. The Effort-Reward-Imbalance Model

In the long run, however, all three motives lead to higher levels of (emotional) exhaustion, fear, and depression as well as decreased recreation, sleep quality, job satisfaction, work performance, and

mental health status (Feuerhahn et al., 2012; Kinman, 2016). Therefore, we do not want to focus only on the efforts and rewards of doctoral students, but also on the motivational patterns of pursuing a PhD. Several motives have already been acknowledged, e.g., the quest for a personal/social achievement, an intellectual stimulation, the interest in professional/career development, or the interest in improving research skills (Leonard et al., 2005; Skakni, 2018). The motives may influence to what extent doctoral students control their PhD process (Grover, 2007). Personally and professionally motivated PhD students, for example, are more likely to persist in a doctoral program (Hoskins & Goldberg, 2005). Highly motivated individuals tend to be more committed (Georgellis et al., 2001) and engaged at work (Van Beek et al., 2012). This can also be understood as a health-adverse coping pattern in which employees feel obligated to work more than required by their employment contract (Montano & Peter, 2021; Siegrist, 1996). Therefore, our research also focuses on coping patterns that might moderate the perceived lack of reciprocity and health outcomes (Kim et al., 2017). Interestingly, coping patterns may not only buffer the negative effect of academic stressors on health outcomes, but also strengthen it. Schmidt and Hansson (2018) even consider that some coping strategies might have a dual function, such as the relationship with supervisors and the scholarly community. On the one hand, the relation could be part of a support system. On the other hand, it could be a stressor due to conflicts and high expectations. Therefore, it is important to analyze how PhD students perceive stress factors during their doctoral studies.

The Transactional Model of Stress and Coping

A common model to analyze how people perceive and cope with stress is the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984). This model shows that individuals master, tolerate, or reduce internal and external stress factors by evaluating the situation (primary cognitive appraisal) and assessing available coping resources (secondary cognitive appraisal). In general, there are two different coping mechanisms called problem-focused and emotion-focused coping (see Figure 2). According to these strategies, individuals either react on stress factors by managing and solving a problem actively or mitigate unpleasant situations by regulating their emotions and distress.

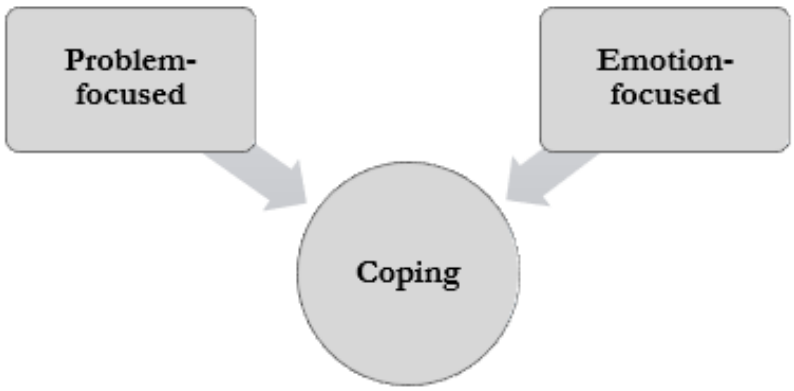

Figure 2. The Transactional Model of Stress and Coping

Both problem- and emotion-focused coping strategies have already been found in students pursuing a doctoral degree, e.g., (1) planning (Martinez et al., 2013) and receiving funding (McAlpine & Norton, 2006) as problem-focused coping strategies and (2) social support (Smith et al., 2006), activities with friends (Byers et al., 2014), doing exercise, crying, or isolating as emotion-focused coping (Martinez et al., 2013). It should be considered that some of the emotion-focused coping strategies can also be self-handicapping for PhD students (Kearns et al., 2008). Typical examples mentioned by the authors are behaviors, such as overcommitment, procrastination, or perfectionism. Therefore, it is important to investigate which coping strategies are commonly used among PhD students and to

identify those that lead to self-sabotaging behaviors. This could help to identify and take countermeasures against self-handicapping coping strategies that might moderate the lack of reciprocity between efforts and rewards. Lau (2019) stated that the model helped him to analyze his own stress reaction and self-handicapping coping strategies during his PhD. As the author only reported about his coping experiences, we want to broaden this view. We apply the Transactional Model of Stress and Coping by looking at coping strategies of a variety of PhD students.

THE CONCEPTUAL FRAMEWORK OF THE STUDY

This study aimed to apply the Effort-Reward-Imbalance model (Siegrist, 1996) and the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984) as theoretical frameworks to explore the perceived efforts, rewards, motives, and coping strategies of a sample of PhD students in Germany. By considering both the models, the study focuses on stress factors and motives of PhD students as well as on coping strategies. Figure 3 shows the most important elements of each model that we considered for our investigation.

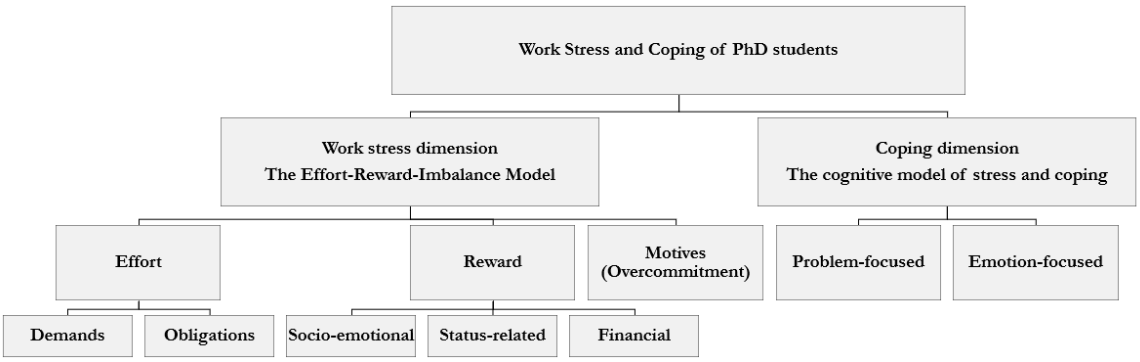

Figure 3. The conceptual framework of the current study

As there are only few studies that focus on university students (Hilger-Kolb et al., 2018; Hodge et al., 2019; Portoghese et al., 2019; Wege et al., 2017) or academic staff (Kinman, 2016) while using the Effort-Reward-Imbalance questionnaire, we decided to follow a qualitative approach. This offers the opportunity to gain an in-depth understanding of the circumstances of PhD students and to understand which elements of the models apply to PhD students. This allows us to be able to understand the relationship and consequences of efforts. Furthermore, the investigation can help to address illnesses by indicating a variety of practical implications and countermeasures against the increasing worldwide trend to leave academia. To address our study objectives, we proposed the following research questions:

1) Why do PhD students pursue a doctoral degree?
2) What efforts and rewards do PhD students perceive during their doctoral training in Germany?
3) How do PhD students cope with stress related to their doctoral education?

METHOD

The study presents analyses of qualitative data from semi-structured interviews with 21 PhD students from seven universities in Germany. Interviews were carried out from September to October 2021. The qualitative approach was chosen to gain explorative and deep insights into PhD students' efforts, rewards, motives, and approaches to cope with a potential mismatch between efforts and rewards. This allowed us to describe a complex social phenomenon from the perspective of the people affected (Malterud, 2011). Also Mayring's (2003) qualitative content analysis offers important features

for our research as it is a well-validated, systematic, and rule-based process. Compared to other content analysis it allows the examination of deeper, underlying latent context of a text (Cho & Lee, 2014). Furthermore, it offers the opportunity to combine deductive and inductive approaches, allowing one to consider theoretical models during conceptualization as well as to discover new themes emerging from the data (Cho & Lee, 2014.). Also, the method helps to focus on the relevant aspects of the research questions (Cho & Lee, 2014.). Therefore, we chose Mayring's qualitative content analysis.

PARTICIPANTS

Participants included PhD students pursuing a doctoral degree at German universities. To get a broad view about different efforts, rewards, motives, and coping strategies of PhD students we included male and female students from various fields of studies with different financial backgrounds (e.g., scholarship, employment at university or company) and stages into their PhD. Specific selection criteria were the enrollment as a doctoral student and the ability to speak either German or English.

To recruit the PhD students, we sent an email to different organizers of scientific colloquia from the two biggest universities in Bavaria, briefly informing them about our study and asking them to forward the participation request to their PhD students. The request included information about the study and the available interview appointments. Those who agreed to participate were invited for an online interview via Zoom. The objective of this sampling strategy was to recruit PhD students who represented a broad spectrum of experiences and perceptions (Malterud, 2011). Additional recruitment was conducted by snowball sampling, i.e., participants were verbally encouraged to forward the interview invitation to their friends and colleagues after the interview. This sampling method was used to increase the number of participants and to collect a broad dataset (Noy, 2008). Overall, 21 PhD students from seven different universities took part in our interviews. Data collection was completed following the principal of saturation, defined as the point where no new themes emerged (Kaiser & Hennink, 2020).

DATA COLLECTION

A semi-structured interview guideline was developed based on the theoretical framework of the Effort-Reward-Imbalance components: efforts, rewards, and motives (see Appendix A). As we also investigated how PhD students coped with stress, we added an interview section asking about coping strategies based on the Transactional Model of Stress and Coping. Further questions, such as warm-up and follow-up questions, were also asked during the interview. A pilot test of the interview guideline was carried out with two PhD students, who were distantly known to the interviewer. They did not have any insight in the research project before the interview. The criteria used to choose participants for inclusion in the pilot study were similar to those used for the sample selection. The pilot allowed us to make slight adjustments to the interview questions and their order. As we only made small adjustments and the first two interviews comprised relevant information, they were included in the analysis.

TRUSTWORTHINESS

To assess the rigor of this study, we followed the four standards of qualitative research, known as credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). Credibility was achieved through data, investigator, method, and theoretical triangulation (Korstjens & Moser, 2018). We made sure to gather our interview from PhD students with a variety of PhD settings (e.g., external students, scholarship holders, university students) and with different characteristics (e.g., PhD year, financing). Furthermore, the interviews were coded, analyzed, and interpreted individually by the first and second authors to acknowledge and reduce biases (credibility). After both authors coded the interviews separately, the authors discussed their coding schemes until they reached agreement. The first author updated the codes used in the interviews accordingly. Theoretical triangulation was

achieved by adding two theories into our conceptual framework. Transferability was established trough an in-depth description of the data (e.g., quotes, interview guide, study framework) that ensures that the findings can be transferred to other settings or groups. Additionally, the study implemented several elements that contribute to dependability (Miles & Huberman, 1994), for example, a study design with clear research questions and the specification of the theoretical constructs and analytical framework.

PROCEDURE

The interviews were mainly conducted in German. International PhD students (n = 2) were allowed to switch to English if necessary. The first author of this study pseudonymized and transcribed each interview. Furthermore, direct quotes used in this paper were back and forth translated into English by the first and second author of the study (Brislin et al., 1973). The last three authors of the paper knew the participants by only their initials. Before starting the interview, the interviewees gave written informed consent and had the chance to ask questions. An interview lasted for approximately 45 minutes, with the length of interviews ranging from 25 to 85 minutes. This was mainly caused due to the variation in richness of description by the interviewees. Interviews were recorded via video conferencing. During the interviews neither the participants nor the interviewer perceived technical issues, and all participants where familiar with using an online conferencing tool. As we did conduct the interviewees only online and not face-to-face it is not clear if rapport would have been different if face-to-face. Also, it is not clear, if the results would have been different if audio-only recording would have been used. However, we believe that the interview situation was quite natural to the interviewees, as they were used to the situation due to Covid-19. Short field notes were taken during and after the interviews.

DATA ANALYSIS

In the first step, the audio recordings were transcribed verbatim in German and subsequently anonymized to protect the participants' identity and ensure confidentiality. Secondly, the data analysis was carried out in a deductive-inductive process according to Mayring's (2003) qualitative content analysis by the first and second author. They started with one interview to test-code the established coding categories that were retrieved from the initial coding scheme (see Figure 4). Then the authors added new categories as new themes and sub-themes emerged from the analysis of different interviews. Disagreements on the sub-categories were thoroughly discussed until consensus was reached and the coding system was slightly revised. The discussions helped to reduce personal involvement and preconceptions on the interpretation of the results. Also the authors picked typical statements for each result section and translated them to English (Brislin et al., 1973). The software MAXQDA (2018) was used for the analysis. The final coding system can be found in the Appendix C.

RESULTS

Following the theoretical framework, the data was categorized into efforts, rewards, motives, and coping strategies. Further themes emerged during the data analysis. Figure 4 illustrates the main themes. The result section gives an overview of the main themes, including sub-themes, and are supported by illustrating quotations.

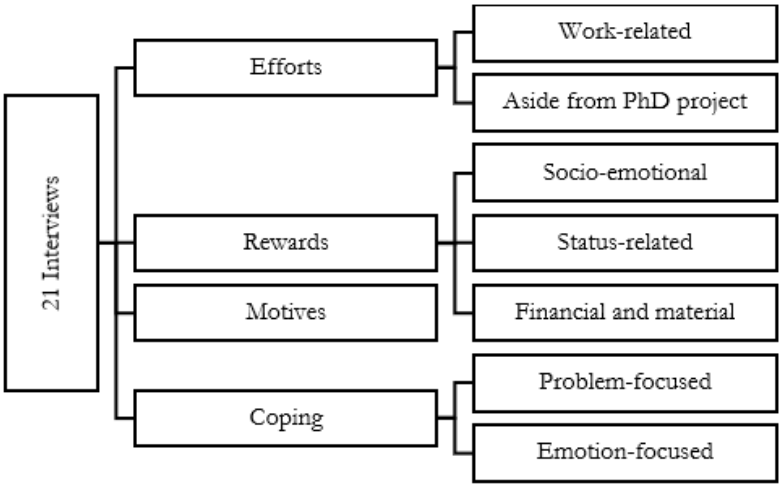

Figure 4. Main themes of the study

PARTICIPANT CHARACTERISTICS

Table 1 gives an overview of the socio-demographic characteristics of the participants.

Table 1. Socio-demographic characteristics of participants

Gender	female	14
	male	7
Age	25-29	15
	30-34	5
	> 35	1
PhD duration in years	< 1	5
	1	4
	2	5
	3	5
	4	2
Study field	Psychology	12
	Neuroscience	1
	Physics	2
	Law	1
	Management	2
	History	1
	Business Information	1
	Engineering	1
Main funding source	Job at university	7
	Scholarship	6
	Job at research organization	1
	Job at company (external PhD)	7

EFFORTS

Respondents named several efforts they made during their PhD. The major ones comprised work-related efforts that were caused by the nature or the scientific approach of the PhD project as well as efforts aside from the actual PhD project. The nature of a project describes the structure of the program. It includes typical characteristics of this process as well as its implication for the individual student (e.g., long-term project, mainly individual tasks). The second category includes all information about the scientific work methods of the PhD project and its effects on work stress of PhD students (e.g., topic research, method selection). Efforts aside from the PhD project comprise efforts that were not directly linked to the thesis and rather arose from the position as a PhD student, such as preparing lessons and teaching. All categories are described in detail in the following section.

Work-related efforts

While working on a PhD project, students made a variety of efforts. Some of these efforts were caused by the nature of the project. The project is often set up as a long-term project with little or no external structure nor exchange with colleagues and other PhD students. Students worked on their project for years until results became visible. This went along with psychological stress, such as feelings of social isolation, loneliness, and a lack of inspiration as well as motivation problems.

Due to little external structure (e.g., fixed working hours, regular holidays), some students had trouble with detaching from work, especially while working from home and with personal digital devices, such as laptops and phones. Furthermore, students struggled to structure their workday and project and feared that their time management was not realistic and that they would take longer than predicted to finish their PhD. This was especially stressful for students with fixed-term financial support and for those who just started their doctoral program. After directions were set, the uncertainty about the limited amount of time became less. Furthermore, PhD students mentioned uncertainty about the PhD process and their own performance and skills as well as their future job prospective (see Appendix B). Notably, the most common uncertainty mentioned was financial uncertainty. It was often connected to uncertainty about the future and job insecurity. Representative quotes on the work-related efforts due to the nature of the project can be found in Table 2 (left column).

Other efforts were caused by the scientific approach of the project, such as finding and narrowing down the topic, reviewing the literature, choosing a scientific method, writing, presenting, and publishing results (quotes from the interviews can be found in the right column of Table 2). The interviewees characterized the first elements of the scientific methodologies and technologies as typical tasks (e.g., reviewing literature), while the last steps were described as high stress factors (e.g., feedback and publication process). Especially the peer-review process was seen as time-consuming, straight forward, and sometimes even toxic. Regarding the feedback of supervisors, the interviewees often had to wait long periods and struggled to incorporate the feedback of professors as the expectations were too high, too far away from the project, or ambivalent. It was also reported that some professors did not have any time for questions or giving feedback. Both waiting for a long-time or not receiving any feedback caused stress. Besides, we recognized a general unclearness about the supervisory relationship by PhD students who just started their PhD training.

Table 2. Sample quotations about work-related efforts

Nature of the project	Scientific approach of the project
"Even if you have a team, somehow you work for yourself. So, at the end of the day, you sit alone in front of your laptop and write a paper. Of course, you can exchange ideas about it, but at the end of the day you are a lone fighter."	*"What I thought was exhausting and stressful is the specific topic search, with the specific content and theories. I had imagined it to be easier."*
"The truth is that I sometimes still have problems structuring myself because it depends 100% on myself. There is very little external structure that arises, for example by meetings or teamwork that give a certain structure."	*"I perceived the beginning most stressful, so the first 3-4 months because there was no clear and specific topic … getting an overview is not that easy."*
"The PhD does not produce daily results …., so there are definitely days where you ask yourself at the end of the day: `Man, what did I actually do today?' You have nothing tangible and presentable, although you may have invested time all day. An instant gratification does not take place, so you may have to lay out your motivation strategies in a less output-oriented manner."	*"And then … there is a certain pressure in science to publish with a very high-ranking …, but the whole review process takes time, sometimes months. I find that really exhausting."*
	"This whole academic culture is rather toxic, compared to corporate cultures I know. So, the feedback in peer review journals is not friendly, very direct, and perhaps somehow toxic … most of the time it has hardly anything to do with the quality of your work, but the general academic culture has been shaped that way."

Efforts aside from the PhD project

Almost every interviewee named non-work-related and work-related responsibilities besides working on their thesis. On a non-work-related level, stress was mainly caused by social obligations, finding time for leisure activities, household responsibilities, and dealing with a relocation. On a work-related level, all students had to actively engage in networking (e.g., looking for a project partner, attending conferences) or handle it in the background of their PhD project (e.g., career planning). All other work-related responsibilities that caused stress and limited the time available for the actual PhD thesis varied between different PhD students, e.g., PhD students working at the university vs. PhD students working in the industry.

PhD students who worked at the university described tasks that were not directly related to their own PhD project as further efforts. Interviewees mentioned that it was expected of them to give feedback to colleagues or to collaborate on papers. Supervising undergraduate and master theses or teaching was also part of their obligations. While some of our interviewees described teaching as a further time-consuming task with low rewards, others associated teaching with fun and a high personal value. Furthermore, some students were required to participate in different extracurricular formats, e.g., research colloquium, paper club, and lectures of graduate schools (see Table 3, left column, for representative quotes).

PhD students receiving a scholarship named the application process, the interim reports, and the attendance of seminars as main efforts outside of their PhD project. While writing a report on the progress of the PhD project was mandatory, the attendance of social and educational events was voluntary. Still, PhD students felt obligated to attend events and seminars of the scholarship holder. Besides those obligations, volunteer work and own projects increased the workload. Students who worked at the university in addition to their scholarship further faced the efforts mentioned above. Table 3 (middle column) gives example of non-thesis related efforts from students holding scholarships.

External PhD students who worked in part-time jobs outside of academia faced difficulties balancing the time between the PhD project, job-related work, and switching off properly during leisure times. Furthermore, some of the PhD students struggled with networking and exchanging experiences with their fellow PhD students because they had little to no contact with their institute. If the doctoral degree was pursued during a sabbatical, further barriers such as staying in contact with colleagues or the pressure to finish the PhD project in the given and funded time were added to the efforts of working on the thesis (see Table 3, right column).

Table 3. Sample quotations about the mentioned work efforts besides the PhD project

University PhD students	Scholarship holders	External PhD students
"In the first semester I spent one of five working days a week correcting homework, preparing seminars, and giving group exercises. That takes up a lot of time." *"There are also formats at our department … that I find very exciting, but they create additional work. For example, we have a paper club were we regularly read and discuss papers. That does not necessarily have anything to do with my own dissertation."*	*"Applying for the scholarship was an enormous amount of work …, but it has paid off in the long run."* *"One further obligation … is to write a detailed report on my work … once a year. It doesn't take up much of my work, of course, but it was only due a few weeks ago, so I'm thinking about it."* *"I have started my own project at the foundation, which of course costs quite time and to a certain extent it is also an obligation, that I have chosen myself. … It clearly takes time off the thesis, but I can live with it."*	*"In order to be able to earn a little extra living, I work for a company once a week. That means that there is an obligation outside of my PhD project … and then you have other obligations, such as maintaining contact with other employees, so that you are still connected to the company."* *"I don't have a great network in the institute because I'm not part of a project or employed at the university. That was my personal decision, but as a result, I have a smaller network, which is required when it comes to career planning."*

REWARDS

In accordance with the Effort-Reward-Imbalance model, we focused on status-related, socio-emotional, and financial rewards in our interview questions (see Figure 4). Findings are reported below.

Socio-emotional rewards

Participants distinguished between personal and professional environments when asked about socio-emotional rewards. On a personal level, PhD students with an academic family background reported that their family perceived their PhD as a "normal" career path. Most of them received a lot of emotional support and appreciation from their family and friends. Some students were supported by other PhD students or scientists from similar research fields in their personal environment. PhD students without an academic background reported different reactions. Some received high respect and appreciation for pursuing a PhD degree while others had to deal with critical questions, such as "When are you going to start a real job?" They also reported that some family members struggled to understand the characteristics of a PhD degree. Independent of their family background, PhD students wished for the support of their families. They expressed that they were not only looking for interest, but also encouragement and emotional support whenever they faced conflicts, tensions, or doubts during their PhD. Table 4 shows sample statements of how a PhD degree is perceived by family and friends from different educational backgrounds.

Table 4. Sample quotations of socio-emotional rewards

Academic background	Non-academic background
"Most of my friends are also PhD students, so they know how it works and so on. So there is appreciation, but not too little or too much." *"I don't think it's very special that I am doing a PhD … because my family has done it as well."*	*"The appreciation from my family is very abstract. They don't have any idea what studying and doing a PhD means, but on an abstract level they are very proud because they know that it is something great."* *"My family was really happy when I told them about my PhD plans. They started to call me doctor and I was like 'Folks, stop it, I'm not a doctor, I don't want to be called like that'. So, they show me high respect."*

On a professional level, PhD students received support from supervisors, colleagues, and other PhD students at different occasions, such as group seminars, colloquia, or (team) meetings. PhD students described the exchange with other doctoral students as very open, collaborative, productive, or supportive. The PhD candidates often had similar feelings, experiences, and problems. During the exchange, they got new insights, ideas, created problem-solving strategies, and felt connected to each other.

Furthermore, the socio-emotional reward from supervisors had a great influence on the PhD students. The feedback from supervisors was often described as extremely valuable, helpful, and encouraging. One person even implied that the positive feedback would impact their performance. Feedback from postdoc supervisors was often described as work-related, very precise, and helpful to answer specific questions. It also provided guidelines and helped to prioritize tasks. Professors rather gave feedback on a meta-level (see Table 5). Some PhD students mentioned that they were surprised how positive the feedback from their supervisors was, especially if things did not go well or when they would have judged their own work worse. Moreover, some PhD students who reported getting regular feedback described themselves as lucky because they had the feeling that their peers got less feedback and appreciation. Other interviewees, however, assumed that all PhD students receive equal feedback independent of their workload or PhD setting (e.g., internal or external).

Besides the recognition of their own work by supervisors, interviewees also appreciated the recognition during the publishing process – especially those who received little to no feedback from their supervisors. The reviews encouraged some of the participants and helped them to get new insights into their topic. Nevertheless, there were also critical voices about the long-time span from writing the paper until it was published. The recognition itself was also criticized as it is non-materialistic (e.g., verbal or in the form of quotations) instead of a salary increase.

Another reward, that was often mentioned, was freedom throughout the PhD. The interviewees referred to different types of freedom: (financial) freedom due to a scholarship, freedom in time management and workplaces, freedom to do own projects and to decide what to work on. The latter, however, was also a perceived as a stressor because participants missed guidance and had trouble motivating themselves.

Additionally, PhD students with a scholarship mentioned the non-material support offered by their scholarship as a socio-emotional reward. They felt like scholarship events (e.g., seminars, weekend getaways, meetings with tutors) helped them to build up new motivation, get new insights, and broaden their views. Table 5 summarizes sample quotes of socio-emotional rewards from the professional environment.

Table 5. Sample quotations of socio-emotional rewards on a professional level

PhD students	Supervisors	Scholarship holders
"It is also helpful if you talk to other PhD students about how you are doing. Everyone can for example relate if you had to throw everything over again … and that's kind of supportive when you know: 'Ok, I'm not the only one who is desperate about it and better times will come again'."	*"My supervisor always adds interesting ideas. He always sees the bigger picture and puts my work into a larger framework. He also tries to elaborate the practical relevance. … It is therefore a good addition to the feedback from my postdoc supervisor. He gives me feedback on a more specific level."*	*"Umm then, of course, from the scholarship holder financially and ideally, which also makes a big difference."*
"I would say the most valuable thing is the exchange between the doctoral students. We have such an open, collaborative and productive relationship with one another … You would need a lot more time if you had to make every mistake by yourself, whereas now, we have a few people who have a lot of experience. It often happens that others have already had the problem. … That is definitely very valuable."	*"I really have the feeling that I am supported and that they also push me. … I also see my supervisor as a role model and have the feeling … that I am actually being addressed individually."*	*"So financially, of course, through my scholarship holder, but also ideally. It is part of the scholarship to support their students with seminars. They were incredibly enriching. … You get fresh input, which has nothing to do with your topic. … Then you go back to your dissertation and say 'Hey, I had such an enriching and cool weekend, now I'm back to deal with my dissertation."*

Status-related rewards

The Effort-Reward-Imbalance model states that status-related rewards can be divided into three different sub-categories: job security, career promotion, and professional development opportunities (Siegrist, 1996). Following this approach, we analyzed our interviews.

Participants had different opinions about the job security at the university. Some criticized the system heavily as many postdoc positions only offered fixed-term contracts. They stated that career paths are very strict and positions are rare due to the great difference between vacancies and demand. This uncertainty and the necessity of mobility were perceived as burdensome, especially regarding starting a family and staying in touch with the personal environment. Others worried less about job security, although they acknowledged that the situation was leaving something to be desired. Yet when professorship or a permanent contract was reached, the interviewees rated the job security as quite good (see Table 6, left column).

Opportunities for career promotion were described as not adequate, slow, complicated, difficult, very limited, rather bad, or awful, especially if participants related to a professorship or compared the career promotion opportunities with the industry. Most of them saw better career opportunities outside of academia and were less attracted by the career track at the university due to different reasons. For example, the interviewees were unsatisfied with the temporary employment, the academic fixed-time contract act, scarce funds, and the mobility required in academia. They argued that those conditions would lead to uncertainty, pressure, and competition between researchers. One participant even felt that the uncertain job and financial situation robs their energy. Overall, most of the participants asked for a change in terms of job security and career promotion at German universities. They refereed to how other countries handle the job security of academic employees. Table 6 (middle column) contains quotes regarding career promotion.

The professional development opportunities were described from unsatisfactory to quite good. Most of the participants mentioned that they learned a lot during their PhD, including personal and professional skills (see Table 6, right column). Especially working in an interdisciplinary environment, attending conferences and seminars, and the variety of PhD tasks were mentioned as development opportunities, although they were also recognized as additional burdens.

Table 6. Sample quotations for status-related reward

Job security	Career promotion	Development opportunities
"I know that oftentimes, one gets fixed-term or part-time contracts. So, I'd say that if one wants to do research … there isn't a lot of appreciation, regarding job security or career promotion." *"It's a requirement to be extremely flexible in terms of location that is not compatible if I, as a woman, for example, want to have a child because then, you are not that flexible."*	*"I do not think that the career opportunities are good or adequate."* *"There are opportunities for career promotion, but they are actually rather bad."* *"I find the career opportunities very slow and complicated."* *"The opportunities for career promotion are awful. … The pyramid is very narrow. As soon as you have a certain residence preference, a professor has to retire before you can get it."*	*"I see a few development opportunities by attending courses during the PhD and being able to attend interdisciplinary courses. And I also think that the conferences … are opportunities for personal development, not only regarding your research project, but also when it comes to presenting yourself, your own content. …. I see all that as great development opportunities."*

Financial and material rewards

Many interviewees stated that their wage was not enough, dissatisfying, or not fair compared to jobs outside of academia and in relation to their workload. Furthermore, PhD students criticized that they cannot make any savings with their salary.

The interviewees mentioned that they were conscious about the low salary before starting a PhD and accepted it for different reasons. They said that they were used to it due to their student life before starting their PhD (e.g., lifestyle, rent, shared apartments). Some even mentioned that they started their PhD right after their master's degree because they thought it would be easier to keep the same lifestyle instead of lowering it again after a few years of working in the free economy. PhD students who stopped working in private enterprises to do their PhD mentioned that they had to get used to the decrease in salary but were ok with the situation. Albeit not being as high as in private enterprises, they argued that the wage was high enough to afford a living. Furthermore, one interviewee stated that they valued their passion more than a high salary.

Also, we identified three groups who were quite satisfied with their financial situation: PhD students with a scholarship, a third-party project, or with financial support from their company (e.g., sabbatical with the same salary).

Aside from the financial reward, we also asked the participants how satisfied they were with the material rewards. Most of the interviewees stated that they were quite satisfied. They were sufficiently provided with software and hardware, had access to offices, printers, program licenses, and, in some cases, a budget to compensate research participants. A few participants mentioned room for improvement, e.g., the allocation of work laptops, next-generation laptops, height-adjustable desks, or the access to charged software programs. Representative quotes for both financial and material reward can be found in Table 7 respectively.

Table 7. Sample quotations for financial and material rewards

Financial rewards	Material rewards
"As I said, I have a 75% job at the university. Of course it's not fair in terms of working hours and stress, but I knew before that it was unfair. I had a different motivation for these 3-4 years. You can live with the salary, but you can't save or have a luxury life with it." *"The problem is my salary. It's not that good compared to the free economy, but for me passion is more important than money."* *"But as I said, you don't do a PhD for material reasons, but for ideal reasons. This is a decision that everyone has made for themselves, so one can argue that it is still justified during the PhD. Later I think it's clearly a difficult topic."*	*"I am happy with the environment I have. I will get the software I need for my research or access to computer rooms for experiments and trials. It's okay. Everything else is just my personal equipment, which is okay, but not perfectly designed for a PhD. That means, I just take what I have instead of buying something extra."* *"There are still work laptops to come. I think that is important because it helps you to switch off. … I have an office that is somehow central, that's great and good. I also think that university offices should be equipped with large standing tables because that simply contributes to health, and I think that should be standard now."*

Effort-Reward-Imbalance

When asked about how they would describe their ratio of efforts and rewards during their PhD, more than half of the participants stated that they did not feel properly rewarded for their efforts compared to other PhD students. Most of them felt like the socio-emotional reward and financial reward could be improved. The latter was mostly related to a PhD position at the university with a low salary. Also, interviewees felt like their performance was not adequately rewarded from their personal and professional environment. Further factors creating an imbalance of high efforts and low rewards were the review process and the status-related rewards at the university.

Motivational Patterns for Gaining a PhD Degree

The interviews revealed different motives for why an Effort-Reward Imbalance in the form of high efforts and low rewards would be maintained. The doctoral students mentioned that they were quite aware that a PhD does not lead to instant gratification and that extrinsic motivation decreased during the process. They rather focused on less output-oriented as well as intrinsic and long-term goals, such as the contribution to research by aggregating tangible results, which can be used by other scientists in the future. To reach this goal, some interviewees wanted to become experts in their fields of research. For others the improvement of their own skills and further education was more important than academic success. They enjoyed research and appreciated that they got paid to work on a project that met their personal interests. Furthermore, interviewees valued the flexibility and freedom offered during a PhD, e.g., in form of flexible work schedules. This was especially highly valued by PhD students who had worked in private enterprises before. At the same time, the flexibility also triggered unhealthy work habits, such as working to an unhealthy extent or putting too much pressure on themselves.

Coping Strategies of PhD Students

When designing the study, it was important for us not only to have a look at the efforts, rewards, and motives, but also at coping patterns. As mentioned above, PhD students put in a lot of effort. Especially high workload drained their energy. Therefore, we asked participants how they switched off

and recharged their batteries. We could identify different strategies and classified them into problem-focused and emotion-focused strategies.

Problem-focused coping strategies

Concerning the PhD project there were several problem-focused strategies mentioned. To handle the workload and keep a healthy work-life balance, many PhD students tried to structure their workday and take active breaks. They used different strategies such as working with To-Do Lists, time blocks and breaks (e.g., Pomodoro technique) or orientating their work tasks on their productivity curve. Some even had strategies to make sure that they stopped working by setting an alarm clock or arranging dinner plans. To switch off after work, students also liked to set boundaries, for example, by actively discussing their working hours with their colleagues or setting daily work limits. Some also deleted messenger services and email programs from their personal devices to limit their reachability. In addition, many of the interviewees liked to seek information and assistance from other PhD students. They used formal and informal meetings as well as lunch breaks to discuss problems or exchange views related to their PhD. Often the meetings created new insights on how to deal with specific problems. Additionally, students recognized that others were feeling the same way, which is also an emotion-focused coping strategy. Quotes from the interviews for all three types of problem-focused coping strategies can be found in Table 8.

Table 8. Sample quotations for problem-focused coping strategies

Work routines	Setting limits	Social exchange
"I plan my day with blocks and breaks. … I know that I am most productive in the morning, so I do the more demanding tasks that I think require a higher cognitive performance in the morning and then around noon when I have the feeling that my productivity is decreasing, I tend to do things like answering emails … or organizational stuff." *"I try to divide my days into different categories and work according to them. So for example, I have a couple of hours where I focus on reading papers and others where I focus on writing."*	*"So, for me it is very important that I do not read work emails in the evening and on the weekend because when I read them, I start thinking about work. That means deleting [the e-mail program] from my phone was the most important step for me."* *"With time, I've noticed that you cannot please everyone and that you cannot deliver top quality in all areas, that does not work and look at yourself and ask 'Ok, where do I want to give 100% and where is it enough to do a bit.'. I rather ask myself where I want to give 100% and where it is enough if I do less."*	*"[W]e founded a kind of self-help group with four doctoral candidates in which we regularly meet virtually and talk about how the last few weeks have been, what we have struggled with, what the problems are. I was able to develop an openness that I hadn't experienced in science before. That was really mind-blowing."*

Emotion-focused coping strategies

There were several emotion-focused strategies mentioned in the interviews (see Table 9 for an overview of quotations from the interviews). Almost every interviewee liked to engage in leisure activities to switch off from work, especially physical activities or by spending time with family and friends. PhD students also referred to calm and creative activities, such as reading, meditating, knitting, or playing the piano. Some also liked to switch off from work by consuming media, for instance, by listening to music, playing video games, or watching TV. One of the interviewees even liked to combine watching TV with a self-care routine, e.g., by painting her nails. Further self-care routines were related to sleeping strategies, such as sleeping in. Another emotion-focused coping strategy was to get distance from work during the weekend and taking active breaks or going on vacation. Furthermore,

PhD students liked to cope with stress by actively motivating themselves, especially in tough times (e.g., by asking themselves why they started their PhD). In addition, we could also identify less effective strategies, such as keeping busy with other projects or doing household work. Interestingly, some PhD students seemed to be aware that those coping strategies only offered short-term solutions to their problems. For example, one external PhD student stated that keeping busy with projects from her company is probably not refueling her energy.

Table 9. Sample quotations for emotion-focused coping strategies

Engaging in leisure activities	Distance from work	Less effective strategies
"Hmm, I really like going out, so I go for walks and that helps me to switch off completely and at the same time when I switch off, the best ideas for any problems come up." *"Then definitely sport, it gives me an incredible amount of energy and also lets me switch off. So, I really enjoy swimming, running and doing yoga and, umm, that's when I very rarely think about the doctorate.* *"Meditating, not that long, but that always gets me out quite well. Going for a walk always gets me out as well. Also doing sports or simply distraction, i.e. meeting friends, making music."*	*"When I get out on Friday, I try to stop working and not to work at the weekend … and that works quite well."* *"I then decided for myself, for example 'I have a weekend' and quite rigorously so, 'weekend is weekend. I don't work then'. I don't think about the dissertation then and the dissertation does not exist."* *"It helped me to say 'I have this free time and I will not let it be taken away from me … because that is my time where I have free time where I can pursue my hobbies'. Similarly, I say 'I stop working at 6 p. m', and the evenings belong to my friends, me, and my hobbies and work does not belong there."*	*"I work [on projects of my company], but that's not always refueling energy. So when I work and do things that probably aren't cognitively demanding, then I can switch off quite well."* *"There is a lot of things to do, such as cleaning at home* [laughs] *or I like to do my nails or to watch TV, but the problem with watching TV is that you sometimes cannot stop."*

DISCUSSION

The study provided unique insights into the perceived efforts, rewards, motives, and coping strategies of PhD students in Germany by using a qualitative research approach and renowned stress models. Following the theoretical framework of the Effort-Reward-Imbalance model (Siegrist, 1996) and the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984), we created a comprehensive coding system. To adapt the model to the PhD context we expanded the system by several sub-categories (see Appendix C).

We identified crucial efforts caused by the PhD project and efforts in addition to the project. On a work-related level, most PhD students struggled with the nature of the project (e.g., long-term project, little teamwork), which evoked feelings of isolation and uncertainty, lack of inspiration, problems of motivation, and detachment from work. Some interviewees also mentioned that they struggled with the scientific approach, especially with the feedback process by reviewers and supervisors. Common efforts aside from the PhD project were social obligations as well as work-related efforts in addition to the actual PhD project. Those efforts were also commonly stated in other studies (Mackie & Bates, 2019; Schmidt & Hansson, 2018; Tomasz & Denicolo, 2013).

While looking at the rewards, we focused on status-related, socio-emotional, and financial rewards. For socio-emotional rewards, we could identify rewards on a personal and professional level, such as

appreciation from family, encouragement, and emotional support from family, friends, other PhD students, supervisors, and colleagues, or scholarships. Status-related rewards were divided into the subcategories job security, career promotion, and professional development opportunities. It became quite clear that a lot of the interviewees saw the university system as burdensome, especially regarding the academic fix-term contract act and the requirement of mobility. Compared to work in the private sector, the university system was less attractive, especially regarding career promotion opportunities as well as the financial rewards offered by the university. The mismatch between workload and wage was often criticized particularly by students working at the university.

Additionally, our study identified five different motives for gaining a PhD degree: (1) an intrinsic motivation, (2) an interest in improving one's skills, (3) becoming an expert, (4) contribution to research, and (5) the flexibility and freedom offered by a PhD degree. Compared to the theoretical framework of the Effort-Reward-Imbalance model, the motive for doing a PhD due to career promotion opportunities was not explicitly stated by the interviewees. Those students who mentioned career promotion opportunities explained that the interest in the title got less important for them during their PhD process while their intrinsic motives became stronger. Some interviewees even expressed explicitly that an intrinsic motivation is necessary for gaining a PhD degree. Interestingly, all interviewees explicitly used the word "intrinsic". This might be because many interviewees were striving for a PhD degree in Psychology. Therefore, we believe that most of our interviewees related to the common definition of intrinsic motivation from Ryan and Deci (2000, p. 56), which defines intrinsic motivation "as the doing of an activity for its inherent satisfactions rather than for some separable consequence. When intrinsically motivated a person is moved to act for the fun or challenge entailed rather than because of external prods, pressures, or rewards." This assumption is backed up by interview statements that expressed that PhD students gained a PhD out of fun, joy, and personal interest. Prior studies showed the consequences of intrinsically motivated PhD students; for example, they were more likely to persist in a doctoral program (Hoskins & Goldberg, 2005).

In addition to the investigation of efforts, rewards, and motives, the study took into consideration how PhD students cope with stress. We could identify three different problem-focused and five different emotion-focused coping strategies. Most commonly, PhD students coped with stress by being physically active, meeting friends, having work routines, or seeking assistance from other PhD students. In line with Schmidt and Hansson (2018), we believe that some coping strategies might have a dual function as stressors and coping opportunities, such as spending time with family and friends. On the one hand, interviewees felt pressured to find time for free time activities. On the other hand, they actively planned and engaged with their personal environment to switch off. The dual function caused by obligations in childcare were not reported in our interviews – probably because of the low number of participants with children. This should be taken into consideration while interpreting the results, especially as other studies already showed that PhD students struggled to juggle between work and family (Wasburn-Moses, 2008). This might cause feelings of guilt, worry, and anxiety (Smith et al., 2006). Therefore, some coping strategies should also be considered as being part of the effort category of the Effort-Reward-Imbalance Model.

Comparison of Findings to Literature

In this section, we discuss the findings of our study by comparing them to the prior literature. Firstly, we focus on the efforts that PhD students reported in our study and relate them to prior studies. During our study, we could see obvious parallels to other studies that reported PhD project related efforts, such as feelings of isolation (Grady et al., 2014; Tomasz & Denicolo, 2013), uncertainty (El-Ghoroury et al., 2012; Lau & Pretorius, 2019), as well as efforts aside from the PhD project, e.g., teaching. Interestingly, many studies focused in great detail on the specific effort categories of the relationship with the supervisor or the feedback process (Ives & Rowley, 2005). Our study, however, intended to get a broad picture about all efforts that could affect work stress of PhD students. This has two major advantages. Firstly, the efforts that have been investigated can be connected to each

other (e.g., work-related and non-work-related efforts) and secondly, they give a variety of implications on how to improve the work situation of PhD students in several different aspects (e.g., behavior of supervisors, postdoc, family). According to Volkert et al. (2017) the main obstacle for leaving academia is having an unsupportive personal environment as well as a difficult supervisor relationship. Both issues have also been clearly raised by our interviewees. PhD students with a non-academic family background often reported about family members who struggled to understand the sense of a PhD and were less supportive. Besides, our students reported about obstacles caused by a burdensome supervisor relationship.

Furthermore, our study shed a different light on the socio-emotional, status-related, and financial rewards. While especially the financial situation of PhD students is often described as miserable (Chen, 2021; Hunter & Devine, 2016), our study implies that the perceived situation differs between different types of PhD. Whereas the financial situation of PhD students working at the university is perceived as unsatisfying, external PhD students often do not have a problem with their financial situation and future prospective as they are supported by a company and will go back to their company after finishing their doctoral degree. Including different types of PhDs and rewards, we gained a broad picture of the perceived rewards that could influence work stress of PhD students instead of looking at single aspects, such as the reward from family members (Breitenbach et al., 2019) or supervisors (Ives & Rowley, 2005).

Our interview also investigated motivational patterns for doing a PhD degree and clearly showed that most of the motives were of intrinsic nature. For example, PhD students wanted to become experts in their field of study, improve their own skills, and honored the flexibility and freedom offered by a PhD degree. This is similar to the results from Morton and Thornley (2001) and Leonard et al. (2005), who showed that students gained a PhD degree out of interest in the subject, one's own development, and improvement of research skills. However, previous studies also showed a variety of other motives, such as career success and social justice (Pretorius & Macaulay, 2021) or the encouragement of family and friends or lectures (Guerin, 2015). This could be explained by the group of PhD students we mainly interviewed. As the study by Tarvid (2014) shows, the motivation can vary between different fields of study by exploring three different groups of PhD students. The author reported that Group 2, which mainly consisted of natural science students, showed a much stronger labor market orientation than Group 1, which included psychology students. Therefore, it should be taken into consideration that our study might not show all motives of PhD students to pursue a doctoral degree. Also, it must be taken into account that motives vary by internal and external factors, e.g., age, interest, personal goals, family support, or fit with supervisor (Sverdlik et al., 2018).

Furthermore, we asked our interviewees how they cope with stress and divided their answers into problem- and emotion-focused coping strategies. In accordance with past findings, our interviewees used common coping strategies, e.g., work routines and engagement in leisure activities, being physically active, or spending time with family and friends (Byers et al., 2014; Martinez et al., 2013; Smith et al., 2006). We also found hints for self-handicapping coping strategies. However, these results were rather superficial, while other studies have explored them in more detail. They describe, for example, busyness, perfectionism, procrastination, regular changes of the thesis topic, or avoiding communication as self-handicapping coping strategies (Ahern & Manathunga, 2004; Kearns et al., 2008).

Strengths and Limitations

There are considerable strengths in this study. Our sample consisted of heterogeneous participants (e.g., in terms of age, gender, fields of study, employment types, and PhD duration). Thereby, we were able to capture different perspectives on efforts and rewards in the academic field as well as different strategies to cope with them. We used a purposeful strategy to analyze the data (Mayring, 2003) and rich descriptions to improve the transparency and trustworthiness of our results (van Nes et al., 2010). Furthermore, we based our results on theoretical frameworks and evidence from prior

studies (Malterud, 2011). However, the unique contribution of the study is that we focused on work stress of PhD students by implementing the effort-reward-imbalance model and combining it with the Transactional Model of Stress and Coping. To the knowledge of the authors, this has not been done before.

Also, some limitations should be considered when interpreting the findings of this study. In our study, we identified that the participants' understanding of "efforts" and "rewards" varied. Several of the interviewees asked if we could further define both categories. Also, most participants initially reported financial rewards. Material rewards were only addressed after follow-up questions were asked. It might be possible that the material rewards (e.g., software and hardware, program licenses) were less important to PhD students or that the word "material" led to confusion, as some of our interviewees requested examples. During the coding process, we were also questioning if the terms of the Effort-Reward-Imbalance model require a general adjustment as some terms led to confusion and did not perfectly match the context. For example, it was quite unclear how to differentiate best between a high intrinsic motivation and overcommitment. We, therefore, recommend setting definitions of the categories based on theoretical models before starting the analyzation process.

Also, the findings are not representative of PhD students in general due to the chosen sampling method and a variety of other factors. By using qualitative research methods and non-probability sampling, the results cannot be generalized. In our sample, most PhD students pursued a degree in Psychology at the two biggest universities in Bavaria, while other research subjects and universities were only represented by one individual. Similarly, the number of participants of different funding types varied. While the number of PhD students working at the university, having a scholarship, or gaining a PhD externally were balanced, only one PhD student at a non-university research organization took part in our study. As we based our interview guide on established theoretical models, we might have missed a bigger variety of perceived efforts and rewards. It is further important to mention that the interviews varied greatly in richness of detail, which is also mirrored in the time range of the interviews. This could be influenced by the satisfaction with the PhD program (e.g., PhD students who were unhappy with the situation mentioned more challenges). Also, it should be considered that we only investigated the perspective of the PhD students while looking at efforts, rewards, motives, and coping strategies. Perspectives of the supervisor, colleagues, family, and friends are missing. This is due to the fact that the Effort-Reward-Imbalance model is focusing on the individual and its perceived stress factors. Therefore, future research should compare perspectives of both PhD students and their social environment.

As the participation in the interviews was voluntary, participation out of interest or discontent with the prevalent university system might have biased the results. Furthermore, it is difficult to compare the data with findings from past decades and other countries due to altered student profiles and changes in the conceptualization of doing a PhD (Acker & Haque, 2014). The temporal context of the study period should also be noted: the interviews were conducted during the COVID-19 pandemic, which might have affected the perception of efforts and rewards (e.g., home office, virtual lectures, social distancing).

Theoretical and Practical Implications

The results of our study provide insights into numerous types of efforts, rewards, motives, and coping strategies of PhD students and allow us to draw several theoretical and practical conclusions. In terms of research-related implications, we ask for more qualitative as well as quantitative methods. This allows us to follow the approach from Hoskins and Goldberg (2005) and Wao and Onwuegbuzie (2011) to explore the PhD population with more qualitative methods and offers, on the other hand, the opportunity to generalize and quantify our results with a higher sample size. Especially in a context in which established models have not been applied before, qualitative approaches offer great possibilities to gain first insights into what degree these models apply in these contexts. Subsequently, the results can be generalized and quantified with a higher sample size using qualitative

measures. We also invite other researchers to look at different PhD settings instead of focusing on PhD students at the university because we noticed that efforts and rewards strongly varied between different PhD settings (e.g., external PhD, graduate school PhD, working at the university, or scholarship holders).

Practical implications can also be derived from our insights on coping strategies in combination with efforts such as "being constantly available". PhD students should be informed at the beginning about the requirements of a PhD to lessen the burdens and to teach them how to handle different stress factors. Doing so, they could get important hints about job crafting skills that are necessary to handle potential mismatches between efforts and rewards and prevent negative health outcomes (Creed et al., 2020).

Accordingly, we recommend including the results of this study into a concept for PhD-themed kick-off events or mentoring programs that accompany and support the PhD students from the beginning and help to overcome obstacles. Also, workshops should be integrated into the PhD journey. Firstly, effective coping strategies can be developed (e.g., recovery and emotion regulation trainings) and, secondly, workshops can specifically act as countermeasures against the reported efforts. The PhD students reported, for example, about work-related efforts, such as problems with time and project management as well as with the scientific approach of the project. These efforts could be tackled by offering workshops on working techniques (e.g., time management, project management) or improvement of scientific skills (e.g., statistical methods, academic writing, and publishing). Furthermore, mindfulness workshops should be taken into consideration (e.g., mediation, stress management, strategies to detach from work) as well as networking workshops that help students to connect and exchange their experiences. Importantly, the exchange with advanced PhD students seemed to be highly valued by our interviewees. Therefore, we suggest a peer-to-peer mentoring program. During our discussions, we also thought about an exchange platform where different disciplines and less and more experienced PhD students can exchange their experiences, tips, or ask for input. This could also influence the socio-emotional rewards and the "networking" effort, which was not directly related to the PhD project but often reported as an effort in addition to the PhD by our interviewees.

Besides, it is highly relevant to inform the organizational level (and especially the supervisors) how they can incorporate the findings into the university system, as they are mostly responsible for offering PhD workshops, improving PhD programs, and helping to create a good "leadership" culture. Supervisors should be informed about the efforts, rewards, motives, and coping strategies of PhD students, e.g., via workshops and newsletters. This information can be helpful for them to further support their students. In addition to introducing coping strategies to their PhD students, the responsible university staff should also be aware of how their own behavior influences the work stress of PhD students. For example, supervisors should acknowledge that the amount of pressure and workload they put on their PhD might influence negative health outcomes. By learning about the Effort-Reward-Imbalance model, they could achieve a better fit between the PhD student and the project by setting clear goals and expectations in accordance with their PhD candidates. Additionally, considering the rewards system, supervisors should learn how to show their appreciation and support on an emotional level (e.g., how to give feedback) and also on a financial level (e.g., financing participation in a conference). This would show their students that they are willing to offer opportunities for career development that might act as a countermeasure against the increasing worldwide trend of doctoral graduates leaving academia.

In future studies, effects of different coping strategies should be explored. So far, it is quite unclear which strategy has the greatest impact on the Effort-Reward-Imbalance in PhD students. The efforts and rewards are likely to be part of a complex interplay of personal and doctoral stress (Brown & Watson, 2010; McAlpine & McKinnon, 2013). The coping strategies could also be influenced by the PhD stage, as previous studies showed that most of the PhD students especially struggled during their first PhD year (Ali & Kohun, 2006). As students with a non-academic background face addi-

tional stressors in their personal environment (Holley & Gardner, 2012), it is recommended to consider different types of PhD students in future research. Therefore, additional work is required to explore how the coping strategies interact or influence different outcomes. Longitudinal studies and interventions are necessary not only to understand the changes in efforts and rewards of PhD students, but to investigate ways improve their situation.

CONCLUSION

The findings of this study show that the Effort-Reward-Imbalance model (Siegrist, 1996) and the Transactional Model of Stress and Coping (Lazarus & Folkman, 1984) is applicable in the context of PhD students. The results pose a sound theoretical framework to explore efforts, rewards, and motives of PhD students as well as problem-focused and emotion-focused strategies to cope with stress during a doctoral training. Furthermore, the use of a qualitative methodology displays that PhD students stated additional efforts, rewards, and motives besides the classical Effort-Reward-Imbalance questionnaire (Siegrist, 2012), such as non-work related efforts and efforts aside from the PhD project. It is important to emphasize that not only PhD students themselves but also the management level and especially the supervisors have a huge impact on the perceived efforts and rewards of PhD students, as well as the PhD students' setting (e.g., external, internal). Therefore, the perceived efforts and rewards can be influenced by countermeasures on a variety of different PhD stages as well as on a personal and organizational level. On a personal level, PhD students can be informed about stress factors and coping strategies by kick-off events and personal development workshops. Their supervisors can be included in the process via mentoring programs, which help to create a better relationship and feedback process. On an organizational level, the knowledge should be incorporated in the recruiting process and supervisor workshops. All these measurements are elementary to promote healthy behaviors in the PhD journey of a student. If these measures are encouraged from the beginning, they could work as a countermeasure against a potential imbalance between efforts and rewards that can lead to mental health issues such as depression.

ADDITIONAL STATEMENTS

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AUTHORS' CONTRIBUTIONS

Melanie Vilser conceptualized the study, conducted, transcribed, coded the interviews, and drafted the first version of the paper. Sabrina Rauh coded the interviews independently of Melanie Vilser. Later versions of the papers were discussed with Sabrina Rauh, Irmgard Mausz, and Dieter Frey. All authors approved the final paper.

INFORMED CONSENT

Informed consent about participation in the study was obtained from all participants.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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APPENDIX

APPENDIX A - INTERVIEW GUIDE

Warm-Up

- How did you get into doing a PhD?*[2]

Motives

- Please describe your own work style.*
- What drives you to do a PhD despite the challenges and burdens?
- What demands do you make on yourself regarding your doctorate?

Efforts

- Please explain your typical doctoral activities.*
- What requirements and obligations do you have regarding your PhD?
- What (further) obligations do you have apart from your PhD project?
- What do you perceive as exhausting or burdening during your doctorate?

Effort-Reward-Imbalance

- Compared to other PhD students, how would you describe your ratio of efforts and rewards?

Rewards

- Socio-emotional rewards
  - How would you describe your relationship with your supervisor / colleagues / other PhD students?*
  - Do you think that your efforts are valued appropriately?
  - Who supports you during your doctorate and how?
- Status-related rewards
  - How do you feel about the opportunities for career promotion and professional development?
  - How do you feel about the opportunities for job security?
- Financial and material rewards
  - How satisfied are you with your doctorate in financial and material terms?

Coping strategies

- Are you able to switch off from your doctorate?
- How do you switch off and recharge your energy?

Closing

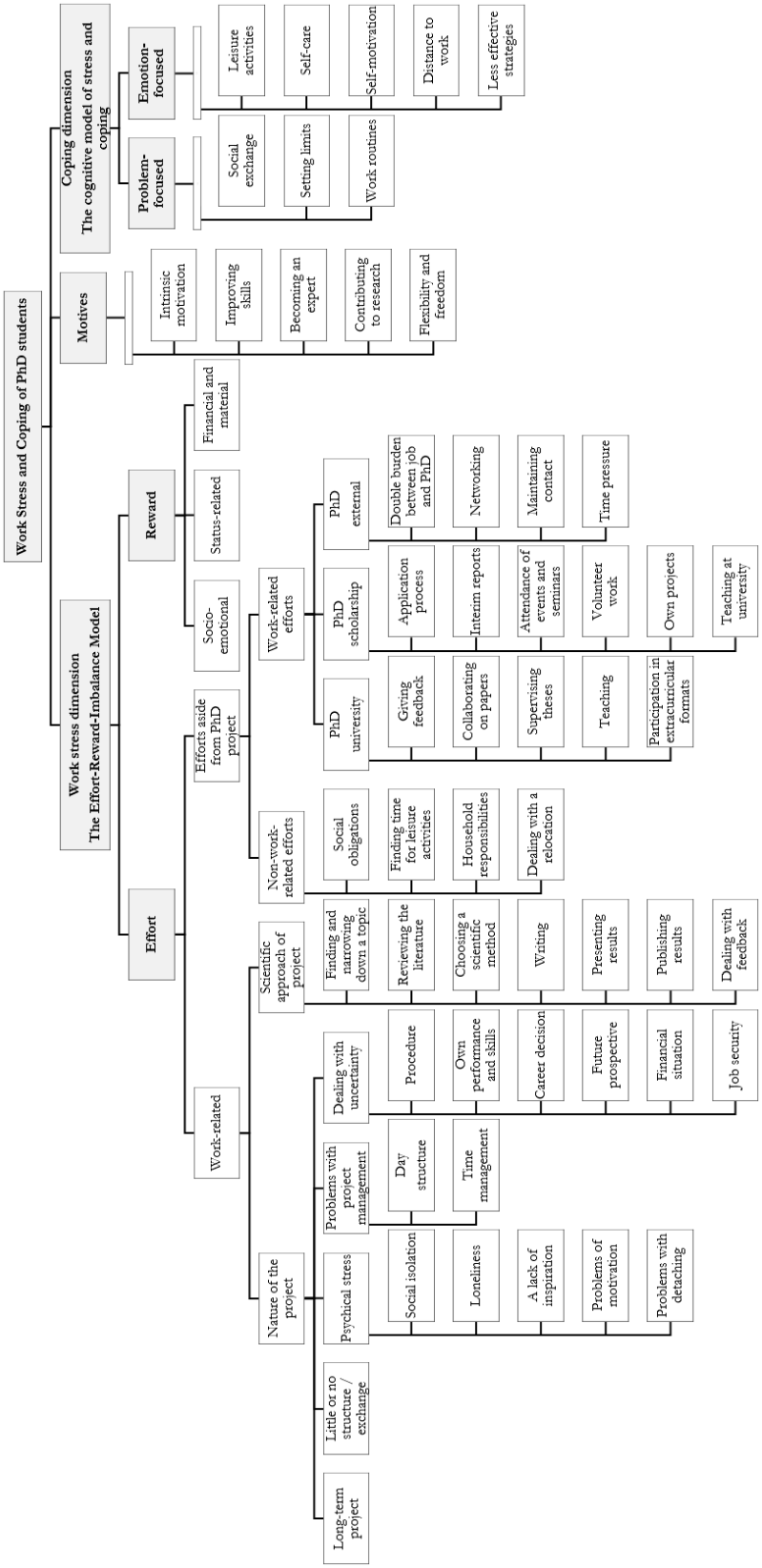
- I have asked all my questions. Can you think of anything else that you would like to add or report regarding your PhD?

[2] Questions with a * functioned as warm-up or transition questions.

APPENDIX B - UNCERTAINTY THEMES

Types of uncertainty	Typical questions from the interviewees
Procedure	How does a PhD work? Which statistical method should I use? Am I going to lose interest in other topics due to the limited free time?
Own performance and skills	Am I really good at the doctorate? Are other scientists better than me? Is my work good enough? Have I done enough for my PhD during the week, or should I have accomplished more? Man, what did I actually do today?
Career decision	Does a scientific career really suit me? Did I make the right career decision? Will the PhD be of any use for me if I do not manage to stay in science? Are my qualifications too high for the job I want to apply for?
Future prospective	Where am I going in the future? What will I do after my PhD? What does my future look like? What comes next, will it be science or not?
Financial situation	How am I going to afford my pension? Can I put enough money aside for my future? Will I get a scholarship? Will I have enough money at the end of the month / next month? How am I going to pay my bills? Should I drop out because I can't afford living? How am I going to fund my PhD when the financial support stops?
Job security	Will my contract be extended? Will I finish my doctorate in the financed time?

APPENDIX C – CONCEPTUAL FRAMEWORK OF THE STUDY



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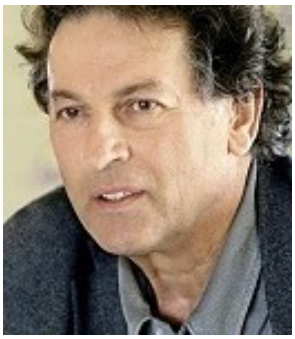


Prof. Dr. Dieter Frey is the Chief Executive Director of the Center for Leadership and People Management and held the Chair of Social Psychology at the Department of Psychology at LMU Munich. He has been an active member in science for many years as well as having worked as a consultant and trainer on the topics of leadership, motivation, innovation and change management processes. He is a member of the Bavarian Academy of Sciences and was elected German Psychology Laureate in 1998. From 2003-2013 he was the director of the Bavarian Elite Academy.

Part II

Effort-Reward Imbalance within a PhD Student Population: Adaptation and Validation of the ERI Scale for Doctoral Students

Vilser, M., Mausz, I., Frey, D. & Siegrist, J. (under review). Effort-Reward Imbalance within a PhD Student Population: Adaptation and Validation of the ERI Scale for Doctoral Students. *International Journal of Stress Management.*

The paper was presented at the 21st congress of the European Association of Work and Organizational Psychology (EAWOP), Katowice, Poland.

Abstract

The effort-reward imbalance (ERI) model is a theoretical model in the work context that identifies stressors and their adverse effects on health. This paper attempts to apply the theory to the PhD context and describes the adaptation and validation of the Effort-Reward Imbalance Scale for doctoral students (ERI-PhD) in a sample of 1275 PhD students gaining a doctoral degree in Germany. We calculated item-total correlations and Cronbach's alpha to assess the internal consistency and used exploratory and confirmatory factor analysis to test the theoretical and factorial structure of the tool. The factorial time invariance was tested with a six-week follow-up design (n = 705). The relationship between ERI components and different PhD groups (e.g., woman vs. men, external vs. internal PhD students) was examined to test discriminant validity. Linear regression analysis of the ERI-PhD with mental health (PHQ-4) were examined to test the criterion validity. Exploratory factor analysis using a randomized half of the sample yielded a four-factor structure solution. Using the other half of the sample, confirmatory factor analysis confirmed that the four-factor solution fitted the data the best. Also, the ERI level varied among demographic and PhD related variables and contributed to the explanation of poor mental health. The PhD version of the ERI questionnaire is a valid and reliable new instrument for assessing the perceived social reciprocity between efforts and rewards and its effects on mental health (i.e., depression and anxiety). In the light of the stress-related PhD conditions (e.g., isolation, work-life conflicts) and many PhD students leaving academia, the tool can provide valuable explanations.

Keywords: Effort-Reward Imbalance, Higher Education, Mental Health, PhD Students

Introduction

Work stress is a common phenomenon in our globalized world. However, there are groups that experience more work stress than others, such as academics. Compared to the general population, academics appear to suffer the most from stress, along with healthcare workers (Metcalfe et al., 2018). They also seem to have the highest numbers of mental disorders, along with social services and teachers (Goodwin et al., 2013).

In particular, young academics appear to be at high-risk of job-related stress (Bazrafkan et al., 2016; Mattijssen et al., 2020). They are faced with a variety of stressors such as time pressure, financial concerns, low integration into the scholarly community, social isolation, self-doubts, and uncertainty about the doctoral process (Cornwall et al., 2019). Accordingly, many of them have feelings of constant strain, unhappiness, anxiety, or depression, which are typical symptoms of psychiatric disorders. In comparison with working-professionals, PhD students experience significantly more severe symptoms of depression and anxiety (Hazell et al., 2021). Also, they show more symptoms of poor mental health compared to the general highly educated population, highly educated employees and higher education students (Levecque et al., 2017). This does not only have a negative impact on the personal lives and health of PhD students but also on their work performance (e.g., productivity, presenteeism, absence) and future career development (Guthrie et al., 2017; Mattijssen et al., 2020). Furthermore, PhD students who are less committed to their work have a higher turnover rate to industry (Guthrie et al., 2017). It is even said that one PhD student's key motivator to leave academia is the protection of their own mental health (Metcalfe et al., 2018).

However, there is no common-standardized instrument to measure work stress and its effects on mental health of PhD students. Researchers tend to emphasize qualitative research methods (e.g., Bazrafkan et al., 2016; Wang et al., 2019) and isolated factors (e.g., financial stress) instead of taking a multidimensional approach (Moberg, 1979) and focusing on common work stress models. This can not only be seen while looking at PhD students, but in the

general research field of academia: most of the studies are cross-sectional and are not using job-related stress models (Kinman, 2019). The few studies who did, either used the ERI model or the job demand-control model (Kinman, 2019). However, the ERI seems most appropriate, due to its different components which help to get a broader view of work stress (Kinman, 2019).

Particularly unsatisfactory is the situation in Germany. As Briedis et al. (2020) state, there is relatively little research on the situation of doctoral students and their health, as studies often do not focus on collecting data about health. Therefore, the authors nudged to investigate health in the doctoral panel "National Academics Panel Study" (NACAPS) of the German Center for Higher Education and Science Research (DZHW). The panel found out that only a third of the investigated PhD students did not experience any physical or mental impairments in the previous four weeks of the survey (Briedis et al., 2020). Also, research has started to investigate the mental health of PhD students at research institutes. One main finding was that almost every second PhD student experienced depressive symptoms during the course of gaining a PhD degree (Peukert, 2020). Compared to the German population, this is around ten times more often (Peukert, 2020). However, until now, there has been a dearth of research on the subject in Germany (de Vries, 2020; Kunz et al., 2021). Accordingly, there is a high need for a common stress theory as well as a questionnaire, that helps to investigate and explain the psychosocial traits and stress-related health risks of a PhD.

Effort-Reward Imbalance Model

A commonly used instrument to measure the origin of job stress is the effort-reward-imbalance (ERI) questionnaire (Siegrist, 1996). Due to its predictive power of adverse physical and mental health outcomes, it has received a lot of attention (Ren et al., 2019).

The ERI questionnaire is based on the theory of social reciprocity, "a fundamental principle of social exchange that guarantees equivalence of give and take between two individuals or parties" (Siegrist, 2010, p. 609). Accordingly, the ERI model assumes that

employees want to achieve a balance between their job performance (efforts) and the rewards given by their employers, such as salary, job security, esteem, or career promotion. Unfortunately, not all jobs offer this opportunity because of the global economy, which is characterized by short-term contracts, low salaries as well as low levels of safety at work (Siegrist, 2008). Some employees even agree to those conditions on purpose (e.g., fear of losing their job, hope for career promotion). In turn, lacking reciprocity can lead to anger, frustration, or continuing strain reactions, which might cause illnesses such as cardiovascular diseases. Individuals who are excessively engaged in their work (i.e., overcommitted) are especially affected by this risk because they might commit way more often than they are rewarded for their work (Siegrist & Wahrendorf, 2016). For enumerating the described scenarios, Siegrist uses three model components called effort, reward and overcommitment. Effort refers to work demands; reward to socio-emotional, status-related, or financial aspects such as esteem, career promotion or salary and overcommitment to a distinct coping pattern (Siegrist, 1996).

Originally, the ERI questionnaire was developed to identify unfavorable psychosocial work characteristics in forms of high efforts and low rewards and explain stress-related health risks in different industry sectors, e.g., industrial, electronic, health care, human and educational services (Peters & Hopkins, 2014). It consists of a long version with 22 items and a short version with 16 items, capturing three psychometric scales (i.e., effort, reward and overcommitment), which have been reviewed in a variety of studies (van Vegchel et al., 2005; Koch et al., 2014). Early ERI studies mostly focused on looking into cardiovascular results. They could, for example show, that “failed reciprocity at work […] is associated with altered functions of cardiovascular, hormonal, immune, and inflammatory markers” (Siegrist & Li, 2020, p. 15). Later studies investigated psychological and behavioral effects (van Vegchel et al., 2005). Also, the original questionnaire has been validated and adjusted for several different contexts (see overview of Peters & Hopkins, 2014). For example, a measurement for students (Wege et al., 2017) and household work (Sperlich et al., 2012) has been developed,

resulting “in new explanations of elevated risks of mental health and well-being” (Siegrist & Li, 2020, p. 23). Unfortunately, none of the questionnaires fit the PhD context very well.

Besides, there has been one study that combined the ERI with the stressor-detachment model and tested it on doctoral researchers at Bielefeld University in Germany (Kunze et al., 2021). Its questionnaire was not published during the design of our study. The authors of the study asked for a longitudinal approach, measurements across different universities, and the use of a more accurate item to measure the subjective health of PhD students. Our study meets these expectations.

Also, it must be considered that PhD-positions might differ a lot from jobs in the industry. PhD students especially value the freedom and flexibility offered by a PhD, compared to a job in industry (Vilser et al., 2022). Furthermore, the work situation of PhD students in Germany can look very different. For example, students can work at a university, at a research institute, gain a degree with the support of a scholarship holder, a company, or completely independently (Federal Ministry of Education and Research, 2019). However, many studies do only focus on the university setting, whilst other research populations are not taken into account (Guthrie et al., 2017). Our study counteracts these issues by using the ERI theory; developing and testing the ERI scale in the PhD context, and by broadening the view on different work environments and contexts that exist for PhD students. Accordingly, the study emphasizes the need for a standardized tool to assess PhD students' work-related stress. As our introduction outlined, PhD students are a particularly vulnerable population to work-related stress and mental health issues (e.g., due to financial concerns, long working hours, perfectionism). As a result, we want to contribute to the development and validation of a standardized measurement that a) supports research on PhD students, b) makes it easier to compare study results, c) takes different PhD settings into account (such as scholarship holders and students employed in the industry), d) follows the call for a longitudinal design and d) increases the number of PhD-related investigations in Germany.

Aim of the Study

To sum it up, the aim of this study was to adapt and validate the ERI questionnaire in a sample of German PhD students. We evaluated the factorial structure of the instrument by exploratory and confirmatory factor analysis (Orcan, 2018; Sakaluk & Stephen, 2016). Furthermore, we tested if the ERI measure supports to distinguish between different PhD groups (Murphey, 2003), which we characterized by gender, age, number of children and PhD type (discriminant validity). In addition, we tested the criterion validity by calculating the correlation between the ERI-PhD and mental health (i.e., PHQ-4). While doing so, our research might have an impact on the number of PhD students quitting their doctoral studies by looking at the key constructs causing stress and mental health problems (i.e., anxiety and depression).

Method

Study Design and Sample

To examine the psychometric properties of the ERI questionnaire for doctoral students, we contacted all 156 German universities, which offer the option to gain a PhD degree (Hochschulkompass, 2022), as well as the 13 largest scholarship holders from the German Federal Ministry of Education and Research, asking if they could forward our invitation to their PhD students. Overall, 100 universities and six scholarship holders agreed to forward the invitation and/or inform their PhD students via newsletters or web posts about our study with two measurement points. 23 universities explicitly declined to forward our invitation, and 33 universities, as well as seven scholarship holders, did not respond to the invitation and the follow-up e-mails. Further recruiting took place via LinkedIn and snowball sampling. In particular, we invited the subjects in our e-mail and at the end of our survey to forward the invitation to other doctoral students. Six weeks after the first survey, a follow-up survey was sent to those participants who agreed to take part in both measurement points. Altogether, 1294

participants completed the questionnaire on the first measurement point, and 705 participated in the second measurement point (dropout rate: 54.48 %).

After data screening, 19 participants were removed for the following reasons: minimum age of 18 years (n = 1); strong response tendency throughout the questionnaire (n = 1); doctorate at a foreign university (n = 8); invalid values (n = 2); and extreme outliers (n = 7). Table 1 shows the main characteristics of the study sample.

Measures

All measurements were recorded via Unipark and applied in the German language. Participants had to answer all questions, to reduce missing data.

Sociodemographic Characteristics

Participants reported demographic characteristics including their age, gender, number of children, PhD year, and PhD type (e.g., working at a university, research institute). Table 1 gives a detailed description of the sociodemographic characteristics (see next page).

Table 1

Sociodemographic and PhD-related Characteristics of Participants

	First measurement point		Second measurement point	
	n	%	*n*	%
Age	30.44 (5.98)		30.10 (6.11)	
Gender				
Male	445	34.9	229	32.4
Female	813	63.8	473	67.0
Diverse	11	0.9	3	0.4
PhD level				
< 1 year	179	14	108	15.3
1 year	157	12.3	90	12.7
2 year	274	21.5	152	21.5
3 year	266	20.9	155	22.0
4 year	200	15.7	105	14.9
5 year	104	8.2	54	7.6
> 6 year	84	6.6	38	5.4
Other	8	0.6	3	0.4
Type of PhD				
Without employment	161	12.6	82	11.6
At university	851	66.7	482	68.3
At university of applied sciences	62	4.9	34	4.8
At institution outside of university	61	4.8	33	4.7
At private sector	69	5.4	31	4.4
Scholarship holders	163	12.8	87	12.3
Other	28	2.2	21	3.0
Number of children				
0	1086	85.2	614	87.5
1	92	7.2	50	7.1
2	60	4.7	27	3.8
3	21	1.6	11	1.6
> 4	4	0.3	0	0
Field of research				
Mathematics and natural science	395	31.0	219	31.0
Law, economics, social sciences	261	20.5	137	19.4
Humanities	224	17.6	131	18.6
Engineering	157	12.3	84	11.9
Human medicine, health science	77	6.0	49	6.9
Sports	32	2.5	13	1.8
Agricultural, forestry, nutrition	23	1.8	13	1.8
Veterinary medicine	16	1.3	12	1.7
Art	21	1.6	10	1.4
Others	46	3.6	27	3.8

Effort-Reward Imbalance

The survey included a total of 22 items assessing the effort-reward imbalance questionnaire, which was reviewed and revised based on feedback from an expert group, which consisted of two professors, five postdocs, and four PhD students (see Appendix). Based on different versions of the ERI-PhD the expert group rated, which item would fit best to evaluate the ERI-PhD in a variety of PhD contexts (e.g., working at the university, having a scholarship) (content validity). The final version was pre-registered prior to the study at the Open Science Framework (OSF, 10.17605/OSF.IO/ZGH2R). Relative to the original version, six items referred to effort by assessing the quantitative, qualitative, physical[3], and over-time workload (e.g., "I have constant time pressure due to heavy workload on my PhD"). 10 items assessed reward by asking for esteem, career promotion, salary, job security (e.g., "Considering all my efforts and achievements of my PhD, my salary / income is adequate"). Six items assessed overcommitment (e.g., "My PhD rarely lets me go, it is still on my mind when I go to bed"). Each item was scored on a four-point Likert scale ranging from "strongly disagree" to "strongly agree". After factor analysis, four items were removed due to loadings of less than 0.4 (i.e., E2, E3, R5, R6) and two overcommitment items rather loaded on effort. The respective alpha coefficients for overcommitment ($\alpha = 0.83$) were high and for effort ($\alpha = 0.78$) and reward ($\alpha = 0.77$) acceptable (Blanz, 2015). According to Siegrist (2014) the original ERI version usually shows satisfactory internal consistency ($\alpha > 0.70$).

Effort-Reward Imbalance Ratio

To detect the degree of mismatch between efforts and rewards, we calculated the ERI ratio analog to Siegrist formula (ERI ratio = e/r*c). We used the sum score of the effort scale as a nominator ("e") and the sum score of the reward scale ("r") multiplied by a correction factor of 0.75 (which is calculated by dividing the average effort score by the average reward

[3] The item assessing physical load can be excluded if the subject does not include physical load and white-collar workers (Siegrist et al., 2004). We wanted to include the item in the questionnaire as this was the first development of the scale for PhD students.

score) to adjust for the number of items ("c") as the denominator (Siegrist et al., 2004). In our case, the correction factor and ERI ratio was 0.75. In order to differentiate between a slight (ERI ≤ 33th percentile), moderate (34th to 64th percentile) and severe imbalance (ERI ≤ 65th percentile), we further divided our sample into three groups (Sperlich et al., 2012).

Mental Health Measures

We used the Patient-Health Questionnaire (PHQ-4) to screen for the two main criteria for psychiatric disorders: anxiety and depression (Kohlmann et al., 2014). Anxiety can be "characterized by feelings of tension, worried thoughts, and physical changes like increased blood pressure" and depression by "extreme sadness or despair that lasts more than days" (American Psychological Association, n. d.). PhD students were asked to rate from "not at all" (1) to "nearly every day" (4) how often they had been bothered by anxiety ("feeling nervous, anxious or on edge" and "not being able to stop or control worrying") and depression ("feeling down, depressed or hopeless" and "little interest or pleasure in doing things"). After appropriate recoding sum scores were computed for each scale. The presence of depression and anxiety symptoms was indicated by the established cut-off point of ≥ 3 (Kroenke et al., 2007; Löwe et al., 2005). The PHQ-4 has a good internal reliability (α = 0.84).

Statistical Analysis

Firstly, means and standard deviations (SD) were computed according to age, gender, PhD level, PhD type, number of children, and field of research. Secondly, the internal reliability of the scales was assessed by examining the Cronbach's alpha coefficients and the corrected item-total correlations of the scales (see Table 2). Thirdly, exploratory factor analysis (EFA, Table 3) was performed on a randomized half of the sample using maximum likelihood estimation and promax (i.e., oblique) rotation to examine the factorial structure of the model (Sakaluk & Stephen, 2016). Fourthly, in line with Orcan (2018) we combined exploratory factor analysis with confirmatory factor analysis (CFA). The CFA was performed on the other half of the sample to test the dimensional structure of the theoretical ERI model. More

specifically, we used four different models: a single-factor model, a model with three first-order factors, a second-order model, and a model, that represented the results of the EFA (see Figure 1). To assess the models, we evaluated the goodness-of-fit index (GFI), which is based on multiple indices such as CFI, TLI, SRMR and RMSEA (compare Table 4). Fifthly, the factorial invariance of the ERI scale was tested across two measurement points. Sixth, we assessed the discriminant validity by computing single factor analysis (ANOVA) to compare the ERI components (i.e. effort, reward, overcommitment) between age, gender, PhD level, and type (see Table 5). In addition, we used hierarchical linear regression modeling to assess to which degree the ERI model is in relation with an external criterion (i.e., PHQ-4). We calculated a four-stage model for the ERI components and a three-stage model for the ERI ratio (see Table 6 and 7). Gender and age were entered at the first stage. The PhD level (e.g., first year of doing a PhD degree) and PhD type (e.g., PhD at a university or PhD at a research institute) were entered at stage two. Stage three either consisted of adding effort and reward or the ERI Ratio. Overcommitment was entered at stage 4 (see Table 6). This was due to other study results which suggest that the overcommitment component of the ERI model might not be an intrinsic part of effort and rather be an independent concept that influences or moderates the perception of high efforts and low rewards (van Vegchel et al., 2005). Calculations are based on SPSS 28 and Jasp 0.16.2.0.

Results

Table 2 displays mean values, standard deviation, item-total correlations, and Cronbach´s alpha if item is deleted.

Table 2

Mean, SD, Item-Total Correlation, and Cronbach's Alpha Coefficients

Scale	*M*	*SD*	Corrected Item-total-correlation	Cronbach´s alpha coefficients when item deleted
Effort				
E1	2.75	0.88	0.42	0.59
E2	2.80	0.91	0.02	0.64
E3	2.96	0.89	0.24	0.61
E4	2.85	0.95	0.32	0.60
E5	2.09	0.93	0.22	0.61
E6	2.85	0.83	0.32	0.60
Reward				
R1	2.81	0.87	0.14	0.62
R2	2.76	0.79	0.13	0.62
R3	3.36	0.77	0.03	0.63
R4	2.56	0.94	0.10	0.63
R5	2.88	0.90	0.05	0.63
R6	3.13	0.89	0.11	0.62
R7	2.75	0.80	0.16	0.62
R8	2.62	0.79	0.16	0.62
R9	2.65	0.80	0.18	0.62
R10	2.40	0.94	0.01	0.64
Overcommitment				
OC1	2.80	0.81	0.29	0.60
OC2	2.74	0.95	0.38	0.59
OC3	2.96	0.84	0.33	0.60
OC4	2.35	0.96	0.29	0.60
OC5	3.02	0.86	0.42	0.59
OC6	2.31	0.89	0.30	0.60

Exploratory Factor Analysis

To determine the factorial structure of the ERI-PhD EFA was performed on a randomized split of half of the sample (n = 655) using maximum likelihood estimation and promax (i.e., oblique) rotation of the common factor analysis based on parallel analysis (Sakaluk & Stephen, 2016). The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis (KMO = 0.873), and a significant test statistic was indicated by Bartlett's test of sphericity ($p < .001$). We removed the items E2, E3, R5 and R6, as their factor loadings were less than 0.4 (Field, 2013; Guadagnoli & Velicer, 1988). After removing the mentioned items,

the factor analysis yield a four-factor solution. The results of the item analysis are presented in Table 3.

Table 3

Exploratory Factor Analysis of the Items of the ERI-PhD

Scale	Factor 1	Factor 2	Factor 3	Factor 4	Uniqueness
Effort					
E1	0.905				0.325
E4	0.822				0.433
E5	0.417				0.809
E6	0.471				0.793
Reward					
R1 (esteem)			0.937		0.289
R2 (esteem)			0.765		0.459
R3 (esteem)			0.464		0.647
R4 (promotion)				0.587	0.698
R7 (promotion)				0.592	0.625
R8 (esteem)			0.620		0.429
R9 (promotion)				0.717	0.521
R10 (promotion)				0.582	0.620
Overcommitment					
OC1	0.503				0.613
OC2		0.784			0.404
OC3		0.651			0.576
OC4	0.437				0.553
OC5		0.942			0.208
OC6		0.541			0.619

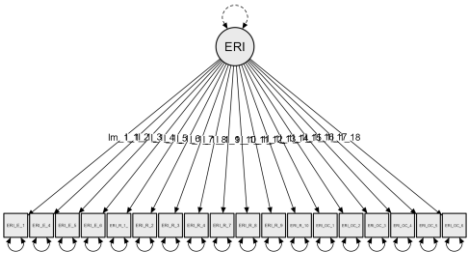
Confirmatory Factor Analysis

To confirm the structural validity of the ERI-PhD, the factor structure obtained by EFA was tested and compared to the original structure using CFA on the second half of the randomized subsample. In CFA we also removed the items E2, E3, R5 and R6, which had a factor loading less than 0.4 in the EFA (Field, 2013; Guadagnoli & Velicer, 1988). Overall, we tested four different models (see Figure 1).

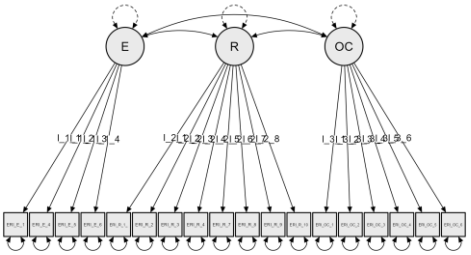
Figure 1

CFA Models of ERI-PhD

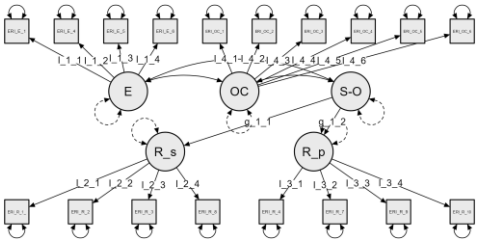
1) One-factor model



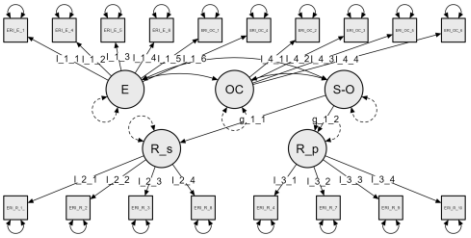
2) Three-factor model



2) Higher-order model



4) EFA model



The first model was a one-factor model, in which all items were predicted to load onto a single factor / on the same underlying dimension. This model was not a good fit of the data (see Table 4). The second model was a three-factor model with the three first order factors / component's effort, reward and overcommitment. It did not fit the data well. Only SRMR and RMSE had acceptable values, as they were close to 0.08 and 0.06 (Hu & Bentler, 1999). The third model that was tested was a higher-order model, with the reward components on the second order of the model. Although this was a better fit than the first and second model, however the fit indices for CFI and TLI were still too low (see Table 4). Lastly, we tested the model indicated by EFA (i.e., OC1 and OC4 loading on effort). As shown in Table 4, the last model indicated a good fit of the data as the fit indices CFI and TLI were above 0.90 (Bentler, 1990) and SRMR and RMSEA below 0.08 and 0.06 (Hu & Bentler, 1999).

Table 4

Fit Indices of Tested Models

Model	$\chi 2$	*df*	CFI	TLI	AIC	BIC	SRMR	RMSEA
One-factor	1617.929	135	0.586	0.531	27170.130	27330.518	0.111	0.131
Three-factor	712.169	132	0.838	0.812	26270.371	26444.123	0.068	0.083
Higher-order	514.388	130	0.839	0.874	26076.589	26259.253	0.058	0.068
EFA model	435.389	130	0.915	0.900	25997.590	26180.254	0.051	0.061

Factorial Invariance of ERI scale across Two Measurement Points

As a final step of the factor analysis we investigated the factorial invariance across time. The fit indices across time indicated a good fit of the data ($\chi^2(129) = 569.195$, $p < 0.001$, CFI = .904, TLI = .887, SRMR = .060, RMSEA = .070).

Discriminant Validity

Besides the investigation of the ERI structure, we also investigated the discriminant validity between the ERI questionnaire and different PhD groups, that we distinguished by demographic characteristics (i.e., age, gender) and PhD characteristics (i.e., PhD level and type of PhD employment).

In terms of age, the youngest PhD students had the lowest ERI-Imbalance, and at the same time, the highest overcommitment scores (see Table 5). With increasing age and PhD level, the ERI-Ratio increased. At the same time, reward scores decreased with age and PhD level. Following, the PhD group older than 35 and studying the longest, reported the lowest reward scores. In terms of gender, male PhDs showed a lower ERI Ratio, lower effort, and overcommitment scores in comparison with female PhD students. At the same time, they reported slightly higher reward scores. In terms of PhD level, the overcommitment score increased with study years (excluding the results of the fifth year). Also, the data showed that PhD students working at a university or at a research institute (e.g., Max-Planck, Leibniz) had the highest effort and overcommitment scores, followed by PhD students having a scholarship. In comparison, PhD students who gained their PhD while working at a non-PhD-related industry job had the highest reward scores. In terms of parenthood, PhD students with one child or two children report the highest ERI ratio and overcommitment score, followed by PhD students without children. The group with three or more children, as well as students without children, report the highest reward scores. PhD students with one child reported the lowest reward and high effort scores. Supplementary Table 5 for detailed results.

Table 5

Associations between ERI Components and Sociodemographic Characteristics

	Ratio		Effort		Reward		Overcommitment	
Age groups	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
< 25	0.66	0.22	2.50	0.65	2.93	0.51	2.92	0.72
25-29	0.71	0.24	2.58	0.61	2.80	0.50	2.73	0.73
30-35	0.79	0.27	2.67	0.60	2.66	0.53	2.79	0.71
> 35	0.79	0.26	2.65	0.65	2.61	0.49	2.70	0.65
	$F = 13.06$	$p < 0.001$	$F = 2.33$	$p = 0.073$	$F = 11.90$	$p < .001$	$F = 1.86$	$p = 0.135$
Gender								
Female	0.76	0.26	2.64	0.61	2.71	0.53	2.79	0.72
Male	0.71	0.24	2.57	0.62	2.80	0.49	2.68	0.71
Diverse	0.78	0.33	2.48	0.70	2.47	0.66	2.84	0.86
	$F = 5.07$	$p = 0.006$	$F = 2.43$	$p = 0.09$	$F = 5.47$	$p = 0.004$	$F = 3.38$	$p = 0.034$
Number of children								
0	0.74	0.26	2.62	0.61	2.75	0.52	2.78	0.72
1	0.78	0.23	2.64	0.59	2.67	0.49	2.65	0.68
2	0.76	0.24	2.60	0.63	2.72	0.52	2.75	0.63
3	0.70	0.23	2.35	0.66	2.74	0.64	2.32	0.66
4 or more	0.50	0.16	1.83	0.99	2.84	0.93	2.06	0.66
	$F = 1.48$	$p = 0.205$	$F = 2.68$	$p = 0.030$	$F = 0.54$	$p = 0.703$	$F = 3.57$	$p = 0.007$
PhD level								
< 1 year	0.64	0.14	2.28	0.25	2.93	0.50	2.66	0.75
1 year	0.67	0.23	2.51	0.65	2.82	0.49	2.68	0.72
2 year	0.68	0.23	2.46	0.59	2.80	0.48	2.72	0.74
3 year	0.71	0.22	2.57	0.60	2.72	0.48	2.80	0.70
4 year	0.75	0.24	2.66	0.63	2.63	0.53	2.83	0.70
5 year	0.80	0.27	2.73	0.58	2.56	0.57	2.79	0.69
> 6 year	0.85	0.30	2.71	0.60	2.54	0.56	2.87	0.63
Other	0.84	0.26	2.78	0.61	2.52	0.68	2.94	0.61
	$F = 9.50$	$p < 0.001$	$F = 4.44$	$p < 0.001$	$F = 8.69$	$p < 0.001$	$F = 1.55$	$p = 0.136$
Type of PhD employment								
Without	0.71	0.26	2.41	0.62	2.64	0.49	2.68	0.72
University	0.76	0.26	2.65	0.61	2.74	0.52	2.78	0.72
University of applied sciences	0.71	0.25	2.49	0.56	2.83	0.57	2.64	0.64
Institution outside of university	0.74	0.28	2.71	0.71	2.79	0.48	2.79	0.80
Private sector / industry [a]	0.64	0.21	2.39	0.47	2.93	0.47	2.55	0.63
Private sector / industry [b]	0.66	0.32	2.33	0.81	2.90	0.85	2.10	0.63
Scholarship	0.72	0.22	2.58	0.68	2.76	0.45	2.72	0.80
Other	0.71	0.21	2.64	0.58	2.67	0.40	2.42	0.83
	$F = 1.49$	$p = 0.15$	$F = 2.95$	$p = 0.002$	$F = 1.37$	$p = 0.20$	$F = 1.94$	$p = 0.043$

[a] PhD related [b] Non-PhD related

Criterion Validity

As research has been indicated that scale validation is supported if at least two different forms of validation have been examined (Boateng et al., 2018), we did not only test the discriminant validity but also the criterion validity by looking at the associations of ERI and its components with mental health (see Table 6 and 7). The hierarchical regression revealed that at stage one and two, gender contributed significantly to the regression models in Table 6 ($F^{model1}(2,1266) = 5.24$, $p < 0.05$, $F^{model2}(4,1264) = 3.89$, $p < 0.05$) and Table 7 ($F^{model1}(2,1266) = 5.24$, $p < 0.01$, $F^{model2}(4,1264) = 3.89$, $p < 0.01$). Both tables show that the sociodemographic characteristics explain 0.8% and the PhD attributes 1.2% of variation in mental health. Introducing the ERI ratio (see Table 7) or the effort and reward component (see Table 6) explains an additional 16% - 17.3% of variation in mental health. Adding the overcommitment component (see Table 6) explains an additional 9.3% of variation in mental health ($F^{model4}(7,1261) = 69.49$, $p < 0.001$, $R^2 = 0.27$).

Table 6

Regression Analysis of Mental Health by Socio-Demographic Characteristics and ERI Measures

	Model 1		Model 2		Model 3		Model 4	
	ß	*t*	*ß*	*t*	*ß*	*t*	*ß*	*t*
Gender	-0,08	-3,02*	-0.08	-2.98*	-0.05	-2.03*	-0.04	-1.79
Age	-0,03	-1,06	-0.05	-1.75	-0.05	-1.84	-0.03	-1.04
PhD Type			0.00	0.12	0.01	0.20	0.00	0.15
PhD Level			0.07	2.25*	-0.03	-1.16	-0.04	-1.37
Effort					0.27	10.00***	0.08	2.74**
Reward					-0.25	-8.99***	-0.21	-7.99***
Overcommitment							0.37	12.75***
R^2		0.01		0.01		0.19		0.28
F		5.24*		3.89*		47.83***		69.49***
ΔR^2				0.00		0.17		0.09
ΔF				2.53		134.07***		162.69***

Note. $N = 1269$.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.0001$

Table 7

Regression Analysis of Mental Health by Socio-Demographic Characteristics and ERI Ratio

	Model 1		Model 2		Model 3	
	ß	*t*	*ß*	*t*	*ß*	*t*
Gender	-0,08	-3,02**	-0,08	-2,98**	-0.05	-1.95
Age	-0,03	-1,06	-0,05	-1,75	-0.06	-2.14*
PhD Type			0.00	0.12	0.01	0.27
PhD Level			0.07	2.25*	-0.03	-0.92
ERI Ratio					0.41	15.63***
R^2		0.01		0.01		0.17
F		5.24*		3.89*		52.57**
ΔR^2				0.00		0.16
ΔF				2.53		244.30***

Note. $N = 1269$.
$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.0001$

Discussion

This is the first study which aimed to adapt and test the ERI to the PhD context to address the lack of a standardized instrument to discover psychosocial traits and explain stress-related health risks of doctoral students. The results indicated a four-factor solution, which is in line with other studies (e.g., Tsutsumi et al., 2001; Zurlo et al., 2010). Specifically, the ERI PhD scale differed in three aspects from the original scale: First, two overcommitment items rather loaded on effort (i.e., “I get easily overwhelmed by time pressure in my PhD” and “People close to me say I sacrifice too much for my PhD”). Second, the items regarding security did not seem to fit the questionnaire very well as they loaded on career promotion (i.e., “In my PhD I have experienced or I expect to experience an undesirable change in my work situation” and “My employment security during my PhD is poor (e.g., financing, execution)”. Following, the ERI-PhD only consists of the reward components “esteem” and “promotion”. Third, also two effort items had to be removed (i.e., “I have many interruptions and disturbances while working on my PhD” and “I have a lot of responsibility in my PhD”). As this is the first validation of the ERI-PhD scale, results seem difficult to compare. However, the

factor structure clearly represents the three main components of the model and shows similarities to the four-factor model of other ERI validation studies (e.g., Tsutsumi et al., 2001; Zurlo et al., 2010). Also, the described loading of overcommitment has already been investigated in the ERI student setting (Hwang et al., 2019) as well as the lacking fit of the job security items (Peters & Hopkins, 2014). Furthermore, criterion validity could show that ERI significantly relates to mental health. This is not surprisingly, as previous research has shown, that the ERI is associated with anxiety and depression (Presley, 2017). Furthermore, our analysis shows that the ERI components differ according to sociodemographic and PhD-related factors (discriminant validity). It can be interpreted that some PhD students are more stressed and have a greater risk of developing an effort-reward imbalance than others. In our study sample, it can be seen that: 1) female students, 2) students with one child, 3) PhD students with long studying periods, 4) PhD students older than 35, and 5) PhD students working at a research institute and at a university seem to have a greater risk of an effort-reward imbalance in the form of high efforts and low rewards. In comparison, male PhD students and external PhD students (e.g., students working in the industry or having a financed year on leave from their company) seem to have a lower risk of an effort-reward imbalance. This latter finding is in line with other studies (e.g., Evans et al., 2018; Hinz et al., 2016; Ren et al., 2019). Also, the World Health Organization (WHO) states that mental illnesses are overrepresented in women in general (Guthrie et al., 2017). This might partly be due to the varying gender values of labor (Zhao et al., 2019). While men rather value work first, women's values are formed by work and family, which might influence the different perception of the ERI components. Further, academic women seem to be more stressed by salary and organizational expectations (Tytherleigh et al., 2005) and show a higher work intensity than men (Hogan et al., 2014). As more and more PhD students are female (Offerman, 2011), this trend should be taken into account by supporting female students to juggle better with an effort-reward imbalance during their PhD.

Our study also showed that the perceived efforts and rewards appear to vary according to the number of children (2). Interestingly, students with one child seem to experience higher efforts and lower rewards. The trend is reversed with a rising number of children, as already reported in another PhD study (Sverdlik & Hall, 2020). This could be explained by the fact that PhD students with their first child might face a variety of "new" efforts and rewards (e.g., childcare), whereas PhD students with more children are already used to the efforts and rewards associated with having a family. Furthermore, they could have a stronger support system in their social environment to juggle between PhD and family life. However, a closer look needs to be taken into that topic for future investigations.

A further PhD characteristic that we investigated in our study was the time period PhD students used to obtain a doctoral degree and how it might influence the perception of efforts and rewards. It could be seen that PhD students studying for several years perceived higher efforts and lower rewards than PhD students who were in their earlier years (3). However, it seems to be difficult to draw any conclusion due to the research´s lack of different PhD levels. Most studies focus on early-stage PhD students, arguing that the stressors during the beginning of the PhD are unique (e.g., Cornwall et al., 2019; Hockey, 1994). Yet, our study results show that the focus should not only be on the early PhD stage. Instead, PhD students studying for years seem to struggle even more with an effort-reward imbalance. Probably, this is due to a perceived decrease in rewards, as they have been working on their PhD for quite some time without achieving rather early on. Therefore, it could be useful to enhance the self-efficacy of PhD students to increase their belief in their abilities to reach their goal of finishing their PhD studies. This would enable PhD students to tackle difficult situations and to perform successfully (Overall, Deane & Peterson, 2010). Still, we agree that supporting PhD students from the beginning on is an important aim that could be reached by strengthening competences of project and time management and by providing regular feedback from supervisors.

Also, a perceived age difference in efforts was apparent from our data (4). PhD students between 30 and 35 had higher effort scores, followed by PhD students older than 35. The age difference is consistent with other contexts (Ren et al., 2019; Unterbrink et al., 2008), and may point to the fact that stress management becomes more difficult with rising age (Pulopulos et al., 2018).

Besides the difference in age, the data also shows a variance in effort while looking at the work setting of PhD students (5). This can be explained by the different requirements of job tasks. While PhD students working at the university have a high load of extra tasks like preparing teaching and supervising theses, external PhD students or PhD students with a scholarship have very different tasks besides writing their thesis, e.g., job-related work, volunteer work (Vilser et al., 2022). Summing it up, there are a variety of sociodemographic characteristics and PhD-related elements that influence the perception of efforts and rewards. As this is the first study that developed and investigated the ERI-PhD, there is need for further investigations.

Strengths of the Study

The strength of this study is reflected in several different points. Firstly, the main strength of the present study is the large sample and longitudinal design, which helps to analyze the stability and temporal invariance of the ERI-PhD. To our knowledge, there are only a few studies that test the ERI over time (de Jonge et al., 2008; Rantanen et al., 2013). Furthermore, our study is, besides the study of Kunz et al. (2021), one of the first that adapted the original ERI questionnaire to reflect the psychosocial work characteristics of doctoral students. Therefore, we believe that the measurement can accurately reveal the doctoral student's ERI. As the ERI model is a theoretical model, it conceptualizes how to reduce the complexity of work stress and help to gain unique insights into the perceived ERI of doctoral students. It can provide a valuable basis for future research and practical implementations, as well as interventions in the PhD context. This is an important step to improve PhD working conditions

and reduce dropout rates. If there is a good understanding of stress factors and their health risks, young researchers can implement this knowledge during their doctoral studies and throughout their academic career. Secondly, the study tries to counteract the limited research on mental health of PhD students (El-Ghoroury et al., 2012). Until now, there was no standardized instrument to assess stressful work and its effects on health in a theoretical context, such as the ERI model, which made it difficult to achieve comparable explanatory results. With rising interest in academics and their mental health (Barthauer et al., 2020; Hirisch, 2018), we hope that the ERI-PhD will contribute to this improvement. Thirdly, our study is not restricted to a specific university, department, or discipline in Germany. Instead, we reached out to all universities in Germany that offer the option to gain a PhD degree, as well as all large federal scholarship holders. Therefore, the results are generalizable to PhD students all over Germany.

Limitations and Future Research

There are some crucial limitations to the study which need to be addressed. In general, this was the first study that adjusted the ERI questionnaire to the context of doctoral students. Therefore, further analysis are needed, especially with an international doctoral sample, as our study did focus on PhD students who gained their doctoral degree at German universities. In addition, it should be noted that our study used self-reported data. This might have increased the probability of incurring common method variance. Hence, it would be interesting to move to a mix of self-reported and objective measures, such as heart rate or cortisol levels. On top of that, it would be interesting to not only investigate the ERI on current PhD students, but also to compare the results with postdoctoral students. It might even be useful to simultaneously use the ERI-PhD with the questionnaire of Sperlich et al. (2012) to differentiate between PhD work and private/household stress factors. For example, the age of a child could influence to what extent a PhD student feels stressed (besides the PhD project). If a PhD student already raised his children, he is probably putting less effort into parenting and has more

time to focus on the PhD project. Therefore, it could be investigated whether the ERI score decreases or increases with the age of a child.

Practical Consequences

This paper does not only raise awareness on the importance of ERI theory in the PhD context. Our investigation helps to educate and enlighten PhD students and their supervisors about the ERI principles and adverse effects of a potential imbalance. With our study results, it is clearer which groups are particularly affected by an imbalance and need greater support (e.g., women, PhD students working at the university or at a research institute, PhD students with a child). On the one hand, PhD students can be made aware of the efforts and rewards from the start of their doctoral program, and on the other hand, their resilience can be developed, specifically to help them deal with the demands, enabling them to complete a PhD in a healthier way. Supervisors can, in turn, address rewarding aspects (e.g., salary, recognition, appreciation) and lessen some of the burdens (e.g., conflicts with supervisors, isolation during the doctorate). To do this effectively, we recommend integrating mandatory supervisor training (for instance on the topic of leadership or well-being in the workplace) into the doctoral programs of German universities. So far, the academic landscape in Germany is marked by an absence of respective programs for supervisors.

Conclusion

In sum, the adjusted ERI-PhD questionnaire is an appropriate tool to measure the psychosocial work characteristics and stress-related health risks of doctoral students. It raises awareness of the mental health conditions of PhD students and might lead to new perspectives and methods in recruiting, leading, and supporting PhD students during their doctoral degree. Besides, the tool is significantly helpful for PhD students as they can use the questionnaire to self-examine their level of work-related stress in terms of the ERI ratio and its relationship with health risks.

Additional Statements

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Authors' Contributions

MV conceived of the study design and carried out the study. She drafted the manuscript and performed the statistical analysis. IM and DF participated in the design of the study. JS, IM and DF have been involved in revising the manuscript critically. All authors read and approved the final manuscript.

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Appendix

The Effort-Reward Imbalance Scale for PhD students (ERI-PhD)

		Stimme gar nicht zu	Stimme nicht zu	Stimme zu	Stimme voll zu
E1	Aufgrund des hohen Arbeitsaufkommens an meiner Promotion besteht häufig großer Zeitdruck.	☐	☐	☐	☐
E4	Ich bin bei meiner Promotion häufig gezwungen, Überstunden zu machen.	☐	☐	☐	☐
E5	Die Arbeit an meiner Promotion ist körperlich anstrengend.	☐	☐	☐	☐
E6	Im Laufe der Zeit ist die Arbeit an meiner Promotion immer mehr geworden.	☐	☐	☐	☐
R1	Ich erhalte von meinem/r Betreuer/in bzw. einer entsprechenden wichtigen Person die Anerkennung, die ich verdiene.	☐	☐	☐	☐
R2	Ich erhalte bei meiner Promotion in schwierigen Situationen angemessene Unterstützung.	☐	☐	☐	☐
R3	Ich werde bei der Arbeit an meiner Promotion ungerecht behandelt. [a]	☐	☐	☐	☐
R4	Die Aufstiegschancen in meinem (Fach-)Bereich sind schlecht. [a]	☐	☐	☐	☐
R7	Wenn ich an meine akademische Ausbildung denke, halte ich meine berufliche Stellung für angemessen.	☐	☐	☐	☐
R8	Wenn ich an all die erbrachten Leistungen und Anstrengungen meiner Promotion denke, halte ich die erfahrene Anerkennung für angemessen.	☐	☐	☐	☐
R9	Wenn ich an all die erbrachten Leistungen und Anstrengungen meiner Promotion denke, halte ich meine persönlichen Chancen des beruflichen Fortkommens für angemessen.	☐	☐	☐	☐
R10	Wenn ich an all die erbrachten Leistungen meiner Promotion denke, halte ich meine finanzielle Situation (z. B. Gehalt, Stipendium) für angemessen.	☐	☐	☐	☐
OC1	Beim Arbeiten an meiner Promotion komme ich leicht in Zeitdruck. [b]	☐	☐	☐	☐
OC2	Es passiert mir oft, dass ich schon beim Aufwachen an Probleme bezüglich meiner Promotion denke.	☐	☐	☐	☐
OC3	Das Abschalten von meiner Promotion fällt mir sehr leicht. [a]	☐	☐	☐	☐
OC4	Diejenigen, die mir am nächsten stehen sagen, ich opfere mich zu sehr für meine Promotion auf. [b]	☐	☐	☐	☐
OC5	Die Arbeit an meiner Promotion lässt mich selten los, sie geht mir abends noch im Kopf herum.	☐	☐	☐	☐
OC6	Wenn ich bei meiner Promotion etwas verschiebe, was ich eigentlich heute erledigen müsste, kann ich nachts nicht schlafen.	☐	☐	☐	☐

Note. Removed items after EFA: E2, E3, R5, R6. Scale adapted from Siegrist, J. (2012). *ERI-L 16 Items and ERI-OC 6 Items.* https://www.uniklinik-duesseldorf.de/patienten-besucher/klinikeninstitutezentren/institut-fuer-medizinische-soziologie/das-institut/forschung/the-eri-model-stress-and-health/eri-questionnaires/questionnaires-download

[a] Reversed item. [b] EFA shows that items load on effort.

Translation of the Effort-Reward Imbalance Scale for PhD Students (ERI-PhD) [c]

		Strongly disagree	Disagree	Agree	Strongly agree
E1	I have constant time pressure due to heavy work load in my PhD.	☐	☐	☐	☐
E4	In my PhD I am often pressured to work overtime.	☐	☐	☐	☐
E5	My PhD is physically demanding.	☐	☐	☐	☐
E6	Over the past few years, my PhD has become more and more demanding.	☐	☐	☐	☐
R1	I receive the respect I deserve from my supervisor or a respective relevant person.	☐	☐	☐	☐
R2	In my PhD I experience adequate support in difficult situations.	☐	☐	☐	☐
R3	I am treated unfairly in my PhD. [a]	☐	☐	☐	☐
R4	My job promotion prospects are poor. [a]	☐	☐	☐	☐
R7	My current occupational position adequately reflects my education and training.	☐	☐	☐	☐
R8	Considering all my efforts and achievements of my PhD, I receive the respect and prestige I deserve.	☐	☐	☐	☐
R9	Considering all my efforts and achievements of my PhD, my job promotion prospects are adequate.	☐	☐	☐	☐
R10	Considering all my efforts and achievements of my PhD, my salary / income is adequate.	☐	☐	☐	☐
OC1	I get easily overwhelmed by time pressure in my PhD. [b]	☐	☐	☐	☐
OC2	As soon as I get up in the morning I start thinking about problems related to my PhD.	☐	☐	☐	☐
OC3	I can easily relax and switch off from my PhD. [a]	☐	☐	☐	☐
OC4	People close to me say I sacrifice too much for my PhD. [b]	☐	☐	☐	☐
OC5	My PhD rarely lets me go, it is still on my mind when I go to bed.	☐	☐	☐	☐
OC6	If I postpone something of my PhD that I was supposed to do today I´ll have trouble sleeping at night.	☐	☐	☐	☐

Note. Removed items after EFA: E2, E3, R5, R6. Scale adapted from Siegrist, J. (2012). *ERI-L 16 Items and ERI-OC 6 Items.* https://www.uniklinik-duesseldorf.de/patienten-besucher/klinikeninstitutezentren/institut-fuer-medizinische-soziologie/das-institut/forschung/the-eri-model-stress-and-health/eri-questionnaires/questionnaires-download

[a] Reversed item. [b] EFA shows that items load on effort. [c] Translation is not validated.